INCLUSIVE GREEN ECONOMY POLICIES AND PRACTICE

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FOREWORD

The United Nations Environment Programme (UNEP) launched a Green Economy Initiative in 2008, which aimed at encouraging investment in improving the environment as a new engine for economic growth. The initiative resonated with policy makers such that “green economy” was adopted as a major agenda item for the 2012 United Nations Conference on Sustainable Development.

Governments and businesses are intuitively attracted to the notion that investing in clean technologies, clean water, and clean mobility, etc. can improve the environment while creating jobs and markets. Some of them acted upon this notion accordingly, such as in China and the United Arab Emirates. For the green economy model to sustain beyond anecdotal examples, however, it needs a systematic framework that speaks to policy advisers and business executives, as well as the graduate students who will step into those positions in the coming years.

This textbook attempts to offer that systematic framework for the green economy model. It builds on and extends from the traditional economic growth model by articulating the contributions to productivity from investing in natural capital, clean technologies, and green skills, enabled by fiscal, finance, trade, and labour policies. It also addresses the importance of institutions and progress measurement for ensuring that transition towards a green economy is pro-poor, inclusive, fair, and just. We hope that this textbook will inspire the students of today and prepare them to shape the Inclusive Green Economy of tomorrow.

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LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline the main challenges facing humanity and analyse their drivers;
- Articulate how the inclusive green economy model seeks to address these challenges; and
- Understand the major characteristics that underpin national strategies on inclusive green economy, the related analytical tools, key actors and initiatives as well as the critical role of public policy in turning the inclusive seen economy model into practice.

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He has published a range of academic journal papers in this field, and continues to engage with the UN on a range of projects relating to the inclusive green economy and SDGs.

CHAPTER CONTENTS

1. Main challenges and drivers

1.1 Persistent poverty and inequality

In the years leading up to 2015, significant progress was made across a range of development objectives agreed under the Millennium Development Goals (MDGs), including addressing poverty and hunger, education, gender equality, and health outcomes in the low-income world (United Nations, 2015). This progress has taken place in the context of a quadrupling of the global population to well over 7 billion people over the last 100 years, during which time global economic output (measured by GDP) has increased more than 24-fold (UN Environment, 2012; Maddison, 2003; Krausmann et al., 2009) (Figures 1 and 2). Continued economic development and growth in low-income regions is seen by many as the key mechanism for addressing remaining social development challenges and leaving no one behind.

However, despite the gains made, inequalities remain profound across all dimensions of life. The richest one per cent of the world's population now control close to 50 per cent of global assets, while the poorest half owns a mere one per cent (Stierli et al., 2014). About one in eight people still live in extreme poverty, nearly 800 million people suffer from hunger, 1.1 billion people are living without electricity, some 2.5 billion people lack basic sanitation facilities, and water scarcity affects more than 2 billion people worldwide (United Nations, 2016; World Health Organization & UNICEF, 2013). While economic development and globalization have brought immense progress and advancements, they have also led to the loss of jobs in many sectors and geographical regions, and increasing vulnerability of employment worldwide (see also Chapter 7) (Felbermayr et al., 2011; Davis & Harrigan, 2011; Lee & Vivarelli, 2006).

1.2 Overstepped planetary boundaries

Economic growth has indeed driven an increase in household income in both high- and low-income countries along with a reduction in extreme poverty and expansion of the middle class. This growth, however, has been accompanied by rapidly changing consumption and production patterns, with steeply rising environmental impacts and pollution on a global scale (Figures 1-4, over the page). Over the past century, **primary energy** use has increased more than ten-fold, while water use has increased more than six-fold (Figure 3). Global material consumption rose to 70 billion metric tonnes in 2010, with two-fifths of

Key term:
Primary energy
Energy that has not been transformed in any way from its original form.

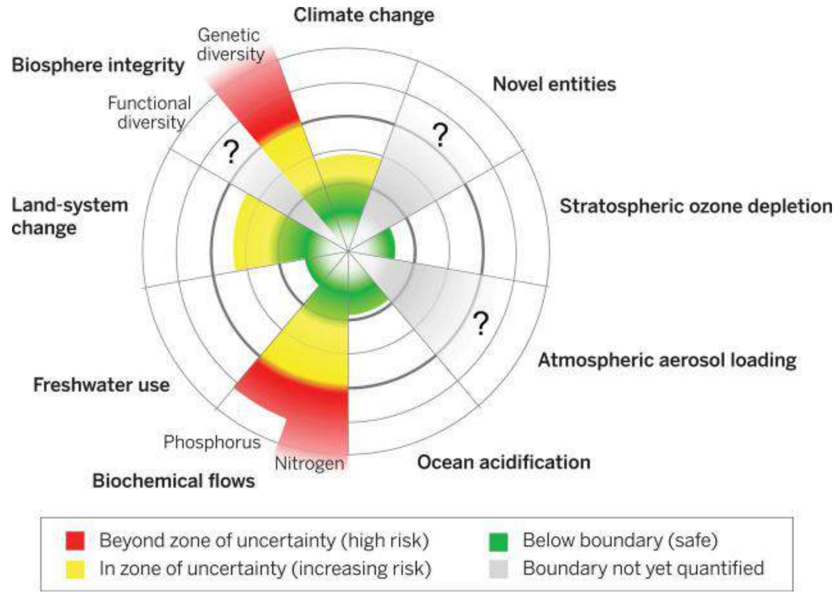
Box 1: The planetary boundaries concept

Considerable research has been done in the past decade to better understand and measure planetary biophysical limits, with increasing attention towards delineating safer limits or thresholds for human activity. Among the most comprehensive efforts to delineate such limits is the work on establishing nine planetary boundaries, which represent a safe operating space for humanity [zotpressInText item="{BS33HN7F}"] (Rockström et al., 2009, Steffen et al., 2015).

The nine planetary boundaries concept, which was introduced in 2009 and has been influential in global sustainability policy development, aims to define the environmental limits within which humanity can safely operate. These boundaries include: global freshwater use, extinction rates, CO_2 concentrations, the quantity of phosphorus and nitrogen flowing into the oceans, amongst others (Figure 1).

Their analysis suggests that humanity has already transgressed three of these boundaries (climate change, biodiversity loss and nitrogen) and is well on the way to crossing several others.

In Figure 1, the green zone shows the safe operating space, the yellow zone is the zone of uncertainty, where risk is increasing, and red represents the high-risk zone. The planetary boundary itself is located at the intersection of the green and yellow zones. The grey wedges represent processes for which global-level boundaries cannot yet be quantified.



all global raw materials extracted solely to enable exports to other countries (Figure 4) (Wiedmann et al., 2015). This is projected to reach 140 billion tonnes by 2050 (UN Environment, 2011a; Bringezu et al., 2014). At the same time, inefficiencies, extremely low recycling rates, for example in the case of special metals for modern technologies and applications, and a lack of resource productivity targets means that many resources are wasted (Graedel et al., 2011).

Scientific assessments of global trends highlight that development gains made in recent decades are now under threat as a result of declining natural resources and environmental damage (Millennium Ecosystem Assessment, 2005; UN Environment, 2012; UN Environment, 2011a; Intergovernmental Panel on Climate Change [IPCC], 2014; UN Environment, 2016). There is growing evidence that humanity is harming biophysical systems and exceeding safe planetary limits or thresholds (Box 1) (Rockström et al., 2009; Steffen et al., 2015). In particular, there is ongoing anxiety over **anthropogenic climate change** and its economic, social and environmental consequences (Hansen, 2010; Stern, 2008; IPCC, 2014).

> **Key term: Anthropogenic climate change**
> Climate changes influenced by the actions of humans, in particular emissions of greenhouse gases from fossil fuel combustion and deforestation.

1.3 The 'take-make-dispose' model

The growing evidence of natural resource depletion, environmental decline and inequality demonstrate that our traditional economic model and policy approaches have not provided a foundation for sustainable development. From an economic perspective, the dominant take-make-dispose model is a major driver for the challenges described above. This model is based on decreasing prices, increasing throughput and consumer demand, and growing ecological and environmental footprints (UN Environment, 2015). The production of goods for consumption, for example, requires energy and materials – minerals, water, food, and fibre – and our current economic model relies upon these materials and energy being easily accessible, cheap and available in large quantities. Most economic development and growth strategies have encouraged rapid depletion of these natural resources and degradation of the ecosystems that underpin them. The scientific evidence also highlights that impacts on the environment often disproportion-

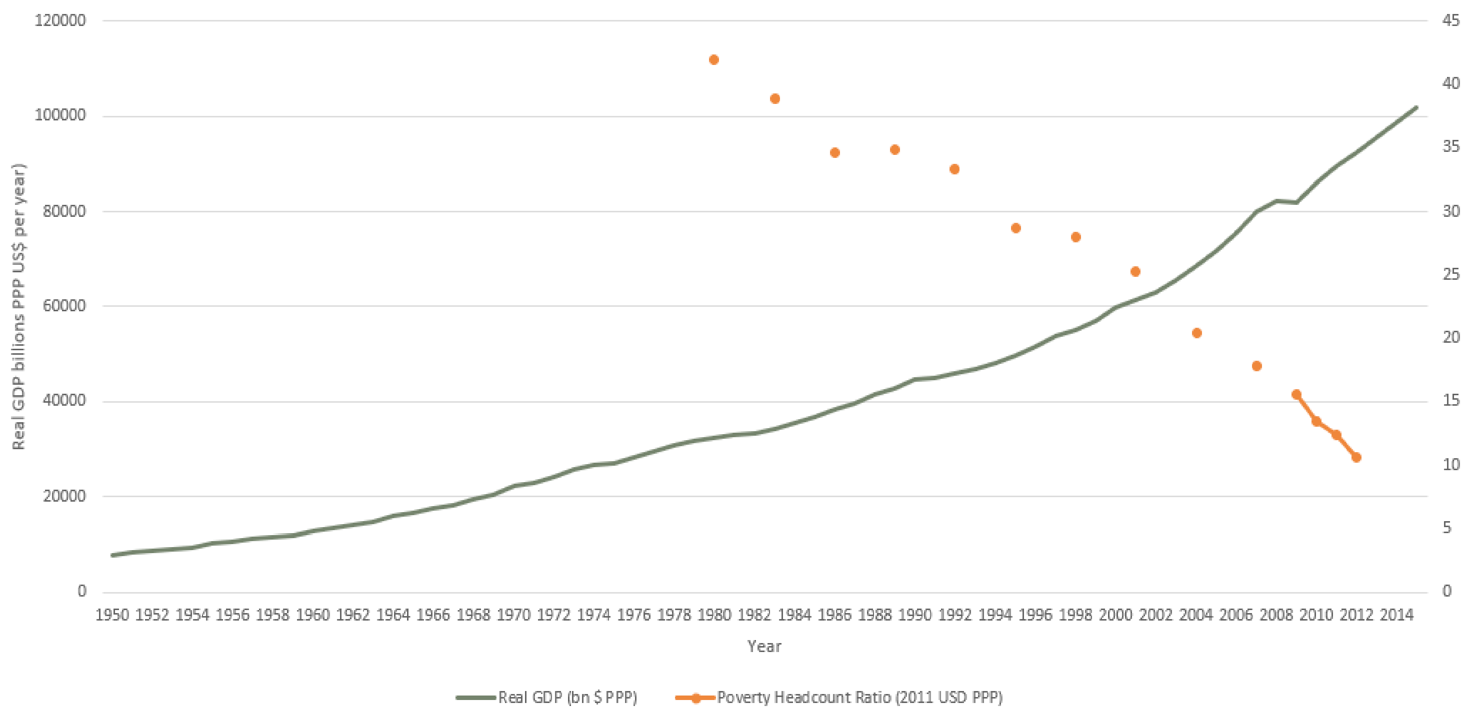
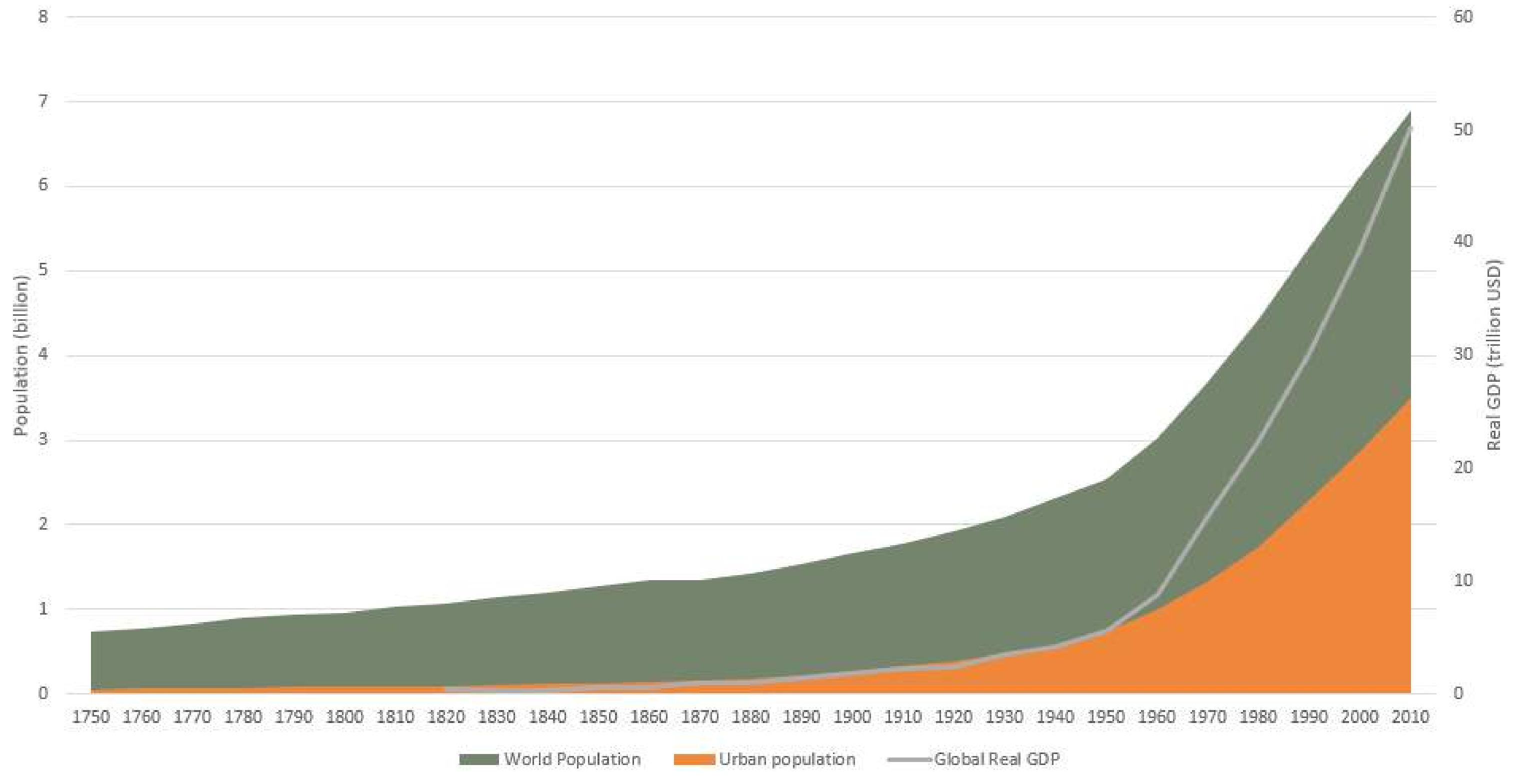


Figure 2: (above) Global trends in population and GDP 1750 to 2010 (Steffen et.al, 2015)

Figure 3: (below) World Real GDP (in billions at purchasing power parity (PPP) in US$) 1950 to 2015 (World Economics, 2017) and Poverty Headcount Ratio at US$1.90 a day (percentage of the population living on less than US$1.90 a day at 2011 prices at PPP) (World Bank, 2018)



ately burden the poorest and most vulnerable in society (see also Chapter7).

The problem of overuse of environmental resources is further driven by the failure of the market to fulfil its purpose of price discovery and efficient resource allocation towards maximising public welfare. For the most part, market participants, those participating in the market by producing, selling, providing services etc., have taken little account of the **negative externalities** of their activities. Investment horizons, for example, are generally shorter than the lifetime of the underlying assets and the environmental impacts that they create (UNEP Inquiry, 2015). Also, nature provides several key economic functions, including the provision of resources, life support systems, and a sink for wastes and emissions (see also Chapter3), which are in general, inadequately reflected in financial terms (Ghisellini et al., 2016), and thus not recognised by market forces primarily operating on the basis of price.

Key term: Negative externalities
A negative externality is a cost suffered by a third party as a result of an economic transaction. In a transaction, the producer and consumer are the first and second parties, and third parties include any individual, organisation, property owner, or resource that is indirectly affected.

In many cases this leads to the unsustainable use of these resources with resulting public loss, as in the case of fossil fuel investments and climate change. Market failure is often reinforced by policy failure, i.e. misaligned incentives and antiquated institutions guiding investment and economic activity (UN Environment, 2015). The concessions, licenses, subsidies and incentives provided by governments provide a key driver for investment, innovation and economic growth. However, these incentives have been geared largely towards a 'brown economy' founded on fossil fuels and intensive use of natural resources.

2. The 'Inclusive Green Economy' model

2.1 The need for a new model

The scale of the challenges over the coming decades is clear. We will need to meet the needs of a growing population of between 9 and 10 billion people by 2050 in terms of

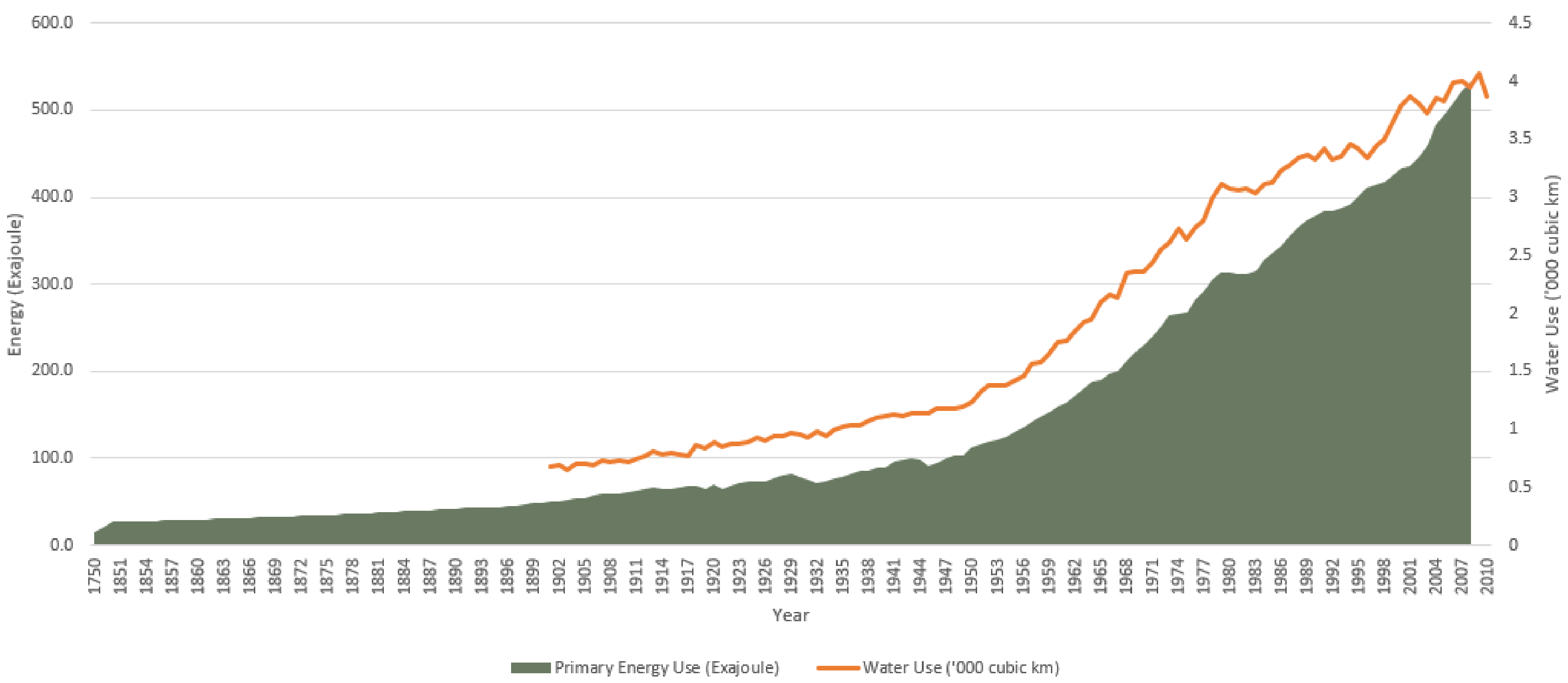
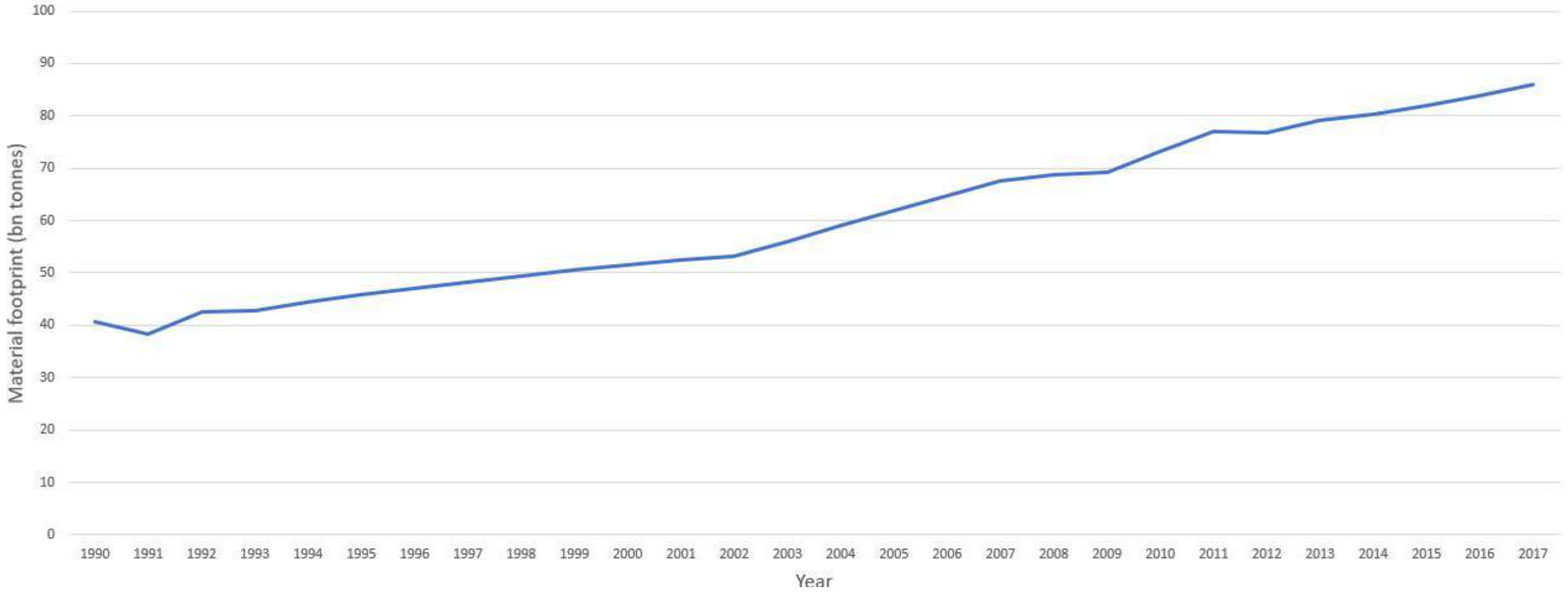


Figure 4: (above) Global trends in energy and water consumption 1750 to 2010 (Steffen et al., 2015)

Figure 5: (below) Material Footprint (billions of tonnes) 1990 to 2010 (UN Environment, n.d.)



employment, income, energy, food, water, minerals and other materials, while keeping resource consumption and environmental impacts within the Earth's natural limits or carrying capacity (UN Environment, 2011a).

According to expert predictions, food demand is expected to grow by 50 per cent by 2030, energy consumption will increase by 45 per cent and the need for water by 30 per cent— all the while supply is being increasingly limited by environmental boundaries (Global Sustainability Panel, 2012).

Many of these challenges are interlinked and have been integrated into the *2030 Agenda for Sustainable Development* and the Sustainable Development Goals (SDGs) adopted by the international community in 2015. This is a promising start. However, the integrated goals and targets cannot be achieved with the same take-make-dispose model and traditional 'siloed' approach to policy and planning that we have used in the past. Current policy frameworks and governance arrangements will need to be adapted to adequately address the magnitude, range, interconnectedness and urgency of these challenges.

2.2 The search for a new model

Responding to these challenges requires a fundamental economic redesign and transformation towards what we call the inclusive green economy (IGE), an economy which is "low carbon, efficient and clean in production, but also inclusive in consumption and outcomes, based on sharing, circularity, collaboration, solidarity, resilience, opportunity, and interdependence. It is focused on expanding options and choices for national economies, using targeted and appropriate fiscal and social protection policies, and backed up by strong institutions that are specifically geared to safeguarding social and ecological floors" (UN Environment, 2015, p.6). The contours of a macroeconomic framework for an IGE are elaborated in Chapter 2 of this book. Subsequent chapters then focus on further characteristics, policies and approaches for building an IGE.

This IGE model can be traced decades back. The environment and its natural resources have not historically had a strong footing in the traditional model of the economy, despite the emergence in the 1970s of two major sub-disciplines of economics that looked more closely at the natural environment, namely **environmental economics** and r**esource economics** (Pollitt et al., 2010; Costanza et al., 2014; Shogren & White, 2007; Tietenberg & Lewis, 2016) (for an in-depth discussion of economics and the environment, see Chapter 2). These sub-disciplines tend to adopt economic traditions and incorporate the environment and its associated problems into existing economic concepts, preserving as much of the conventional economic thinking as possible (Söderbaum, 2008). Their primary focus is on the efficient use of non-renewable resources, as well as addressing negative external effects (or 'externalities') arising from economic activities by placing a price on the environment (e.g. through taxes or property rights) (Ayres & Warr, 2010). Some of the earlier milestones in the evolution of the IGE concept are highlighted below in chronological order.

Key term: Environmental economics
A field in the discipline of economics which investigates the relationship between the economy and the environment based on the extraction, use and waste of natural resources. (Adapted from https://environmental-science.org/)

Key term: Resource economics
A field within the discipline of economics which analyses interactions between the economy and nature by looking at the supply, demand, and allocation of natural resources. (Adapted from https://wikipedia.org/)

2.2.1 Origins

In 1989, building on economic traditions, the term 'green economy' was first coined in a pioneering report for the Government of the United Kingdom by a group of leading environmental economists, entitled *Blueprint for a Green Economy* (Pearce et al., 1989). The report was commissioned to advise the UK Government on whether there was a consensus definition on the term 'sustainable development', as well as on the implications of sustainable development for the measurement of economic progress and the appraisal of projects and policies. The report interprets sustainable development as "non-declining human welfare over time" – that is, a development path that makes people better off today without condemning the people of tomorrow to a lower standard of living. A key message of the report was that economics could and should come to the aid of environmental policy.

In 1991 and 1993 the authors released sequels to the first report entitled *Blueprint 2: Greening the World Economy* (Pearce, 1991) and *Blueprint 3: Measuring Sustainable Development* (Pearce, 1993). These sequels extended their previous message to global problems – climate change, ozone depletion, tropical deforestation, and resource loss in the developing world. All reports built upon research and practice in environmental economics spanning back several decades. The authors argued that because today's economies are biased towards depleting natural capital to secure growth, sustainable development is unachievable (UN Environment, 2011b; Allen & Clouth, 2012).

In 1992, an international agreement on sustainable development known as *Agenda 21* gave global recognition to environmental challenges, such as climate change, biodiversity decline and pollution, but failed to gain much traction or influence in development and economic policy. In 2000, the adoption of the MDGs provided stronger impetus for policy change and investment that was sharply focused around a limited set of goals and numerical targets, and succeeded in catalysing international cooperation and investment towards social objectives. However, the goals were limited in scope and failed to adequately address interlinkages with environmental and economic dimensions of development. It is exactly the linkages between the environmental and economic dimensions of development that is creating the very shocks we see today in the form of volatile world markets, resource scarcities and disasters (Geoghegan, 2013).

2.2.2 Revising the green economy concept

In 2008, the green economy concept was revived in the context of discussions on the policy response to multiple global crises. Amidst the unfolding global financial crisis and concerns of a global recession, UN Environment championed the idea of green stimulus packages and identified specific areas where large-scale public investment could kick-start a green economy (Atkisson, 2012). As a result, several governments were inspired to implement significant green stimulus packages as part of their economic recovery efforts. In October 2008, UN Environment launched its **Green Economy Initiative** to provide analysis and policy support for investment in green sectors and for greening resource- and/or pollution-intensive sectors.

Key term: Green Economy Initiative

Green Economy Initiative: A UN Environment initiative designed to assist governments in greening their economies by reshaping and refocusing policies, investments and spending towards a range of sectors, such as clean technologies, renewable energies, water services, green transportation, waste management, green buildings and sustainable agriculture and forests. Adapted from https://greeneconomycoalition.org

As part of this initiative, UN Environment commissioned one of the original authors of *Blueprint for a Green Economy* to prepare a report entitled a *Global Green New Deal* (GGND). The report was released in April 2009 and proposed a mix of policy actions that would stimulate economic recovery and at the same time improve the sustainability of the world economy. The Global Green New Deal called on governments to allocate a significant share of stimulus funding to green sectors and set out three objectives: (i) economic recovery; (ii) poverty eradication; and (iii) reduced carbon emissions and ecosystem degradation. It also proposed a framework for green stimulus programs, as well as supportive domestic and international policies (United Nations Environmental Management Group, 2011).

The *Global Green New Deal* significantly influenced governments' response to the financial crises and economic recession through the adoption of expansionary policies

RIO+10 CONFERENCE

Responding to these challenges requires a fundamental economic redesign and transformation towards what we call the inclusive green economy, an economy which is "low carbon, efficient and clean in production, but also inclusive in consumption and outcomes, based on sharing, circularity, collaboration, solidarity, resilience, opportunity, and interdependence".

that incorporated a green fiscal component (Barbier, 2010). Almost the entire global green stimulus was made by G20 countries, with measures including support for renewable energy, **carbon capture and sequestration**, energy efficiency, public transport and rail, improving electrical grid transmission, as well as other public investments and incentives aimed at environmental protection. Of the US$ 3.3 trillion allocated worldwide to fiscal stimulus over 2008 to 2009, US$ 522 billion (around 16 per cent) was devoted to green expenditures or tax breaks, amounting to 0.7 per cent of GDP (Robins et al., 2009; Barbier, 2010).

> **Key term: Carbon capture and sequestration**
> Carbon capture and sequestration: The processes of capturing the CO2 emitted from industrial uses and its storage in appropriate facilities or underground. Adaopted from https://www.iea.org

At the national level, the Republic of Korea's Green New Deal plan allocated a remarkable 95 per cent of its US$ 38.1 billion fiscal stimulus to green initiatives, making up 3 per cent of its GDP. China assigned one-third of its US$ 647.5 billion fiscal stimulus plan to green measures, also totalling 3 per cent of its GDP. While the European Union dedicated more than half of its spending to low-carbon investments, the total amount spent was rather small: US$ 22.8 billion, or 0.2 per cent of its GDP. In the United States, 12 per cent of the US$ 787 billion American Recovery and Reinvestment Act and 0.7 per cent of GDP were invested in green initiatives (Barbier, 2010). A review of stimulus policies aimed at renewable energy technologies in the USA concluded that the stimulus programs had a positive effect on the renewable energy sector, including significant and immediate growth in investments, installations and contribution to the energy supply (Houser et al., 2009). It also helped to boost manufacturing capacity and the renewable energy supply chain. Combined with the economic downturn, this contributed to a decline in CO2 emissions and carbon intensity. Estimates indicated positive employment effects.

In June 2009, in the lead up to the UN Climate Change Conference in Copenhagen, the UN released an inter-agency statement. Included, was the hope that the economic recovery would be the turning point for an ambitious and effective international response to the multiple crises facing humanity based on a global green economy (UN Environment, 2009).

In March 2010, recognising the critical link between economy and the environment, governments adopted 'green economy in the context of sustainable development and poverty eradication' as one of the two themes for the *2012 UN Conference on Sustainable Development (Rio+20)*, leading to a great deal of international attention and research. This resulted from the growing recognition that achieving sustainable development rested heavily on 'getting the economy right' (UN Environment, 2011b). Indeed, the global financial shocks, as well as other crises such as climate, water, and food, were at the forefront of discussions leading up to Rio+20. These crises highlighted the fact that the institutions and policies put in place to address sustainable development were not only weak, but had mostly been directed to tackle the symptoms rather than the sources of environmental degradation. These sources were to be found in government and corporate fiscal, tax, budget, trade, energy, agriculture and other policies, and in the economic model and values underpinning them (International Institute for Sustainable Development [IISD], 2010).

2.2.3 The Green Economy Report of 2011

In November 2011, UN Environment released its Green Economy Report. To develop the report, UN Environment partnered with think tanks and commercial actors (including Deutsche Bank and the Millennium Institute), lending credibility to its economic analyses (Atkisson, 2012).

> ***Importantly, the report also provided a working definition of green economy which has since been widely cited – "one that results in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource-efficient, and socially inclusive"***

(UN Environment, 2011b).

This definition is considered consistent with the broader concept of sustainable development, recognising its holistic character (economic, social and environmental) and focus on **intergenerational equity** (Ocampo, 2011). The report emphasised that economic growth and environmental steward-

> **Key term: Intergenerational equity**
> To consider the needs of future generations in deciding how to use current natural resources. Adapted from https://stats.oecd.org

ship can be complementary strategies, challenging the still commonly held view that significant trade-offs exist between these two objectives. Through quantitative analysis and modelling, it demonstrated how investment in the environment can be a key strategy for economic growth and job creation. For instance, with investments in renewable energy, water and energy-efficient technologies, sustainable agriculture production techniques, and waste minimization and reuse technologies.

A range of other influential international organizations followed suit, publishing reports and resources on the green economy in the lead up to Rio+20, and showing the scale of momentum behind the approach. These included the Green Economy Coalition, a coalition of organizations from different sectors, including NGOs, research institutes, UN organizations, businesses, and trade unions; UN Department of Economic and Social Affairs (UNDESA); the UN Conference on Trade and Development (UNCTAD); the International Labour Organization (ILO), the World Bank; the Organization for Economic Cooperation and Development (OECD); the Global Green Growth Institute (GGGI); Stakeholder Forum; and the Green Growth Leaders, amongst others.

2.3 Inclusive green economy and the Sustainable Development Goals

Despite the growing international interest in the green economy, negotiations among countries in the lead up to Rio+20 were challenging. This was partly due to the lack of an internationally agreed definition or universal principles for the green economy, the emergence of interrelated but different terminology and concepts (see Appendix 1 for related concepts), a lack of clarity around a green economic model, associated business models and policy measures, as well as missing experience in the design, implementation and review of the costs and benefits of green economy policies (Allen & Clouth, 2012; Ocampo, 2011; Khor, 2011). Another concern voiced by civil society was that a green economy could be viewed as a means for the commoditization of nature (see Chapter 3) and risked a sell-off of natural resources to large corporations (Wilson, 2013). Following many months of difficult negotiations, it was agreed that the green economy should be conceptualised as an important tool for achieving sustainable development. While some general guiding principles were agreed (mainly for addressing perceived risks), a universal definition was not adopted.

Although there remains no internationally agreed definition for the green economy, a range of definitions has been published in the literature. For example, the *Green Economy Coalition* succinctly defines green economy as ‘a resilient economy that provides a better quality of life for all within the ecological limits of the planet’ As concluded by Allen and Clouth (2012), these definitions are broadly consistent and, as was the case with sustainable development, there would be little added value now in attempting to arrive at a single universal definition. It is the implementation and application of the green economy that is more important.

After Rio+20, UN Environment and its collaborators (ILO, UNIDO, UNDP and UNITAR) launched a Partnership for Action on Green Economy (PAGE) and broadened the concept of green economy to address concerns over equity and inclusiveness and better strengthen the notion of ecological thresholds. The reformulated inclusive green economy integrated a broader range of concepts such as equity, sharing, circularity, collaboration, solidarity, resilience, opportunity, and interdependence (UN Environment, 2015).

In 2015, the adoption of the *2030 Agenda for Sustainable Development* and the *Sustainable Development Goals (SDGs)* provided a new development vision for all countries based on a framework of timebound goals and quantifiable targets and indicators. The SDGs are comprehensive and integrated, and encompass social, economic and environmental dimensions of sustainable development, underscoring the interlinkages between these dimensions. They offer an opportunity to reframe economic policy around sustainability, including sustainable consumption and production, equitable outcomes and human wellbeing, leaving no-one behind, integration and synergies, and investment in the environment. These represent the core elements of an inclusive green economy.

The success or otherwise of the SDGs, however, will largely depend upon implementation by governments, businesses, civil society and a broad range of stakeholders. While the SDGs help to set the destination, it remains to be seen whether countries and businesses will be able to overcome the key implementation challenges that have limited progress on sustainable development in the past. These include the lack of a sustainable design for our economy, as well as sustainable business models that can drive investment and growth in green sectors, jobs, technologies and products. IGE provides an approach towards addressing these challenges. It is an alternative model to achieve sustainable development and the SDGs, which refocuses on the institutions, rules of the game, and policies and incentives that are shapers and drivers of markets, trade and finance (UN Environment, 2015).

3. Turning the new model into practice

With the increasing interest in adopting an IGE pathway, a considerable volume of research, tools and guidelines have emerged, which aim to support implementation at the national level. They clarify the objectives and underpinning characteristics of the inclusive green economy, offer operational principles for applying the approach, detail policy options and measures available to governments and business, and provide advanced tools and methods for practitioners to support analysis and evaluation (see Appendix 2 for a non-exhaustive list of tools to guide green economy strategies).

3.1 Major characteristics of the inclusive green economy

The major characteristics underpinning existing national strategies on the IGE and analytical tools are briefly addressed here as an initial introduction, and are covered in detail in the subsequent chapters of this book.

A central tenet of the green economy is that investing in the environment not only safeguards our environment for future generations but that it also makes sound economic sense. It holds the promise of achieving integrated or synergistic ("win-win") outcomes that simultaneously link socio-economic benefits with environmental sustainability. By focusing on macroeconomic benefits, proponents of the green economy aim to mobilise central planning and finance ministries as well as the private sector to make green investments and policy decisions. Decision and policymakers in central government ministries with authority over the government's budget, finances and investments, may be interested in several aspects of an inclusive green economy, including:

- the prospects for enhancing economic growth, productivity and prosperity;
- the potential for creating green jobs and generating employment;
- the possibility of gaining new areas of comparative advantage in the international market place; and
- the opportunity for diversifying economies away from resource-intensive brown growth.

To achieve such outcomes, building an IGE requires macroeconomic structural transformations that change the way economies grow, with increased green investment, production, consumption, trade, employment, etc. The macroeconomic framework for an IGE is elaborated in Chapter 2. There is, however, no blueprint. Decision makers will need to be able to assess different options based on their national circumstances, and put in place the necessary enabling conditions to guide and manage the transition and address any trade-offs.

There are a range of policy measures available to governments to put in place the appropriate enabling conditions. In most countries, the existing enabling conditions favour and encourage excessive use of fossil fuels, resource depletion and environmental degradation. For a green economy pathway, these enabling conditions must be realigned to favour investment in green sectors and the decoupling of the economy from the consumption of non-renewable resources and the generation of pollution and waste. For example, investment into the reuse or recycling of natural resource inputs; primary reliance on renewable sources of energy; preservation of critical (or non-substitutable) natural capital; and minimising pollution and other environmental impacts – including greenhouse gas (GHG) emissions – so that they remain within safe environmental thresholds. At the same time, policy measures must encourage broader socio-economic objectives including economic growth, equality, employment, health and wellbeing, and poverty reduction.

Major challenges for turning this model into practice do exist, particularly in terms of 1) the timeframe of a macroeconomic transformation, 2) the current gaps in underlying knowledge, 3) the lack of skills and technology, 4) the limited availability of information, finance, capacity and also 5) the political will to set the necessary changes in place (UN Environment, 2015). There are winners and losers in all major transitions and a considerable hurdle is to overcome vested and entrenched interests, which may exert their influence to maintain a brown economy status quo that they find beneficial. This represents a political and governance challenge for politicians as well as for leaders of business and civil society.

3.2 The role for public policy

Building an IGE depends crucially on the active role of public policy as a shaper and driver of the economic and societal transition towards sustainable development. This implies, first of all, a role for public policy in correcting misaligned incentives and market failures and thereby establishing a level playing field. However, beyond this, public policy does not only have a corrective but rather a crucially normative function: markets themselves cannot make value-based decisions, such as deciding on issues like inequality or redistribution (UN Environment, 2015). These decisions rely on societal processes that can be facilitated, bundled and convened by public policy.

Furthermore, public policy can help to accelerate directional change: the scale and pace of the economic transition that is required over the next few decades is vastly greater than anything so far achieved in human history, and will entail a much greater level of ambition than envisaged in sustainable development strategies that countries have enunciated to date (UN Environment, 2011a; Boston, 2011). Acting upon this level of ambition requires a strong role for the public sector as a convener and an agent that sets the enabling conditions to steer private sector investments and economic activities towards green technologies, jobs and sectors. As such, public policy can assume an important role in directing and accelerating structural economic change (see also Chapter 9) which is required to decouple economic growth from both the quantity of natural resources consumed as well as environmentally damaging impacts (UN Environment, 2011a).

In *The Future We Want* and the *2030 Agenda for Sustainable Development*, governments agreed that there are multiple pathways to sustainable development and the SDGs, and that each country must choose the most appropriate pathway according to its national circumstances and priorities. The critical role of governments in steering the transition towards the SDGs is widely acknowledged. However this will need to be done in partnership with business, civil society, consumer groups and other stakeholders. Achieving the SDGs through building inclusive green economies is a shared responsibility, however governments will be critical players in shaping a country's pathway towards a green economy. The formulation of a national green economy strategy, which is informed by a consultative multi-stakeholder process, can provide a useful mechanism for articulating the preferred pathway, and setting out clear targets and expectations for producers, consumers and other actors in the economy.

3.3 National green economy strategies

Early experiences with national sustainable development strategies (NSDSs) were generally connected to environmental conventions and agreements without clear linkages to central economic planning (Swanson et al., 2004). They lacked clear objectives and achievable (**SMART**) targets, disregarded economic instruments and fiscal reform, and failed to concretely set out the expectations for producers and consumers in the economy (OECD, 2001; OECD, 2006; Dalal-Clayton & Bass, 2002; Swanson et al., 2004; Meadowcroft, 2007; European Sustainable Development Network, 2009; UN DESA, 2012). They consequently had limited success in forging a pathway to sustainable development.

Key term: SMART
Acronym for Specific, Measurable, Achievable, Relevant and Time-bound.

The promotion of Low Emission Development Strategies (LEDS) through the UN Framework Convention on Climate Change (UNFCCC) processes, as well as Poverty Reduction Strategy Papers (PRSPs) in response to the MDGs, led to considerable methodological and institutional improvements, including sound economic analysis, national ownership and engagement with the private sector and civil society. The primary focus of these strategies, however, has been on promoting economic growth, income, employment and energy security objectives while also reducing GHG emissions and addressing climate vulnerabilities. As such, their scope has generally been too limited to take advantage of the broader set of opportunities that are presented by the inclusive green economy.

The emergence of national green economy and green growth strategies has continued to advance national practice in sustainable development planning, building on experience with PRSPs and LEDS in terms of approaches, tools and methods while also incorporating a broader range thematic and sectoral issues, including objectives relating to agriculture, industry, natural resources (e.g. water), transport, waste, and pollution (Allen et al., 2017). This more holistic and integrated scope is better aligned with the broad scope and intent of the SDGs and their targets. In recent years, a diverse range of countries have embarked upon a national green economy pathway to sustainable development, and it is expected that this will continue in the context of national planning for the SDGs.

To achieve SDGs via an inclusive green economy pathway, governments and stakeholders need to adopt a cohesive set of policies and measures that have a clear influence on the flow of investment and finance (both new and existing, public and private) towards the greening of key sectors in the economy. To be effective, this will likely require a combination of policy instruments and measures, including economic and fiscal policy reforms, norms and regulations, education and moral suasion, and industrial and innovation policies (World Bank, 2012; UN Environment, 2011b; OECD, 2011; Brand, 2012; African Development Bank et al., 2012; UN DESA, 2012; Barbier, 2011; UN Environment, 2015). Complementary measures will be needed to address risks and trade-offs associated with structural adjustments in the economy, such as the loss of jobs in traditional sectors. The development of a national green economy strategy has become an important tool for assessing the costs and benefits for different policy and investment options, whilst also bringing these measures together within a cohesive framework. Subsequent chapters of this book describe the main policy frameworks and enabling conditions for building inclusive green economies.

3.4 Tools to guide green economy strategies

A range of guidelines and toolkits has been developed, which provide guidance for the preparation of national green economy plans or strategies, particularly in the areas of **integrated or sustainability assessment** (European Commission, 2009), low-carbon or climate resilient development (UNDP, 2011), **nexus-based approaches** (UN Food and Agricultural Organization [FAO], 2014), and green growth or green economy (Green Growth Best Practices, 2014; UN Environment, 2014b; UN Environment, 2014c; African Development Bank [ADB], OECD, United Nations & World Bank, 2012; PAGE, 2017b). Many of these guidelines draw upon emerging concepts and analytical methods from economics and the sustainability sciences, providing a step-by-step approach to national development planning based on decision theory and the generic steps of the policy planning cycle.

Key term: Integrated assessment

A participatory process of combining, interpreting and communicating knowledge from various disciplines in a way that a cause-effect chain – involving environmental, social, and economic factors – associated with a proposed public policy, plan or programme can be assessed to inform decision-makers. Adpated from https://unep.ch

Key term: Nexus-based approaches

Approaches that examine the interrelatedness and interdependencies of environmental resources in order to take into account the functioning and management of complex systems. Adpated from https://flores.unu.edu

An early review by the Green Growth Best Practices initiative provides a global assessment of good practices and lessons learned in green growth planning, analysis and implementation (Green Growth Best Practices, 2014). It highlights that there is no single approach to the green economy; however, common elements can be seen in the way countries are developing their national strategies, policies and measures. It provides a detailed manual and toolkit for the preparation of a national green growth plan, focusing on eight interlinked elements or steps that are commonly used in analysis, planning, implementation and monitoring (Figure 6, overleaf). Initial steps focus on establishing national targets and baselines (e.g. linked to the SDGs), assessing and communicating costs and benefits, and prioritizing different options and pathways towards achieving national targets. The guide promotes a range of decision support tools to inform these initial agenda-setting and analytical stages, including quantitative modelling and analysis.

UN Environment and PAGE have published a range of resources and tools to support national green economy planning and policy making. These include a Green Economy Toolkit for Policymakers, comprised of three publications that provide practical guidance on how to formulate and assess policies, measure progress, and model future effects of the transition (UN Environment, 2014b; UN Environment, 2014c; UN Environment, 2014a). The toolkit sets out the five steps of a typical green economy policy assessment (Figure 7).

More recently, PAGE has produced additional technical resources to assist with green economy analysis, including an integrated framework for green economy modelling as well as a progress measurement framework methodology (PAGE, 2017b; PAGE, 2017a). A range of training manuals, webinars and e-learning courses are

Figure 6: Key elements for National Green Growth Planning (Green Growth Best Practice, 2014)

also available through PAGE to support the operationalization of their tools and publications. These range from introductory modules to more advanced materials on green economy policy assessment and green jobs assessment, as well as greening of economic sectors such as industry, agriculture, buildings, energy, transport, water and waste.

A central foundation for developing a green economy strategy lies in the analysis of the costs, benefits and impacts of different policy and investment options. Common deci-

Figure 7: The steps of a typical green economy policy assessment

sion frameworks include cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis. Quantitative modelling can be an important tool used to support such analyses. Models can be used to predict the outcomes of different policy choices and development trajectories and therefore build scenarios of what the future might hold, taking into account a range of factors and variables.

A broad range of modelling tools are available to support policy analysis, including macro-economic models that enable an assessment of dynamics and impacts across sectors of the economy (e.g. Computable General Equilibrium models, and system dynamics models), as well as sectoral models which enable a more detailed assessment of a sector of interest (energy, agriculture, water etc.) through simulation and optimization at a sectoral level (e.g. partial equilibrium models or systems engineering models). For example, Allen et al. (2016) reviews 80 different modelling tools that can support national policy assessment for the SDGs, many of which have been applied in the development of green economy and low carbon strategies. The LEDS Global Partnership also includes an online toolkit which lists around 80 tools to assess impacts and linkages between national development priorities and low emission development strategies (LEDS Global Partnership, n.d.).

These publications, guidelines and toolkits provide a useful starting point for countries and stakeholders who are embarking on a national green economy planning process (see Appendix 2 for a non-exhaustive list of tools).

3.5 Key actors and initiatives

The IGE has emerged as a strategic priority for many governments and there is a growing catalogue of countries with national green economy strategies, assessments and other studies. Much of this work has been supported by international organizations and partnerships. There are a multitude of actors involved in supporting green economy initiatives worldwide, including governments, UN system organizations, NGOs and the private sector, as well as platforms, partnerships, programs, funds and other initiatives.

A review of green economy partnerships and initiatives in 2013 reported that at that time there were around 60 different initiatives globally supporting green economy, green growth and low-carbon development, as well as over 30 donor countries and a broad range of implementing organizations including UN Environment, the Global Green Growth Institute, the World Bank, UNDP, FAO, GEF, UNIDO, IFAD, UNFCCC, OECD, ILO, REEEP and REN21 (UN DESA, 2013). These actors continue to provide support for the green economy through a multitude of platforms and partnerships (Box 2). Information about many of these initiatives can be located on the Green Growth Knowledge Platform which provides a portal to a broad range of research, publications and data on the green economy.

Since 2008 through its Green Economy Initiative and more recently through PAGE, UN Environment and its partners (UNITAR, UNDP, ILO and UNIDO) have supported the preparation of green economy stocktaking and scoping studies, national modelling or quantitative assessments, green fiscal assessments, and national

Box 1.2. Green economy platforms and partnerships

Platforms

- Green Growth Knowledge Platform (with its headquarters in UN Environment Geneva)
- Green Industry Platform (UNIDO, UN Environment
- Green Growth on-line e-learning facility (UNESCAP)
- WIPO Green platform
- Climate Change Knowledge Portal (World Bank)
- Climate Information Platform (UNDP with several partners)
- Reegle (REEEP and REN21)
- Sustainable Development Knowledge Platform (UN DESA).

Partnerships

- The Global Green Growth Institute, established in 2010, brings together a range of national governments, research institutes, intergovernmental organizations and private sector actors
- The Partnership for Action on Green Economy (PAGE), established in 2012, is being led by UN Environment with its partners the International ILO, UNIDO, UN Institute for Training and Research (UNITAR)
- The Green Economy Coalition is a global network of organizations from NGOs, research institutes, the UN, business and trade unions for information exchange, awareness-raising and research
- The Low Emissions Development Strategies (LEDS) Global Partnership is coordinated through Open Energy Info (OpenEI).
- International Partnership on Mitigation and Measurement, Reporting and Verification (MRV), REEEP, and REN21
- World Bank's Wealth Accounting and Valuation of Ecosystem Services (WAVES) Partnership, as well as the Economics of Ecosystems and Biodiversity (TEEB) initiative led by UN Environment with a range of partners

green economy roadmaps and strategies. Country-level engagement includes green economy scoping studies in 22 countries, green economy modelling or quantitative assessments in 12 countries, and support for the development of national green economy roadmaps, strategies or action plans in six countries (UN Environment, 2015). A total of 12 developing countries are currently receiving funding and technical support for green economy planning through PAGE, which aims to support 20 countries by 2020.

Through its Green Growth Planning and Implementation Division, the Global Green Growth Institute (GGGI) has been working since 2010 with a range of partner governments to support the development of national Green Growth Plans. As of 2018, they had provided support to 26 countries. Their approach involves macro-economic and sectoral analyses to identify green growth opportunities as well as the design of sectoral and financing strategies. To undertake this work, the GGGI has partnered with respective national governments as well as a number of other organizations, including UNESCAP, the Korea Institute for International Economic Policy, the Korea Legislative Research Institute, the European Bank for Reconstruction and Development (EBRD) and UN Environment.

Based on the general framework outlined in its Green Growth Strategy launched in 2011, the OECD has mainstreamed green growth into its national and multilateral policy surveillance exercises in order to provide policy advice that is targeted to the needs of individual countries. These include its Economic Surveys, Environmental Performance Reviews, Innovation Reviews, and Investment Policy Review, as well as the Going for Growth annual report and the Green Cities Programme. These analyses cover advanced, emerging and other economies, and include several studies specifically focused on green growth indicators and assessments in a range of countries.

3.6 Progress in countries' transitions to inclusive green economy pathways

Overall, UN Environment (2015) reported that 65 countries had embarked on a green economy pathway or a related strategy worldwide, with 48 of these developing national green economy plans as the centrepiece of these strategies. Although much of this work remained at a scoping or early analytical phase, a number of countries have published national green economy strategies or roadmaps. The Republic of Korea was a front-runner in these efforts, finalising its *National Strategy for Green Growth and Five Year Plan* in 2009. Box 1.3 lists some of the related country strategies.

There is also considerable related experience with low-carbon development planning. Based on UNDP estimates in 2017, around 88 countries have adopted some form of LEDS in the context of UNFCCC commitments. Over the past decade, several emerging economies with substantial GHG emissions (notably Brazil, China, India, Indonesia, South Africa and Republic of Korea) have developed integrated strategies on climate change and development or low-carbon growth. Moreover, a number of the lowest-income countries have elaborated integrated climate and development strategies, for instance Papua New Guinea, Bangladesh, Rwanda and Kenya. The Partnership on Transparency in the Paris Agreement provides a summary of global good practices in LEDS implementation.

Box 1.3. A selection of national green economy strategies

- Cambodia's National Green Growth Road Map (2009)
- France's National Sustainable Development Strategy: Towards a Green and Fair Economy (2010)
- Ethiopia's ClimateResilient Green Economy Strategy (2011)
- South Africa's Green Economy Accord (2011) and Green Economy Strategy (2014)
- Rwanda's Green Growth and Climate Resilience Strategy (2011)
- Viet Nam's Green Growth Strategy (2012)
- UAE's Green Growth Strategy (2012)
- Chile's National Green Growth Strategy (2013)
- Peru's National Green Growth Strategy (2014)
- Kenya's Green Economy Strategy and Implementation Plan (2015
- Malta's Green Our Economy – Achieving a Sustainable Future (2015)
- Indonesia's Green Growth Roadmap (2015)
- Fiji's Green Growth Framework (2015)
- Egypt's Green Economy Strategy (2016)
- Jordan's National Green Growth Plan (2017)
- Uganda's Green Growth Development Strategy (2018)

4. Concluding remarks

This chapter has highlighted that the achievement of the *2030 Agenda for Sustainable Development* and the SDGs will depend in large part upon getting the economy right. In practical terms, an alternative is needed to today's dominant take-make-dispose economic model which generates widespread environmental damage, encourages wasteful consumption and production, and drives ecological and resource scarcities.

Proponents of a green economy expect that this requires an approach focused on economic policy, and will entail far greater ambition than has been observed under the banner of sustainable development. This requires a new paradigm of economic development – one that focuses on improving human wellbeing and equality while also reducing environmental impacts and resource consumption. This relies on major policy changes and depends significantly on investment, innovation and related technological advances.

A large and growing number of governments in both the high- and low-income world are now exploring a green economy pathway towards sustainable development and the SDGs, with some pursuing concrete steps. While there is yet to be a clear model of an IGE, there are many examples of green sectors and technologies ranging from renewable energy, energy and water efficiency technologies, organic agricultural production techniques, and waste minimising or reuse technologies.

Governments (at various levels – national, provincial, municipal) and businesses around the world are putting in place measures to stimulate investment and growth in such technologies, which will build green economies over time.

As a result, there is a growing catalogue of case studies, success stories, guidelines, methods and tools as well as empirical evidence that can assist countries and stakeholders in building inclusive green economies. A broad range of international organizations, stakeholders, think tanks and researchers have contributed to this work through technical and financial support, as well as the elaboration of operational principles, policy toolkits and methodologies that can be utilised by governments and stakeholders to support implementation.

Despite growing interest in a green economy, however, this agenda still remains on the margins of economic policy in most countries. Influential organizations such as the OECD, World Bank and G20 have endorsed the green economy or green growth, but there has been little mainstreaming into their core work programs and economic policy advice. Indeed, the take-make-dispose economic model seems very much entrenched. One pertinent reason for this are political and economic vested interests in existing economic assets. Developing new business models to support sustainable consumption and production may involve substantial disruption and "creative destruction" in many industries. The massive change in economic structures brought about since the turn of the millennium by information and communication technologies provides some actual examples of how quickly economic structures can be shifted. While this has largely been a process undirected by governments or leading social coalitions, a green economy transition will require such guidance. Chapter 6 on institutions discusses in more detail the process of the institutional change that is required.

The emergence of the inclusive green economy agenda reflects a confluence of interests. For one, there was a growing sense among many in the sustainable development community that a new approach was needed in order to engage with and influence economic policy. Secondly, the financial and economic crises, which started in 2008, triggered awareness around the failure of conventional economic policy to address environmental risks and inequality. This awareness has generated a growing demand for change. Thirdly, the growing material reality of climate change and resource degradation for business has generated recognition of the increasing risks to their way of working, as well as new opportunities to be seized.

An analysis of the political economy of a transition to a green economy is beyond the scope of this chapter, and indeed, of this book. Other chapters do provide frameworks for thinking about how various areas of economic policy can address and support a green economy transition. As countries continue to develop green economy strategies and policies, the growing evidence base and increased awareness will likely contribute to further momentum.

5. Appendices

5.1 Overview of related concepts

The emergence of the IGE as a model for achieving sustainable development has been accompanied (or preceded) by a range of related concepts, including green growth, low carbon development, circular economy, steady-state economy, and bioeconomy, amongst others. These concepts have emerged from a range of different disciplines and therefore have different epistemologies, ideologies, theoretical constructs, scales of implementation, areas of focus, and usage of terms, which make them complex and sometimes difficult to navigate. They also have different supporters and target audiences, and are at different stages of development ranging from purely theoretical to applied.

However, they also have a number of similarities in that they recognise that today's dominant take-make-dispose economic model generates widespread environmental damage, encourages wasteful consumption and production, and drives ecological and resource scarcities. They offer alternative approaches and tools to advance sustainable development that does not rely upon the dominant linear approach to development. They have similar objectives around improving efficiencies, minimising waste, internalising externalities, and decoupling growth from resource consumption. They aim to tackle major sustainable development challenges, including decarbonization and reducing **material throughput**.

While some are very closely related to an IGE , e.g. green growth, for the most part, these approaches can only be considered desirable characteristics of an inclusive green economy. They are generally not economic models, and they do not offer a transition pathway towards sustainable development. In recent years, key concepts and methods from these different approaches have been integrated into the inclusive green economy approach, in particular the ideas around circularity and sharing drawn from the circular economy.

Concept	Definition	Main emphasis
Green Growth	Concept closely related to green economy, which harmonizes economic development with environmental sustainability, whilst improving eco-efficiency and enhancing synergies between environment and economy.	Environmentally sustainable economic growth
Low Carbon Development	Low emission development strategies (LEDS), which include national economic development plans with reduced emissions and climate resilient economic growth.	Low emissions trajectories
Circular Economy	Turning goods that are at the end of their service life into resources for others; closing loops in industrial ecosystems and minimizing waste through material reuse, extended product life, repair, re-manufacturing or upgrading.	Waste reduction, material reuse and redesigned value creation from products and services
Steady-State Economy and De-Growth	An economy where the main biophysical stocks and flows are stabilized and the flows of material and energy stay within ecological limits.	Reduction in consumption and production
Bioeconomy	Where the use of biological resources (plants, animals, microorganisms) plays a leading role and biotechnology has an important impact on economic output.	Improving environmental efficiency of industrial production

Key term: Material throughput

Material throughput: A consideration of all the types of energy and materials used in creating a product throughout every stage of the economic cycle from extraction to disposal. Adapted from: http://www.sustainablescale.org/

5.1.1 *Green Growth*

The concept of green growth is closely related to green economy, but has gained impetus especially through the Asia-Pacific Region. At the Fifth Ministerial Conference on Environment and Development (MCED), held in 2005 in the Republic of Korea, governments and other stakeholders from Asia and the Pacific agreed to move beyond the sustainable development rhetoric and pursue a path of green growth. To do so, they adopted the Seoul Initiative Network on Green Growth and a regional implementation plan for sustainable development. This commenced a broader vision of green growth as a regional initiative of the UN Economic and Social Commission for Asia and the Pacific (UNESCAP), where it was viewed as a key strategy for achieving sustainable development as well as the MDGs (UNESCAP, 2012). This was illustrated by the placement of the headquarters of GGGI in the Republic of Korea, which aimed at helping the Asia and Pacific region to 'leapfrog' over the industrialization patterns of the developed world, and avoid the trap of 'growing first, cleaning up later' (Atkisson, 2012). GGGI is dedicated to diffusing green growth as a new model of economic growth, with a particular focus on energy and climate change.

With the publication of its Green Growth Strategy in 2011, the OECD became a key proponent of green growth, with several subsequent publications and programs to support countries in assessment and implementation (OECD, 2011). The OECD shifted the emphasis of green growth from a more traditional focus on environmental impacts, towards a more coherent growth agenda.

At the G20 Seoul Summit in 2010, leaders also recognized green growth as an inherent part of sustainable development, which complemented efforts by UN Environment and others to encourage a Global Green New Deal. Leaders agreed to take steps to create enabling environments for the development of energy efficiency and clean energy technologies, which featured heavily in the response of G20 countries to the global financial crisis. In 2012, the Mexican Presidency of the G20 introduced inclusive green growth as a crosscutting priority on the G20 development agenda.

A number of other international organizations, think tanks and academics have also turned their attention to green growth, including the World Bank (2012) and the Green Growth Leaders. In February 2012, the World Bank along with UN Environment, the OECD and GGGI launched a new international knowledgesharing platform – the Green Growth Knowledge Platform (GGKP) – bringing together, under the same roof, the major international organizations supporting and promoting both green growth and green economy. GGKP aims to enhance and expand efforts to identify and address major knowledge gaps in green growth theory and practice, and to help countries design and implement policies to move towards a green economy.

5.1.2 Low Carbon Development

The concept of low carbon development has its roots in the UNFCCC adopted in Rio in 1992, where it is commonly referred to as low-emission development strategies (LEDS – also known as lowcarbon development strategies, or lowcarbon growth plans). LEDS are generally used to describe forwardlooking national economic development plans or strategies that encompass lowemission and/or climateresilient economic growth (OECD and International Energy Agency [IEA], 2010). Low carbon development is an important component of a green economy or green growth agenda, with LEDS as a tool for setting clear targets, assessing options and ensuring policy coherence across key sectors with a strong carbon footprint (e.g. energy, agriculture) or that are vulnerable to climate change impacts.

LEDS have attracted interest in the climate negotiations as a soft alternative to voluntary or obligatory GHG emission reduction targets in developing countries (Van Tilburg et al., 2011). The initial proposal to introduce LEDS was put forward by the European Union in 2008, highlighting how information on planned lowcarbon pathways can help to inform the international community about funding needs and priorities and to help gauge the level of global climate change action (OECD & IEA, 2010). More recently, the Paris Agreement in 2015 reiterated that all parties should strive to formulate and communicate long-term low emission development strategies.

The discourse of integrating climate change and development builds on a large body of literature, which was assessed by the IPCC in its fourth assessment report, and distinguished between the 'climate first' approach and a 'development first approach (Ellis et al., 2009). The concept of low carbon development takes a development first approach which rethinks development planning and proposes structural solutions, such as alternative infrastructure, with lower emission trajectories (Morita et al., 2001). It focuses on addressing and integrating climate change with development objectives and is therefore a useful approach for low-income countries. In practice, the plans are often combinations of new and existing elements, all combined in a new way to address preexisting economic policy objectives along with the need to slow climate change and prepare for its impacts.

A growing number of international organizations and consultancies have also been involved in lowcarbon development programmes, including the UNDP, UN Environment, the World Bank (including through its Energy Sector Management Assistance Program), ClimateWorks, the Climate Development Knowledge Network, the World Wildlife Fund (WWF), the European Union and a variety of bilateral donors. In 2011, the LEDS Global Partnership was founded to facilitate peer learning, technical cooperation and information exchange to support the formation and implementation of LEDS.

5.1.3 Circular Economy

The conventional economic model is rooted in a linear and unidirectional concept of production, which commences with natural resources entering one end of the production process and economic products emerging at the other (George et al., 2015). Market economies focus primarily on increasing the value of these economic products, with little regard given to the depletion of natural resources and accumulating wastes. This linear model relies upon large quantities of cheap, easily accessible materials and energy and an infinite capacity of the Earth's natural systems to absorb the waste, pollution and environmental impacts associated with production.

As an alternative to the linear approach, the idea of a 'circular economy' was first developed in the 1960s by a pioneer ecological economist who conceived the Earth as a single spaceship with limited reservoirs for extraction or pollution (Boulding, 1966). Environmental economists have further developed the spaceman concept by articulating the need for a shift from an open-ended economic system to a closed-loop circular economy (Pearce & Turner, 1990). The closed-loop, or circular approach, presents the opportunity to address how we create value in our economies and minimise the liabilities or externalities that they create, which are fundamental characteristics of an inclusive green economy.

In contrast to a linear economy, the circular economy focuses on a continuous positive development cycle that preserves and enhances natural capital, optimises resource yields, minimises system risks by managing finite stocks and renewable flows and fosters system effectiveness by designing out negative externalities (Webster, 2015). In simple terms, a circular economy turns goods at the end of their service life into resources for others, minimizing waste and closing loops in industrial ecosystems. Circular economy business models can be divided into in two groups: they either promote reuse and extend service life through repair, remanufacture, upgrades and retrofits; or turn old goods into new resources by recycling materials (George et al., 2015). This challenges traditional economic and business logic because it replaces production with sufficiency: reuse what you can, recycle what cannot be reused, repair what is broken and remanufacture what cannot be repaired (Stahel, 2016). A study of seven Euro¬pean nations found that a shift to a circular economy would reduce each nation's GHG emissions by up to 70 per cent while growing its workforce by about 4 per cent (Stahel, 2016).

However, the concept has been slow to gain traction. Creating wealth by making things last focuses on preserving physical stocks, and runs contrary to current business models as well as mainstream economics, which focus on **product throughput**, new **capital formation** and productive output. Nevertheless, concerns over resource security and negative externalities such as carbon emissions are shifting perspectives, with many seeing materials as assets to be preserved, as opposed to continually consumed. Business models that adopt a sharing approach are also increasing in popularity, as evidenced by the popularity of companies such as Uber, AirBnB, and Mobility.

> **Key term: Product throughput**
> The amount of a product a company can produce and deliver in a specific period of time. Adapted from https://www.investopedia.com/

> **Key term: Capital formation**
> Growth in total capital stock.

In the past decade, countries such as the Republic of Korea, China and the United States have started research programmes to foster circular economies by boosting remanufacturing and reuse. The European Commission adopted a wide-reaching Circular Economy Action Plan in 2015. Japan, Austria, Germany and the Netherlands have also developed strategies compatible with circular economic activities (Stahel, 2016). In China, the circular economy has been acknowledged by the central government as an important strategy for achieving sustainable development (George et al., 2015).

5.1.4 Steady-State Economy and De-Growth

Other concepts that have been influential in the discourse around the need for an alternative economic model includes the 'Steady-State Economy' (Cobb & Daly, 1973; Daly, 2008; Czech, 2013; Dietz & O'Neill, 2013; O'Neill, 2015) and 'Degrowth' (Latouche, 2009; D'Alisa et al., 2014).

The concept of a steady-state economy was largely developed by ecological economist Herman Daly in the

1970s (Daly, 1977), although its roots stem from classical economists. It describes an economy where the main biophysical stocks and flows are stabilised, and material and energy flows are kept within ecological limits. Steady-state economics is one of the most influential theories in ecological economics for considering the interrelated nature of ecological and economic systems. Ecological economics takes major inspiration from the work of Georgescu-Roegen (1977) and the Club of Rome (Meadows et al., 1972), who argue that there are strict physical limits to growth which will inevitably end the growth of the economy (Malmaeus & Alfredsson, 2017).

Daly (1996) outlines the features of a steady-state economy in some detail, based on a constant and sustainable level of physical throughput as a fundamental boundary condition. This vision describes an ecologically sustainable economy that uses materials and energy within the regenerative and assimilative limits of the planet's ecosystems (Pirgmaier, 2017). As we approach or overshoot the sustainable scale, the aim can no longer be quantitative growth but qualitative development, leading to "an economics of better, not bigger" (Daly, 2008; Daly, 1996).

By incorporating this concept of finite, or sustainable scale, the steady-state framework is different from the standard environmental economics solution of getting prices right. However, others argue that if scale is set first, then there is nothing wrong with using the market mechanism for determining prices that reflect relative resource scarcity (Pirgmaier, 2017). Critique of steady-state economics has been limited. Mostly ignored in mainstream economics, large parts of the ecological economics community consider it a useful and pragmatic vision of a sustainable society (Costanza et al., 2014).

Distinct to this, degrowth has been defined as an equitable reduction of economic production and consumption which increases human well-being and brings material and energy use within ecological limits (Schneider et al., 2010). Whereas the concept of steady-state advocates that market mechanisms can be used to stabilise resource use, degrowth is sceptical of commodification, and often even of capitalist institutions (O'Neill, 2015). Although degrowth economists tend to emphasize social outcomes in comparison with their steady-state counterparts, the two concepts are complementary (Kallis, 2011). For example, if a sustainable economic scale has been exceeded, a process of degrowth may be necessary before a steady-state economy can be achieved (O'Neill, 2015).

Overall, while both concepts provide useful theoretical insights into the characteristics of alternative economy, recent research suggests that no country in the world has yet achieved a true steady-state (i.e. stable stocks and flows at a level of resource use that is environmentally sustainable) (O'Neill, 2015). To place this in context, an inclusive green economy aims to offer an alternative economic model and transition pathway which may contribute to desired characteristics such as a steady-state of material throughput in an economy.

5.1.5 Bioeconomy

The concept of bioeconomy has its roots in the biological sciences and biotechnology sectors. As an important input factor in many sectors of the economy, biological resources cannot be ignored when attempting to solve the global challenges of a rapidly growing world population, the depletion of fossil resources, and environmental protection and climate change (OECD, 2009; Efken et al., 2016; McCormick & Kautto, 2013). The bioeconomy is defined as all industrial and economic sectors and their associated services which produce, process or in any way use biological resources, such as plants, animals, or even micro-organisms (Efken et al., 2016). These sectors include for example agriculture and forestry, the food industry, fisheries, aquaculture, parts of the chemical, pharmaceutical, cosmetic, paper and textile industries, as well as the energy industry.

In a bioeconomy, biotechnology contributes to a significant share of economic output as it offers technological solutions for many resource and health-based problems the world is facing (OECD, 2009). A bioeconomy involves three elements: biotechnological knowledge, **renewable biomass**, and integration across applications. Biotechnology can support sustainable development by improving the environmental efficiency of primary production and industrial processing, and by helping to repair degraded environmental resources such as soil and water. To place this in context, an inclusive green economy would drive growth

> **Key term: Renewable biomass**
> A renewable source of energy derived from organic matter such as wood or waste.

and investment in the sectors and technologies that make up the bioeconomy.

Bioscience leaders such as the European Union, Japan and the United States view the expansion of the bioeconomy as a means of reindustrialising and creating wealth, while emerging indus¬trial economies such as China and India view biotechnology as a nascent field of innovation in which they can quickly compete (El-Chichakli, 2016). Countries such as Brazil, South Africa and Malaysia are also investing to add value to their vast biological resources. This represents an emerging opportunity where building an inclusive green economy can help to drive investment.

Additional resources

- Uncovering Pathways to an Inclusive Green Economy
- The UN's Sustainable Development Goals
- Re-thinking Progress: The Circular Economy

5.2 Appendix 2: Tools to guide green economy strategies

Policy tools

Green Economy Toolkit for Policymakers
Lessons from Country Experiences (GGBP)
Modular Applied GeNeral Equilibrium Tool (MAGNET)
Inclusive Green Growth Toolkit
EC4MACS
Green Jobs Assessment
World Induced Technical Change Hybrid model (WITCH)
De-risking Renewable Energy Investment (DREI)
Sustainable Energy Roadmap and Implementation Plans (SERIP)
The Integrated MARKAL/EFOM System (TIMES)
Low-Emission Development Strategies (LEDS) Tool
Green Bonds for Cities: A Strategic Guide for City-Level Policymakers in Developing Countries
Roadmap Model
SimCLIM (CLIMSystems)
The CURB Tool: Climate Action for Urban Sustainability
Green Industrial Policy and Trade: A Tool-Box
Resource Watch: Data for a Sustainable Future
The Sustainable Asset Valuation Tool (SAVI)

Systemic tools

Threshold 21
International Futures (IF)
WorldScan
Integrated Green Economy Modelling Framework
Green Economy Progress (GEP) Measurement Framework
PoleStar
Regional Economic Models, Inc. model (REMI)
Jobs and Economic Development Impact Models (JEDI)
Global Change Assessment Model (GCAM)
2050 Pathway Calculator
Climate Change and Health: A tool to estimate health and adaption costs
Energy-Environment-Economy Global Macro-Economic (E3ME)
Integrated Global System Modelling Framework (IGSM)
Integrated Model to Assess the Global Environment (IMAGE)
Intertemporal Computable Equilibrium System (ICES)
MARKet Allocation (MARKAL)
Mitigation Action Assessment Protocol (MAAP)
Green Growth Indicators 2017
Sustainability Map
Resource Watch: Data for a Sustainable Future
The Sustainable Asset Valuation Tool (SAVI)
Trade and Environment Database (TREND)
Green Business Model Navigator

Sectoral tools

Energy:
Model of Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE)
Indicators for Sustainable Energy Development
Cost of Renewable Energy Spreadsheet Tool (CREST)
Clean Energy Emission Reduction Tool (CLEER)
Ventana's Energy, Environment, Economy-Society model (E3S)
Wien Automatic System Planning package (WASP)
EnergyPlus Building Energy Simulation Program
Model for Analysis of Energy Demand (MAED)
Derisking Renewable Energy Investment (DREI)
Renewable Energy Data Explorer (RED-E)

Soil and Water:
Soil and Water Assessment Tool (SWAT)
AQUEDUCT

Agriculture:
Predicting Ecosystem Goods and Services Using Scenarios (PEGASUS)
Agricultural Model Intercomparison Project (AgMIP) Tool
Agriculture and Land Use National GHG Inventory and Mitigation Analysis Software

Transportation:
Trip Reduction Impacts of Mobility Management Strategies (TRIMMS)
Transport Co-benefits Calculator (TCG)

Climate:
SDG Climate Action Nexus Tool (SCAN)
Harmonized Emissions Analysis Tool Plus (HEAT+)
Global Change Assessment Model (GCAM)
Adaption Support Tool (CLIMATE-ADAPT)
Energy-Environment-Economy Global Macro-Economic (E3ME)
Gender and Inclusion Toolbox: Participatory Research in Climate Change and AgricultureTool (ALU)

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CHAPTER 2: THE MACROECONOMICS OF A GREEN ECONOMY

CHAPTER 2:
THE MACROECONOMICS OF A GREEN ECONOMY

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Appreciate the need for a clear and comprehensive macroeconomic framework for research and policy analysis to support an inclusive green economy;
- Understand the concept of multiple capital stocks – including human, physical, natural, social, institutional – and their utility in advancing the inclusive green economy;
- Become aware of the limitations of existing modeling tools in macroeconomics for guiding the transition process and short-run macroeconomic policy; and
- Appreciate the role of economic accounts and statistics in informing policy and, the benefits of developing and adopting extended frameworks of the System of National Accounts.

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CHAPTER CONTENTS

1. Introduction

The world today faces many unprecedented economic, social and environmental challenges. Whereas the specific nature of challenges may vary in different countries and regions, the degradation of the global environment is affecting all of the world's regions and interrelates in complex ways with our social and economic systems. Environmental degradation, as a result of unsustainable lifestyles and systems of production and consumption, have become an economy-wide phenomenon, with far-reaching consequences on the welfare of the world population.

As is argued in chapter one of this publication, this calls for a shift from a siloed approach, seeking to maximize certain economic benefits, to an integrated approach covering broader aspects of sustainable development. **Macroeconomics**, the discipline concerned with the study of economy-wide phenomenon, has in the past concentrated on explaining the dynamics of inflation, employment, growth, exchange rates, etc. To guide an integrated approach to policy-making towards an inclusive green economy, a transition that affects almost every aspect of production and consumption in the economy, the discipline of macroeconomics itself needs to evolve (see, for example, Vines and Wills, 2018).

> **Key term: Macroeconomics**
> Macroeconomics is distinguished from microeconomics which concentrates on specific products, groups of consumers, firms and markets. Readers wishing to deepen their understanding of economics, and the treatment of sustainability and inclusion, should consider consulting online CORE textbook, "The Economy" (CORE Team). See also https://www.youtube.com/watch?v=MKO1icFVtDc

We argue that a fully suitable macroeconomic framework for addressing a green economy transition does not yet exist, though there are many useful elements that can guide both research and policy. This chapter will review previous and ongoing efforts from a range of economic paradigms, recognizing their different contributions, as well as the relevant weaknesses. Thus, our perspective is one that openly recognizes ongoing differences and debates between competing perspectives on macroeconomics. The reader should take away an overview of these frameworks and signposts on where to find more in-depth information. In pursuing this objective, the chapter takes a policy perspective which means that the possible implications for specific domains of economic policy are clearly articulated. This approach is intended to provide a unifying departure point for other chapters in this book.

2. Origins of green macro-economic thinking

Economics – most broadly defined as the study of "human behaviour as a relationship between given ends and scarce means" (Robbins, 1935) – has a long tradition of looking at resource and growth concerns. Some classical economists were very much concerned with the potential limits to improving people's living standards, particularly as population increased. Malthus' (1798) predictions that population growth would diminish the benefits of improved agricultural productivity resulted in economics being labelled "the dismal science". It is typically claimed that Malthus failed to foresee the possibility that technological change would outpace population growth and this indeed appears to be the case, at least in aggregate, over the past 200 years. Now, with growing awareness of planetary boundaries, the basic Malthusian idea is gaining renewed attention (Clark, 2007; Galor and Weil, 2000; Peretto and Valente, 2015).

Economists began early to look at the question of how to optimally use natural resources, including both renewable and nonrenewable resources [1]. This field of research continues to advance, with many insights for resource management where resources are examined separately. This line of enquiry does not generally consider the situation where such resources are critically necessary, or almost irreplaceable, in providing life-support functions for society – and hence the economy. The "scale issue" refers to the possibility that economic activity reaches a level that threatens such support functions on which it depends. In other words, the scale issue concerns the question of how big an economy can become, relative to the natural systems and environment in which it is embedded. Interestingly, macroeconomics was initiated to address a different type of scale issue – aggregate employment – not one of the environmental constraints.

The development of macroeconomics as a separate sub-discipline is generally credited to Keynes, who realized that the circumstances of the Great Depression could not be explained by prevailing theories of the time, which stressed the notion of equilibrium. In his *General Theory*, Keynes (1936) analyzed why an economy might remain in a period with less-than-full employment of labour and other resources, and proposed that the economy has systemic features (including feedback effects) and thus behaves differently than a series of inter-linked equilibrating markets [2]. At the time of writing the General Theory, Keynes was concerned with stimulating a return to full employment in the short run. This resulted in the stream of macroeconomics concentrating on short-term fluctuations in economic activity and the potential to stabilize these. Subsequently a second stream developed, examining longer term trends and factors explaining growth in aggregate output and income levels. In the following sections, we treat these long and short-term perspectives separately. But first, we briefly review a selection of the important contributions from economists and scientists in other disciplines that have challenged the manner in which economics has treated environmental limits, or the scale issue.

Modern macroeconomic models of growth (e.g. Solow, 1956; Swan, 1956; Ramsey, 1928), initially developed in the middle of the twentieth century did not devote much attention to resource or environmental limits. (Box 2.1 provides a general overview of models found in econom-

Box 2.1: Models in economics

An economic model is a simplified version of reality that allows us to observe, understand, and make predictions about economic behavior. This chapter refers to many different economic models. For readers with limited background in economics, we provide a short overview of various types of models.

Theoretical models

These are by far the most common type of model in economics. Theoretical models tend to be fairly simple in terms of the amount of detail they capture. These models are intended to deduce analytical insights and propositions concerning some mechanisms and relationships between economic variables. In this chapter, essentially all of the models discussed in Section 5, including the vast literature of economic growth models, are theoretical models. One common question that such models have been used for is "under what conditions can economic growth continue, with fossil fuels providing most energy, and the risks posed by climate change?" While it is not possible to prove that a theoretical model is "correct," it is often possible to compare the predictions of a theoretical model with historical data to see whether this provides support for the model.

In macroeconomics, there is a basic distinction between neoclassical and Keynesian models (or new Keynesian models). The basic difference revolves around whether supply (as in neoclassical models) or demand (as in Keynesian models) plays a more prominent role. Almost all of the long-run growth models discussed in Section 5 can be termed neoclassical. The aggregate demand framework presented in Section 6 is based on Keynesian models. Macroeconomic textbooks (such as Burda and Wyplosz, 2009; Romer, 2011) explain these differences in considerable detail. In addition, there are less orthodox, but interesting and perhaps promising from a green economy perspective, developments in macroeconomic models. Some of these are mentioned in the chapter and are published in journals such as Ecological Economics (for example, Rezai et al., 2018; mentioned in Section 5).

Simulation models

These are based on theoretical models which are calibrated to real-world data. Simulation models are used to analyze how certain measurable variables (such as, output, employment, productivity, emissions) will change under different assumptions, typically concerning policy, technology, or demographics. These models are usually calibrated using historical data and should be able to replicate robustly the actual path taken by key variables. Simulation models help to better understand which factors and mechanisms play an important role in how the economy will react to modelled changes or shocks. Unfortunately, other stakeholders, such as policy makers, often treat or interpret the numerical predictions of simulation models as precise forecasts, which is not their intended use. Simulation models are discussed primarily in Section 7 of this chapter.

Econometric models

These are statistical models that are most often used to estimate the parameters (such as an elasticity of substitution) of theoretical models. Econometric models can also test the propositions of a theoretical model. If an econometric model is judged to be fairly robust, it can be used for predicting, or forecasting, the values of economic variables under different assumptions. Given the business cycle fluctuations in macroeconomics, a specialized class of econometric models, the dynamic stochastic general equilibrium models, have been quite widely used for predicting short-run changes in aggregate variables. These models do not include environmental variables and do not receive much attention in this chapter (though they are mentioned in Section 7).

1 Optimal usually refers in economics to maximizing net benefits, which are benefits minus costs. In the context of natural resource use, benefits are simply the income or revenues from exploitation of the resources. Hotelling (1931) developed a seminal analysis for exhaustible resources, while Dasgupta and Heal (1979) provided a major advance for renewable resources.

2 Referred to as General Equilibrium Theory.

ics.) Nonetheless, growing awareness of environmental consequences of industrial growth prompted some original thinking by certain economists, based upon the understanding that the economy was embedded within and dependent upon nature. Boulding (1966) promoted this idea with the concept of the Spaceship Economy, which sees the economy as a closed system, much like a spaceship, with a requirement to manage all energy, material and waste flows internally. Georgescu-Roegan (1971) analyzed the implications of the laws of thermodynamics for understanding the economic activity, emphasizing the entropy principle and the conservation of energy. Such contributions remained decidedly outside of the mainstream of economic thinking. Many economists indeed reacted critically to the publication of the Limits to Growth in 1972, which proposed that limited supplies of certain natural resources would constrain economic growth, possibly within decades (Meadows, et al., 1972). Having seen what happened to Malthus' predictions, economists saw considerable potential for innovation to overcome such constraints (Solow, 1974).

Interest in *growth theory* revived in the 1990s, with the development of a new generation of theoretical models that incorporated technological progress as an outcome of the economic system (as opposed to a process that simply took place on its own) [3]. With growing awareness of sustainability challenges, in particular, climate change, some economists expanded their models to include negative economic impacts from GHG emissions (Smulders, 1994; Smulders, 2005; Acemoglu et al., 2012; Aghion and Howitt, 1998). This led to a range of theoretical models that incorporated some form of resource constraint, either as an input, or as a sink for environmental pollution, as well as the important process of innovation, which offer solutions for addressing such limits as the negative economic implications manifested themselves.

A recent revival of interest in the ideas proposed by Malthus examines under what conditions limits to growth, in terms of resource availability, might hold. Historical analysis of living standards over the long term suggests that the Malthusian mechanism, by which population growth outpaces increases in production, is supported by some evidence, even when incorporating the offsetting influence of innovation (Clark, 2007). Unified growth theory begins to address more directly what can be termed the scale issue: the size of the human economy in terms of population and the demand on limited resources (e.g. Ashraf and Galor, 2011; Peretto and Valente, 2015). There has however been little attention in this work to recognize environmental limits or planetary boundaries [4].

A similar challenge is apparent with respect to social objectives concerning equality and inclusiveness. Since its inception in the aftermath of the Great Depression, macroeconomics has generally concentrated on issues of full employment. While issues of the relative distribution of labour income, or the earnings of labour relative to the return to capital, have also received some attention in specific analyses (Piketty 2014; Raval 2017; De Nardi, Fella and Yang 2017), they have not been a core focus of macroeconomic models in general.

In parallel to these developments in growth theory, an alternative stream of literature has developed under the broad area referred to as ecological economics. One of the focuses of ecological economics has been the implications of limits to the overall scale of economy. Additional work in this area has analyzed and proposed how economic patterns of production and consumption need to change to respect these limits. In current policy terms, these have manifested themselves in concepts such as low-carbon economy, circular economy (McCarthy et al., 2018) and bioeconomy (OECD, 2018), among others. These are however general, aspirational concepts, as opposed to analytical frameworks. There is still little direct consideration of how to think about macroeconomic dynamics, and the management of the economy to achieve economic objectives of employment and adequate living standards, while respecting the scale issue in the form of planetary and local boundaries. It might be argued that unless and until this integration takes place, economic policy will continue to devote insufficient attention to sustainability.

3. The economy in pictures: stocks and flows

This section reviews some of the basic representations of the economy in graphic form. Although economics has largely been developed using mathematical representations and models of key concepts and rela-

3 In technical terms, this is referred to as making innovation endogenous in a model, rather than exogenous.

4 One example is the modeling of limits to land and food production by Lanz, Dietz and Swanson (2017).

tionships, there is also a strong tradition of presenting figures and diagrams for essential frameworks. Indeed, these illustrations can end up being more powerful in terms of their impact, particularly with a broader audience (Raworth, 2017). We begin with a traditional approach to macroeconomic flows and then progress to some more recent attempts to capture the relationship between society and environment, and the importance of capital stocks.

The conventional representation of the macroeconomy concentrates on the circular flow of income, as depicted in Figure 1. The diagram is based on the simple idea that expenditure and income are related: one person or firm's expenditure is another person or firm's income. This basic accounting identity – total income equals total expenditures – lies behind national income accounting (see Section 7 below).

Figure 1 indicates how households, firms and the government interact in this flow of income and expenditures. In the circular flow diagram, Households and firms are represented as the private sector, because in essence households own firms through equity investments including pension funds [5] Governments and the private sector together account for domestic expenditures (*C + I + G*), which is equivalent to the total production of goods and services. The national economy also interacts with other economies – the "rest of the world" – through trade. Imports (*Z*) are expenditures on goods and services produced elsewhere (so they are another country's income). Conversely, exports (*X*) are income earned by selling goods and services to other countries. Thus, an economy's total income is the sum of its consumption of its own goods and services by households (*C + I*), its government expenditures on goods and services (G), and its net exports (equal to deducting imports from exports; *X* - *Z*). A government pays for its expenditures through taxes (*T*) it levies on the private sector. These are therefore deducted from total income (at the top of the diagram) to arrive at household and business income (the private sector).

This circular flow diagram arose out of Keynesian macroeconomics in the aftermath of World War II. It has been a key feature of economics textbooks since then, beginning with Samuelson (1948) [6]. It is important to reiterate that the diagram is based on an accounting relationship – that income equals expenditure. However, this representation does little in explaining how these components (for example, household consumption, savings, investment, etc.) are determined. Critically, it does little to explain how these variables change over time and how other factors (for example, population and demographics) might explain changes in one or more of these flows. The circular flow diagram is thus more a representation of flows in the economy, rather than a model of how the economy functions and changes. Nonetheless, the diagram is extremely important as it

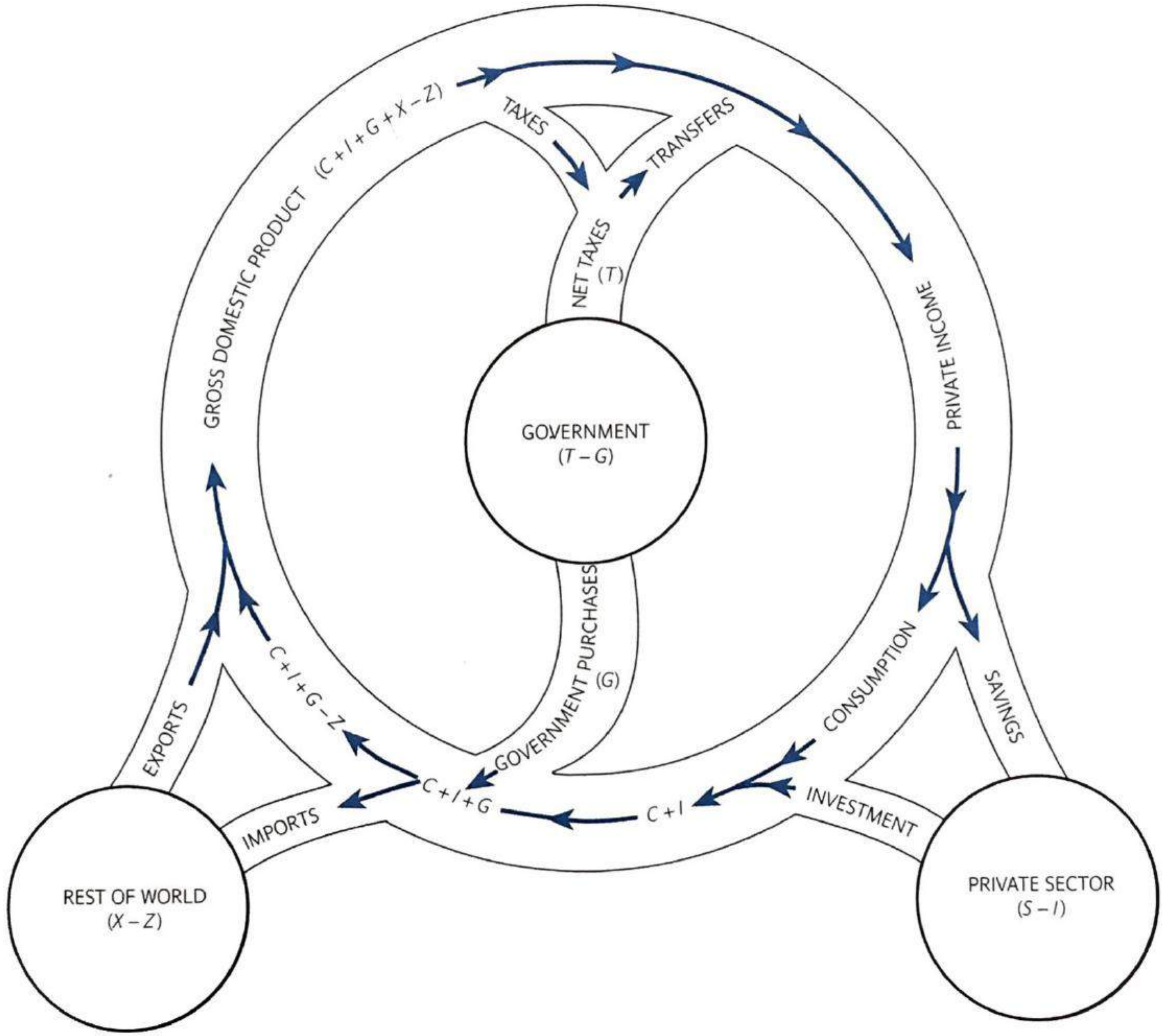

Figure 1: Circular flow diagram (Source: Burda and Wyplosz, 2009)

5 Note that the diagram does not capture the distribution of ownership of firms among households, which is currently very unequal (see for example, Piketty, 2014; Boushey et al., 2017). It also does not represent government-owned companies, which can be seen as an important simplification.

6 Raworth (2017) credits Paul Samuelson (1948) with popularizing the circular flow diagram in his comprehensive and widely-used textbook, and also provides an interesting perspective on the role of such diagrams in influencing how we have compartmentalized the economy.

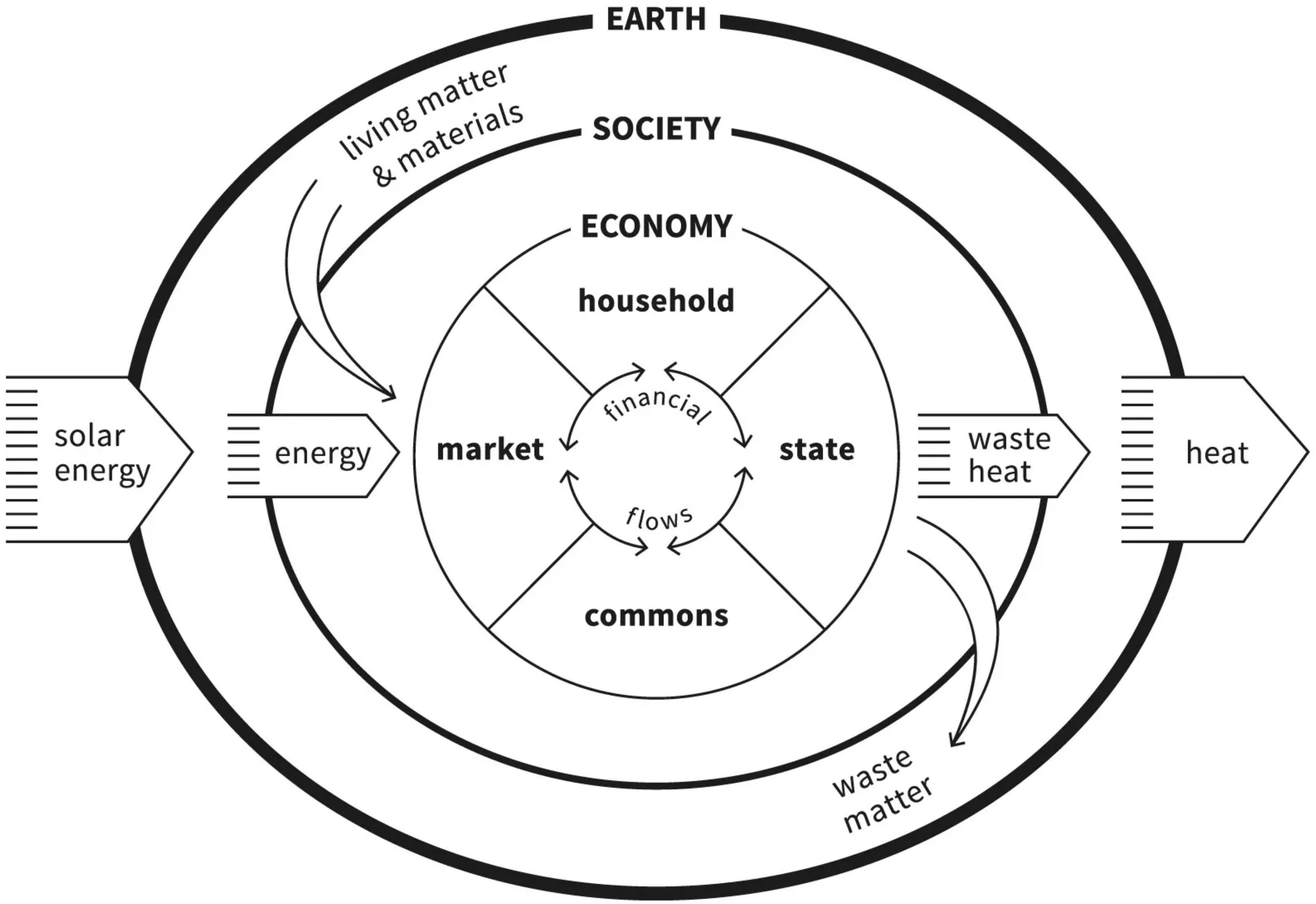

Figure 2: Embedded economy (Raworth, 2017)

provides the basis for thinking about such relationships and models. This means that the diagram plays a key role in determining how economists have then proceeded to study the macroeconomy.

Ecological economists have criticized the circular flow diagram for not representing any energy, resource or waste flows. Some of these are included, for example, as household and business expenditures on energy and would be part of their total expenditures. The problem though is that such flows, given their biophysical nature, are different from other monetary flows and cannot be viewed as simply circular in nature. This suggests that the economy should be seen as embedded within a natural system from which energy and resources are obtained and which must also assimilate waste flows (which include GHGs).

Figure 2 (left) is one representation of an embedded economy, which shows how the economy is nested within the living world (Earth). In the centre, the circular flows of the economy are now represented in a more simplified manner (as compared to Figure 1) between state (government), households and businesses (the private sector), with an additional representation of the shared or commons economy. The idea is that the circular financial flows are what is found in the centre. Most importantly, Figure 2 emphasizes the two principal types of biophysical flows: energy and materials. In this framework, all energy essentially flows from the sun. The economy uses energy, mostly stored by living matter (recently or in the distant past) or more recently directly (through solar power and thermal generation). The economy also emits waste heat to natural systems and additionally, there is a flow from the earth back into space, where living matter and materials flow into the economic system and waste matter flows back to the earth's natural systems.

Figure 2 also presents the economy as nested within society to emphasize the range of social structures and institutions that support the economy. This also represents the idea that the economy is a part of society. This presentation of the embedded economy also portrays the spaceship earth idea mentioned above (Boulding 1966).

The nesting of the economy inside society within the natural environment is represented in Figure 3 (overleaf), which connects each of these domains to the most relevant of the 17 SDGs. As with Figure 2, this suggests that the economy should meet social needs but within environmental limits. This interrelated understanding of the various dimensions of sustainable development contrasts with earlier representations of sustainable development as the intersection of three areas – economic, social and environment – and the initial understanding of sustainable development as resting on three distinct pillars., which remained the most popular way of visualizing the concept since its emergence as a concept in the 1980s.

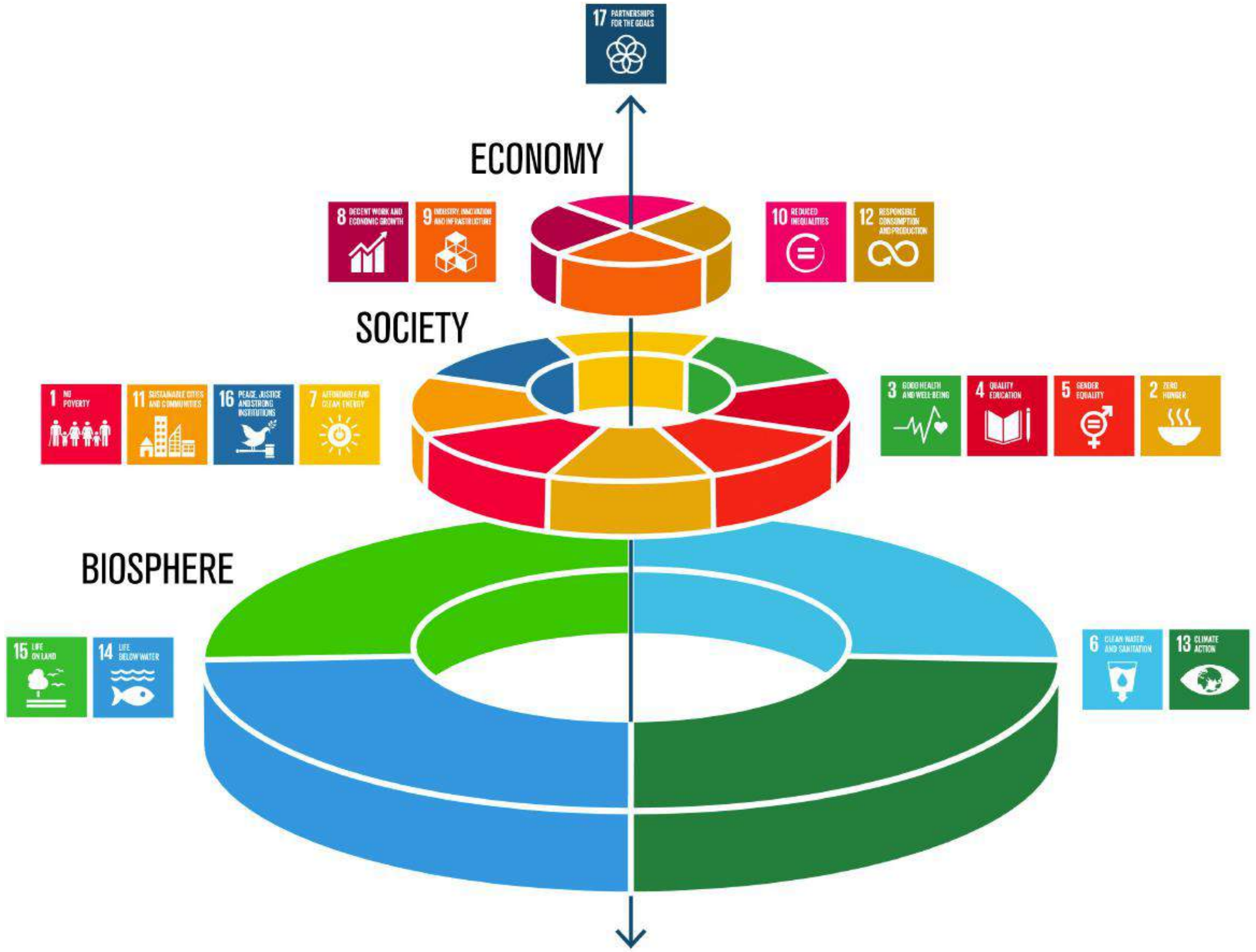

Figure 3: The Sustainable Development Goals, according to biosphere, society and economy (Rockstöm and Sukhdev, 2016)

The emphasis then was on rebalancing the attention and priority given to competing objectives, or goals. As stated, the nested model in both Figures 2 and 3 emphasizes that the economy ultimately needs to operate within environmental boundaries, suggesting that there are ways to align economic, social and environmental objectives. This is the essence of the green economy.

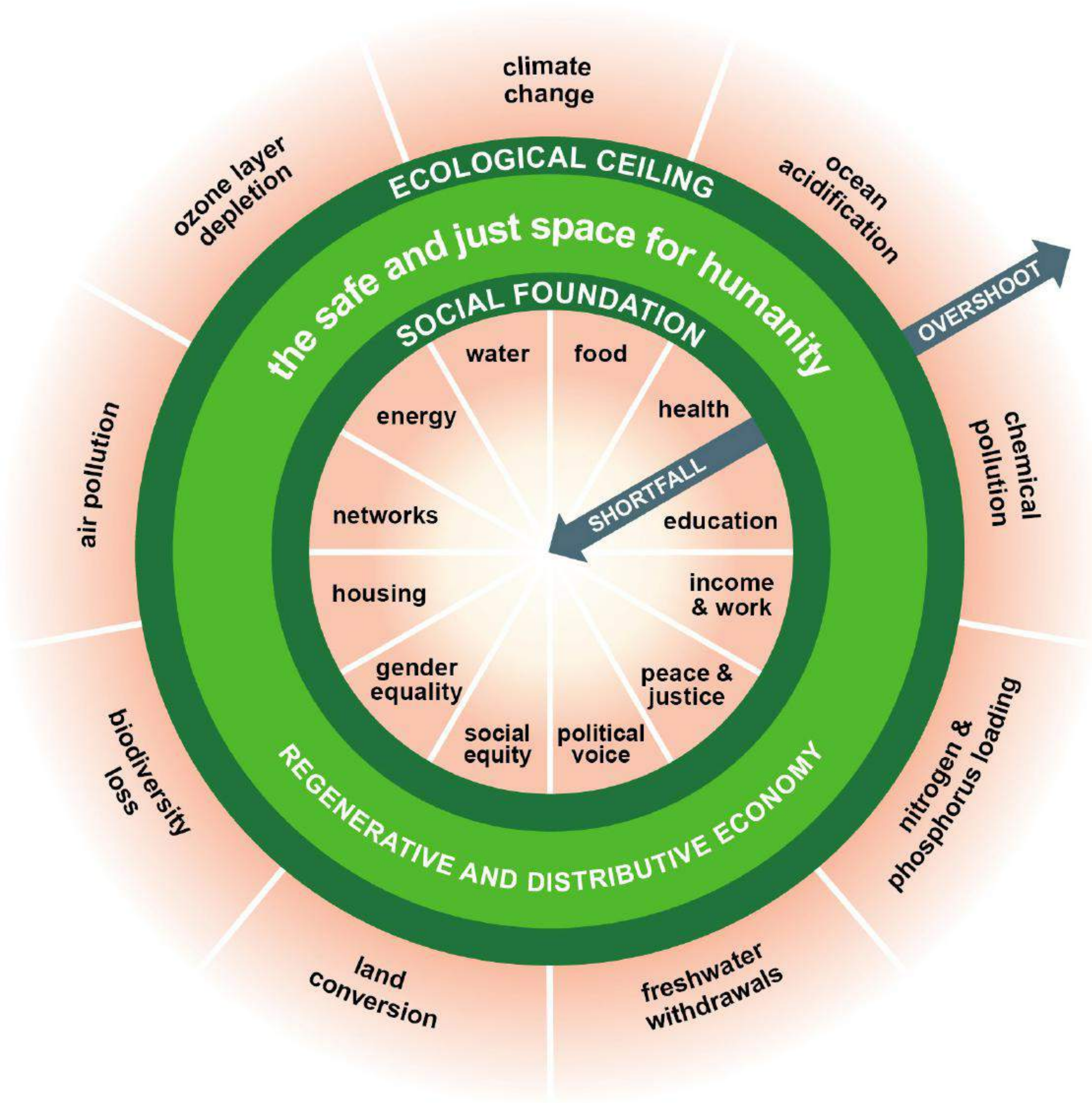

Figure 4: 'The Doughnut' economy (Raworth, 2017)

The concentric rings in Figure 3 are a visualization that has been employed by Raworth (2017) in 'The Doughnut', presented in Figure 4. The Doughnut takes the nine planetary boundaries, as proposed by Rockstrom et al. (2009), as an outer ring or limit for humanity and its economy. The economy should not expand in scale – as measured by resource and energy use, and waste emissions – beyond this ring. The inner ring represents social and economic goals.

The space between the rings – *the doughnut* – is the area representing a "safe and just space for humanity", in other words, for the economy. A regenerative and distributive economy will be found in this space, meeting social and economic goals, while respecting planetary limits. This figure calls for a reorientation of economic policy – with a focus on moving the economy into this green Doughnut.

It should be noted that there is a difference among these figures. Figures 1 and 2 represent principle characteristics of how the economy functions. They are descriptive. In contrast, Figures 3 and 4 explain how broad social, economic and environmental goals are related to each other, and the place of the economy in meeting these. These figures are prescriptive. The latter two provide a means for orienting the goals of policy and action by government and other stakeholders. As discussed in Section 4, this reorientation and alignment is a necessary component of an IGE agenda. The sections below discuss some elements of this emerging model.

While Figure 2, of the embedded economy, emphasizes flows, as does the circular diagram in Figure 1, other recent pictures have sought to represent important stocks in the economy. Together, stocks and flows constitute the essential building blocks in understanding how complex systems function, such as the economy. Economics has conventionally concentrated on the stock of capital, which traditionally has referred to physical capital in the form of machines, buildings and other structures, as well as the stock of labour. Capital and labour are combined in a production function to produce goods and services. Classical economists in the 18th and 19th century recognized the importance of land as an important stock for economic production, primarily for agriculture and forestry.

More recently, natural capital has been suggested to represent the stock of natural resources and ecosystems that provide a flow of goods and services for the economy.

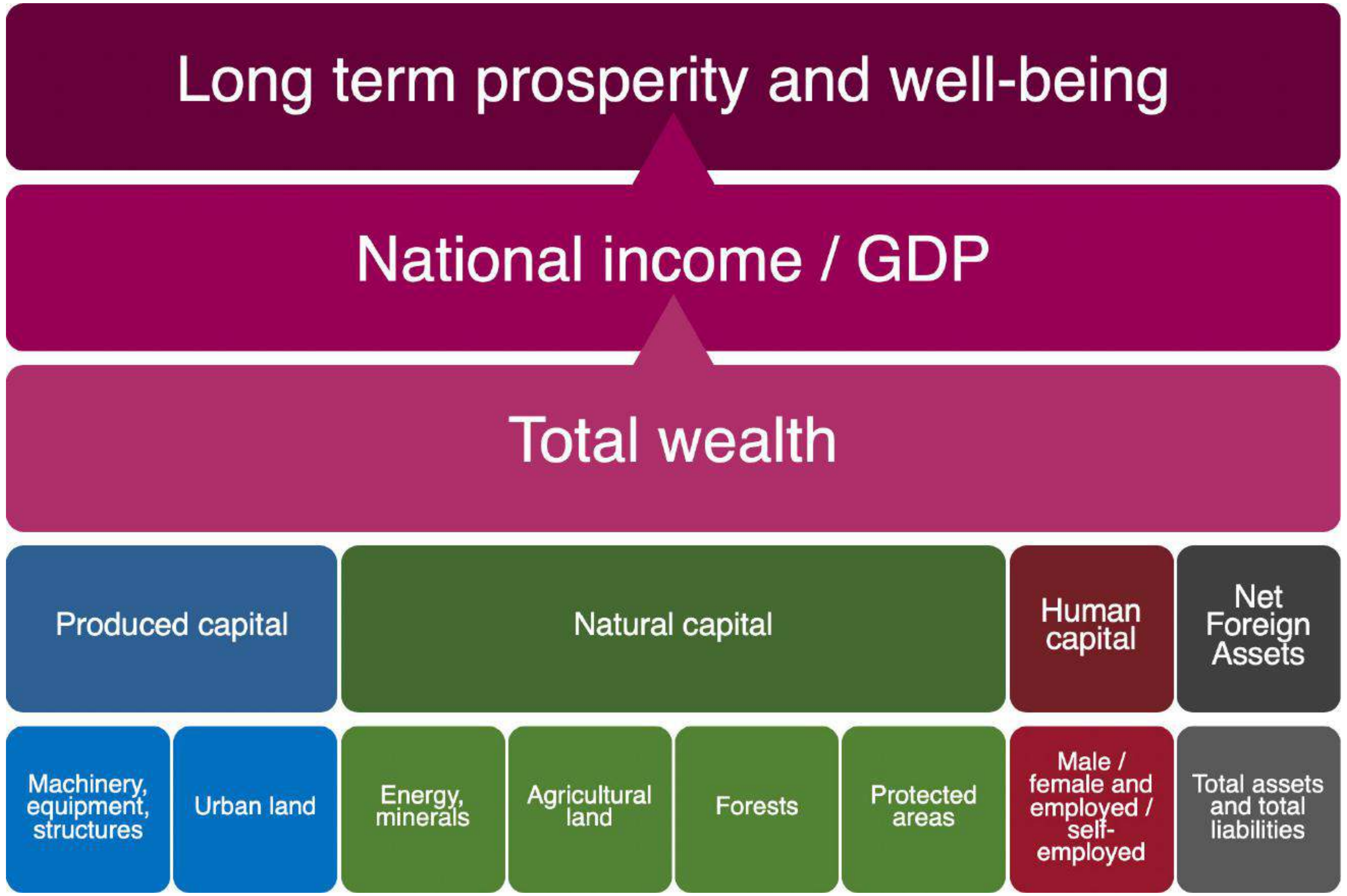

Figure 5: The three capitals and wealth model (World Bank, 2017)

Natural capital can refer to specific natural resources stocks, such as forests, agricultural land, fisheries, etc. It also represents the stock of ecosystems that supply economically useful services, such as the absorption and neutralization of waste products, including wastewater, hazardous chemicals, or gases, including CO_2 or CFCs (ten Brink, 2012). Natural capital is a multi-level and complex concept, making it challenging to measure and operationalize (see Chapter 3). This is however also the case for physical capital, and indeed other capital stocks.

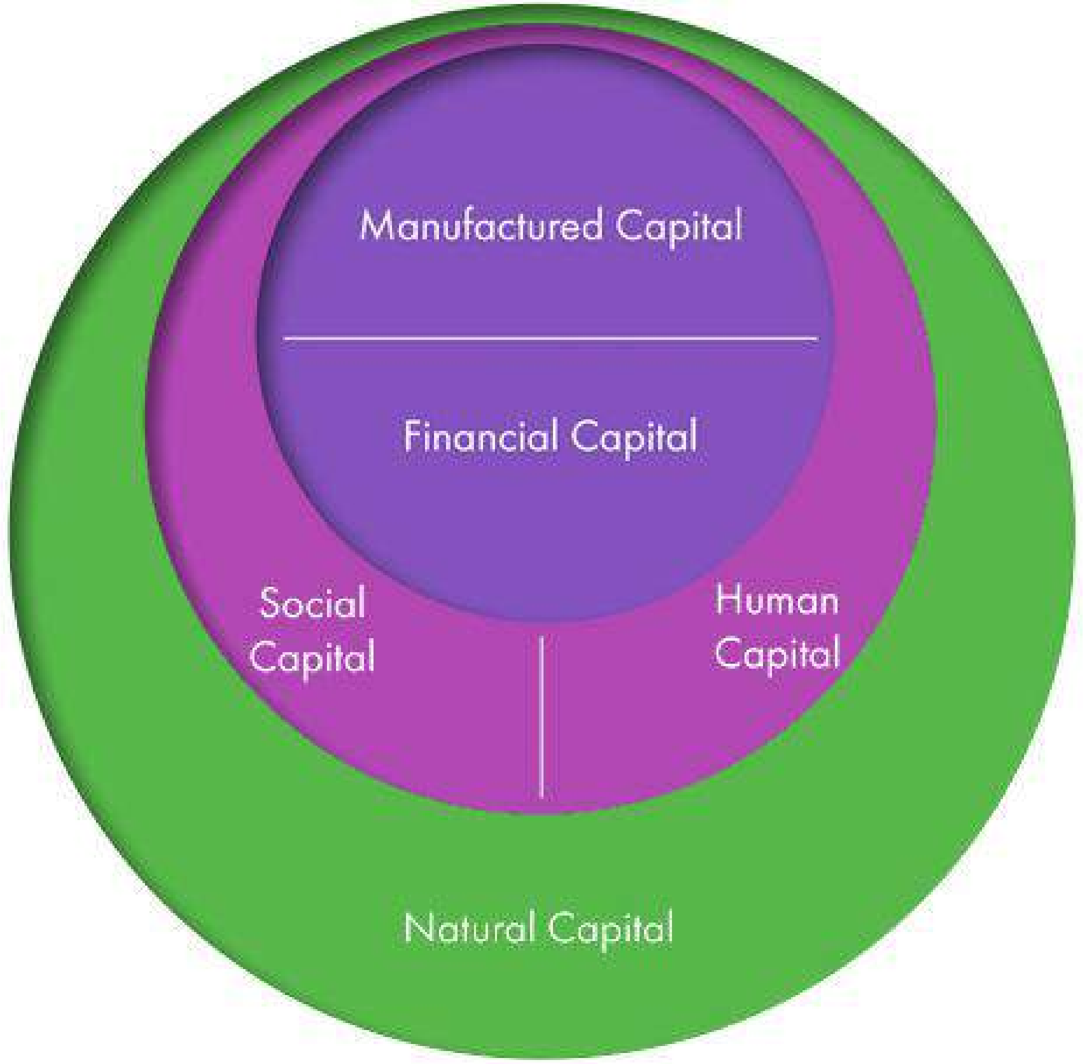

Figure 6: Five Capitals Model (Forum for the Future, 2018)

There are several other and similar frameworks that describe the range of capital stocks. As an example, the World Bank has advanced work on wealth accounting at the national level (Lange et al., 2018), which has concentrated on the produced capital (also referred to as physical capital, or durable capital), natural capital and human capital as the main stocks of productive wealth in an economy. Human capital captures a broader interpretation of the stock of labour, including also considerations of skills, education, etc. The Bank's 'three capitals and wealth' model (see figure 5, right) demonstrates how these forms of capital together comprise an economy's total wealth (a stock), from which a flow of goods and services (or national income) is derived and how it corresponds to the economic statistic, gross domestic product (GDP).

Related perspectives have added further categories of capital stock. Figure 5 shows the *Five Capitals Model*, which integrates social and financial capital. Financial capital is especially relevant from a business perspective. Much of macroeconomics has tended to view financial wealth as a title or claim on other forms of wealth or capital and therefore is not included as a separate type of capital within its models and analytical frameworks. For example, equity shares in a company represent ownership of its assets, after satisfying creditors' claims. Since the 2008-2009 crisis, the need to integrate financial stocks into macroeconomics has been more widely recognized.

Social capital generally refers to collective and institutional structures, at either a general value and belief level (e.g. trust), or at a specific institutional level (e.g. rule of law). There is a rich literature of economic research on the importance of institutions in economic performance [7]. Figure 7 shows the six capitals framework proposed by the International Integrated Reporting Council (IIRC 2013; GGGI 2016). This framework adds intellectual capital as an additional stock, which can be thought of as a stock of knowledge, including technologies.

7 See, for example, Acemoglu (2009), Michalopoulos and Papaaioannou (2013), and Alesina and Giuliano (2015).

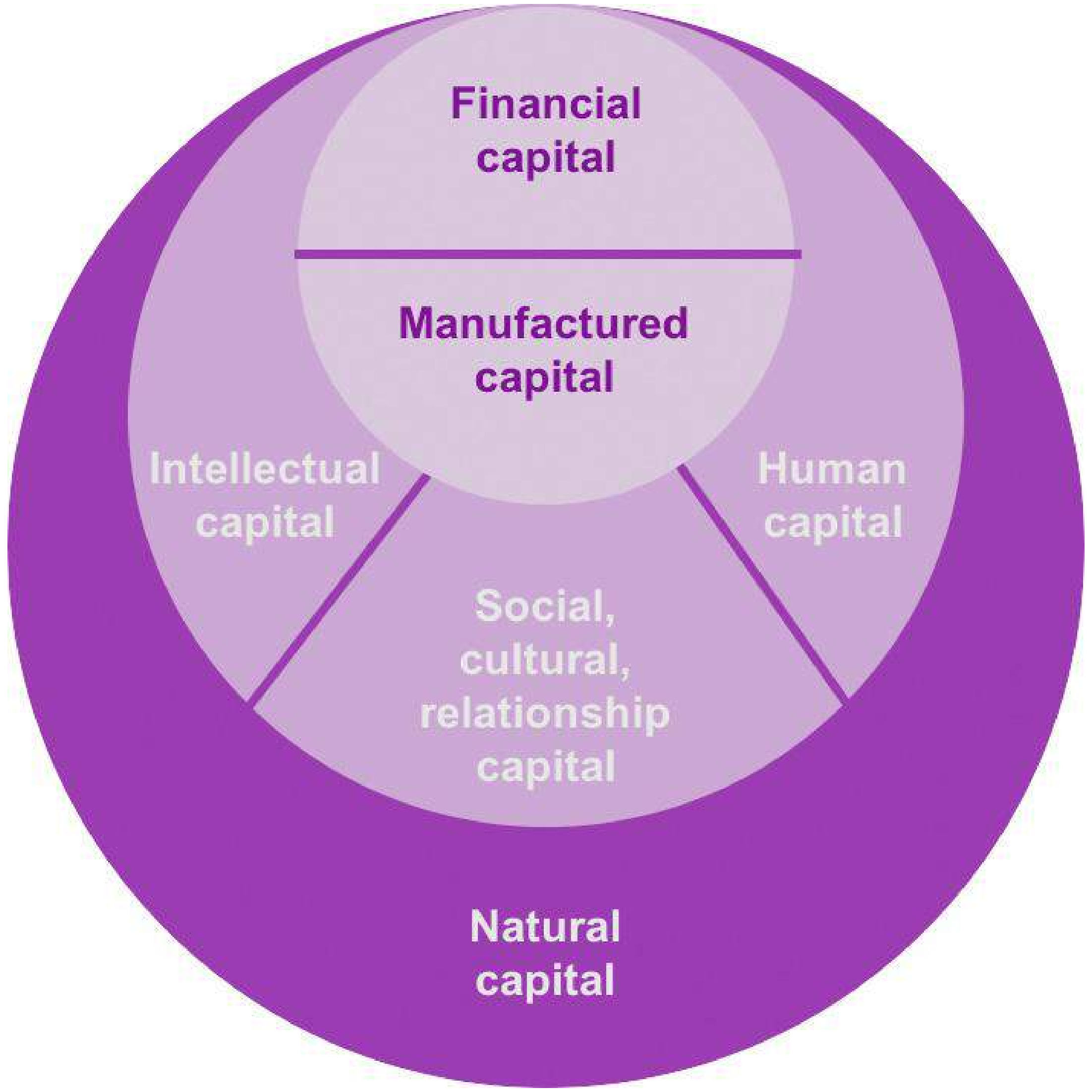

Figure 7: Six forms of capital (IIRC, 2013).

As will be seen in Section 5, this concept has been given more attention in recent economic frameworks for understanding growth. Before moving on to a discussion of growth, we summarize this section by pointing out that the different capital frameworks are similar. Many of the frameworks here also present the idea of nested capitals, with natural capital providing a basis for both social and more purely economic (physical and financial) capital. As will be discussed in Section 7, efforts have progressed in how these various capitals can be measured.

It may seem confusing that there is no definitive list of the different types of capital, and that seemingly different frameworks are used by different stakeholders. For the purposes of considering a transition at a macroeconomic level to an IGE, the most important types of capital to consider are produced, human and natural capital. These three categories have received the most attention in attempts to account for national wealth. Social and intellectual capital are arguably equally important, particularly in being able to produce a greater flow of benefits from the various capitals, but have received less attention in analyses of national wealth, perhaps reflecting even greater measurement challenges. Financial capital plays a greater role at the level of individual companies or households than it does at the national level.

4. Growth

The scale issue that was referred to in Sections 2 and 3 is often interpreted as questioning the pursuit of economic growth. There are two general lines of argument criticizing growth as an objective. One is that economic growth simply cannot continue because it entails further increases in resource use and waste emissions, particularly of GHG. This is the basis of the "de-growth" perspective. The other argument advanced is that economic growth should not be the primary focus of economic policy, in the first place. These two lines are quite different in origin and implications. The first is based on considerations of environmental limits on economic activity, while the second is concerned with how this activity should be oriented and assessed. Both are discussed in this section.

Beginning with environmental limits, it is clear that economic growth has been characterized in the past by increased resource use and emissions (OECD, 2011). The concept of green growth is based on the expectation that growth, in economic activity, can be completely decoupled from material and energy use, so that the latter remain within local or planetary boundaries (OECD, 2011). In terms of the different categories of capital, the nature of growth would change as it becomes increasingly costly to substitute physical capital for natural capital, particularly forms of natural capital, such as ecosystem services, which support many production and consumption activities, as well as human health.

A distinction is made between *relative* and *absolute* decoupling. Relative decoupling occurs when the rate at which resources are used increases more slowly than the rate of economic growth. This means that the intensity of resource use, measured for example by the amount of GHG emissions per unit of GDP, would be declining. However, overall resource use would still be increasing, and is likely to be unsustainable over the longer term. Absolute decoupling, in contrast, occurs when the use of resources stops rising, and possibly decreases, while economic growth continues to rise.

As an example, green growth refers to absolute decoupling. There is evidence that some OECD countries have already achieved some partial decoupling, where "partial" refers to decoupling of growth from some forms of pollutants or natural capital (EEA, 2014).

It is important, however, to distinguish between production and consumption perspectives, particularly in using national-level data. The last few decades have seen major changes in the global economy with considerable growth in industrial production, particularly in China, India and other emerging market economies and those that export to OECD countries. An analysis of the resource use or emissions per capita, that is based on what a country's consumers use, can indicate that the associated impacts have simply been shifted from one producing area to another (EEA, 2014).

From a global perspective, there has been a geographical shift where resources are used or wastes emitted. This suggests that decoupling and green growth ultimately needs to be assessed from a global perspective, to reflect relevant planetary boundaries, such as GHG emissions and climate change. A consideration at national, regional, or local levels is still relevant for two reasons. One is that global challenges need to be disaggregated to lower levels to develop goals, targets, policies and programmes to achieve them. The other is that various sustainability boundaries are more relevant at other levels, such as in the case of freshwater management, with local limits presenting challenges in many places.

The feasibility of absolute decoupling remains a subject of debate. Some argue that growth inherently includes increases in material and energy use, based on an analysis of historical trends (Victor, 2012). One framework that is often used to support this analysis is the IPAT equation, proposed by Ehrlich and Holdren (1971):

$$I=P\times A\times T$$

where I = impact, P = population, A = affluence and T = technology.

The IPAT equation simply suggests that the total impact on the environment is determined by the interaction between population size, average affluence (or income) and technology [8]. Impact (I) can be interpreted in various ways, or dimensions of sustainability, such as GHG emissions and climate change. It can also represent the use of other forms of natural capital or even specific resources. As affluence increases, which can be interpreted as economic growth, resource use increases. Technology also plays a role in determining the impact. Absolute decoupling would require that changes in technology could more than compensate for increases in affluence (as well as population). In terms of the Doughnut (Figure 4), absolute decoupling can be thought of as moving from outside the outer ring back towards the "safe" band or space, particularly with respect to the objective of income and work, which is what GDP growth represents.

The IPAT equation is useful for identifying the components of resource use and environmental impact. The equation is however more of an accounting identity and contains no information about how those components change over time. Proponents of green growth claim that there are still many unexploited and unexplored possibilities for technological development, such as in the case of renewable energy, or circular manufacturing processes. Considering the potential energy sources available on earth, the amount of freshwater available, and the potential agricultural production, among other resources, it is not possible to conclude that decoupling and green growth are unfeasible [9]. From a macroeconomic perspective, it is not clear at all how long it might take to reach such a state, as well as other features of the transition path. As discussed in the subsequent section, some analyses are available, particularly concerning climate change, but much remains uncertain. As pointed out by Raworth (2017), this debate is very difficult, if not impossible, to settle as it involves beliefs about what is technologically and socially possible [10].

The other line of criticism around economic growth actually questions the pursuit of this growth as an economic policy objective in the first place, indicating that this is neither necessary nor sufficient for the achievement of social goals such as increased happiness, welfare or equity, or reduced poverty. A growing body of research in the economics of well-being has found evidence that measures of happiness and well-being are not highly correlated with economic growth. One interpretation is that growth creates more income and wealth but that this might not be very equally distributed in society. This suggests that growth is not sufficient and that additional policies, such as social security programmes and income redistribution through fiscal policy, are necessary to ensure that the fruits of economic growth are shared. Another perspective is that happiness and well-being are much less related to income and material standards of living, and more influenced by factors such as security and the strength of social relations, to name but a few. From this perspective, economic growth is not necessary to improve people's well-being. This proposition might be challenged in the context where people's basic needs of food, shelter, water and health are not met, by some basic standards, such as the SDGs.

This reasoning is underpinned by a group of thinkers that propose a redefinition of the concept of economic progress, as one that does not necessarily involve growth (Jackson, 2011). In many ways, this involves a measurement agenda, as there is certainly a broader consensus that the conventional measure of growth - increases in GDP - is flawed. Indeed, GDP was never intended as a measure of well-being, even economic well-being. Yet, it has become just that to many people, especially policy-makers. There is considerable analysis that illustrates the close – but not perfect – correlation between GDP and various social and economic indicators, and this is illustrated by its incorporation into the Human Development Index. The popularity of GDP might be a result of its convenience, given the availability of data. This, however, is the result of substantial government investment – a policy decision – in data collection

8 Note that the equation is not a precise mathematical model, although it can be calibrated for particular impacts. For example, if I is total GHG emissions, and P is population size, A is GDP per capita and T is GHG emissions per unit of GDP, then the equation "works" just as an accounting identity does.

9 Hepburn and Bowen (2015) also use the IPAT identity to demonstrate that no-growth is also not necessarily going to deliver a level of greenhouse gas emissions corresponding to little or no increase in average temperatures of the earth's atmosphere.

10 Raworth (2017) describes this first view as "economic growth is no longer possible – and so it cannot be necessary", which is opposed by a second view, namely that "economic growth is still necessary – and so it must be possible".

and statistical offices to adopt the System of National Accounts [11].

Some economists focus the need for solutions in improved measures of economic activity and growth, as discussed below in Section 5 [12]. Those who question growth prefer to see a focus on other aspects, and suitable indicators of progress, such as happiness among others, without directly considering whether such progress involves growth as measured by GDP (van den Bergh, 2017). Raworth (2017) also suggests being "agnostic about growth", arguing that resolving the debate around growth is less relevant than devoting more attention to such other goals. Ideas and frameworks such as the nesting of SDGs in Figure 3, and Doughnut Economics presented in Figure 4, emphasize the need to assess economic performance in terms of other outcomes and indicators. To formulate and guide policy, it is also necessary to have frameworks – theories and models – that describe the functioning of the economy in these terms. At the very least, frameworks need to integrate outcomes in terms of social and environmental considerations. The following sections will review long-run and short-run perspectives on the macroeconomy. It will be seen that there are a few limited macroeconomic frameworks that include some of the issues. It should, however, be clear that these remain inadequate for the task of policy guidance and remain an open and urgent field for research and development.

11 Tily (2015) provides an account of how economic growth as an objective came to dominate economic policy making in the 1950s and 1960s.

12 Hepburn et al., (2018) provide detailed arguments in favour of the green growth agenda.

5. Growth in a green economy: towards balanced capital stocks

5.1 The production function and capital stocks

Macroeconomics has two principal domains and associated lines of analysis: one looking at fluctuations in economic activity related to business cycles and shocks, and another examining long-term processes of economic growth. This latter area studies long-run structural change in the economy, through a process called 'capital accumulation'. Economists working on this topic, attempt to identify specific factors that either promote or inhibit growth with a particular focus on institutions and policies that concern, for example, education, trade and innovation [13]. These determinants of long-run growth have been studied by economists since the 1950s. The core of this area of macroeconomics has been the aggregate production function, in which labour and capital are combined to produce goods and services with the use of some technology, as in the original Solow growth model (Solow, 1956; see Box 2.2) [14]. These goods and services are either consumed or invested in the production of more physical capital. The model has been used to assess under what conditions an economy

13 A comprehensive treatment is found in the leading graduate level textbook by Acemoglu (2009).

14 The discussion here concentrates on "mainstream" neoclassical macroeconomics. There are various other approaches and lines of research. From a green economy perspective, "Keynesian" models have recently been developed to incorporate climate change, as well as income distribution and inequality issues (see, for example, Rezai et al., 2013; 2018) and some other approaches have been proposed (Rezai and Stagl, 2016).

Box 2.2. The Aggregate Production Function

The aggregate production function is a central concept in the economic analysis of growth at the macroeconomic level. The production function provides the amount of goods and services that can be produced given existing factors of production. Classical economists defined three factors of production: physical capital, labour and land. The aggregate production function was introduced in the Solow growth model with only physical capital and labour, corresponding to the stock of human capital. The production function has been expanded to include natural capital (natural resources).

In its most general form, the production function is written mathematically as:

$$Y=f(K,L,R)$$

Where K represents the stock of physical capital, L the stock of human capital (or labour), R the stock of natural capital (including resources, though not limited to those), and Y is total production. Thus, in this simple sense, the production function embodies the technological possibilities existing in an economy.

The general form of the production function above does not tell us how much output can be produced. For that purpose, a specific function needs to be used. Economists have used a number of different functions. One of the most popular is termed the Cobb-Douglas function:

$$Y=K^{\alpha}\times L^{\beta}\times R^{\gamma}$$

This includes three new parameters, or variables (α,β,γ), which determine how much the additions to the respective capital stocks will increase production. The nature of the production function also determines the degree to which capitals can be substituted for each other in the economy. Acemoglu (2009) provides a detailed discussion on the aggregate production function and its use in economic growth theory.

reaches a balanced growth path, which is characterized by constant growth rates in key indicators such as output, capital stock, and capital per worker. The Solow growth model was developed to help explain observed differences in growth rates across countries. The model proposes that such differences must arise primarily due to differences in the effectiveness of labour, and not due to differences in the amount of physical capital accumulated. This resulted in considerable research into the many factors that can influence the effectiveness of labour, including knowledge, education, infrastructure, institutions, such as property rights.

A major limitation of early growth models is that natural and environmental resources were ignored as inputs to production, as were the resulting pollutants that have a negative effect on the stocks of natural, physical and human capital. The production function was based on only two capital stocks (physical and human), and did not explicitly recognize natural capital (Common and Stagl, 2005). Some opportunities have been exploited to expand the types of capital included in these theoretical models. For example, Ayres et al. (2013) offer a particularly salient extension of the use of the production function in analyses of economic growth by including energy as an additional input to production. A version of the Solow growth model that integrates both land and natural resources as two additional inputs into the production function is included in the opening chapter of a popular graduate level textbook on macroeconomics (Romer, 2011) [15]. This analysis emphasizes the importance of the rate at which technological progress can overcome the growing scarcity of natural resources. It also relies, to some degree, on being able to substitute other inputs, such as labour and physical capital, for natural capital. The nature and extent of substitutability between natural capital and other capitals is a critical issue for a sustainable economic development pathway.

In the aggregate production function framework, there is more than one combination of different types of capital, together with other inputs, that produce a given amount of output. For example, machinery (physical capital) permits the production of many goods using less labour (human capital). Traditionally, physical capital has been considered as substituting for natural capital in production processes. Agricultural crops, on the one hand, can be produced using either extensive techniques, employing more land with less mechanization and chemical inputs, or intensive practices, applying more of such capital and inputs to a given parcel of land. There is thus a certain degree of substitutability between the services provided by different capital stocks. At the same time, there is still complementarity. Machinery, on the other hand, is combined with land and labour to produce crops. This means that the process of industrialization is traditionally seen as one in which stocks of natural capital, such as minerals and forests, are drawn down through the production process while stocks of physical and human capital are built up (Acemoglu, 2009).

Clearly, though this process has limits in the aggregate. Some stock of natural capital, for instance. is required in order to produce food. This suggests that there may be a critical lower threshold for natural capital, and if crossed, economic production would decline or even collapse. There can be tipping points after which such feedback effects lead to an acceleration of change. Natural capital is a multi-dimensional concept – there are many individual stocks of natural capital and some are nested inside others (natural resources inside ecosystems, for instance). Natural capital that provides environmental and ecological services to maintain the productivity of other types of capital is an essential factor of production. Therefore, it seems logical that in some ways natural capital is substitutable, but that in others it provides a necessary complement to inputs in production from other capital stocks [16]. Clearly, if natural and physical capital were perfect substitutes, there would never have been a need to develop physical capital in the first place (Costanza and Daly, 1992). Empirical analysis of this issue suggests that the substitutability of natural capital is either low or moderate (Cohen et al. 2017), although such conclusions are limited to understanding history, based on past and current technology.

There is a clear link between substitutability and technology. The substitutability and complementarity among various forms of capital is captured by the technology in the production function [17]. If natural capital is being depleted, which leads to negative consequences for the economy, then innovation and technological change might be expected to adjust. In this way, the increasing

15 The model is based on work by Nordhaus (1992), as part of a critical review of the revised Limits to Growth modeling (Meadows et al., 1992).

16 The extent of substitutability between natural capital and other capitals has led to the distinction between weak and strong sustainability. Weak sustainability assumes that natural capital can generally be substituted for by other forms of capital, while strong sustainability considers such substitution possibilities as being more limited. The multi-dimensionality of the concept of natural capital can give rise to such seemingly different perspectives. The possibility of substitutes for specific natural resources is greater than for ecosystems providing essential life support services.

17 In mathematical terms, the technology is represented by the function and its specific parameters (see Box 2).

scarcity of natural capital might prompt new production methods that do not deplete natural capital stocks. This is the basis of an optimistic perspective on the potential for technology to solve sustainability challenges. Thus, the degree of substitutability is dynamic and path-dependent. The technologies, and hence substitutability, of tomorrow depend on the decisions made yesterday and today, particularly in which physical, human, and technological assets investment is channeled.

5.2 Theoretical growth models

A large body of theoretical work has analyzed the processes of substitution and technological change in the context of economic growth models, incorporating natural capital in the form of environmental quality. This is a stock to be managed, given its effects on consumers' welfare, while its implications for production are generally indirect. The highly abstract and theoretical nature of these models does allow, however, an interpretation of environmental quality as a stock of natural resources necessary for production. Brock and Taylor (2005) conducted a review of this research. One key interest at the time concerned the relationship between economic growth and the environment, particularly the so-called '*Environmental Kuznets Curve*' (EKC). The EKC, which has been the focus of considerable analysis and debate (Brock and Taylor, 2005), proposes that environmental quality will first deteriorate with economic growth and development, at lower levels of national income and in the initial period of industrialization. However, once the service sector of an economy begins to develop and incomes reach a certain level, environmental quality will improve with further growth. Interest in the EKC was motivated by a seemingly apparent observation in empirical data at the national level (e.g. Stokey, 1998). In essence, the question is whether economic growth could occur without decreasing environmental quality, and if so, under what conditions [18].

The 2005 review by Brock and Taylor covers a wide range of economics literature including the theory of resource depletion and growth, the implications of endogenous growth theories, and the relationship between environmental quality and national income levels. Three mechanisms that determine the relationship between economic growth and environmental quality are discussed, namely scale, composition and technology effects. The scale effect reflects the simple direct relationship whereby increased production generates more pollution. The composition effect refers to the relative shares of cleaner versus more polluting sectors in the economy. Thus, if growth in cleaner sectors is outweighs growth in more polluting sectors, then the overall increase in pollution will be less than when both types of sectors grow at the same rate. Technology effects also achieve the same outcome, through improvements in production processes, resulting in less pollution per unit of output. In order for growth to not generate additional pollution, the composition and technology effects must outweigh the scale effects. Brock and Taylor (2005) show that for a perpetual process of economic growth to continue, there must be continual reductions in pollution per unit of output and ultimately zero-pollution technologies must emerge [19].

Technological progress is the source of long-term sustained growth in neoclassical theory, through enhanced productivity. In the conventional growth model, innovation and technological change provides profitable opportunities for investing in new capital stock. The principal factor driving a shift in the long-run capital accumulation process towards an IGE is the amount, and also nature, of technological progress. To-date this technological change has largely been oriented towards 'brown' physical capital, embodying a relationship of substitutability with natural capital. Technological progress can modify the production function by changing the degree of substitution among different factors, i.e. physical, human, and natural capital, which can help change the production pattern (for example by producing with less emissions). Innovation and technological progress can also ease the constraint from a diminishing stock of exhaustive but essential resources through the discovery of renewable substitutes.

Brock and Taylor (2005) identified four types of growth models to examine the relationship between economic growth and environmental quality and the role of scale, composition and technology effects. The first is the *Green Solow Model* (Forster, 1973; Solow, 1973; Stiglitz, 1974; Brock, 1977; Stokey, 1998; Aghion and Howitt, 1998; and Jones and Manuelli, 2011), in which reduc-

18 The EKC was criticized by many on economic grounds, such as ignoring the effects of international trade on patterns of pollution (e.g. Stern et al., 1996). There was also criticism of interpretations of the EKC as an economic "law" instead of a pattern in empirical data resulting from policy decisions and choices, even if these were not explicitly concerning environmental regulation (Swanson and Ziegelhofer, 2012).

19 Some ecological economists would argue that zero-pollution production technologies are not possible at an aggregate (economy-wide) level given the laws of thermodynamics. This then calls into question the possibility of continual (never-ending) economic growth. The neoclassical and growth analysis defends itself by not specifying over what timeframe and extent of growth, this condition needs to be met.

tions in pollution emissions result from exogenous technological progress made in the abatement process. The model provides three results. First, the dynamics of the Green Solow Model is sufficient to produce the EKC even with fixed abatement intensity. Second, the model predicts that stricter environmental policy may cause differences in income but does not have long-term effects on the growth rate. The third result is that, although technological progress in increasing production may result in more emissions, improvements in environmental technologies can deliver an overall mitigation of emissions. The technology effect outweighs the scale effect [20]. Hence, the Green Solow Model, with relatively simple assumptions including ongoing improvements to production technology, allows the possibility of a decoupling of economic growth from pollution.

The second type of model, the *Stokey Alternative*, builds upon Stokey's (1998) work on the limits to growth, by incorporating increased abatement activities. When abatement is modeled as a factor of production, similar to Copeland and Taylor (1994), the analysis is similar to the drag on growth from the depletion of natural resources. When abatement is modeled as an economic activity that uses scarce economic resources (capital and labour), increase in the intensity of abatement to maintain environmental quality will have a drag on economic growth (Brock and Taylor, 2005). However, if abatement is characterized by constant returns to scale, a positive relationship between growth and environmental quality is still possible in this type of neoclassical model, although growth proceeds at a lower level.

20 Note that the Green Solow model consists of only one sector and production technology; so the composition effect is not relevant.

The third type of model incorporates both the "source and sink" roles of nature: energy uses exhaustible fossil fuel stocks and also generates pollution emissions that deteriorate environmental quality. With a constant intensity of abatement (without technological progress), the model shows that the economy can grow while reducing emissions because of continuous changes in the composition of inputs. However, abatement cannot be achieved without a cost. Growth slows as the scarcity of natural resources increases. These analyses suggest that abatement or composition shifts alone are insufficient to deliver long-term sustainable growth. Technological progress directly targeted at lowering abatement costs can be expected to play a key role in determining growth and environmental outcomes. The fourth type of model was developed based on the analysis of Brock and Taylor (2005), emphasizing the importance of technological progress in abatement. The analysis highlights the value of including both the direction and rate of technological progress as outcomes of the model (rather than as assumptions).

Theoretical growth models remain inconclusive about the feasibility of economic growth in the face of environmental deterioration. Brock and Taylor (2005) noted in their review that "the relationship between economic growth and the environment is not well understood: we have only limited understanding of the basic science involved – be it physical or economic – and we have very limited data." Research in this area continues to advance, including attention to trade and the international coordination of policies (Acemoglu et al., 2014).

Other models have tried to calibrate the basic theoretical models to data, with a focus on GHG emissions and climate change. These models, known as integrated assessment models, include a dynamic general equilibrium model of the economy, with a basic model of the global warming process. Such models include GHG emissions as an output of economic production, but this also results in a direct feedback from climate change on both production and/or the welfare of consumers. The Stern Review (Stern, 2007) was a major contribution in this area. One benefit of these calibrated models is the possibility to analyze different scenarios for policy. The Stern Review compared economic growth with mitigation policies to a baseline, business-as-usual scenario.

There is and never will be, a single theoretical model that definitively answers the questions about the relationship between economic growth and sustainability. The insights from this field of research need to be derived by examining the literature as a whole to identify common findings that appear robust across varying assumptions [21]. What has emerged from these models is that economic growth with environmental sustainability might well be feasible. Innovation and technology play a critical role in this process, with the support of policy, to shift production towards cleaner ('greener) sectors or industries, and to develop cleaner technologies [22].

5.3 Policy implications of growth models

The research on reorienting economic growth to respect environmental limits emphasizes two types of policy

21 This is indeed the purpose of the review by Brock and Taylor (2005).

22 Recall that "cleaner" can be interpreted both as less polluting and as making less use of natural capital.

goals: the need to ensure sufficient maintenance of, and investment in capital stocks, and measures to promote investment in physical capital that is more complementary to natural capital (as opposed to being substitutable) [23]. With respect to the first goal, Hartwick (1977) demonstrated that Solow's (1974) analysis required that natural capital depletion be matched by a corresponding increase in physical capital investment – a net savings rule known as the Hartwick Rule. This analysis assumed substitutability between an exhaustible natural resource and physical capital. This framework has formed the basis of the comprehensive wealth accounting developed by economists working with the World Bank (Hamilton and Hartwick 2014; Lange et al., 2018). However, a related approach recommends that a broad inclusive measure of wealth needs to be maintained (Arrow et al., 2012). This is the basis of inclusive wealth accounting developed by the United Nations University, UN Environment and partners (UNU-WIDER, 2012). Both approaches indicate that policy should measure either the stocks of the different types of capital, or changes in those stocks, and ensure that the capital asset base, or wealth, grows, or at least does not decline. This requires accounting frameworks to be in place at the national level (see section 8). It should be noted that these approaches, in general, make few or no recommendations on the substitutability of physical capital for natural capital.

The second policy goal concentrates then on measures to shift the composition of production to respect environmental limits, by directing investment towards green economic activities and to research and development (R&D) on cleaner technologies. From a macroeconomic perspective, investment is the flow that adds to the capital stock. Investment does not only change the quantity of the capital stock but can also effectively adjust its structure – the types of capital. The role of investment in increasing capital stock is obvious. For example, investing in workshops, machines as well as inventories of raw materials and semi-products can maintain or increase the output of man-made capital; investing in medical care and health, culture, recreation and education can maintain or increase the quantity and quality of human capital; investing in pollution 'prevention and control' as well as in ecological conservation can maintain or indeed increase the quantity and quality of natural capital.

Investment can change, or green, the industrial structure of capital – green sectors relative to brown sectors - in two ways. First, investment can change the production processes for existing goods and services. Second, investment can shift from the production of traditional products to that of green ones (e.g. shifting from vehicles with internal combustion engines to vehicles with hybrid engines or electric vehicles). Investment directed to green sectors and green technologies will gradually promote the greening and cleaning of the industrial structure, driving green growth through composition and directed technology effects. These green technologies are both "hard", such as renewable energy technologies, and "soft", referring to social and institutional innovations, which can be seen as part of social capital. The next section further elaborates on how investment fits into a short-term framework.

Growth models indicate that an IGE cannot be achieved without policy support and institutional reforms. Fundamentally, this is due to the externalities associated with investment in the new generation of capital and technological progress, as well as overall path dependency in the economy [24]. Growth theory emphasizes several types of policies to reorient investment:

- Adjusting relative prices, particularly through fiscal and market-based instruments (such as carbon pricing);
- Setting regulations and limits to resource use and pollution;
- Innovation policies to stimulate technological progress, particularly for clean physical and natural capital; and
- Targeted public investments, particularly in infrastructure.

As implied by the preceding discussion, growth models emphasize the role of incentives in investing in innovation. Thus, R&D policies play a particularly important part in addressing environmental externalities in addition to conventional information externalities.

The last type of policy in the above list results indirectly from the models, which generally do not include a distinction between public and private investment. In particular, growth models pay relatively little attention to infra-

23 This is out of the recognition that substitutability is more limited than has conventionally been assumed, as discussed above.

24 Path dependency here refers to the idea that the relative prices of investment and production processes are affected by earlier decisions and the nature of capital that has been accumulated. For instance, the existing stock of physical and intellectual capital in fossil-fuel technologies is much greater than that in renewable energies, given past history. This means that the additional cost of adding energy generation potential is often lower for fossil fuel technologies. For this reason, we refer to a transition to a different path.

structure, which can also be seen as a form of physical capital. Infrastructure, however, tends to be owned or managed by the public sector and is generally complementary to privately-owned physical capital in supporting the production process. Infrastructure, which is the result of government decisions, also determines the relative profitability of alternative types of physical capital – such as brown versus clean – and hence influences the innovation and investment processes. For example, much of the energy system, particularly electricity generation and distribution, can be considered as part of infrastructure, and similarly for transport.

The types of energy and transport systems clearly affect the environmental impacts of many economic activities. Much investment in the economy is undertaken by public sector actors (governments or semi-public agencies), and this public investment needs to be targeted to support the transition to an IGE. Infrastructure exhibits network economies which creates a bias towards lock-in with a given technology. One example is the grid, which is designed to distribute electricity from a limited number of large generating plants. Newer technologies, offering distributed solutions, face an initial period of resistance, which reflects the sunken?? investment costs in the existing infrastructure. Tipping points can, however, be reached beyond where old networks are replaced by new ones (Zenghelis, 2016).

Investment here also refers to investment in human capital. The knowledge and skills required for a green economy transition are also necessary to support technological progress. Our discussion of the economics of growth has concentrated on the relationship with the environment while ignoring the issue of inclusion and social equality. There is a separate line of research that has incorporated inequality among workers into growth models (e.g. Grossman and Helpman, 2018). This is part of the increasing attention to inequality in economics (e.g. Piketty, 2014), with theoretical research working to develop models that explain patterns of increasing income inequality [25]. It is too early though to assess the main findings of this area of research.

6. Short-run dynamics: Transforming the components of aggregate demand

Most attention, both by researchers and policy-makers, concentrates on short-run macroeconomic issues such as the trends in macroeconomic indicators and especially their deviation from steady paths due to business cycle fluctuations or other shocks. The frameworks that are used to understand these movements and the possible effects of policies include neo-Keynesian and real-business cycle models. These models focus on the role of fiscal and monetary policies in avoiding or minimizing temporary downturns in employment and output. Aggregate demand analysis, which is concerned with the overall level of activity in the economy, plays a central role. Changes in aggregate demand are important because they are correlated to some extent with changes in employment and inflation. The policy focus on growth – in aggregate output – is based on interest in the implications for employment and inflation. Understanding how the components of aggregate demand are changing provides insight into the source and possible duration of changes in the overall total.

The main components of aggregate demand are provided in the circular flow diagram in Figure 1: consumption (*C*), investment (*I*), government spending (*G*), and net exports (exports minus imports; *X* – *M*). This is typically represented by the conventional accounting identity,

$$Y=C+I+G+(X-M)$$

where aggregate demand (the right side of the equation) is equal to aggregate supply (Y). In conventional macroeconomic analysis, attention is focused on the level and change in these components, and their contribution to aggregate demand. It is also relevant to break down some of these components into sub-components. For example, consumption is commonly divided into durable and non-durable goods. In the case of investment, the industrial sector that is undertaking these expenditures can also be of interest [26]. Similarly, exports are usually disaggregated by major commodity or service sector.

25 Some recent research has referred to the idea of "directed technical change" (Acemoglu, et al., 2012), as an explanation for reduced demand for unskilled and semi-skilled labour, relative to skilled labour. This has been suggested as a principal mechanism accounting for increased income inequality in a number of developed countries. Note that "directed" refers to the nature of technological change that the economy has pursued, and not to a process that has been consciously directed by governmental policy.

26 The circular flow diagram (Figure 1) illustrates the dynamic relationship between income and investment. Current investment forms a part of current income, which depends in part on the production capacity created due to past investment. Investment thus plays two roles in determining economic growth. In the short term, investment requires the use of man-made capital, human capital and natural capital, and may cause environmental deterioration. Investment is therefore an important factor influencing total demand. In the long-term, increases in production capacity contribute to a greater supply of goods, thus increasing output and income.

For an IGE, it is important to understand where the potential to support a transition process exists among fiscal and monetary policy interventions, even if this process might take place over a longer period. In addition, the standard macroeconomic framework of aggregate demand, linked to national accounts, provides a useful organizing principle for understanding other aspects of the macroeconomics of an IGE, many of which are treated in more detail in ensuing chapters.

An IGE is characterized by methods and patterns of production and consumption that are low, or even zero, in carbon emissions, resource-efficient and waste minimizing. Another way to describe this is with reference to planetary and local boundaries for critical natural and environmental resources. In an IGE, the activities of production and consumption remain within these boundaries. In the aggregate demand framework, this would apply to each of the components. Thus, investment would be in physical capital for production technologies and facilities that are green, following the above definition. All the goods and services produced, and therefore either consumed (by households or government) or exported, would also be green.

There are no existing examples of a 'real' IGE (as yet). There are however emerging sectors and technologies that can be considered as greener than others, if not entirely green. Examples include: renewable energy technologies, energy efficiency technologies across a range of uses and sectors (such as manufacturing, transport, buildings), waste minimizing technologies in production and processing, and agricultural production techniques with fewer emissions and pollutants. Some of these technologies, such as renewable energy for power generation, effectively involve new economic sectors, or at least a completely new physical capital stock, such as wind turbines, concentrating solar plants, etc. These sectors and their capital stock are more easily characterized as green compared to other technologies, such as in energy efficiency, that contribute to the greening of an existing process or capital stock. These latter cases may not lead immediately to a level of energy or resource use (or waste generation) that can be considered to be at a sustainable level. However, such incremental improvements can be viewed as part of a transition process. Indeed, from an economic perspective, it is important that this transition process takes place as smoothly as possible in terms of disruption to employment and income.

The transition process towards an IGE is characterized by an increasing share of green activities and sectors in each of the components of aggregate demand: household consumption, government expenditure, investment and net exports. Each of these components can be influenced by specific areas of economic and public policy, in an effort to direct demand (Perez, 2016). Among the components of aggregate demand, investment plays a key role, as this is how the capital stock accumulates. Investment is therefore the component of aggregate demand that will ultimately determine the future potential for green production and consumption by households, government and foreigners who purchase the economy's exports. This is achieved by investment, at least in part, in clean physical capital, in contrast to only investing in conventional physical capital. Similarly, the current potential for green production is determined by the nature and amount of past investment flows. Thus, the role of policy is to shift the composition of a company's investment. Relevant policy frameworks to achieve this include fiscal policy (see Chapter 9 on fiscal policy and Chapter 10 on the finance system), monetary policy and sectoral policies and regulations (see Chapter 12 on industrial policy). Fiscal policy could include incentives in business taxation to favor green investment, operating either directly on businesses or indirectly through the financial sector, which provides investment funds to business. There is a wide range of sectoral policies, including incentives, standards and regulations, that can influence green investment. In the energy sector, this could include such a diverse range as support of R&D, requirements for renewable content and incentives such as feed-in tariffs, to name just a few [27].

The overall level of investment is generally influenced by monetary policy, in particular by the level of interest rates set by the central bank for deposits it holds on behalf of commercial lending banks. The central aim of monetary policy is typically to maintain an acceptable level of price inflation and, depending on the country, to also aim for maximum employment. There are, however, various means of deploying interest rate policies, as well as other financial regulations by the central bank (e.g. concessional refinancing), to promote increased flows of investment capital into clean physical capital (UNEP Financial Enquiry 2016; see Chapter 10).

Government spending (*G*) is also an important com-

27 The wide range of sectoral policies is not covered in detail in this book, which places more emphasis on the broad areas of economic policy. The report, Towards a Green Economy (UNEP 2012), takes a sectoral approach, providing a broad overview of sector-specific policies to support a transition process.

Box 2.3: Discounting

The economic evaluation of public projects is undertaken using cost-benefit analysis (CBA), which seeks to quantify, in monetary terms, all the costs and benefits associated with the investment under consideration. Many of the benefits, as well as a portion of the costs, will be generated in the future. In the case of infrastructure projects, the relevant time period under consideration could be many years, and in some cases, decades. In order to add up these current and future flows of costs and benefits, a discount rate is applied to future flows. This discount rate is typically expressed on an annual basis, for example 5% per year. This rate would mean, for example, that one dollar of benefits arising in the second year would be counted as $0.952 (when rounded to one-tenth of a cent), and from the third year, as $0.907, and so on. In general, the present value, PV, of some future value V after t years, given a discount rate of r, is calculated as follows:

$$PV=V/(1+r)^t$$

The discount rate, particularly the rate used from a social perspective, is not the same as the interest rate, which would typically be higher, even though the concept of discounting is similar to compounded interest. Discounting in the context of publicly financed projects or investments is justified on the basis of people having a certain amount of preference for consumption today over tomorrow, and the assumption that consumption possibilities are expected to grow in the future as a result of economic growth (Gollier, 2012).

The practice of discounting has been challenged for promoting unsustainable resource extraction and degradation, and as being unfair towards future generations, as their welfare is given less importance than that of the current generation (Common and Stagl, 2005). Economists generally view the practice as being justified, but that the appropriate rate needs to be calculated carefully (Gollier, 2012, provides a thorough and advanced treatment). Arrow et al. (2014) propose that a declining discount rate be used, based on incorporating the uncertainty of future growth, the risk of catastrophic events, and the possibility that such risks might be correlated with each other.

ponent of aggregate demand for a green economy transition. In many economies, government spending accounts for over a third of aggregate demand, and in some cases, even approaches half of the total. Again, macroeconomic analysis tends to concentrate on the overall size of government expenditures, but for an inclusive green economy transition, it is more relevant to look at the components of government spending. Government spending can be broken down into two types: regular government procurement and investment in infrastructure. For the former, focus has been on the potential for government, given its large size relative to the economy, to promote economies of scale for green products and services through green public procurement [28]. Investment in infrastructure was mentioned in the previous section, and the part of this investment devoted to making public infrastructure more environmentally sustainable, should be increased to support a transition to an IGE. An important policy tool for this purpose is the 'social discount rate' used for public projects (Gollier, 2012). There are strong arguments for using a lower rate than has conventionally been the case in many countries, and also of using lower rates for benefits that arise further in the future, as is the case in some countries, including the United Kingdom and France (See Box 2.3).

Government spending is financed primarily through taxation of households and businesses. Fiscal policy, therefore, offers various possibilities for environmental fiscal reforms as well as progressive taxation. This seeks to influence both household consumption (*C*) and business investment (*I*) decisions, meaning that fiscal policy is influencing the greening of aggregate demand in these components, as well as government's own direct expenditure. Both spending and taxation by government are covered by Chapter 9 on fiscal policy.

Household consumption is the largest component of aggregate demand. In a green economy transition, goods and services that are low carbon, resource-efficient, waste minimizing and more sustainable, increasingly dominate consumption. In some ways, this follows from business investment in clean physical capital and government investment in green public infrastructure and that this type of investment makes greener goods and services available and accessible to households. There are also ways in which consumption can become greener simply through choice and behavior change. Thus, the greening of household consumption will represent the outcome of a range of such policies and activities to support sustainable consumption and production (SCP), which is SDG12. From the perspective of an inclusiveness it is relevant to examine the distribution of consumption levels across individuals and households, to identify whether any are living below poverty levels. It is also relevant to examine the trends in the material living standards of lower-income relative to higher income groups to ensure more equal outcomes and add policy interventions where necessary.

As with previous components of aggregate demand, the greening of the external account can also be considered as shifting to a composition of goods and services that support reduced environmental impacts and social inclusion. This includes not only the goods and

28 The European Commission has voluntary green public procurement guidelines (http://ec.europa.eu/environment/gpp/index_en.htm). For a more global perspective see the initiative of IISD (https://www.iisd.org/topic/public-procurement-and-infrastructure-finance).

services exported to other countries (*X*), but also the composition of imports (*M*). This perspective is somewhat different from typical aggregate demand analysis, in which imports are deducted from aggregate demand. However, an IGE effectively involves a global transition. A given country may advance towards a green economy by transforming its own domestic production and consumption, in advance of other countries. Progress would be somewhat diminished though if there is a corresponding increase in imported goods and services that are less green. Therefore, it is necessary to examine how imports evolve and ideally to have policies and regulations that promote an increase in the share of those that are green. This raises issues of trade policy, which are discussed in Chapter 11.

7. Models for policy analysis

The sections above lay out the existing macroeconomic models of an IGE. A rebalancing of physical (manufactured), human, social, natural, and financial capitals is a long-term process which is driven by transforming the components of aggregate demand, particularly consumption, investment and government spending. The transition pathway is almost impossible to forecast accurately due to the complex nature of economic systems, and the large degree of change required. In particular, the exact nature and specific direction of innovation and technological change is very difficult to predict, despite the fact that the overall nature of this process – towards technologies that are carbon-neutral, resource-efficient, and providing income-earning opportunities for labour – is generally clear.

Macroeconomic policy analysis to support and inform this transition process can draw on some existing practical tools, but there are limitations. As was mentioned in Section 5, growth models are generally theoretical in nature, and are therefore not suited for guiding specific policies on how to promote the transition. Growth models suggest that innovation and industrial policy will play a strong role and other chapters address these policy areas in more detail. Much existing macroeconomic analysis is based on general equilibrium models, such as computable general equilibrium (CGE) models, or dynamic stochastic general equilibrium (DSGE) models. DSGE models have been developed primarily for analyzing business cycles and fluctuations, and the influence of the primary levers of macroeconomic policy, such as monetary or overall fiscal policy. They have very little, if any, sectoral disaggregation, which effectively precludes their application to structural transformation processes [29].

CGE models have been developed with considerable sectoral disaggregation and have been applied to analyze the short and long-run effects of policies such as taxes, subsidies and tariffs on traded goods, to name a few. The strength of these models depends upon their emphasis on equilibrating processes of supply and demand through the price mechanism. In addition, the GHG emissions of individual economic sectors have been integrated into CGE models, which are then usually termed integrated assessment models (IAMs). Such models provide the tools applied for quantitative assessment used by the Inter-governmental Panel on Climate Change (IPCC, 2013) and also the Stern Review (Stern, 2006). Some IAMs, for example the OECD's ENV-Linkages and ENV-Growth models (Chateau et al., 2013ab), have been linked with land use models to assess the impacts of economic policy on agriculture and related sectors, such as forestry. This provides powerful tools for assessing the interactions between the economic sectors dependent on natural capital and the rest of the economy. Such models, however, tend to be less useful for guiding policy at the national level, given their global, comprehensive coverage, which reduces the level of disaggregation of sectors and regions. Such models are also less helpful in analyzing the growth of new sectors, such as green sectors.

Indeed, the rebalancing of capital stocks envisioned in a green economy transition provides challenges for general equilibrium modeling approaches, particularly with respect to the new technologies needed. An additional challenge arises from the still limited means by which measures of natural, social and human capital can be quantified and integrated into models. Models for the integrated assessment of development pathways have been constructed, generally relying on a system dynamics methodology (UNEP, 2014). The T21 model has been used to support the assessment of green economy policies in several developing countries. This model incorporates a range of indicators of natural capital, as well as of human capital. System dynamics

29 Many macroeconomists are questioning the extent to which DSGE models are valid tools even for understanding business cycles, particularly in the aftermath of the 2008-9 financial crisis, as the possibility of such a recession was not even foreseen in such models. Some critical reviews of DSGE models can be found in a special issue of the Oxford Review of Economic Policy (Vines and Willis, 2018; see in particular the individual articles by Blanchard 2018, Krugman 2018, and Stiglitz 2018).

models tend, in their implementation, to underplay equilibrating feedback effects, though this is not a limitation of the methodology. Some experience has been gained in integrated modeling approaches that combine system dynamics with CGE (and input-output) models (PAGE, 2017b).

System dynamics models are one example of what can be called non-equilibrium simulation models (Mercure et al., 2016). These start from a theoretical framework that is grounded in dynamical processes, shaped by institutions and policy, rather than equilibrium relationships (as is the case with DSGE and CGE models). This perspective also recognizes the important role of government policy in promoting new pathways. A related area of research is developing increasingly sophisticated agent-based models of economic interactions and even economies, though in highly simplified form (Haldane and Turrell, 2018). Such approaches appear to be particularly adapted to incorporating insights and findings from behavioural economics concerning non-rational decision-making (Kahneman, 2013; Thaler and Sunstein, 2009). Even more potential exists to incorporate insights from psychology, as well as history, geography, spatial planning, immunology and other areas to make economic models better suited to current challenges (Zenghelis, 2017; see also Grubb, 2014).

Thus the range of sophisticated quantitative tools available still falls short of providing the information that a policy maker or analyst would like to have. This includes a detailed assessment of how a specific package of public investments and expenditures, combined with policy measures, such as regulations and fiscal instruments for example, will support the emergence and growth of green sectors and overall greening of other sectors. In addition, the assessment should also capture likely effects on different income groups of workers and households. Although models are continually being improved, a macroeconomic analyst needs to remain honest, transparent and cautious in terms of the potential to offer robust quantitative advice for policy. This limitation should not be an excuse to justify business-as-usual in economic policy-making, even when there are stakeholders who do not yet support the need for an IGE transition. The macroeconomic frameworks do not give us precise answers, but they provide sufficient justification for expecting this transition to be possible and prosperous [30]. A final point is that modeling efforts are limited by available data and the next section discusses this important limitation.

8. Data and accounting

A transition to an IGE consists of shifting the components of aggregate demand, as seen in Section 7. This implies a need for appropriate data on the components of aggregate demand to support the setting of policy targets and monitoring their achievement. The principal source of macroeconomic data is the System of National Accounts (SNA), which is an internationally agreed approach to tracking the level of economic activity (Lequiller and Blades, 2014). There are various components to the SNA, including a number of flow accounts, such as a production account, an income account, a transfer account, a household expenditure account, and an external transactions account. There are also stock accounts, including an asset account (balance sheet) and an external balance of payments.

The SNA tracks and generates various macroeconomic aggregate indicators, of which GDP is the most well known and cited. GDP is a flow variable that represents the overall level of economic activity. The theoretical framework behind GDP is one of macroeconomic equilibrium between supply and demand, with a circular flow between income, consumption and output. Thus, GDP can be measured in three different ways: the total level of final sales (as opposed to intermediate sales), the total amount of value-added, and the total amount of income to capital and labour.

The specific definition of GDP contains a certain amount of arbitrary choices, such as the extent to which non-market activities or transactions are included (Lequiller and Blades, 2014). GDP should therefore be seen as a pragmatic but imperfect implementation of an elegant concept. As discussed in Section 5, GDP was never intended as a measure of well-being, but rather a measure of the overall amount of production or income (which are two sides of the same coin) in the economy. Nonetheless, it is generally assumed by many stakeholders that ‘more is better’. In other words, from an economic perspective, generally, a positive sign are higher levels of GDP.

The lack of integration of an environmental and resource management perspective in the SNA has long been an

30 This is not meant to ignore the different effects that certain groups or stakeholders (among industries and households) will experience in any transition. Some other chapters in this book give some attention to this issue of winners and losers (for example, Chapter 7 on inclusion).

	Industries	Households	Accumulation	Rest of the world	Environment	Total
Supply table						
Natural inputs					Flows from the environment	Total supply of natural inputs
Products	Output			Imports		Total supply of products
Residuals	Residuals generated by industry	Residuals generated by final household consumption	Residuals from scrapping and demolition of produced assets			Total supply of residuals
Use table						
Natural inputs	Extraction of natural inputs					Total use of natural inputs
Products	Intermediate consumption	Household final consumption	Gross capital formation	Exports		Total use of products
Residuals	Collection and treatment of waste and other residuals		Accumulation of waste in controlled landfill sites		Residual flows direct to environment	Total use of residuals

Figure 9: Basic form of a physical supply and use table in the SEEA (United Nations, 2012)
Note: Dark grey cells are null by definition.

issue of concern (Coyle, 2015, Stiglitz et al., 2009). An example of the issues involved is the generation of environmental pollution and possible activities to remediate the damage they cause to human health or other economic activities. A manufacturing activity that generates chemical pollution represents a positive contribution to GDP. If this pollution increases the incidence of chronic or fatal diseases among the surrounding population, this cost might not be captured in GDP. Perhaps in the future, the productivity of the working portion of this population would be reduced, and GDP would be lower. Moreover, if increased health costs are incurred, these would again represent a positive contribution to GDP. In general, therefore, there is no assessment of whether certain economic activities, as components of GDP, are more or less desirable from a social point of view.

Another way in which the SNA and GDP fall short in providing an information base for pursuing an inclusive green economy is the distribution of income and wealth. An increase in national income does not indicate which group of households has benefited. Perhaps much of a given increase was experienced only by the top 20% income bracket of households. Such an increase might even outweigh a decline by households in lower-income brackets. The SNA does recognize the possibility of disaggregating household income by level (UN, 2008). However, this presents various practical difficulties which, while not insurmountable, mean that the accounts are not (yet) commonly calculated in this manner. Nor would that, of course, affect GDP. Due to these limitations, various alternatives and extensions to the SNA have been proposed. Extensions for environmental issues have been formalized in the System of Environmental-Economic Accounting (SEEA). A core framework was adopted as a statistical standard by the United Nations in 2012 (United Nations, 2014). These are effectively a set of complementary ("satellite") accounts to the SNA. The SEEA includes accounts for physical flows in the form of physical supply and use tables (similar to the regular monetary supply and use tables for regular production in the SNA – see Figure 8). These can include natural resources and energy used in production as well as air emissions, water emissions and solid waste. The SEEA also extends the asset accounts of the SNA to cover stocks and flows of environmental assets, including mineral and energy resources such as: land, soil, timber, aquatic, water, and other biological resources. The SEEA thus provides statistics to support an analysis of the direct impacts and dependencies of the economy on environmental resources. These accounts can be constructed at various levels of disaggregation.

Section 7 emphasized that an IGE transition is characterized by an increasing share of green sectors in the components of aggregate demand. The SEEA can provide valuable information to monitor this transition, through two of its components. These components, the environmental protection expenditure accounts (EPEA) and the statistics on the environmental goods and services sector (EGSS), identify economic transactions such as production flows, where the primary purpose is to reduce pressures on the environment or to make a more efficient use of natural resources. These are therefore green components of aggregate demand, particularly in final sales or government expenditure.

These transactions form a fairly strict interpretation of green sectors, but they provide a starting point and the establishment of a framework that differentiates green activities from non-green activities. The implementation of the SEEA, and specifically these components, would constitute a major step forward in providing the information base for monitoring the transition to an IGE. As with the SNA, there is also potential to differentiate green transactions by household groups, where relevant, in order to capture aspects of inclusiveness.

A transition to a green economy also depends on maintaining the capital asset base, or overall wealth, as discussed in Section 5. Wealth accounting at the national, or economy-wide level, provides a framework for measuring the stocks of physical, human, and natural capital. Wealth accounting is motivated by economic theory (Hamilton and Hartwick, 2014; Arrow et al., 2012), and the perspective that economic well-being is determined by the overall level of assets, or wealth, in the economy. It is therefore consistent with the different capital approaches discussed in Section 3. Furthermore, wealth accounting constitutes a specific approach to extending the asset accounts proposed by the SEEA.

The Inclusive Wealth Index, developed by UN Environment and the United Nations University (UNU), is one approach to accounting for various capital stocks (Manage and Kumar, 2018). Presented in the *Inclusive Wealth Report*, the index calculates changes in the value of natural capital assets and human capital, in addition to conventional physical capital [31]. Natural capital is comprised of fossil fuels, minerals, forest resources, agricultural land and fisheries. Adjustments to changes in total wealth are also made for the social cost of carbon emissions (deductions) and improvements in total factor productivity (additions) [32]. Almost all countries have positive rates of capital growth, but only 109 countries have negative rates of growth in natural capital per capita. This illustrates the historical development and growth path in which natural capital is depleted to support the accumulation of physical and human capital. A related comprehensive wealth accounting framework has been developed by the World Bank, providing estimates of adjusted net savings for national economies. This approach is also promoted with developing countries through the World Bank's WAVES initiative.

Inclusive and comprehensive wealth accounting approaches assume substitutability between natural capital and other forms of capital. Changes in various natural capital stocks are valued in monetary terms and aggregated together with monetary values of changes in other capital stocks. The UK government, in contrast, has established natural capital accounts that devote more attention to the changes at the level of the different forms of natural capital, valued in monetary terms. This example illustrates the potential applicability of such accounts to national assessment and policy, while the international wealth accounting initiatives tend to concentrate more on international comparisons. Accounting for various forms of natural capital and its wide range of ecosystem services is a rapidly developing area.

In addition, there are a range of indicators of well-being that have been proposed, and in some cases, adopted by specific governments. These include the Index of Sustainable Economic Welfare (ISEW) and a subsequent version, the Genuine Progress Indicator (GPI). These indicators correct for some of the deficiencies in the GDP mentioned above, by adjusting for a wide range of environmental expenditures, externalities from emissions (e.g. CO_2) and depreciation of natural capital assets. To a large extent, this is based on SNA and SEEA data. There are also other indicators of well-being, such as the General Happiness Index, which focus more on direct measurement of well-being, or happiness. Such indicators are arguably measures of the ultimate objective, as distinct from attempts to measure the state of the economy, which should, of course, be interpreted as contributing towards such ultimate objectives.

The macroeconomic analysis and policy advice of a transition to an IGE also requires macro-level indicators of the economy's impacts and dependencies on the environment. In particular, there is a need for measures of the size of the economy – its scale – relative to both

31 The Inclusive Wealth Report (2012) was presented as an initial report piloting the methodology developed by Arrow et al. (2012). Two subsequent versions have been produced (UNU-IHDP and UNEP, 2014; Managi and Kumar (2018).

32 Estimates of shadow prices are used to value the changes in capital stocks. This attempts to capture the social value, as distinct from the market value.

planetary boundaries and relevant environmental limits. This can be done using empirical tools, such as carbon, ecological and material footprint measurements. Footprint measures can also be disaggregated to a sectoral level, in the form of environmentally-extended input-output tables. These are also envisaged as a component of the SEEA, referred to as an application, partly because input-output tables require considerable effort and analysis, as opposed to simply measurement.

Yet, another innovation is the development of synthetic indices, which combine multiple indicators across different dimensions of economic improvement and sustainability. These are discussed in more detail in Chapter 3, which also presents the Green Economy Progress Index (developed by UN Environment; PAGE, 2017a).

In summary, macroeconomic frameworks require an extended set of national economic accounts that will support the monitoring of the growing importance of green sectors. Work on the necessary frameworks has been ongoing for many years yet implementation still lags behind and needs to be a priority component of a macroeconomic strategy.

9. Conclusion

This chapter has emphasized that an IGE policy agenda is fundamentally about a macroeconomic transition process, characterized by a rebalancing of different forms of capital. The economic development process has traditionally been primarily viewed as the accumulation of physical, manufactured capital. This traditional view did also implicitly include the development of human capital, although this was not given explicit attention. Moreover, it was generally seen as acceptable that this capital accumulation was based in part on a reduction, or drawing down, of natural capital, in particular, the use of nonrenewable resources or the conversion of forestland for other uses. It has now become evident, with climate change and the loss of biodiversity and ecosystem services, that this process is unsustainable.

A sustainable development pathway, in contrast, is characterized by the accumulation of physical and human capital, based on technologies that maintain natural capital. These technologies are embodied in physical capital, as well as in business models and organizational processes. An inclusive green economy thus also develops social capital, particularly in the form of new institutional arrangements. Hence, there is a rebalancing and integrated development of the full range of capitals.

The macroeconomics of this process is rooted in the analysis of capital accumulation and growth, extending earlier frameworks and models to reflect other forms of capital, either directly or indirectly. The transition process in the short run consists of transforming the components of aggregate demand into greener forms of consumption, investment and government spending. This will be driven by measures in a wide range of policy arenas – such as in taxation and spending, investment, innovation, consumption, and trade. These are treated in dedicated chapters in the rest of the book. An important role is played by measurement, not least with respect to the growing importance of greener economic activities and sectors. This issue and overall measurement of progress towards an IGE is also addressed Chapter 10.

While some of the elements of a macroeconomic framework for guiding a green economy transition exist, a fully-coherent set of models and tools to inform policy processes is lacking. Macroeconomics should ideally be extended and developed to address important goals of social and economic policy, such as meeting basic needs while remaining within relevant environmental limits. An assessment that “the economy is doing well” should be based on issues that go beyond aggregate output growth, employment and inflation. This will require integrating environmental and social issues into standard macroeconomic frameworks that form the basis of thinking for all economists, in contrast to the current situation where they amount to extensions explored only by those with interest. Indeed all macroeconomists should be concerned with whether the economy is sustainable. In some ways, the shift in thinking required is similar to the macroeconomic revolution sparked by Keynes, which placed thinking about unemployment and recessions at the heart of economics. As this chapter has pointed out, one priority area is to consider the macroeconomy in slightly more granular terms, for example, addressing explicitly the development of greener economic activities and sectors.

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CHAPTER 3:
NATURAL CAPITAL

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LEARNING OBJECTIVES

This chapter introduces topics and concepts that are essential to further understanding of the current discussions and decision-making that are related to natural capital. This chapter therefore will enable readers to:

- Articulate the concept of natural capital, why it has emerged, its importance, and how it differs from and relates to other relevant ideas;
- Describe a range of methodologies for valuing natural capital;
- Explain how natural capital is implemented in the public and private sectors; and
- Articulate the importance of the labour market for a green transition and the resulting implications and effects on employment;

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CHAPTER CONTENTS

1. What is natural capital?

Natural capital is the name given to natural stocks or assets that contribute to human well-being via the production of goods and services. Forests, for example, can be considered stocks that produce a flow of goods and services for society, such as fuel wood, building materials, non-timber forest products, carbon sequestration; and also services such as climate regulation, recreation opportunities and control of erosion and floods. This capital, also called natural income, contributes to human well-being through the flow of these goods and services (Costanza & Daly, 1992).

Although they are related, natural capital—a stock—is not to be confused with ecosystem services, which are flows of benefits to society over time (their distinction is discussed further in section 2.4 of this chapter). The simplest examples of natural capital are extractive resources—such as minerals—that are extracted, refined, and sold. Others, such as top soil that provides support for crops, can be renewable if managed correctly. Some forms of natural capital are not immediately obvious. For instance, the proximity of wild pollinators to an agricultural field, where pollination contributes to crop yields. Natural capital, therefore, includes a diverse variety of assets that contribute to human well-being in myriad ways.

The wide scope of natural assets becomes evident by their classification into each of these broad categories (Ekins et al., 2003): air (atmospheric properties and climate processes), water (hydrological properties and processes), land (geological and soil processes), and habitats (flora, fauna and their dynamics). All of these have a critical contribution to human well-being and to the global economy, either directly or indirectly.

Identifying and accounting for natural capital is important for the transition away from current economic systems toward more sustainable ones (Bartelmus, 2009). The degree of depletion and regeneration of natural capital and the link between its condition and its contribution to human well-being are fundamental for appropriate natural capital accounting but also for the successful management of the economy (this is explained further in Chapter 10). Renewable natural capital (e.g. forests) includes immutable resources, that cannot be augmented or depleted (such as solar radiation), and also ecosystems (and their components) that can regenerate and provide a flow of services over time depending upon their condition and health. Natural capital is non-renewable, however, when its rate of generation is negligible at human scales (e.g. minerals).

> **Key concept: Substitution**
> Sometimes, more of one capital can compensate the lack of another capital required (e.g. good human skills can compensate limited financial capacity). This ability to compensate between capitals is called substitutability (also called compensability), a concept that becomes important later in section 2.2.

1.1 Natural and other capitals in the production of goods and services

Early economic theorists, notably David Ricardo (1817), proposed that three factors of production, financial capital (K), labour (L) and land (N), are combined to produce goods and services (output or Y). These goods and services support human well-being via a system of voluntary exchanges —the economy. In this traditional triad land captures the value of natural resources, but only to a certain extent. For example, the value of clean air and water, or of biodiversity, cannot be fully captured by the value of the land where these resources are held. For these early economic theorists, land was considered a fixed or immutable factor of production that could not be degraded, renewed, or exhausted. Accordingly, it was commonly omitted from foundational economic models of production (see Chapter 2). The predominant belief that natural resources were abundant or even unlimited contributed to this omission.

The only way that natural resources appeared in the production function was in terms of the financial, physical or labour costs which were required to extract or make use of resources e.g. the costs of extracting a mineral or of cutting and transporting timber. Therefore, the

> **Key concept: Types of capital**
> Another modern classification, popular among economists studying the environment is that of natural (or ecological/ environmental), human and reproducible (or manufactured) capital (Arrow, Mumford, & Oleson, 2012). These can be viewed as equivalent to the traditional land, labour and capital (Costanza & Daly, 1992). To these, some also add the social (and organisational) capital (Dietz & Neumayer, 2007; Ekins et al., 2003). In essence, all variations of the typology of capitals are similar and overlapping, and each may be more useful in specific purposes. skills can compensate limited financial capacity). This ability to compensate between capitals is called substitutability (also called compensability), a concept that becomes important later in section 2.2.

natural asset per se or its regenerative process did not have a price in economic accounting. For example, the existence of the mineral ore (and its depletion), the forest (and its reduction) or natural processes like decomposition or nitrogen fixation were not accounted for. In other words, the price (and implicitly, the value) of these assets was zero and degrading the asset was not considered a cost for the economy. Consider a logging company and its relationship to a forest over time. The company may expect to pay for saws, trucks, and fuel; but not for soil, water, seed generation and pollination that enable the reproduction and growth of trees. Consequently, trees may be cut at an unsustainable rate, leading to a scarcity of timber, an increase in lumber prices for consumers, and perhaps the failure of the business.

The concept of natural capital (and derived ecosystem services) was developed to account for nature's role in economic systems and avoid this deleterious outcome. Attempts have been made to integrate the value of natural capital into economic models so that resources would be used prudently to assure sustainable economic output for future generations. There are several classifications of capitals, which give more nuance to the definition of natural capital (for example, Chapter 2 tackles natural capital within the framework of five capitals, including social capital), but the classification of the three traditional capitals plus the natural one is sufficient to critically understand the fundamental theory that follows in this chapter.

Defining natural capital in contrast to other forms of capital can be misunderstood as if the human or physical capital are not natural. In order to avoid this implication of other capitals being unnatural, the term 'ecological capital' is proposed as a synonym for natural capital (Ogilvy & Costanza, 2016). However, this term is much less common and so, in this chapter, we will use the most common version – natural capital.

1.2 Why is natural capital important? Why is it overlooked?

Only some of the flows of goods and services derived from natural capital are traded in markets and subsequently associated with a price (e.g. timber). For others, markets are underway to correct market failures such as negative externalities (e.g. carbon trading or payments for ecosystem services) and to manage scarcity (e.g. water "banks"). While there have been some successes, it is not easy to integrate ecosystem services into a market economy.

As a result of not being bought and sold in a market, many of the benefits we derive from nature and the costs of depleting natural capital remain not accounted for in economic estimations. These estimations often guide important decisions, such as whether to open new extraction industries or to build large infrastructure. Consequently, these decisions do not account for important contributions of nature, and likewise ignore a decision's detrimental impact on the stocks and flows associated with nature.

Overcoming this caveat in decision-making has become increasingly important in recent times, as highlighted in Chapter 1. The scale of the economy has expanded rapidly since the industrial revolution and our perception of nature as unlimited has dwindled. For example, clean water is scarcer in many places than it used to be, as is nutrient-rich soil. The Millennium Ecosystem Assessment (2005) highlighted how humans have changed ecosystems extensively and rapidly due to economic development, causing the degradation of ecosystem services globally, the substantial and irreversible loss of biodiversity, and the increased vulnerability and poverty in some regions.

To reverse this trend, the main motivations for conserving nature, traditionally, were scientific, ethical, or health-related. However, when significant trade-offs occur between sustainability and immediate economic development, these motivations appear insufficient and economic development tends to take priority. Ultimately, these motivations do not seem enough for economic agents to appreciate humanity's inherent dependence on ecosystems and natural resources (Turner & Daily, 2008) and the many benefits we obtain from them. As a result, ecosystems continue degrading.

Some natural resources that once were perceived as abundant or unlimited, are now scarce. In economics, when a good or service becomes scarce, unless substitutes are found, the price of that good or service increases as does the value of the assets and inputs used to produce the good or service. This perception of increasing scarcity of natural resources brings about a need to rethink the concepts that underpin economic growth and development:

"Wealth creation [combines] the four types of capital (...) to give rise to flows of goods and services which people want, in such a way that the capital stocks and the non-monetary flows of services from natural capital, are maintained or enhanced in quantity or quality. If the capital stock is not maintained, then eventually the flow of goods and services to which it gives rise will decrease, i.e. any level of flow that is associated with a reduction in the capital stock is unsustainable" (Ekins et al., 2003).

Growing concern about the impact of economic growth, the resulting degradation of natural capital and its potentially devastating impact on the well-being of current and future generations, has led increasing numbers of governments, businesses, and consumers to acknowledge that nature is a vital asset to the economy and human well-being. Thus, the concept of natural capital makes another fundamental motivation for conservation, one that resonates directly with economic reasoning:

"Natural capital produces a significant portion of the real goods and services of the ecological economic system, so failure to adequately account for it leads to major misperceptions about how well the economy is doing" (Costanza & Daly, 1992).

Box 3.1: The economic costs of degraded natural capital

Clear examples of missed economic opportunities due to the degradation of natural capital can be found in past natural catastrophes. For example, one reason why hurricane Katrina had such a devastating effect on coastal urban areas was the earlier degradation of the coastal wetland ecosystem that would have mitigated the floods (Barbier, Georgiou, Enchelmeyer, & Reed, 2013; Day Jr et al., 2007). Coastal wetlands form a buffer that weakens the force of incoming water. With the construction of infrastructure that degraded this ecosystem, such beneficial service also diminished. This resulted in the impact of floods being much greater than it would have been, had a healthy wetland ecosystem remained.

Likewise, Pakistan suffered catastrophic landslides in 2007 triggered by high rainfall, killing dozens of people. While the main cause for these landslides was the destabilisation of slopes due to a deadly earthquake that occurred earlier that year, it was also found that forest cover significantly mitigated the impact of landslides (Kamp, Growley, Khattak, & Owen, 2008; Peduzzi, 2010; Sudmeier-Rieux, Jaboyedoff, Breguet, & Dubois, 2011). In the period prior to these catastrophes, forests in the Kashmir area had been dramatically cut. These forests performed, similarly to the wetlands in Louisiana, a buffering function against sudden flows of water and mud, which would have mitigated the devastating effects of high rainfall.

In both cases, the ecosystems had been destroyed after decisions (to build infrastructure on the wetland and to cut trees) were made that did not take into account the value of the ecosystem services provided by these natural assets. An estimate of the economic value related to disaster mitigation provided by each of these ecosystems could be provided, by comparing the actual damage costs with the lower costs of damages if the wetlands and forests had been there to mitigate the sudden water flows.

This concept helps us recognise the many direct and indirect benefits that nature provides for economic development and that otherwise remain largely ignored in economic decisions (see Box 3.1). It also allows us to understand that, where natural capital stocks are reduced or depleted, we run up a debt that must be repaid through restoration.

The remainder of this chapter discusses the concept of natural capital theory and practice in more depth. It narrates how the concept emerged and how it relates to other similar concepts, such as sustainable development or the green economy. It explains the methods used to quantify the value of natural capital so that it can be incorporated into decision-making and also why this task is challenging and not without criticism. Finally, it gives an overview of how the concept has been implemented in practice, both in national accounts and in the private sector. The conclusion section synthesises key messages.

2. Emergence and context of natural capital as a concept

Understanding the origin of the idea of natural capital and its relation to (and distinction from) other concepts around the green economy may help the reader use and discuss this idea with precision and avoid common misunderstandings.

2.1 Brief history

The concept of natural capital may be attributed to Schumacher, an economist famous for his 1973 book named "Small is beautiful", (Gómez-Baggethun et al., 2010), but it was brought to the forefront of academic

Figure1: Evolution of the use of 'natural capital' in publications in English (Source: Google Ngram viewer, 28 June 2018)

debate in the 1990s by papers such as "Economics, equity and sustainable development" by Pearce (1988) and "Natural capital and sustainable development" by Costanza & Daly (1992). Indeed, the term 'natural capital' has been discussed as early as the 18th century by several authors, albeit with a slightly different meaning (Missemer, 2018). In its initial conceptualisations, natural capital was mainly associated with land because land was considered the principal natural asset. The phrase was then used to distinguish financial or manufactured capital from naturally occurring resources and productive inputs. This distinction was needed because at the time, many economists used the term 'capital' to refer only to wealth that had been produced by industry. However, this early usage of natural capital had no explicit regard for environmental degradation.

The idea re-emerged in the 1980s and 1990s (Figure 1) as part of a broader trend of increasing awareness about environmental and sustainability issues. Scholars became concerned about nature not being incorporated in economic models of production. Natural assets were either taken for granted and accordingly treated as inexhaustible, or it was assumed that improved technologies could substitute for natural capital loss or degradation.

2.2 Strong vs weak sustainability and natural capital theory

Much of the debate about integrating natural capital into economic models considers whether the goods and services derived from natural capital can be substituted with human-made ones, such as replacing nutrient rich soil with chemical fertilizer, or a wetland with a water treatment facility. This discussion is central to this debate because, if full substitutability is assumed, one could argue that natural capital depletion would be acceptable insofar as other types of capital perform similar functions (Stiglitz, 1974).

The degree to which we believe that natural capital can be substituted by other forms of capital leads to two views about sustainability: weak and strong sustainability (see a deeper discussion in Barbier, 2011). From a weak sustainability perspective, natural capital can be largely compensated by other forms of capital, and so diminishing natural capital today would be justifiable, as long as it serves to generate other forms of capital that provide the same flows in the future. Succinctly, weak sustainability means "maintaining intact (...) the sum of human-made and total natural capital" (Costanza & Daly, 1992). This view emerged among neoclassical economists in order to solve a practical problem that was observed in the 1970s: non-renewable resources were used for production, but they were exhaustible by definition. Therefore, it was necessary to determine the optimal rate of extraction and of investment in other forms of capital to ensure a balance of current and future income (Dietz & Neumayer, 2007).

A practical implication of assuming that all forms of natural capital are substitutable is that we can express their relative value in the monetary units (Ekins et al., 2003). This price information can then be readily fed into decision-making processes regarding the use, depletion, or restoration of natural resources. However, the complexity of ecosystem dynamics, including ecological tipping points and non-linear relationships, make it very difficult to determine sustainable levels of substitution (Ekins et al., 2003). In addition, manufactured

Key concept: The limits to technological innovation

Daly (1996) theorized: "technology will have diminishing returns and we will eventually reach a thermodynamic constraint, imposed by the physical limits of resources on Earth, including solar radiation".

capital is built from natural capital, either from natural resources directly or by using it as a sink for waste. Therefore, manufactured and natural capital could be considered complements in the long run, rather than substitutes (England, 2000).

In contrast, under a strong sustainability view, the degree of substitutability between forms of capital is low and some forms of natural capital are considered irreplaceable. For example, biodiversity carries genetic information, which can provide new knowledge for medicinal purposes in the future. If that biodiversity is lost, the information therein is lost too and, arguably, this loss cannot be replaced with other forms of capital. This view discards the assumption that one can deplete natural capital as long as it is replaced with other forms of capital.

Some flows provided by natural capital are less substitutable than others, particularly supporting ecosystem services (Barbier et al., 1994, in Dietz & Neumayer, 2007). The most essential forms of natural capital - ones which cannot be substituted with other capitals - are called 'critical natural capital' (Ekins et al., 2003). These are arguably the ones on which practitioners need to focus most.

The **precautionary principle** is an additional argument in favour of strong sustainability. As our knowledge of the contribution of nature to human well-being remains incomplete (e.g. knowledge about biogeochemical cycles, complex ecological dynamics, or effects on psychological well-being), it is wise to proceed conservatively in the use and degradation of natural capital.

Key term: Precautionary principle
An excellent reference work with historical lessons about the precautionary principle is given in two works by the European Environment Agency (EEA. 2013). Late lessons from early warnings: science, precaution, innovation. Copenhagen: European Environment Agency. http://doi.org/10.2800/73322)

2.3 Applying the natural capital concept

Currently, the idea of natural capital is a fundamental component of efforts to incorporate concern for environmental degradation into mainstream economic decision-making. Referring to nature as an asset resonates with other economic concepts and makes the role of nature and natural processes explicit in productive human activities, a role that had been largely omitted in economics thus far. The natural capital concept can also link nature to economic measures of welfare and human well-being.

Conceiving nature as capital opens the door to estimating the value and rates of return of conservation and depreciation of natural assets, including (but not limited to) their associated monetary values. For example, a much-cited study by Costanza and colleagues (1997) provided a minimum estimate of the value of the world's ecosystems, which was remarkably higher than the global GDP at the time. Although the ability to accurately estimate the value of all natural capital is highly contested, this figure nonetheless highlighted how ecosystems are much more important to humans than conventionally thought by economists (Costanza et al., 2017) and by those whom they advised. This endeavour would be later expanded by the Millennium Ecosystem Assessment (2005).

Natural capital and the ecosystem services derived from natural capital may continue to be depleted and consequently their value to the economy may increase as they become more scarce. While determining the economic value of all natural capital is, for many, an impossible task (see section 4.2), the relationship of increased importance because of increased scarcity still stands (Costanza et al., 1997) (See Box 3.2, overleaf).

However, the development of natural capital as a concept has not received universal support. While the concept was popularised in the 1990s, it also received reasonable criticism (see, e.g. Gomez-Baggethun & Perez, 2011; O'Connor & Martinez-Alier, 1998). A major concern is that characterizing the importance of nature for human well-being in this functional, econo-centric way could lead some to think that nature's value is limited to its contribution to the economy. In other words, to confuse the part for the whole. This risk of misconception is critical because it can lead us to ignore other values or reasons why nature is important (see more about different sources of value in section 3.2). As a consequence, we could still fall in the trap of undervaluing nature and degrading it to our own detriment. Much like GDP was created as an indicator of economic growth and, as explained in Chapter 2 and other chapters in this book, from its specific initial intention GDP became misused as an indicator of the broader, more complex concepts of progress and well-being. Some scholars perceive the same risk with natural capital: a useful concept for the purpose it was created for, but potentially harmful if used beyond this purpose.

This concern is particularly justified when a partial monetary valuation is wrongly interpreted or represented as if it were the full value of an ecosystem, instead of a minimum estimate. For example, if the monetary value of timber or biodiversity habitat of a forest is estimated in order to highlight its economic importance, one could conceive that, if the forest disappeared, the loss could be fully compensated by that monetary sum, which is implausible. We see later that this forest may have value for future generations, for recreation and spirituality, or for services which ecological dynamics are poorly understood. All these values may not be reflected in a monetary estimation and therefore such partial estimation should be considered a fragment of the forest's total value. It is important to understand the difference between the price being paid and the total economic value (explained in section 3.2) for the natural capital concept to contribute to sustainability.

Box 3.2: Including natural capital in the aggregate production function

Environmental concerns emerging in the second half of the 20th century led economists to reconsider the fundamental model (explained above), where natural capital was assumed to be infinite and therefore its contribution to output omitted. In response to Malthusian concerns about increasing population, many economists (notably, Stiglitz, 1974) proposed that technology could resolve resource scarcity and pollution, while staying within this economic growth model. However, this also assumed a high degree of substitutability between manufactured and natural capital.

Acknowledging that manufactured and natural capital cannot fully substitute each other makes a general model of economic output more complicated. To overcome this, England (2000) proposed that natural and other capitals should be assumed to be complements, rather than substitutes. The author suggests that, over the long-run and despite technological advances, financial and physical capital demand ever greater amounts of natural capital, either as inputs to production or as sinks for waste disposal. In this model, natural capital is required in increasing amounts together with financial or physical capital, in order to increase output or for economic growth. This can be formalised as follows:

(Eq. 1) $$Y = min\ (A_n K_n, A_m K_m)$$

Where economic output (Y) is a function of natural (K_n) and manufactured capital (K_m), which efficiency of use is mediated by technology (A). For simplicity, labour is excluded from this model because its role remains the same. Technology continues to be important for production, but does not permit unconstrained substitution as in the previous model. Natural and manufactured capital are used together in the minimum amounts necessary (i.e. most efficiently) to keep output at level Y.

Under these models, savings and re-investment within the economy must be equal to the degradation or **depreciation of natural and other capitals**, otherwise the economy contracts and society suffers. Further, as natural capital degrades, it becomes scarcer relative to other capitals, therefore **investment in natural capital** (e.g. conservation and restoration) should increase relative to investment in other capitals. However, the shift of investment from manufactured to natural capital has been limited. This is because, among other reasons and as mentioned above, natural capital is often free for people and businesses, even when it is scarce.

An added complication to these general economic models is that natural capital includes diverse and complex systems. Each example of natural capital —e.g. forests, coral reefs or biodiversity— exhibits particular dynamics whereby they respond differently to degradation and restoration. Much research aims to identify the unique properties and dependencies between natural capital and human well-being (Boyd & Banzhaf, 2007; Ekins, 2003; Fisher et al., 2008).

Key term: Depreciation of natural capital
Depreciation of natural capital was formalized by Pearce and Atkinson (1993) and developed into an empirical model of wealth accumulation by Barbier (2017).

Key term: Investing in natural capital
A clear example of the consequences of depleting natural capital while not investing in alternatives is given by the recent history of Nauru. This Pacific island mined and exported a globally-significant amount of phosphate (necessary to make modern agricultural fertilisers), and enjoyed a brief period of wealth. But the income derived from exported natural capital was not adequately invested and the economy nearly collapsed by the turn of the century (see Gowdy & McDaniel, 1999).

2.4 The relation of natural capital with other concepts

Here we situate natural capital with respect to closely related terms, such as ecosystem services or sustainability, and also within the context of the green economy, which is important in order to avoid common misinterpretations.

Natural capital and ecosystem services (also called environmental services) are closely related and often discussed together, yet they are distinct. Both terms became popular in recent years with the common broad goal of highlighting the contribution of nature to human activity. Natural capital refers to stocks, while ecosystem services are the flow of benefits derived from one type of natural capital —ecosystems. **Ecosystem services** are goods and services useful to humans that derive from ecosystems, via ecosystem processes. For example, a forest is natural capital, and timber or carbon sequestration are ecosystem services. The distinction between ecosystem services and natural capital differs slightly according to the source (see Box 3.3 overleaf).

It is important to clearly understand the difference between natural capital and ecosystem services

Box 3.2: Ecosystem services and nature's contribution to people

Ecosystem services are a specific derivation from natural capital where the natural capital is biotic (derived from ecosystems) rather than abiotic (lifeless subsoil assets and physical flows). Natural capital is sometimes used as a synonym of ecosystems, but natural capital includes assets other than ecosystems, such as mineral stocks. Ecosystems perform certain functions and processes (biophysical phenomena), some of which do not necessarily affect humans. When these functions and processes provide a benefit to humans, these become ecosystem services. When these function and processes have a negative impact on humans (e.g. floods or landslides), they bring about an ecosystem disservice.

Ecosystem services are therefore the ecological functions that contribute to human well-being (Millenium Ecosystem Assessment, 2005). These services are grouped into four broad categories (see a more detailed explanation in Costanza et al., 2017): provisioning (providing material such as food and fuel), regulating (maintaining important variables within a useful range, such as clean water or a stable climate), supporting (e.g. soil substrate) and cultural (or amenity) services (contributions to recreation, spirituality or mental well-being, which are less tangible). Ecosystem services can also be classified into resources, sinks, and processes (Pearce & Turner, 1990).

Ecosystem services have perhaps gained more traction than natural capital and developed into a full interdisciplinary field of inquiry. Both terms have been criticised for a variety of reasons. Natural capital is criticised because it resonates with capitalist and market-oriented perspectives, and therefore brings to the forefront the risks associated to commodifying entities for which no market existed before. These risks are related to incorrect pricing, or to the crowding out of intrinsic motivations to safeguard the natural resource or ecosystem (see section 4.2.c). Ecosystem services have been criticised (although less strongly and only recently) because the term appears to imply a hierarchy, whereby nature provides the services and therefore is subservient of humans.

As an advance to overcome these criticisms, the phrase 'nature's contributions to people' has emerged particularly around the developments of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). For its proponents, this term better comprehends the many reasons why nature matters, than does the phrase 'ecosystem services'. The usefulness and impact of this new concept is still to be seen. Some early critiques of this latter phrase argue that it might be ambiguous, which complicates its legal interpretation.

because this commonly triggers confusion. As an illustration, the presence of bees (pollinators) is the natural capital, the activity of bees travelling from plant to plant is the ecosystem function or process, whereas the pollination that results from this process is the ecosystem service. It is pollination that provides the direct benefit for humans, not the existence of the pollinators. In another example, a healthy marine ecosystem is the natural capital, whereas reproduction and growth of fish is the ecosystem function and the fish we harvest is the ecosystem good.

Key concept: Ecosystem services

Not all benefits from natural stocks are ecosystem services (e.g. mine ores aren't derived from living ecosystems). They may be simply raw minerals for human use, but they don't come from living ecosystems, they come from other sorts of natural capital. The idea of an ecosystem is a concept that tends to be much clearer to ecologists than to economists, hence many environmental economics texts use the terms imprecisely.

The incorporation of natural capital in economic accounts and in management decisions is a useful step towards a green economy. However, natural capital is one component, among several, of the green economy. The green economy encompasses a broader suite of theoretical concepts and practical aspects, as seen throughout this book.

While the general idea of sustainability is commonly agreed, this term is also infamously ambiguous and open to interpretation. Depending on the interpretation, conserving natural capital is not sufficient to secure sustainability. However, many also argue that conceiving nature as a form of capital is instrumental to ensure that economic production systems contribute to achieving sustainable societies. In this latter view, sustainability is understood as the characteristic of a system whereby it maximises well-being and ecosystem health over a long time period. Maintaining natural capital over time is a necessary but not sufficient condition for this goal.

Sustainable development emphasizes intergenerational equity, implying that we should ensure that future generations enjoy the same welfare level as current generations, for example, by securing enough capital stocks for them to obtain this well-being. This leads to some important but unresolved questions: What will be the needs of the future generation? Should we preserve all capitals in their present stock, or can we prioritise some for using them in the present, assuming that future generations will be able to satisfy their well-being in different ways? If so, what types of capital should be preserved in favour of current and future generations? If natural capital is so fundamental, should we consume or expend it at all?

Costanza and Daly (1992) provided some principles to guide these questions that remain useful in present times. Here the distinction between renewable natural capital (e.g. forests) and non-renewable (i.e. at human time scales, e.g. minerals) becomes important. They argue that we should exploit renewable resources at a rate similar to which they are renewed, and that their stocks should never be depleted, so that they can continue regenerating. Non-renewable resources can be exploited, according to the authors, at a rate similar to the rate of creation of renewable substitutes. For example, for an economy to be sustainable, the use of oil and gas could be justified as long as the gains from their use are invested in developing renewable energy alternatives (this simplified example excludes other environmental damages from oil extraction and use, such as biodiversity loss or carbon emissions).

This definition of sustainable development as intergenerational equity has been echoed countless times. A definition of the same phrase that is much less known, but particularly useful to our chapter, is that of Pearce (1988). This scholar defined sustainable development as "the constancy of the natural capital stock". Pearce went further and argued that sustainable development encompasses both intergenerational and generational equity, economic resilience and uncertainty about how natural systems contribute to social ones. This set of principles is still at the core of contemporary interpretations of sustainable development. At the same time, it makes the concept very broad and, for many, ambiguous. Therefore, the specific implications of sustainability are open to interpretation —although some argue that this definitional ambiguity is a reason why the concept is widely accepted (Dietz & Neumayer, 2007).

3. The value of natural capital

3.1 Important for poverty alleviation and progress

Natural capital supports rural livelihoods worldwide, either directly or indirectly, and provides fundamental inputs to the economies of all countries' (timber, minerals, fisheries, soil, water resources). However, the ways by which natural capital contributes to human well-being vary.

In low and lower middle-income countries, the primary sectors (based on natural resources) provide a majority of income and employment opportunities, and so natural capital is directly related to economic benefits. In the absence of industry, service and finance sectors, most people are directly dependent upon natural capital, for example, farming or fisheries. However, gross domestic product (GDP), a commonly used national barometer of economic strength does not include changes in natural capital, and therefore does not reflect the extent or health of ecosystems and natural resources in a country (as discussed above, and in more detail below in section 5.1 on national accounts). A resource-rich country may appear very poor in GDP terms, despite having extensive, healthy natural resources.

Low-income and rural households are often particularly dependent upon natural capital and sensitive to its changes. The abundance and diversity of local natural stocks reduces vulnerability among low-income households and increases their resilience to a variety of shocks, such as a drop in the price of a crop or an extreme weather event. This is because households with low monetary income can obtain goods and services from their surrounding natural capital, such as food, building materials, or medicinal plants. For example, forests provide timber and non-timber forest products (NTFPs) and contribute to the provisioning of water. A comparative analysis of nearly 8,000 households in 24 developing countries (Angelsen, Jagger, Babigumira, Belcher, & Wunder, 2014) found that households obtained 28 per cent of their income from extracting non-cultivated goods from their environment, such as firewood or medicinal plants. Of this, 77 per cent came from forests, and these shares were higher for lower-income households (see a more in-depth discussion in Chapter 7). On the other side of the spectrum, many rural households in higher-income countries increasingly rely upon tourism, which also depends on healthy natural surroundings.

Accordingly, reductions in natural capital can increase household vulnerability, particularly low-income rural households. For example, diminishing flows of food and materials can make such households more dependent on markets to satisfy basic needs, especially food security. Ecosystem degradation and subsequent increasing reliance on markets makes households dependent upon income to pay for those goods. Environmental degradation may generate a vicious cycle of food, water or energy shortages, leading to poverty traps.

However, the relationship between natural capital and poverty is not linear. Does investment in natural capital alleviate poverty? Does poverty alleviation lead to natural capital investments? While investing in natural capital may prevent households from falling into a poverty trap, it may not necessarily reduce poverty (Barrett, Travis, & Dasgupta, 2011). Dependence upon natural resources is linked to persistent poverty, a phenomenon called “the resource curse” (Sachs & Warner, 2001). On the other hand, advocacy for environmental conservation often comes from poor communities who are heavily reliant upon natural capital (Martinez-Alier, 2014).

From a globally-integrated perspective, natural capital fundamentally supports well-being and production in industrialised countries through virtual flows (flows of ecosystem services embedded in goods, e.g. the irrigation water needed to grow vegetables for export). Even for countries where the economy is strongly based on services or technology, the natural flows embodied in internationally traded goods are critical. For example, food imports rely on healthy water sources in the countries from where they are imported. Cheap food imports are the result of healthy soil and abundant water and abundant land and labour in the food-producing country. As an illustration, soya produced in Brazil feeds cattle consumed in the US and China. In order to produce soya, Brazil needs to have arable land and suitable soil to support plant growth (fodder).

Manufacturing sectors are also dependent upon natural capital inputs, such as cobalt and lithium, used in batteries for mobile phones. Much of the world’s cobalt for electronic devices comes from the Democratic Republic of Congo, one of the world’s poorest countries. Producing such components depends on the necessary mineral resources available (unless these are sourced from recycling, which supplies a small proportion of total material needs), for instance, rare earth minerals for the production of communication devices. These benefits of natural capital through international connections are particularly complex to trace, and rarely incorporated into national accounts on a country by county basis.

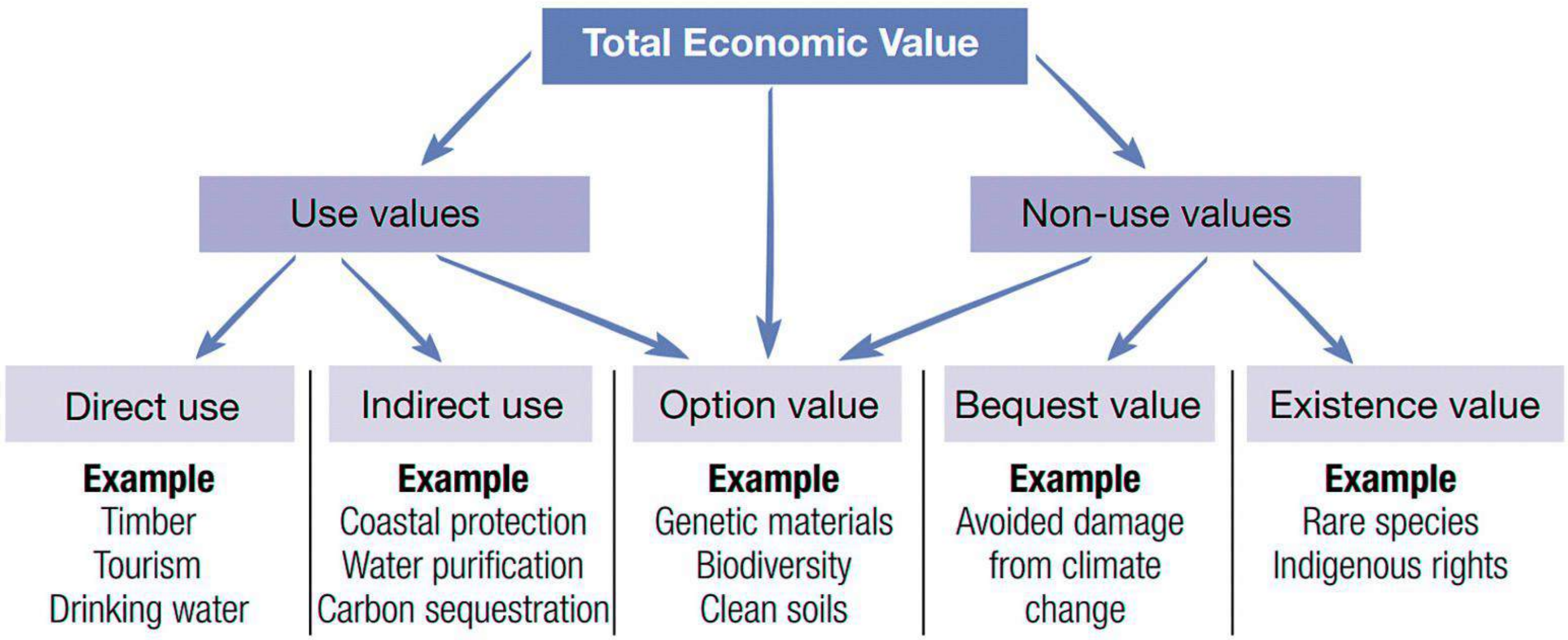

Figure 2: Total economic value (Source: DEFRA)

3.2 Different sources of value of nature

As explained in preceding sections, marketed ecosystem services are a fraction of nature’s essential contributions to human well-being. Measuring the value of nature’s contribution to human well-being can be a very complex task (valuation is dealt with in section 4.1), because nature may be valuable for diverse reasons and to diverse beneficiaries.

Disentangling the variety of reasons why humans may value nature helps understand the complexity of valuation. A useful framework to map sources of value is the **Total Economic Value** (TEV) framework (Figure 2) (originating in the work of Pearce (1992). While typically associated to ecosystems and ecosystem services (see Box 3.3), this framework can be applied to natural capital more generally.

This framework helps us define how natural capital can be valuable for humans and for the economy, and provides a useful starting point to distinguish valuation methods (a topic discussed in section 4.1). According to this framework, nature’s importance to humans may be derived from two broad aspects: use and non-use values. Some versions of this model add a third category of intrinsic values.

Key concept: Total economic value

A more complex version of this framework can be found in TEEB (2010) chapter 5. The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB http://www.teebweb.org/publication/mainstreaming-the-economics-of-nature-a-synthesis-of-the-approach-conclusions-and-recommendations-of-teeb/

Each of the categories of use and non-use values subdivides further. Some versions of this model add a third category of intrinsic, non-human values.

The most intuitive subcategory is direct-use value, whereby the value of a natural asset is signalled by a price in existing markets, for instance, timber. Use values are those accrued to us using a natural asset or service, either now or in the future (option value). Indirect-use values are associated, for example, to urban parks where we may spend our leisure time, but for which we do not pay, or to regulating services such as carbon sequestration or soil formation. Option values relate to having the opportunity to use something in the future. For example, a natural park that we may wish to visit someday, or an ecosystem for which we are not currently receiving goods or services, but we believe may offer future benefits.

Bequest value derives from the belief that someone else might use the natural asset or flow in the future. This source of value is conceptually at the threshold with use values (and some other representations of this framework place it within use values). This is because bequest values do not refer to one's own use, but rather to that of another person. (As a consequence, when aggregating the values of several individuals, bequest and existence values can lead to double accounting.)

Further, people may value a natural entity simply because they know it exists (existence value). For example, people can value polar bears in the Arctic for their mere existence or symbolic meaning, despite the fact that few believe that they will ever see polar bears in their native habitat. Finally, one might believe a natural asset has value for its own sake (non-human or intrinsic values described in Section 4.2; not shown in Figure 2). Intrinsic values cannot be valued in monetary terms, but rather are ethical and moral considerations for the protection of nature which go beyond the scope of the natural capital concept and this chapter.

The TEV framework maps the values or benefits we associate to nature. The next section describes the economic methods that quantify and put in monetary terms these different types of benefits to humans.

Table 1: Range of uses of valuation of ecosystems (source: Costanza et al., 2017)

Use of valuation	Appropriate values	Appropriate spatial scales	Precision needed
Raising awareness and interest	Total values, macro-aggregates	Regional to global	Low
National income and well-being analyses	Total values by sector, and macro-aggregates	Medium	Medium
Specific policy analysis	Changes by policy	Medium to high	Medium to high
Urban and regional land-use planning	Changes by land-use scenario	Regional	Low to medium
Payment for ecosystem services	Changes by actions, due to payment	Multiple, depending on policy	Medium to high
Full cost accounting	Total values by business, product, or activity and changes by business, product and activity	Regional to global, given the scale of international corporations	Medium to high
Common asset trusts	Totals to assess capital and changes to assess income and loss	Regional to global	Medium

4. Valuing natural capital in practice

Quantifying the multi-dimensional values of natural capital (and ecosystem services) and transforming those values into monetary terms can facilitate a more comprehensive evaluation of costs and benefits of natural resource use. For this reason, there has been significant impetus in developing methods to quantify the monetary value of non-marketed natural assets and services, but not without controversy.

The controversy stems, among other reasons, from the fact that there are large data uncertainties and methodological challenges associated with estimating such values. Quantifying natural capital beyond use values is challenging, as explained below in sections 4.1 and 4.2. Therefore valuation can exclude the portion of value that corresponds to non-use value, and estimations of the value of natural capital tend to underestimate the total economic value (this caveat has led to some of the main criticisms of the concept, as explained above in sections 2.3 and 3.2).

In the absence of economic valuation, however, businesses and policy makers often implicitly assign zero value to non-market benefits. While monetary estimates of natural capital may not reflect its full value, the process of valuation and integration of natural processes and economic processes is useful to increase our perception of the costs of degrading nature, and to give it higher policy priority. An example of this communicative and agenda-setting role was the Stern review (Stern, 2007), which brought climate change to the forefront of public and policy attention by estimating the economic costs that climate change would bring to a national economy. Table 1 summarises the distinct reasons why valuation can be useful, in terms of uses that depend on context and policy needs.

4.1 Economic valuation methods

A wide variety of economic methods can be used to estimate the economic value of nature, including values not represented through market prices. As most of nature's contributions to humans have no real market, a range of indirect or non-market valuation techniques have been developed during the last decades. For example, expenditures on homes can be used to estimate the value of adjacent natural space, and travel costs to estimate the value of protected areas. Non-market **valuation methods** are commonly used to estimate values for **cost-benefits analysis** (CBA). Other uses of these methods are to explore or project human behaviour and to assess damages in court cases. Valuation is also used to compare or monitor changes in stocks of natural capital, evaluate trends and steer policies.

Key term: Valuation methods
A long-standing introductory resource for such valuation methods is available at https://www.ecosystemvaluation.org/ by King and Mazzotta.

Key term: Cost benefit analysis
Cost Benefit Analysis is a popular approach to make decisions about prospective policies or projects. In a CBA, the costs and the benefits of an intended policy or project are listed and quantified, and they require that all costs and benefits are expressed in monetary terms.

Non-market and indirect methods are grouped into two broad categories: revealed and stated preferences (see Box 3.3). The choice of a specific method depends on the type of natural capital or ecosystem service to be evaluated, its context and data availability. Revealed preferences methods estimate the value of a natural entity indirectly, through the prices of related items observed in real markets. For example, researchers use the travel cost method to estimate how much people value a place they visit (e.g. a national park), by calculating the costs of travelling from their homes to the place.

Key concepts: Valuation tools
Some examples of valuation web-sites are:
https://www.evri.ca/Global/Splash.aspx
http://www.environment.nsw.gov.au/envalueapp/
http://www2.lincoln.ac.nz/nonmarketvaluation/
http://www.gevad.minetech.metal.ntua.gr/home.php
http://www.beijer.kva.se/valuebase.htm

Box 3.3: Economic valuation methods

A) Market valuation methods (observed in markets):

- Replacement/ substitute costs
- Opportunity costs
- Damage cost avoided

B) Non-market and indirect market valuation methods:

- Revealed preferences (use value)
- Travel cost (typically for recreation values)
- Hedonic pricing (typically for property prices)
- Stated preferences (use and non-use value)
- Contingent valuation
- Choice modelling

C) Benefit transfer (extrapolating values estimated for another similar entity)

Researchers use hedonic pricing to analyse the influence of natural environments on property prices, for example, by looking at properties next to urban parks, and comparing their prices to those of similar properties but which are located far from green spaces.

Stated preference methods ask individuals what they would choose or how they would behave in a hypothetical situation. In these methods, since values, expenditures or transactions are not directly observed, we rely on what people report they would do in a situation. These are usually conducted with surveys. The simplest version of such methods is contingent valuation where researchers ask how much money someone is willing to pay (or to accept) for conserving (or degrading) a natural entity. For example, how much a person would donate to conserve a bird species, or how much they would be willing to accept if the forest nearby was destroyed. These studies yield estimates of the willingness-to-pay, the willingness-to-accept or willingness-to-trade (usually in terms of time) for something. Existence values can be estimated by asking individuals to rank their willingness-to-pay or trade for the existence of nature among a collection of other goods and services for which they are accustomed to paying (Pascual et al., 2010). This is most challenging for communities that use little money, where they can only be asked what they would be willing to trade to protect nature.

More sophisticated forms of contingent valuation surveys aim to make the contingent question(s) as realistic as possible and to minimise potential biases (see more on biases below). For example, inferred valuation asks individuals about the willingness-to-pay of other people —rather than of themselves— as a way to minimise individual biases such as social desirability and hypothetical bias (Lusk & Norwood, 2009).

Choice modelling (also called conjoined analysis) is a set of methods where respondents are shown options with different characteristics, and they are asked to choose one or to rank them. This is particularly useful when we want to know, from a given good with a series of features, how much people value each of the features. For example, we may use several criteria when choosing food, such as strawberries, e.g. organic (or not), seasonality, travelled miles (local) and price. Respondents are presented with several options that vary in these attributes: strawberries that are local but not organic, strawberries that are seasonal but come from the other hemisphere, characteristics about their size, colour, and cost, etc. None of the options presented should appear best in all characteristics, i.e. there is no obvious best choice because each option presents trade-offs. Respondents are asked to choose or rank their preferred options, implicitly revealing their preferences for certain attributes. With the appropriate study design and analysis, such a choice modelling exercise can tell us how much money people would pay for having, e.g. organic versus non-organic strawberries, and how much more importance they give to the features of local versus seasonal.

These methods can be used to quantify the value of both natural capital and ecosystem services. Often, data about benefits to humans represents the benefit flow (ecosystem services and goods) in a time period (such as one year). This data is used to calculate the net present value (NPV) of the natural capital that supports the provision of an ecosystem service over time. The NPV is the sum of present and future benefits, where the latter are discounted, assuming that future benefits have less worth now (see text box on discounting, in Chapter 2). Accordingly, valuation methods apply almost indistinctly to both natural capital and ecosystem services. However, when benefits derived from ecosystem services are used to estimate the value of natural capital, this estimate represents current demand under certain access and benefit-sharing rules. This estimate may be different from one under different conditions. Also, one natural capital stock may offer many present as well as potential or future ecosystem services. Accordingly, it is fundamental to take an open and pluralistic approach (Costanza et al., 2017).

Beyond the methods explained above, spatially-explicit modelling of natural capital and ecosystem services has advanced remarkably in recent years, contributing importantly to valuation efforts. Some significant tools for such spatial modelling are InVest, Aries, or platforms developed for specific countries (such as Bateman et al., 2013 for the UK; or Strand et al., 2018 for Brazilian Amazon).

4.2 Challenges and criticisms of valuing natural capital

Although the importance of nature for human well-being is widely acknowledged, operationalising its importance raises much controversy. This is particularly the case when attempting to associate monetary figures with natural capital and ecosystem services, so it is useful to understand the main methodological challenges and conceptual criticisms of valuation methods found in the academic literature. Most notably, data and knowledge about ecological processes are often insufficient to estimate an exact economic value. The methods rely on strong assumptions too, e.g. that individuals do have a preference for the goods or services under consideration and that they can assign a discrete value to them. Also, valuation may be criticised on ethical grounds because of unintended behavioural consequences of associating economic values with nature. We discuss each of these three challenges in separate subsections below.

Four further caveats deserve mention in this overview. First, the external validity of stated values is often unknown. This means, for example, that it is not possible to confirm whether the stated values for hypothetical scenarios are truly how all individuals would make trade-offs or spend their money. Second, there are unresolved conceptual issues, related to discounting future benefits (discussed in earlier chapters) and to the aggregation of separate components of value. Questions of aggregation consist on whether the different values that each person associates to a natural entity add up, overlap, or multiply to compose its total value.

Third, nature often provides benefits with characteristics of a public good. This means that access to these benefits cannot be restricted (i.e. anyone can obtain this benefit, such as clean air). The costs of conserving or providing these benefits, however, are often borne by one agent, for example, by a forest landowner or by a factory that must filter smokestack emissions. In these instances, the sum of public benefits of environmental stewardship may be much greater than the costs of neglect, but when the benefits accrue to many and the costs are born by few, valuation is not sufficient to make decisions or set regulations.

Fourth, biases introduced alongside data design and collection in surveys are an important concern, particularly for the case of stated preference methods. Biases distort responses in ways that are not random, and so are difficult to detect and handle statistically. They give us a false impression of what reality is. The literature identifies dozens of potential biases (see, e.g., Mitchell & Carson, 1989).

Now we discuss in more detail the first three challenges identified at the beginning of this section.

i) Information

A set of fundamental and largely unresolved challenges are due to imperfect information. Scientific knowledge about ecosystems and their contribution to humans is considerable, but it is also far from complete (Banzahf & Boyd, 2005). Ecosystem processes are rarely linear or made of few components (Kremen, 2005). Rather, multiple factors interact in ways that are often complex, such as with cumulative or interactive effects. For example, a lake ecosystem may at first not react to increasing concentration of pollutants, but once a threshold concentration is achieved, it may degrade rapidly.

This complexity brings methodological challenges for natural capital valuation. It also implies that quantifying the contribution of natural capital to human well-being (and the magnitude of its degradation) will inevitably present uncertainty and likely fall short of its true value. The size of the error margin largely depends on the paucity of data about the particular stock or flow analysed. For example, the value of a river for a hydroelectric dam can be estimated quite clearly in terms of its contribution to electricity production; engineers know how much water is needed to produce a given unit of output. The value of a tree in the street for the local inhabitants can be more complex, it includes the value of the shade it provides, air purification, home for birds that people enjoy listening to, and the market value of its timber should it be cut down.

These information challenges can be disaggregated into more specific issues (Barbier, 2013). First, where a service is derived from a complex landscape (e.g. including forest and rivers, etc.), it is difficult to associate the service to a single natural capital. For example, are hydrological services derived from the forest that captures rainfall, or from the river that transports them? Second, it is difficult to delineate all the benefits accrued from a natural asset, because there may be many benefits, for a multitude of individuals and during differing periods, making it a challenge to account for all of them. For example, a forest can have economic value in the timber it produces, in the air it cleans, or in the water it helps purify.

Third, there is risk of double counting, because natural capital can contribute both directly and indirectly to humans. One capital may contribute indirectly whilst another contributes directly to the same flow that humans use. If one counts both the indirect and the direct contribution for each capital respectively, the benefit may be accounted for twice (Barbier, 2013). Continuing with the previous example, to estimate the total value of the forest, one would add the value of the hydrological services derived from it. To estimate the value of the river, one could add the value of the same hydrological services, to which the river contributes more directly than the forest. In such a situation, one may be accounting for the value of hydrological services twice. This issue of double-counting becomes important in the aggregation of values of natural capital, for example, when attempting to include it in national accounts.

Finally, even when we can measure asset quantities and changes in physical units, translating from physical units to monetary units may introduce additional uncertainty and therefore diminish precision in the quantification. For example, we can quantify with some precision, how many tonnes of CO_2 a forest captures. However, in converting tonnes of CO_2, a relatively well-known value, into USD, we may introduce a degree of imprecision. This is because our knowledge about the factor to transform CO_2 into USD may have an error margin. When transforming the units, this error propagates and amplifies. As a result, we go from a relatively well-known value (although with its own ecological uncertainties), to a value with a wider uncertainty range, which is likely to be less informative to make decisions.

ii) Substitutability and comparability

The above are knowledge-related challenges that could arguably be addressed through further inquiry. However, another set of fundamental challenges in valuation refers to assumptions about the qualities of nature as a capital, specifically, whether (and if so, to what extent) the flows derived from nature could also be derived from other forms of capital.

We mentioned earlier that one type of capital can be substituted by another in some cases. This idea becomes important because, taken to a theoretical extreme, one could argue that natural capital depletion would not matter, as long as other types of capital are large enough to replace it. For example, in the absence of a forest that keeps air clean, humans could obtain the same service of air purification by means of physical capital such as machinery that performs this function (technology is a versatile way of substituting capitals).

The question of substitutability sparks an important criticism in valuation. Essentially, measuring things in the same units (money) inherently implies that they can be substituted. For example, if the value estimated for a small forest were US$10,000, and that of a wetland were US$80,000, one could think theoretically that we can replace the wetland (and the flows thereof) with eight of these forests. This is unrealistic: the wetland purifies water, whereas the forest purifies air (among many other services), and so the air purified by eight forests cannot replace water provided by one wetland, and vice-versa.

While values for natural capital cannot be compared, the value of the same ecosystem services often can. For example, the value of a tonne of carbon sequestered by a forest is the same as if it were sequestered by a peat bog. Each of these ecosystems (the forest and the peat bog) may have a distinct total value as natural capital, because they provide further ecosystem services.
In addition to substitutability (or replaceability), two other concepts are important to understand this criticism more thoroughly: commensurability and comparability. Commensurability refers to whether two capitals can be measured in the same units, or in units that are directly comparable. Comparability refers to whether two capitals, despite not being measurable in the same units, can still be compared quantitatively. Conversely, incommensurability is the lack of common units of measurement for two distinct capitals. If two assets are incommensurable, they are also likely not substitutable with each other. In cases where a decision involves trade-offs between non-substitutable assets, decision tools different from CBA may be used (see further in Gasparatos & Scolobig, 2012; Martinez-Alier, Munda, & O'Neill, 1998).

One of the main decision-making support approaches that goes beyond monetary cost-benefit analysis (CBA) is multi-criteria analysis (MCA). MCA is a very diverse family of decision support tools. In essence, it is used to compare different project options, based on a suite of criteria (such as cost, environmental impact, social impact, etc.). The advantage of MCA approaches is that each criterion needs not be measured in the same units, i.e. they do not need to be all expressed in monetary units as in CBA. However, MCA involves other complexity in terms of how much weight is given to each criterion, and how to aggregate the criteria in order to rank options.

iii) Ethics and behaviour

Some critics of economic valuation argue that associating a monetary figure to a natural entity transforms what motivates us to value it. The entity shifts from something with intrinsic or moral values to something with utilitarian value. This shift can have ethical and moral implications and, more importantly, could lead people to care less about the environment than when they associated intrinsic value to it, hence changing behaviour in a detrimental way (Bowles, 2008).

A phenomenon increasingly studied in the behavioural sciences is that of crowding out versus crowding in intrinsic motivations where a market is created for previously non-marketed goods and services (Ezzine-de-blas, Corbera, & Lapeyre, 2015). This has strong implications for environmental conservation. Put simply, an individual may be motivated to protect a patch of forest on their land because they enjoy it, or they think it is a good thing to do. If someone starts paying them to take care of the forest, motivation crowding out occurs if the individual's motivation to take care of the forest shifts from inherent enjoyment, to the expectation of being paid for doing so. This would mean that, if the payment stops, the individual might stop caring for or cut down the forest if the intrinsic enjoyment faded away when the main motivation became the external payment. The payment is an external incentive, the enjoyment is an internalised motivation, which is suggested to be more durable, though not necessarily stronger (Davis et al. 2018). Crowding in occurs if an individual continues a behaviour after the incentive payment has stopped, such as when an individual continues recycling glass after the discontinuation of a bottle return incentive. Other critiques of linking payments to conservation that lie somewhere between ethics and behaviour are the risks involved with commodification of nature (McCauley, 2006).

Going beyond the framework of the Total Economic Value (section 3.2), nature can be important for its own sake (intrinsic value) (Pascual et al., 2010). For some, quantifying the monetary value of nature seems like an aberration or trivialisation. Some would argue that nature has intrinsic value, that is, it has value in and to itself regardless of whether or not humans exist, and therefore quantification of value is impossible (i.e. we cannot determine how much the polar values its own life, at least not in monetary terms).

Given that environmental harm persists despite strong ethical motivations for sustainability, it is important to acknowledge and consider the diversity of worldviews that stem from different paradigms, and that no specific worldview may be superior to others in helping us toward sustainability. Researchers have advocated for openness to a pluralistic approach to best understand how value paradigms can inform decisions about nature (Chan, Satterfield, & Goldstein, 2012; Small, Munday, & Durance, 2017)

5. Natural capital in the public and private sectors

In addition to methodological and theoretical challenges of valuation highlighted above, the implementation of natural capital encounters two further challenges (Daily & Matson, 2008), which are common to most policy-making. One challenge concerns innovative governance systems that are needed to facilitate the transition to a sustainable economy, including new finance and regulatory frameworks. Another challenge concerns the methodologies and governance systems that are needed to adapt to different social and ecological contexts in order to succeed.

Academic efforts to measure and value natural capital and ecosystem services span a few decades. However, the public and private sectors have only started to implement these approaches in the last few years, mostly during the 2010s. In current practice, the main reference works to implement natural capital accounting are the UN's System for Environmental-Economic Accounting (SEEA; UN, 2014) and the Natural Capital Protocol (ICAEW, 2016), for national accounts and for businesses respectively.

5.1 Attempts to incorporate natural wealth accounting in national accounts

There are two broad approaches to integrate natural capital in national accounting (explained in more detail in Chapter 10). One approach is to make adjustments to standard macroeconomic indicators (adjusted economic measures), such as to the GDP, by incorporating natural assets and their depletion in the calculation. The other one is to create new indicators altogether (composite indicators), including indicators in units other than monetary, such as area of land or volumes of material used in the economy. The former approach tends to be more readily adopted by existing statistical records, while the latter approach has led to a much wider variety of indicators that are, arguably, more comprehensive. An extensive literature discusses the pros, cons and assumptions of each indicator proposed (see McGillivray, 2007; and Neumayer, 2005 for a comprehensive treatment of the topic). Further approaches include dashboards (collections) of indicators and combinations of index and dashboards (see Chapter 10). None of these approaches, thus far, have become the most accepted one among academics, although the SEEA is gaining wide acceptance among practitioners. The SEEA framework encompasses accounting of physical flows (in physical units such as volume of waste, quantity of energy etc.) as well as of monetary values estimated for certain stocks and flows, and therefore combines features of both approaches.

Regarding adjusted economic measures that adapt existing macroeconomic indicators, efforts have been made to understand how national accounting indicators, such as GDP, can measure an economy's sustainability. Especially, how national accounting measures can be expanded or adjusted to reflect accurate information on the changes in natural capital stocks and wealth. One fundamental change that natural capital entails for national accounting is capital depreciation (the loss of value in the stocks). In standard accounting, depreciation is estimated for manufactured capital (buildings, machinery, etc.), but not for the natural environment (Barbier, 2014). For example, destruction of wetlands is not counted as capital depreciation in national accounts, hence giving an incomplete picture of the wealth of a country. Some examples of adapted standard macroeconomic indicators, discussed later in Chapter 10, are the environmentally adjusted or green net national (or domestic) product, Genuine Progress Indicator, Adjusted Net Savings, or Sustainable National Income. Through developing these new indicators, the interest has reverted to accounting wealth instead of money, which requires a more open approach toward what is quantified and how.

The family of composite indices is very diverse — measurements created aside from mainstream macroeconomic indicators. It includes indicators such as the Living Planet Index, Genuine Progress Indicator and Sustainable Net Benefit Index. Many of these indicators are included within the family of indicators derived from the Index of Sustainable Economic Welfare (ISEW). From within these, some important indicators use solely physical units (rather than economic ones), for example, the Ecological Footprint (the amount of land necessary to sustain a human or a city, etc.) or Material Flow Accounts. These indicators are often intended to express progress or changes in well-being. For this reason, discussions on indicators about the natural environment sometimes include the family of happiness indicators (a topic discussed in Chapter 2), which aim to measure human well-being in a more holistic manner.

The MEA and TEEB were milestone global assessments that highlighted the importance of natural capital and ecosystem services. Soon after, the SEEA was developed among several international institutions, and is nowadays the flagship framework to incorporate natural capital in economic decision-making. The UN Statistics Division created "experimental ecosystem accounts as part of the revision of the [SEEA]" (Guerry et al., 2015). Simultaneously, the World Bank-led the Wealth Accounting and Valuation of Ecosystem Services partnership (WAVES), aiming to boost the implementation of the SEEA methodology.

At national scales, important efforts are underway in the policy and practice arenas in order to fully incorporate natural capital into decision-making and their national accounts, e.g. in China (Ouyang et al., 2016) and the US (Schaefer et al., 2015). In 2012 the UK government created the Natural Capital Committee, an advisory entity with the aim of introducing a value of natural capital in national GDP accounts. South Africa has a National Plan for Advancing Environmental-Economic Accounting from 2015, and now Chile, Indonesia, Mexico, Vietnam and Mauritius are also drafting their own.

The inclusion of natural capital into national accounts of wealth fundamentally changes the measures of country-level well-being and sustainability (Arrow, Mumford, & Oleson, 2012). Recent comparative studies reveal unexpected results in terms of which countries demonstrate most sustainable resource use, for example, Vietnam and Sri Lanka have not transgressed many biophysical boundaries as measured by a group of scientists (O'Neill, Fanning, Lamb, & Steinberger, 2018). More inclusive measurements and initiative to adopt them continues to evolve through a mix of government regulations, academic initiatives, and citizen movements.

5.2 Businesses incorporating natural capital

There is growing awareness among some business groups about the importance of preserving natural assets, ensued by some important initiatives (see Box 3.4). This is so despite fear that businesses will put themselves at a competitive disadvantage to those that do not account for natural capital impacts. Without global standards that apply to all competitors, there is often little incentive to individually invest in natural capital. As an alternative, businesses engage in collaborations through initiatives such as the Natural Capital

Box 3.4: Two popular approaches: payments for ecosystem services and ecological restoration

Two main ways to enhance natural capital are 1) restoring degraded ecosystems and 2) preserving the existing capital (where it is under threat). Restoration is otherwise often seen as an expense with no net benefits. However, by including the value of ecosystem service benefits from an increase in natural capital into the accounts, restoration may demonstrate net benefits. A study analysing over 200 cases of a variety of ecosystems found that the internal rate of return was positive for most projects, and as high as 59 per cent for some grassland restoration projects (Groot et al., 2013).

In order to preserve existing natural capital, several policy instruments are available. The most well-known is direct regulation, e.g. establishing protected areas where impacts are restricted. Another instrument that has become popular is payments for ecosystem services (or environmental services; PES), whereby a seller (those who safeguard the natural capital) receives money from a buyer (those who enjoy the service provided by that capital). Over 500 schemes of PES have been inventoried worldwide (Salzman, Bennett, Carroll, Goldstein, & Jenkins, 2018), and they vary largely in their scale, their private or public nature and, of course, in the resource or service they pay for (predominantly biodiversity, water or carbon capture by forests).

The effectiveness of PES has been widely discussed. These programmes are based on certain theoretical foundations, such as the fact that buyers and sellers need to be easily identifiable, the resource to conserve needs to have clear boundaries, and the transactions need to have low costs. In other words, these schemes may work well in some cases, for example in the case of hydrological resources with downstream users and upstream providers, where they can easily communicate to negotiate and complete the transaction.

Whether these schemes have net positive impact (particularly in the long term) has been intensively researched in recent years (Porras, Greig-Gran, & Neves, 2008; Samii, Lisiecki, Kulkarni, Paler, & Chavis, 2014) Sometimes it is difficult to attribute observed improvements to the payment scheme itself, because these improvements might have happened for any other reason. Other times, there is no observable improvement, other than increased income that contributes to alleviate poverty (where the goals of conservation and poverty alleviation are joined together).

The consensus appears to be that these schemes may be effective insofar as their impact is monitored and the payments are conditional to the sellers taking conservation actions or to actual improvements being detected (Wunder et al., 2018). While intuitive, these two aspects of monitoring results and of conditionality of payments are infrequent in PES schemes.

Coalition.

Firms seldom fully grasp the importance of natural assets for their own business. Accounting for the impacts of natural capital can help to internalise the externalities of the business. Full internalisation of externalities may be achieved if the price of the final product reflects the true costs to nature and society. If prices of goods and services actually reflected their total environmental cost, consumption of environmentally harmful products would thus decline, helping with the transition towards sustainability. Such true-cost pricing would also have a dynamic effect on the private sector. As prices start to shift consumption patterns, businesses that are able adapt to minimise natural capital costs would have a comparative advantage. This dynamic response of decoupling revenue from natural capital degradation would further enable a shift towards a green economy.

Natural assets are, as mentioned above, often public goods, meaning that they can be accessed or enjoyed freely by everyone. Their conservation depends on the joint action of a number of actors. These reasons lead to problems of collective action, whereby individual firms do not perceive the direct benefit of their actions, unless they have assurance that other firms will not break the rules. Some actors may “free-ride” on the environmentally-friendly behaviour of other actors, reaping the benefits without bearing the costs. Without strong governance, the motivation of businesses that actually decide to invest in natural capital is often beyond profit maximization motivations, and depends on a variety of other practical and ethical motivations.

The motivations of businesses to incorporate environmental concerns in their behaviour are an important line of inquiry. In some situations, profit-maximising firms do not have incentives to over-comply with environmental regulation if there is no net benefit. However, environmentally-conscious behaviour in firms is observed in, such as with sustainability certifications (e.g. Natural Capital Protocol, Certified Organic, or Forest Stewardship Council Approved) or voluntary initiatives in many variants (local, international, by individual companies or in cooperation with others).

Kolstad (2011) presents a useful classification of what he terms voluntary measures for pro-environmental business behaviour, exploring why firms do so. Such voluntary actions can be classified as market-driven and as regulatory games. Market-driven actions are those motivated by either demand from consumers for green products, or the belief that the green management of companies also signals good management more broadly leading to an increased confidence among the stakeholders with which they interact, such as investors or other companies. These drivers may not bring more profits, but might increase the likelihood of a fruitful business (a market niche or securing relations respectively).

Regulatory games are voluntary agreements, programmes and pre-emptive actions where the government is involved to some degree. Involuntary agreements, additional environmental regulation would increase the costs of companies and be difficult to implement. Accordingly, governments offer a less-than-optimal, but voluntary, option to reduce environmental impact (e.g. a lower pollution standard than socially desirable). The advantage is that a voluntary measure tends to be easier for businesses to implement rather than direct restrictions, hence more likely to be implemented from the viewpoint of the government. In voluntary programmes, governments present a scheme with guidelines and goals with a modest incentive, which companies are free to join. The incentive is not economically sufficient on its own for companies to participate, but it helps in combination with other incentives, such as recognition or technical support. With pre-emptive action, companies somewhat reduce their environmental impact before a restriction is established, in a strategy to prevent regulation that might be harder for them to comply with.

In addition to these reasons why the private sector can be environmentally proactive, we also observe important international initiatives that are stimulating the incorporation of natural capital into private business decision-making. These are often driven jointly by the private sector, academia, and other non-profit organisations, not necessarily involving the public sector and not strictly driven by market motives in their appearance. With growing awareness and interest, the private sector seeks further support through increased innovation in institutional arrangements, investment models and partnerships among different stakeholders. To meet this gap and enhance support to and within the private sector, several international initiatives have emerged in recent years (Box 3.5).

Box 3.5: Reference initiatives to implement natural capital in the private sector

- Coalition for Private Investment in Conservation, launched in 2016 with the aim to find investments in conservation that provide economic returns to private investors.
- Natural Capital Coalition, a partnership of multiple stakeholders to support businesses in incorporating natural capital in their decisions, established in 2014. Their Hub section contains a wealth of resources, including case studies.
- Natural Capital Finance Alliance, provides tools for financial institutions, mostly for risk assessment. It follows the 2012 Natural Capital Declaration launched at the UN CSD. They also provide several case studies.
- Natural Capital Impact Group (formerly Leaders Platform), a global network of private companies supported by academics, mostly focused on developing metrics to help businesses understand their impact on the environment.
- Natural Capital Project, a global partnership of academic and not-for-profit institutions developing tools to account for nature's contributions to society, since 2006.
- World Forum on Natural Capital, biannual conference of academics, business and policymakers, held since 2013, supported by UN Environment, IUCN, WBCSD.

6. Conclusion

In this chapter we have defined natural capital as the natural stocks that contribute to producing goods and services that benefit humans. Examples of natural capital include extractive resources, (e.g. minerals), renewable resources (e.g. fish) and ecosystems (e.g. forests or wetlands). Natural capital is not to be confused with ecosystem services: from natural capital stocks humans derive flows of benefits or income, where derived from ecosystems, these flows are ecosystem services.

The concept of natural capital was developed in order to overcome an important caveat in the traditional economic production function. This production function included financial capital, labour and land, but implicitly assumed no value for the natural resources and ecological processes that contribute to or enable economic productivity, other than the costs of extraction or access. As a result of not having a price or economic value, natural systems and natural capital have been degraded by economic expansion with little regard to the severity of the impacts of this degradation to the economy or human well-being.

Natural capital is highly valuable for low-income households in rural areas that depend directly on their environment, as well as for countries at higher levels of development that depends upon natural resource inputs, domestically or imported. Even though a country's economic wealth may seem loosely related to ecosystems, essential natural resources required for production and staple consumption products, such as food, are brought via international trade from other countries, which in turn need healthy natural capital to export such natural resources or food.

Natural capital gained importance in academic debates in the 1990s, together with a broader trend of increasing awareness about environmental and sustainability issues. However, this way of overcoming the caveats of traditional economic thinking regarding the environment is not without criticism. One key criticism is that, by considering nature a capital next to other types of capitals (human, financial, physical), some may understand that these capitals are interchangeable. This understanding is coined as weak sustainability, and assumes that the depletion of one type of capital (natural) can be fully compensated or substituted with another capital (e.g. financial capital or technology). Because nature is complex and our understanding of it is limited, this assumption is not realistic, and so strong sustainability proposes that some forms of nature's degradation are irreversible and/or irreplaceable.

An important implication of natural capital is that it fosters efforts to quantitatively estimate the value of natural systems, ideally in monetary terms. Accordingly, a variety of methods have been developed to estimate the value of natural capital and ecosystem services: market, indirect market and non-market valuation methods. The total value of such items can be disaggregated and defined using the TEV framework, which distinguishes marketed values, non-marketed values, existential values and other components of the overall value of a natural assets or their flow of services. The choice of the method for estimating such values depends on the type of the value to be estimated, the type of natural system, and the data available.

Valuing natural capital and ecosystem services can be useful for different purposes, from full-cost accounting to informing decisions about natural resource management to raising awareness and interest about the importance of nature. Operationalising natural capital and estimating such values also has caveats and challenges. Some key challenges refer to the lack of sufficient knowledge about complex ecosystems, the assumptions and potential biases underlying valuation methods, the quality of the public good of many environmental goods and services, ethical criticisms and concerns over unintended behavioural consequences of estimating economic costs.

In conclusion, understanding the importance of nature through the lens of natural capital proves useful for a transition to a green economy. This lens increases awareness of nature's importance for the economy and human well-being. Its positive impact is observed in the actions of both governments and the private sector, e.g. through national economic accounting (further in Chapter 10) and business initiatives regarding natural capital or the green economy.

Additional resources

- What is natural capital and why is it important?
- Natural capital: Tony Juniper

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CHAPTER 4:
GREEN TECHNOLOGY

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LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Articulate the meaning and implications of green technology;
- Outline green technology's main contributions to the green economy transition; and
- Understand the policies and practices that enable the development of green technlogy.

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CHAPTER CONTENTS

Foreword

The chapter starts by providing insights into technology's influences within an economy-environment linkage and then discusses the meaning of green technology. Section 2 discusses the role of green technology in advancing the green economy transition, from the greening of individual sectors to industrial upgrading and from creating new-generation capitals to driving the techno-economic paradigm towards sustainable consumption and production. New technologies are often in an unfavorable position in the initial phase. Due to **knowledge spillovers** and environmental externalities, market forces do not provide sufficient incentives for developing or adopting green technologies. Section 3 then examines how policies can help prevent this market failure and promote green technologies.

> **Key term: Knowledge spillover**
> Where information, ideas and knowledge is exchanged among individuals, potentially leading to innovation.Adapted from: https://www.philadelphiafed.org/

1. Understanding green technology

What kinds of technology should be considered green? To set the stage, we briefly review some common features of technology and its influences within an economy-environment nexus. We then discuss the implications of green technology for economic development and countries' transition to green economies.

1.1 The nature of technology

Technology refers to the application of knowledge through human-designed means for achieving specific ends (Dosi & Nelson, 2010)., In the following paragraphs we will further unwrap this description, in order to better understand the essential characteristics and nature of technology.

First, technology is knowledge-driven and science-based. Together, science and technology shape the lifestyles of the majority of the world's population today. These two concepts, often paired, are intrinsically-linked and mutually reinforcing. Science studies the nature and behavior of natural things, which is a verified approach to knowledge.

Based on a body of scientific knowledge that answers the fundamental "what" and "why" questions of nature and behavior, technology instead refers to the application of scientific knowledge in order to deal with the "how to do" questions. It can thus be considered a practical application of scientific knowledge. Technology (more specifically, science and the knowledge behind a certain technology) tends to be non-rival in use, which implies that it is non-depletable, and can thus be reproduced and transferred (Dosi & Nelson, 2010).

Second, technology reflects people's desires and intentions. Technology is usually designed to fulfill a certain purpose. At the same time, it is **stochastic** – unpredictable in its outcomes – and thus not necessarily matching its intended, or originally desired outcome.

> **Key term: Stochastic**
> Random; having an element of unpredictability as opposed to being deterministic. Adapted from: https://stats.oecd.org/

Third, when we speak about a technology, the term may relate to a device such as a mobile phone, a method such as cloud technology, or a way of manufacturing such as 3D printing. Technologies are inextricably linked to all activities along the product line, from design and resource extraction to production and waste management. As a result, any produced good or service can be considered a combination of a set of technologies. Indeed, the power of technology has now gone beyond the production process and has increasingly become present in our daily life. For example, mobile internet is transforming business and social interaction. This has led Dosi and Nelson (2010) to submit that technology can now be regarded as all-encompassing; as final products, recipes entailing a design for a product, or routines of making or doing things.

Lastly, technology can be considered a means to an end. Ecological economists Daly and Farley (2003) described a spectrum with one end representing ultimate goals of development and the other end representing ultimate means. Technology has the potential to satisfy intermediate ends, such as health, safety or comfort, with different means, e.g. resources or energy.

However, in the pursuit of specific economic or social objectives, the ability to make use of resources and energy by way of technology has resulted in profound environmental impacts.

This calls for interdisciplinary knowledge to evaluate potential benefits and costs, as well as any uncertainty and risks related to technological innovation.

1.2 Technology's influences in an economic-environment linkage

Chapter 2 of this publication discussed the role of technological progress in enhancing productivity, and economic growth. This chapter will expand on this perspective by considering the role of technology for countries' transition to inclusive green economies. For simplicity, we will first look at the influences of technology on the linkage between the economy and the environment.

In the traditional economic paradigm, rapid economic growth and wealth accumulation have generally been considered the main route or even the only path towards achieving enhanced well-being, while largely ignoring planetary boundaries. Within this paradigm, technologies have mainly been developed for the purpose of enhancing productivity, and this has resulted in considerable technological progress and increased material prosperity. For example, in the United States total output has grown more than tenfold over the last century (Samuelson & Nordhaus, 2013), while in the last two decades alone economic growth has lifted a billion people across China out of poverty (The Economist, 2014). In this respect, the predominant role that technology has played in stimulating economic growth has been demonstrated by economists such as Solow and Schumpeter (see also chapter 2).

More specifically, certain technologies that are widely applied across a range of sectors, known as **general purpose technologies** (GPTs), have contributed uniquely to both economic growth and economic transformation, in turn leading to far-reaching societal transformations that extend beyond pure economic productivity. Examples of GPTs include the steam engine, electricity, computers, and the internet. Based on the disruptive effects that accompanied their innovative application, these technologies have shaped entire economic periods. In this respect, Kontratiev observed long **economic cycles** of 40-60 years, known as the Kontratiev wave or long wave, which was closely associated with major technological innovations (as shown in Figure 1); forming the basis for the concept of the "techno-economic paradigm (TEP)" (Dosi & Nelson, 2013; Freeman & Perez, 1988).

Key term: General purpose technologies
Technologies that can affect or alter an entire economy. Examples include information technology, steam, electricity and internal combustion. Adapted from https://link.springer.com/

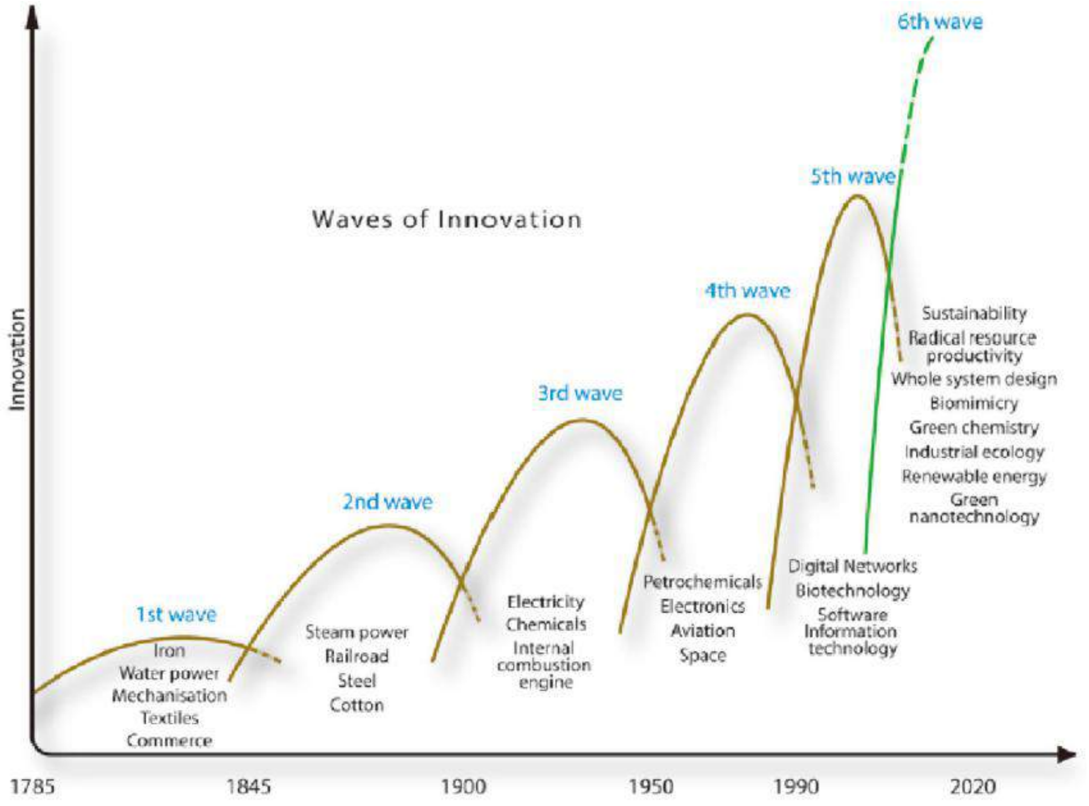


Figure 1. Long-term circles of economy and technological innovation (Weizsaecker et al., 2009).

Key term: Economic cycle
The fluctuation of the economy between periods of growth and recession. Factors including GDP, interest rates, employment levels, spending can help determine the current stage of the economic cycle. Adapted from https://www.investopedia.com/

Considering the techno-economic paradigm, as based on the Kontratiev wave, Weizsaecker argued that the first five long waves of innovation were characterized by technological change that was driven by short-term economic benefits, instead of focus on the long-term optimum. Innovative capacity since the 18th century has focused heavily on enhancing labor productivity and, as a result, **labor productivity** has increased twentyfold over the last two centuries. Today, labor is no longer the limiting factor of growth, and additional jobs are in fact needed to achieve full employment (Weizsaecker et al., 2009). However, economic activities increasingly place pressure on the natural environment because, in focusing on short-term economic benefits, previous waves of innovation failed to address the more holistic and longer-term effects of economic processes on natural systems. At the same time, technology also plays a crucial role in pushing the boundaries of economic growth. Energy-efficient technologies and renewable energy technologies help to meet the growing global demand for energy, while physical, chemical, and biological recycling and **remediation technologies** are essential in the fight against pollution.

Key term: Labour productivity
Labor productivity measures the hourly output of a country's economy; it charts the amount of real gross domestic product (GDP) produced by an hour of labor. Adapted from: https://www.investopedia.com

Key term: Environmental remediation
Removal of pollution and contaminants from the environment e.g. from soil, surface water and so on, in order to restore the environment and to protect human health where it may be at risk due to contaminants. Adapted from: https://www.bls.gov/

Thus, technology can be considered as both a source and solution of environmental issues related to anthropogenic activities. However, for innovation to be a driving force for sustainable development in what Weizsaecker now calls the '6th wave of innovation', it is crucial that the right questions of "how" and "what for" are applied. This, again, calls for a profound change in both development philosophies and technological systems.

1.3 Implications of green technology

As described in the *Green Economy Report* (UN Environment, 2011), a green economy encourages positive interactions between the economy and the environment, and ideally establishes synergies between the economic, societal, and environmental pillars. In this context, integrating new, greener technologies into economic activities of production and consumption can be a key driver in advancing the green economy transition.

As shown in Figure 2, these technologies can be integrated into each stage of the economic activity process. At the initial stage, renewable energy can substitute the use of fossil fuels as a 'clean' energy source. Production and consumption processes can utilize energy conservation equipment, while downstream stages can green their processes through the adoption of air purification or carbon capture and storage (CCS) technology. In this way, green technology is, in fact, environmental technology in a broader sense. While under the take-waste-dispose economic paradigm environmental technology-focused on remediation and was often situated at the end-of-pipe, in a green economy, technology can better understood as a means to ensure the integration of **environmental protection** processes into all stages of economic activities.

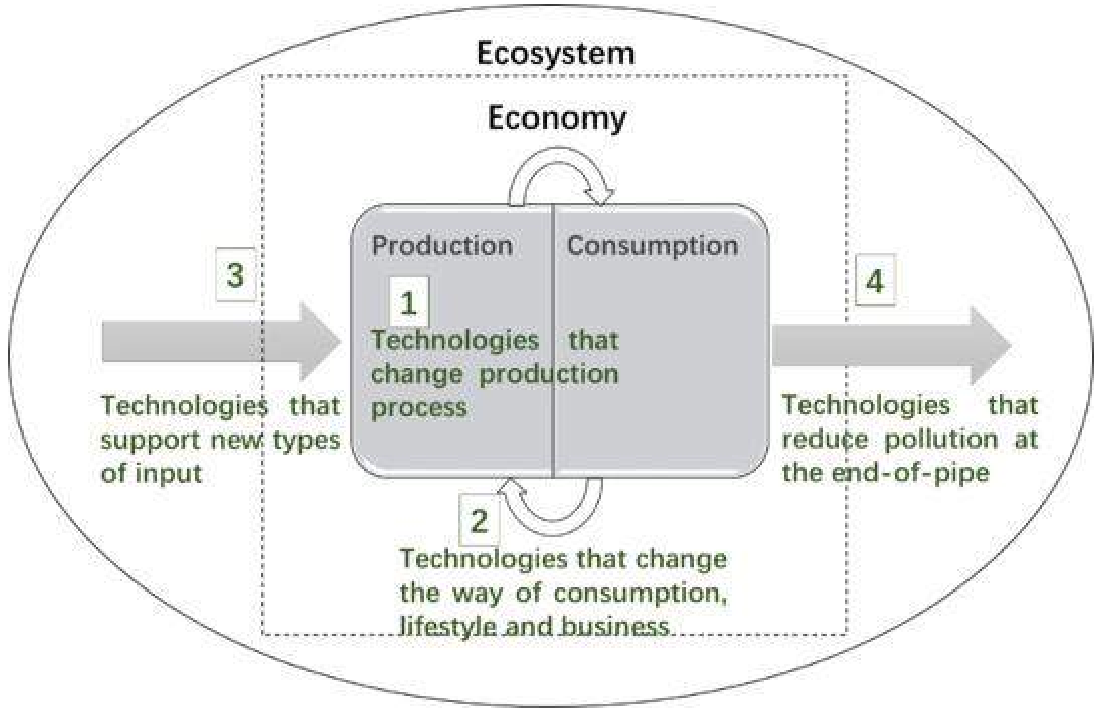


Figure 2. Green technology: integrating environmentally friendly technology into economic activities (by author).

Key term: Paradigm
A paradigm can be a typical example of something, or as in this case, a way of describing a set of ideas that can be used to describe something, like a dominant understanding. Adapted from: http://www.macmillandictionaryblog.com/

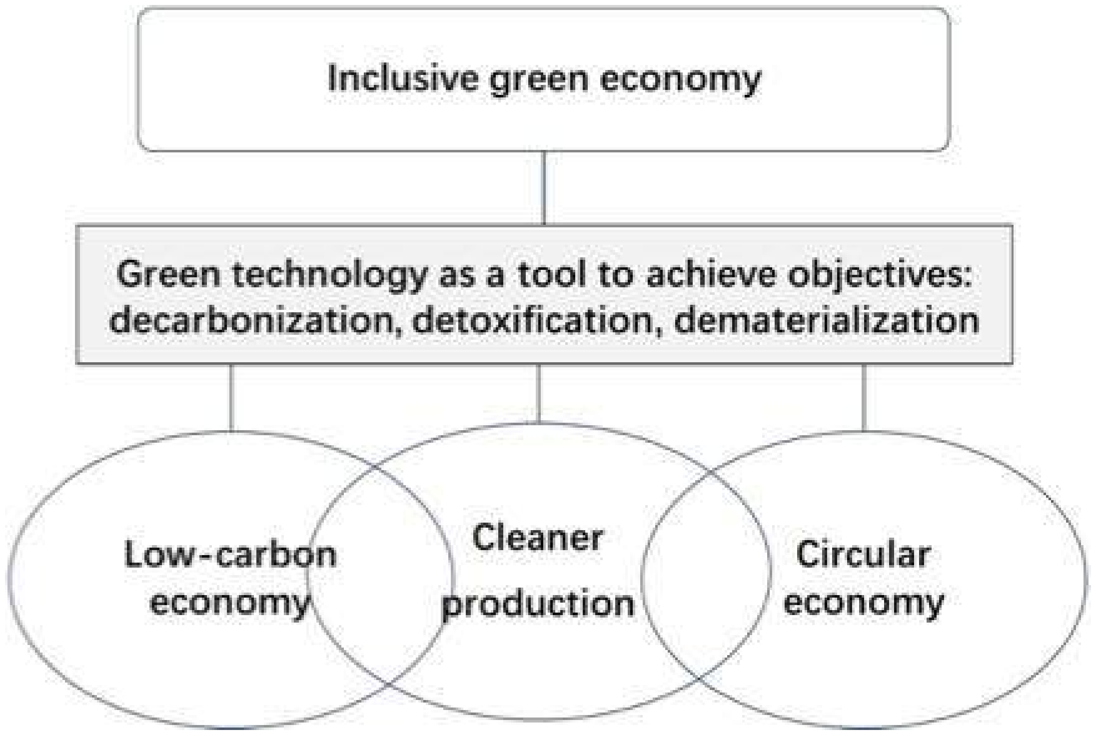
As was mentioned in section 1.1, technology by its own nature is a means to achieve an end. Designing green technologies therefore requires a whole-systems approach, as Weizsaecker et al. suggest (2010),

> **Key term: Environmental protection**
> Activities which attempt to conserve or restore the state of the environment through preventing/reducing the presence of pollutants going into the environment. Adapted from: https://stats.oecd.org/

in which we first set proper objectives, and then identify effective technological solutions.

In considering the pursuit of economic growth within planetary boundaries and capacity-carrying limits, the concepts of circular economy and low-carbon economy have been alternatively developed as important pathways towards the realization of a green economy. The two concepts have different foci within the scope of production and consumption; while the low-carbon economy concept aims to address the problems related to energy flow and carbon emissions, circular economies target the flow of materials and waste (see Box 4.1 in this Chapter as well as Chapter 1, Appendix, and Chapter 2, Appendix) (Sheng & Zhu, 2015).

Figure 3. Green technologies supporting an IGE (by author).



The third important path towards the realization of a green economy is cleaner production, which is defined by UN Environment as "the continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment." (Vieira & Amaral, 2016). As such, cleaner production focuses on the production process as a means to reducing environmental damage and pollution. These three concepts require a cluster of technological innovations (Figure 3). It should also be noted that these pathways largely overlap in practice. For instance, cleaner production overlaps with the other two concepts in terms of production processes, while circularity is key for the achievement of climate change goals. In the following paragraphs, three core objectives of green technologies will be introduced.

1.4 Increasing resource efficiency

Economic logic tells us to maximize productivity of the limiting factor by investing in its increase. This explains why technologies to achieve economic objectives have historically been designed to serve the main purpose of increasing labor productivity and enhancing stocks of human-made capital. At the early stages of economic development, human resources and human-made capital were scarce, while environmental goods and services were in abundance. However, in the context of economic growth, **natural capital** has gradually become the limiting factor in production rates. As such, with the economic logic of investing in the limiting factor in mind, it is submitted that technological efforts and policies must change accordingly to increase natural resource efficiency (Daly & Farley, 2003).

> **Key term: Natural capital**
> The world's natural assets i.e. soil, air, water, living things – from natural capital humans obtain ecosystem services which make human life possible e.g. food, water, materials for fuel, medicines and building materials. Adapted from: https://naturalcapitalforum.com/

At the technology level, there is an abundance of opportunities to improve the efficiencies of use of water, land, and other natural resources. For example, the agricultural sector currently accounts for approximately 70 per cent of total water consumption worldwide. Therefore, the application of high-efficiency **irrigation** techniques has the potential to greatly reduce water consumption when compared with traditional flood irrigation processes. However, the objective of achieving far-reaching **de-materialization** and a substantially higher level of resource productivity requires systematic considerations, such as a shift from the traditional linear economic paradigm to that base on a circular economy. (Box 4.1 details this transition.)

> **Key term: Irrigation**
> Artificially moving water onto land - either spraying the water or pumping it onto the land - to help with crop and pasture growth. Adapted from: https://stats.oecd.org

> **Key term: Dematerialization**
> Reducing the amount of materials used. Adapted from: http://sk.sagepub.com/

Box 4.1: From a linear economy to a circular economy

The strong emphasis that has historically been placed on economic growth as a goal in its self, contributed to ever-increasing throughput of materials and energy within a linear economy, with low entropy resources moving through the economy and finally returning to the global ecosystem's sink as high entropy wastes. Such linear throughputs threaten the former abundance of environmental goods and services, which in turn means that the goal of infinite growth in a finite system will eventually fail. To achieve truly sustainable development, we must, therefore, redesign the economic system, shifting from a linear economy to one that is more circular in design.

Circular economy organizes economic activities into a closed-loop, and is based on whole-system thinking. Initially, circular economy focused predominantly on waste recycling, which did not significantly change the patterns of consumption and production. However, today's notion of a circular economy extends far beyond recycling, and encompasses new modes of production, new business models and new types of lifestyles, embracing innovation. These practices depart radically from those adopted in a take-make-dispose linear model (UN Environment, 2015).

In the book Waste to Wealth, Lacy and Rutqvist (2015) introduce ten key technologies that bring disruptive influences to the economic system and support the shift towards a circular economy. Those technologies fall into three broad categories: digital technology, engineering technology, and a blend of these two (Hybrid technologies), such as Machine to machine communication, 3D printing or advanced recycling technology.

It should be noted that while these technologies present good opportunities by which enterprises can move towards a circular economy, they cannot be considered inherently green. Innovations beyond technology are therefore necessary to optimize their application and to develop their full potential, so as to ensure that they have a positive effect on the environment. This encompasses social and societal innovations, and a shift towards sustainable consumption and lifestyles.

There is still a long way to go in the process towards becoming a circular society, with a recent publication reporting that our world has only achieved 9% circularity to date (The Platform for Accelerating the Circular Economy, 2019). One of the key elements in realizing this shift from a linear economy towards a circular model therefore lies in understanding technology trends, and their potential to disrupt existing value chain, as well as support the creation of new ways ones.

Source: Lacy and Rutqvist, 2015; The Platform for Accelerating the Circular Economy, 2019; UN Environment, 2015.

1.5 Addressing climate change

Economic growth over the last century was largely realized through dependency on fossil fuels as a source of energy. However, energy generation from fossil fuels releases carbon emissions into the atmosphere, which is one of the key drivers of climate change. Green technologies that help prevent and address the effects of climate change can be divided into three categories, which will be elaborated below.

Cleaner energy supply technologies

Key term: Hydropower
Power sourced from water. The energy from flowing water is converted into electricity. Adapted from: https://www.studentenergy.org

Key term: Biomass
A renewable source of energy, organic matter that comes from plants/animals. Biomass contains energy stored from the sun; when it is burned the chemical energy stored in the biomass is released as heat. Examples include: Wood, agricultural crops, food, sewage etc. Adapted from: https://www.eia.gov

Key term: Conventional energy
Energy sources such as coal, oil, gas. They tend to be damaging to the environment i.e. due to greenhouse gas emissions and are non-renewable. Adapted from: https://www.environmentalleader.com

A radical departure from hydrocarbon-based energy generation requires a shift towards more environmentally friendly energy sources. Currently, the most widely applied renewable energy sources include solar, wind, **hydropower**, **biomass**, and geothermal energy, and while these are gradually substituting coal and oil as an energy source, they remain a long way from dominating global energy systems. With the levels of atmospheric carbon dioxide already at a record high and continuing to increase, the technology that generates negative emissions, such as carbon capture and storage, could play a key role in reducing carbon concentrations in the atmosphere.

Energy conservation technologies

Improving the efficiency of **conventional energy** use is another important factor in the context of climate change. Energy conservation technologies should be implemented and applied at a large scale, and across the building, industry, transport, and household sectors. In high-income countries, energy consumption and related carbon emissions mainly result from everyday human activities, with the contribution from industry being much smaller. In these countries then, energy conservation in the household or private transport sectors is of particular importance. On the other hand, in low-income countries most of the energy-saving potential remains in the industrial, building, and transportation sectors.

Adaptation technologies

Adaptation technologies also have a crucial role to play in mitigating the effects of climate change, and this is particularly so in certain sectors and areas. Adaptation technologies encompass products and processes that are resilient or resistant to changing climatic and environmental conditions, as well as tools to understand and insure against climate risks. In the agricultural sector, for instance, the development of drought-resistant cultivation practices or the selective breeding of seeds for more arid and saline soils can bring about higher yields in more extreme climatic conditions. Since climate change makes extreme weather events occur more frequently, improved early-warning systems can also help reduce the damage caused by natural disasters (Dutz & Sharma, 2012).

Improving environmental quality

Environmental degradation is threatening the very well-being and survival of our planet's living creatures, including humans. While the transition to a green economy requires a radical departure from all modes of the current economic paradigm, the current ecological crisis dictates that environmental issues demand our urgent and particular attention. Environmental technologies, in general, require the engagement of a wide range of sectors, activities, and branches of science, in order to improve **environmental quality** in the short- or long-term.

> **Key term: Environmental quality**
> State of conditions in the environment, understood in relation to environmental quality standards. Adapted form https://stats.oecd.org

Armed with a foundational understanding of green technology, let us now turn back to the issue of technology's influence on the linkage between economy and environment. As the above examples have served to demonstrate, if green technologies were to be applied within an optimal system design, negative interactions between the economy and the environment would be significantly reduced. In addition, the transition to a green economy presents ample opportunities to create economic activities around technologies that benefit the environment and, in turn, create economic value and green jobs. The opportunities arising in the context of an inclusive green economy indicate positive interactions between economy and the environment can be expected, and achieved.

In brief, then, green technologies can be understood as a continuously evolving group of methods, materials, products, or services that support resource-efficient, low-carbon, and clean economic development, and which benefit the environment in the long-term.

2. Green technology supporting the transition towards an inclusive green economy

This section discusses why green technology is important for supporting the transition towards an IGE. The transition towards an IGE takes place in two different ways. Firstly, it is achieved by "greening" traditional industries in all sectors of the economy, to enable economic growth while improving environmental quality and social inclusiveness. And secondly, through the fostering of environmental industries, environmental products and services that benefit the environment can be developed to generate a new source of economic growth. Green technologies play a key role in both of these paths, while from a more broader perspective, the green transition will also require profound changes to be effected in both the way that we produce and consume goods.

2.1 Generating green capital

Inclusive green economy is a framework which advocates for a new generation of capital. This includes clean and low-carbon human-made capital, critical natural capital, human capital that is well-educated possesses the skills needed in a green economy, and fundamental, albeit unquantifiable, social capital (Sheng & Zhu, 2015). While technology is not an independent factor of production, it plays a unique role in creating new-generation capitals when combined with other types of factors. For instance, human-made capital can be 'greened' through the application of green technology, such as carbon capture and storage. Those with a strong knowledge and understanding of green technology processes can also be considered green human capital. In its various forms then, green capital can lay the foundations for the greening of production processes by increasing efficiency and mitigating environmental damage and pollution.

One of the most visible contributions of technology to economic development is that it helps overcome the immediate constraints presented by exploiting natural capital. First, technological progress continuously improves the resource efficiencies of material, energy, water, and land use. Second, technological innovations can provide alternative input materials to natural capital, allowing for the macro-replacement of a certain production factor by another factor or another type of capital (e.g. replacing wood with biodegradable plastic). Accordingly, with technological advancement different production factors can be substituted in order to balance the exploitation of different capital stocks (Sheng & Zhu, 2015). In this way, natural resource abundance is not geologically predetermined, but instead technologically and economically constructed. And third, technological progress can reduce environmental risks by improving production processes or developing more environment-friendly products, such as unleaded gasoline or chlorine free bleaching.

However, from a macro-perspective, technology cannot be relied upon to provide suitable replacements to natural resources such as water. The finiteness of natural capital will therefore inevitably constrain economic growth, and the key lies in shifting towards a greener techno-economic paradigm, one that extends beyond the technology level.

2.2 Promoting the greening of traditional industries

The Green Economy Report, issued by UN Environment in 2011, made a strong economic case for investing 1-2 per cent of global GDP in the greening of a number of key sectors. These included sectors derived from natural capital, such as agriculture and fishing, as well as historically 'brown,' material- and energy-intensive sectors such as buildings and transport (UN Environment, 2011). Indeed, otucomes from modeling exercises indicate that investment in the greening of major economic sectors at the global level can be expected to lead to efficiency improvements, resource conservation, and carbon mitigation, advancing the transition towards more resilient, long-term economic growth.

The next section will take two examples, with agriculture as a natural capital sector and transportation as a human-made capital sector, to demonstrate the technological opportunities presented by the green economy transition.

Greening resource- and energy-intensive sectors

Historically 'brown' sectors such as energy generation, manufacturing, buildings, and transport are now key sectors in which the transition towards IGE, through social inclusion and environmental protection, can be achieved. UN Environment (2011) reports that the buildings sector is responsible for one-third of all global energy end use and 40 per cent of solid waste generation worldwide. The transportation sector consumes more than half of all global liquid fossil fuels, and is responsible for nearly a quarter of all energy-related carbon emissions and 80 per cent of the air pollution present in cities in low-income countries (UN Environment, 2011; International Energy Agency, 2013). As such, these sectors provide great opportunities for energy and resource savings. For instance, we will now draw on the transport sector to briefly illustrate how green technologies can provide environmentally friendly solutions that also satisfy the mobility needs of society.

The overall growth in demand for transport has translated into even heavier burdens being placed on the environment: through resource depletion, land grabbing, and air pollution, etc. (UN Environment, 2011). Transforming the transportation sector therefore requires innovative solutions that enable people and goods to move in a resource efficient and environmentally friendly way. Mobility, and the movement of people and goods, also has fundamental social benefits, providing access to jobs, education, recreation, and healthcare. Green

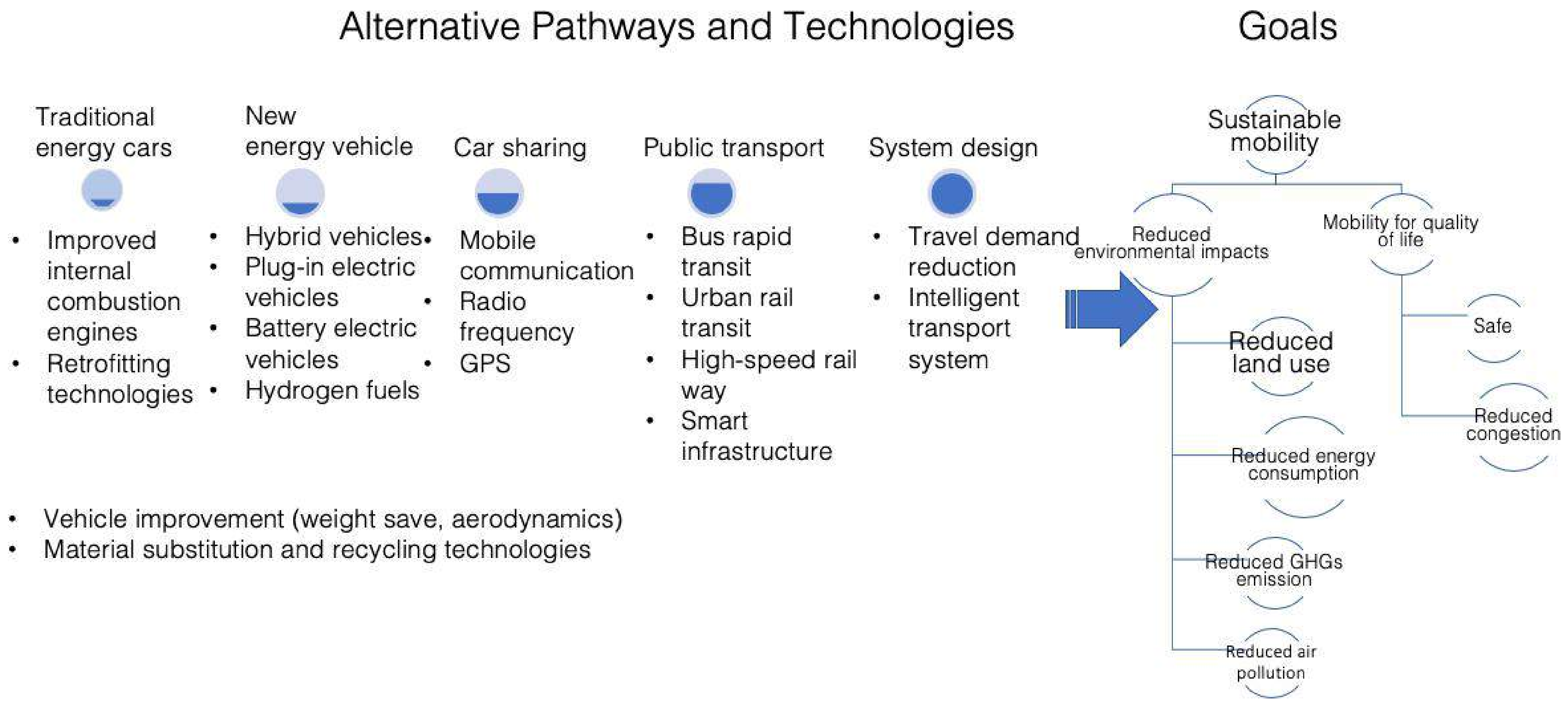


Figure 4. Technologies to support green transport goals via alternative pathways (by author).

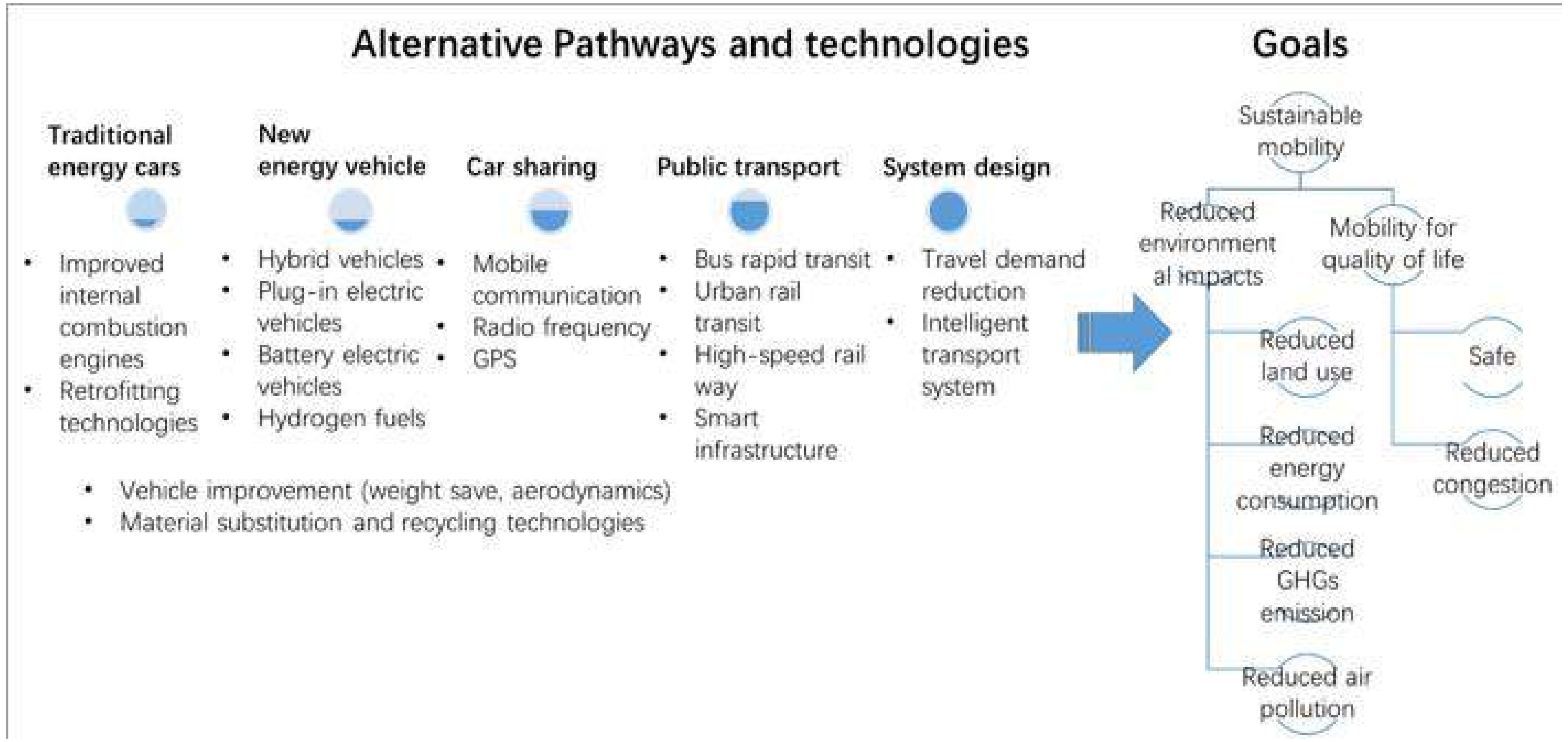
travel demand management systems created. All of these strategies need to be supported by a cluster of technologies, as shown in Figure 4 (above).

In sectors that are based on human-made capital, technology design and development should, in the long-term, aim at radically decreasing material and energy consumption. This can be achieved by shifting to economies that are service, sharing, and infrastructure-mostly living in rural areas, that depend directly on agriculture as a means of sustenance (UN Environment, 2011). Underdevelopment, or the application of brown technology in these sectors, leads to low levels of efficiency and widespread pollution, ultimately resulting in the deterioration of natural capital.

For example, it is estimated that households consume only about half of all global agricultural production, with factors such as harvest loss, animal feed, distribution loss, and waste limiting agricultural efficiency (Lundqvist et al., 2008). In this respect, small investments in simple storage technologies could reduce food waste by a substantial amount. According to the International Assessment of Agricultural Knowledge, Science, and Technology for Development, the Return on Investment (ROI) in agricultural knowledge, science, and technology is on average as high as 40-50 per cent (UN Environment, 2011). Therefore, technological innovation is key to improving productivity and sustainability in the agricultural sector.

Today's agricultural activities are mainly organized in two different ways: small farm agriculture, mostly found in low-income countries, and industrial agriculture in high-income countries. Both types have the potential to deplete natural capital. Industrial agriculture achieves high productivity through high levels of input, such as chemical fertilizers, pesticides, water, and excessive use of farm machinery. By comparison, small farm agriculture uses limited off-farm inputs and has lower productivity. The farming practices used on small farms are based on traditional knowledge, and the yield derived from small farm agriculture is particularly susceptible to environmental change.

The general objectives behind the greening of the agricultural sector is the need to provide food security in the context of a growing global population and to build resilience against the effects of climate change, while using natural resources in a more sustainable way to avoid social and environmental collapse. Major challenges and technological opportunities for greening the agricultural sector are shown in Figure 5 (overleaf).



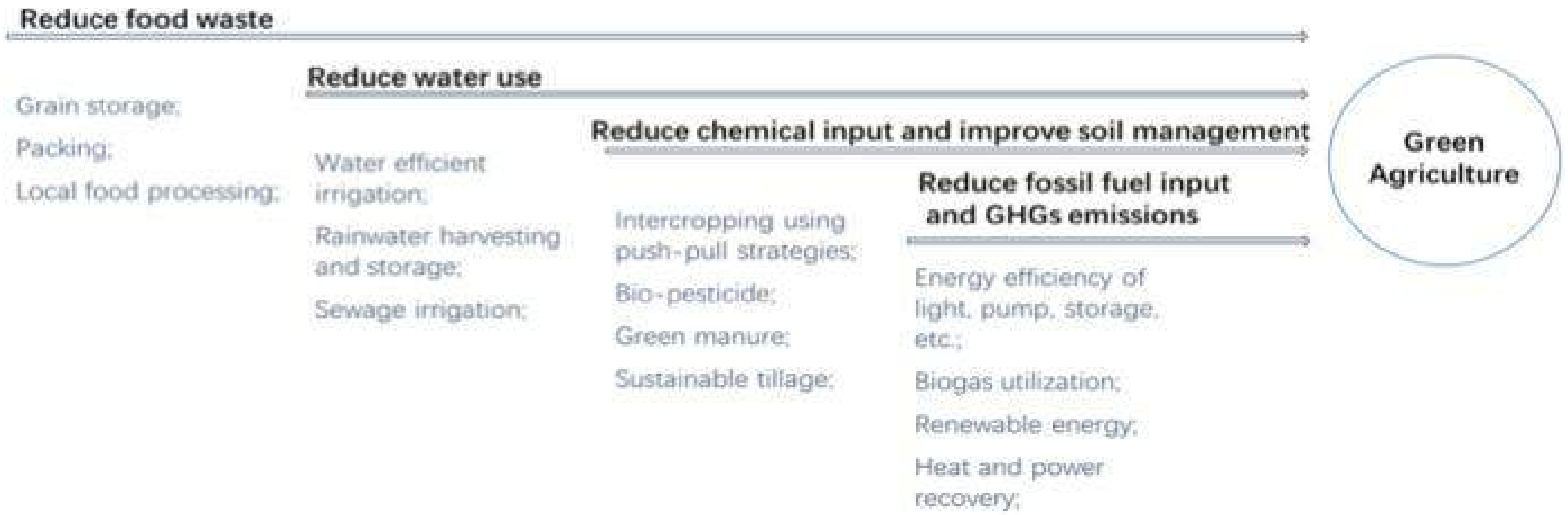


Figure 5. Technologies for greening agriculture sector (by author)

Box 4.2: Innovation in agriculture systems in the digital age

The Global Innovation Index 2017 focused on the agricultural and food sectors. The report analyzed possible entry points for the greening of agricultural systems using data-driven strategies and digital technologies, such as sensors, drones, robotics, and digital communication tools, as well as data generation and analytics enabled by remote sensing and geographic information systems.

Digital technologies provide tools for the precise management of water and nutrients, thereby providing agricultural products of a better quality. Implementing digital technology in an agricultural system may take on different forms. For example, cloud-based services enable continuous and real-time monitoring of production environments, enabling farmers to correct any problems before they become detrimental to yield. So called ‘Cloud-based nitrogen advisors’, for instance, allow farmers to align nutrient additions more precisely with crop needs. On-farm experiences of using cloud-based services have thus highlighted the win-win effect of increased profit and decreased environmental impact.

For example, in Bulgaria, this advanced field equipment has been widely adopted, and associated products and services are now offered by technical service providers. The increasing use of advanced digital technologies within the agricultural sector has created opportunities for precise farming practices and promoted the efficient utilization of natural resources. Digital technologies, such as remote sensors, are also used to provide information on yield loss and risk management.

Source: Dutta et al., 2017.

Since many of the challenges facing the agricultural sector are interdependent, transforming the sector will require an integrated, whole-system approach. For instance, it has been reported that 80 per cent of all agricultural water use could be prevented through the implementation of systematic designs and effective strategies that include crop selection, technological progress, irrigation planning, and sustainable management of water (Weizsaecker et al., 2009). Innovative irrigation techniques could simultaneously increase yields and reduce energy demand. The development of better food processing or packing technologies would not only reduce post-harvest food waste, but also provide new business opportunities and create higher skilled and better paying jobs. Advances in the digital world would also bring new opportunities for improving the sustainability of agriculture, as shown in Box 4.2, above.

Unfortunately, in sectors that are directly derived from natural capital, investment in technology is generally lacking, leading to the inefficient use, and waste of, resources such as water, energy, and food. Investments in technologies that support sustainable development in these sectors, therefore, have a high economic return, and can generate significant environmental and social benefits.

2.3 Environmental Goods and Services (EGS) industries

The increasing international acceptance of green economy as a sustainable economic model is boosting worldwide demand for green products and services. This increasing demand is pulling technological innovation in a greener direction and opening up new green business opportunities. As the preceding sections have shown, environmental technology development and industrialization is a key aspect in the transition towards IGE. Green economy seeks to strengthen positive interactions between economic development and environmental protection, and developing the Environmental Goods and Services industry. presents such a win-win opportunity.

Economic activities in the EGS industry have environmental technologies at their core. According to the recent Environmental Goods and Services Sector Accounts: Practical Guide published by Eurostat (2016), the environmental goods and services sector, or “environmental industry”, is considered to comprise “all entities in their capacity as environmental producers, i.e., undertaking the economic activities that result in products for environmental protection and resource management” (for a more thorough discussion of the EGS industry and the definition of EGS, please refer to Chapter 12).

Products created by the environment goods industry can include instruments and materials for environmental protection, or environmentally friendly products, such as solar panels. Environmental services provided can range from environmental monitoring, consulting services on resource efficiency, environmental auditing and certification, environmental evaluation and assessment, and ecological restoration and protection.

By providing new products and services, the EGS industry generates new growth for the global economy. Moreover, in many countries, such as Germany, the United States, and China, the contribution of the environmental industry to GDP is growing rapidly. In Germany for instance, the environmental industry’s contribution to national GDP amounted to 13 per cent in 2013, and this figure is expected to exceed 20 per cent by 2025 (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2014). Being a new and emerging sector, the environmental industry can also provide social benefits through new job and employment opportunities (for an in-depth discussion of employment and social issues, see Chapter 5). In Brazil, China, and the United States alone, the waste sector employs 12 million people, most of them from extremely poor backgrounds (UN Environment, 2015).

In spite of its emerging nature, the environmental industry is still often not identified as an independent industry classification, and is instead split across the various traditional sectors with which it integrates. In Germany again, many green technology companies have their roots in traditional branches of industry, such as the mechanical or automotive industry, electrical engineering, or the chemical industry (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2014). The environmental industry therefore naturally overlaps with a broad spectrum of industries and sectors. As such, the industry’s development presents good entry points for the greening of a wide range of sectors, and can be considered a catalyst for advancing the overall transition to IGE.

This potential has been augmented by the expansion of international trade in environmental equipment and environmental services, and particularly with respect to environmental technology and technical standards. A competitive market for green technology development is already developing, and both high-income and low-income countries are now striving to seize the opportunities presented by the techno-economic paradigm change – to upgrade their industries and reshape the competitiveness of their economies through the uptake of green technology, R&D and adoption.

2.4 Shift towards a greener techno-economic paradigm

Technological innovation is a key driver of industrial upgrading. As social demands change, different

Box 4.3: The fourth industrial revolution

Today's technology is changing the way that we work, the way that we live, and the way that our economies function. The Economist and engineer Klaus Schwab, Founder of the World Economic Forum, has argued that the speed, scale and impact of these transformations represent the coming of the fourth industrial revolution.

The third industrial revolution, driven by electronic and information technology, represented the first step of digitization. The fourth industrial revolution, rather than being a simple digitization, instead builds on this and is based on a combination of technologies. Mobile internet connects billions of people to each other, and provides access to knowledge on a scale never seen before. Technological breakthroughs in new fields such as 3D printing, artificial intelligence, biotechnology, and materials science, are both fusing, and eliminating the barriers between, the physical, digital, and biological worlds.

These technologies underpin the fourth industrial revolution, and are having profound impacts not just in individual sectors, but also on business modes and lifestyles. Physical products and services can now be enhanced with digital capabilities, in order to increase their value. Technology enabled platforms that combine demand and supply have now become a new form of business organization of their own, that may promote the shift towards a circular economy. Each of these developments possess potential long-term gains in efficiency and productivity.

According to Schwab, 'the possibilities of such a connected world are unlimited'. It creates opportunities for businesses and firms to further advance their technologies by incorporating external ideas, including those of consumers, through a systems of open innovation. Harnessing these opportunities, while proactively managing any new risks that the fourth industrial revolution brings, will help us to accelerate progress towards the sustainable development goals, and the transition towards IGE.

Source: Schwab, 2016.

industrial sectors present technological opportunities for industrial progress. With labor and capital flowing into those sectors characterized by higher productivity and rapid growth, these sectors can then drive an evolution of the industrial structure. For instance, the historical rapid emergence and growth of the textile and the steel industry was driven by a cluster of technologies, and particularly GPTs, which find use in many economic sectors. In a similar way, today's technological breakthroughs in the digital, physical and biological realms, and the fusion of these technologies, are driving the fourth industrial revolution (Box 4.3, overleaf).

Key term: Long wave theory
Nikolai Kondratiev's concept of cycles in capitalist economies, with cycles lasting between forty and sixty years consisting of alternating periods of high and then low growth. Adapted from: https://corporatefinanceinstitute.com

In line with the **long wave theory**, the 5th Kontratiev cycle that began in the 1980s is considered to be the information and communications technology (ITC) cycle (Weizsaecker et al., 2009). As already mentioned, green technology (requires interdisciplinary knowledge of the environmental impacts of any technology use. When considering the 5th cycle, ICT by itself cannot be considered a 'green technology' per se but much rather has certain characteristics that may be considered more or less green, also depending on use and context.

ICT does exhibit some sustainable characteristics. It presents opportunities to improve efficiencies in energy and material use, with digital products such as e-books and digital music de-materialize production and

Box 4.4: Innovation driving the energy transition

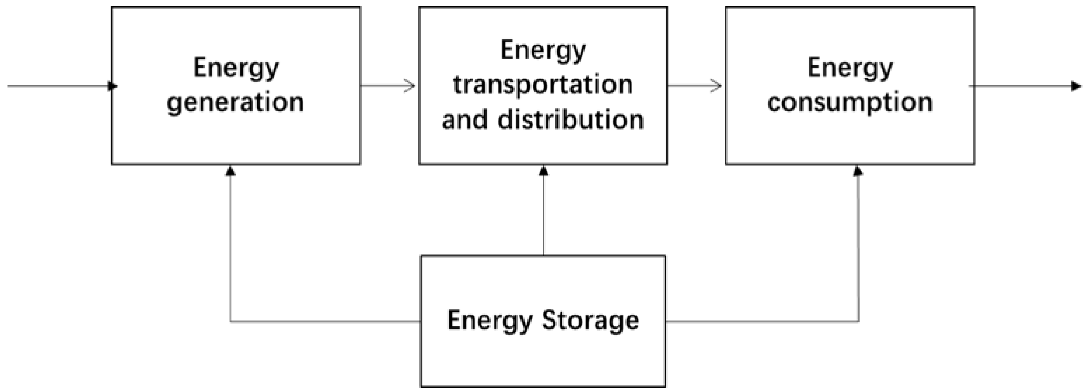
An energy system value chain includes phases of energy generation, energy transportation and distribution, energy consumption, and energy storage, as shown in Figure 6.

Energy consumption continues to increase, driven by factors such as population growth, industrialization and urbanization. Meanwhile, it is estimated that 1.2 billion people in the world today still lack access to electricity. More than 80% of the global energy mix is still based on fossil fuel extraction, while the share of renewable energy remains small. Energy consumption and production accounts for around two-thirds of the global GHG emissions, and a transition towards a sustainable, secure and inclusive global energy system is therefore required. Within this system, technological innovations can play a key role in each stage of the energy system value chain.

Renewable energy and energy efficiency are at the core of this transition, and represent up to 90% of the potential global emission reductions that can be achieved. The decarbonization goal agreed by States in the Paris Agreement requires accelerated improvements in energy efficiency across all sectors, keeping the total primary energy supply at the same level between 2015 and 2050, while the world economy grows threefold. In addition, the development and wide diffusion of renewable energy technologies, and at a global scale can push the economy to move away from its dependence on fossil fuels. By 2050, it is expected that two-thirds of the total primary energy supply will come from renewables.

Source: Dutta et al., 2018

Figure 6. Stages of energy system value chain (Adapted from Dutta et al., 2018)



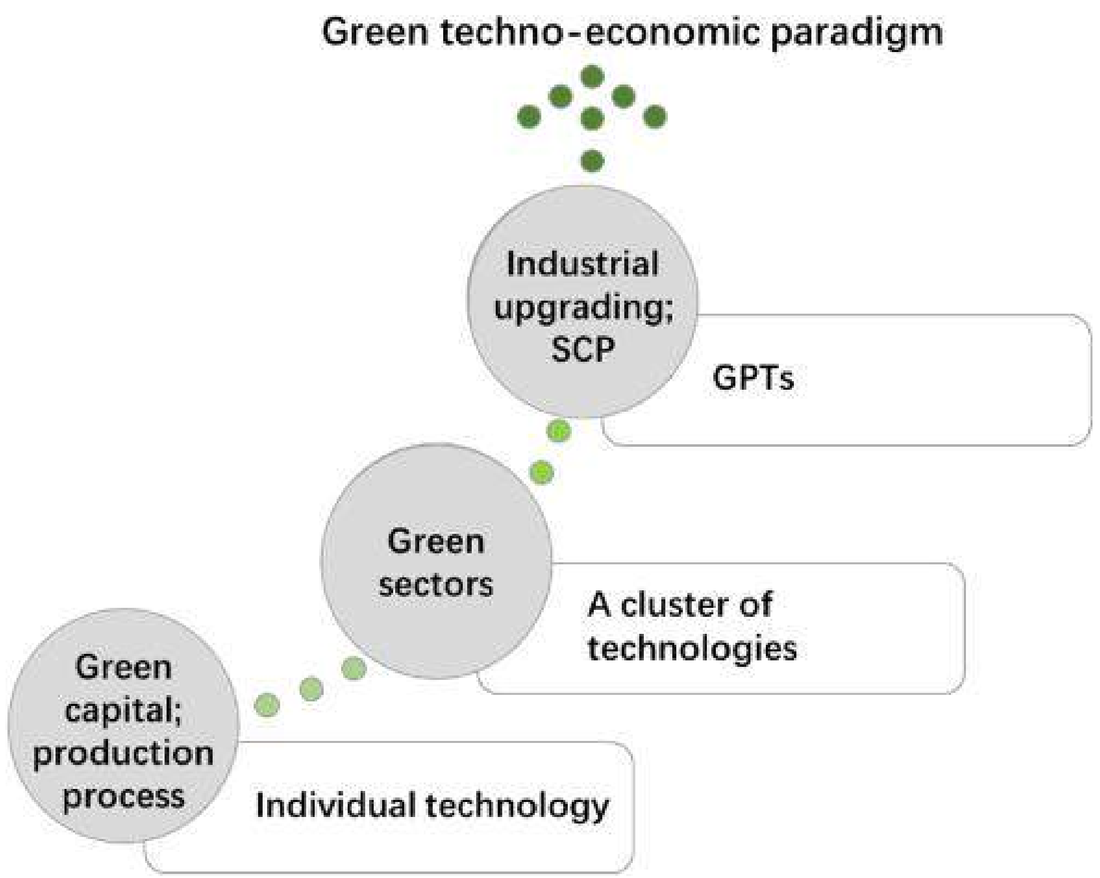


Figure 7. Green technology supports green economy transition at different levels (by author)

distribution processes. It also has a profound impact on economic structures and societal behavior patterns. The now habitual use of email, electronic documents, and the internet (i.e. remote working) has radically reduced the need to travel for work and meetings. However, at the same time it has been suggested that ICT has led to an increase in long-distance travel, through the facilitation of global economic activity (Plepys, 2002; Berkhout & Hertin, 2004). Evaluating its far-reaching environmental impacts is therefore difficult.

As the discussion serves to illustrate, it is hard to identify and measure all of the environmental impacts of ICT, which is also true for many other technologies. ICT is continuing to have a significant impact on our economies. Perhaps more importantly, many new technologies have been enabled and enhanced by ICT, such as the Internet of Things (IoT). Interdisciplinary evaluations and prudent considerations of the environmental impacts of emerging technologies should therefore be taken.

Meanwhile, the global scientific and technological system is becoming ever more complex. Cross-disciplinary integration is accelerating, new disciplines continue to emerge, and scientific frontiers keep expanding. Significant breakthroughs are either being made or are anticipated in basic scientific fields. In this context, technologies that support a green energy system are briefly introduced in Box 4.3.

Green technology can therefore support the transition towards IGE at different levels (Figure 7, overleaf). At the individual technology level, the greening of technology refers to the invention and innovation of specific technology, and the integration of new technical skills into the production process. At the sectoral level, a cluster of technologies can contribute to the greening of individual sectors, based on the integration of heterogeneous areas of knowledge with focus on a whole-systematic approach. Once these have been achieved, a paradigm shift to a green techno-economic paradigm requires the building of a new sense of societal and economic value, predicated on a profound change in production and consumption patterns.

3. Developing green technology: policies and practices

New technologies often find themselves in an unfavorable position in the initial phases of development and marketing, and it is therefore important to encourage the development and market diffusion of new green technologies. This section will examine market failures that inhibit and prevent the success of green technologies, and will introduce the policies that are necessary to overcome these.

3.1 Market failure related to technological green innovation

Market failures prevent financial markets from allocating and directing the necessary amount of financing and resources towards the development of new technologies at a level that would be optimal for society. For this reason, policies that facilitate research and development (R&D), and market uptake of new green technologies are essential. The most common examples of

Key term: Market failure
A situation in which the free market becomes ineffective due to distortion in the market, for example when supply is not equivalent to the demand. Some factors that may contribute to distortion in the free market include government regulations, monopoly of power, minimum wage etc. Adapted from: https://corporatefinanceinstitute.com

Box 4.5: The diffusion of innovation

Innovations are not taken up by everyone at the same speed. Market diffusion proceeds in user groups, starting with lead-users, who initially develop the first prototypes of innovative products, and ending with laggards and change skepticists, who are the final group to uptake and adopt a new technology.

The lead-user theory was originally developed by von Hippel in 1986. He observed that some users experience technology needs at a much earlier stage than others. Those users will then develop prototypes to satisfy their own needs, which will then only later be experienced by the mainstream majority of the population (Franke et al., 2006, von Hippel, 1986). In this respect, it is only once lead-users have developed the prototypes and first commercial versions of products that the market adoption process of innovative products and technology begins.

According to Rogers (1962), the theory of innovation diffusion splits the consumer market into five different groups. Since innovations are not taken up by everyone at the same speed and rate, it is then important to understand the technological needs each of these consumer groups in order to identify what could potentially promote or hinder an innovation's market diffusion. Each of these groups are briefly introduced below (adapted from LaMorte, 2018; For more detailed information, refer to Rogers, 1962):

- Innovators: The earliest adopters of a new innovation or technology. They generally take risks because they are interested in developing new ideas.
- Early Adopters: Opinion leaders who embrace new opportunities. They are aware of consumer needs, which lead-users have already experienced and identified, and are comfortable with adopting new ideas.
- Early Majority: Not innovation leaders, but still embrace new ideas at an earlier stage than the majority of the population. They observe that an innovation works and are then willing to adopt it.
- Late Majority: Generally sceptical towards innovation. They will only adopt an innovation once it has been proven to work by the majority of a population.
- Laggards: Conservative users that are very sceptical of innovation, and are therefore usually the last to adopt new products and technologies.

market failures in this context are outlined below.

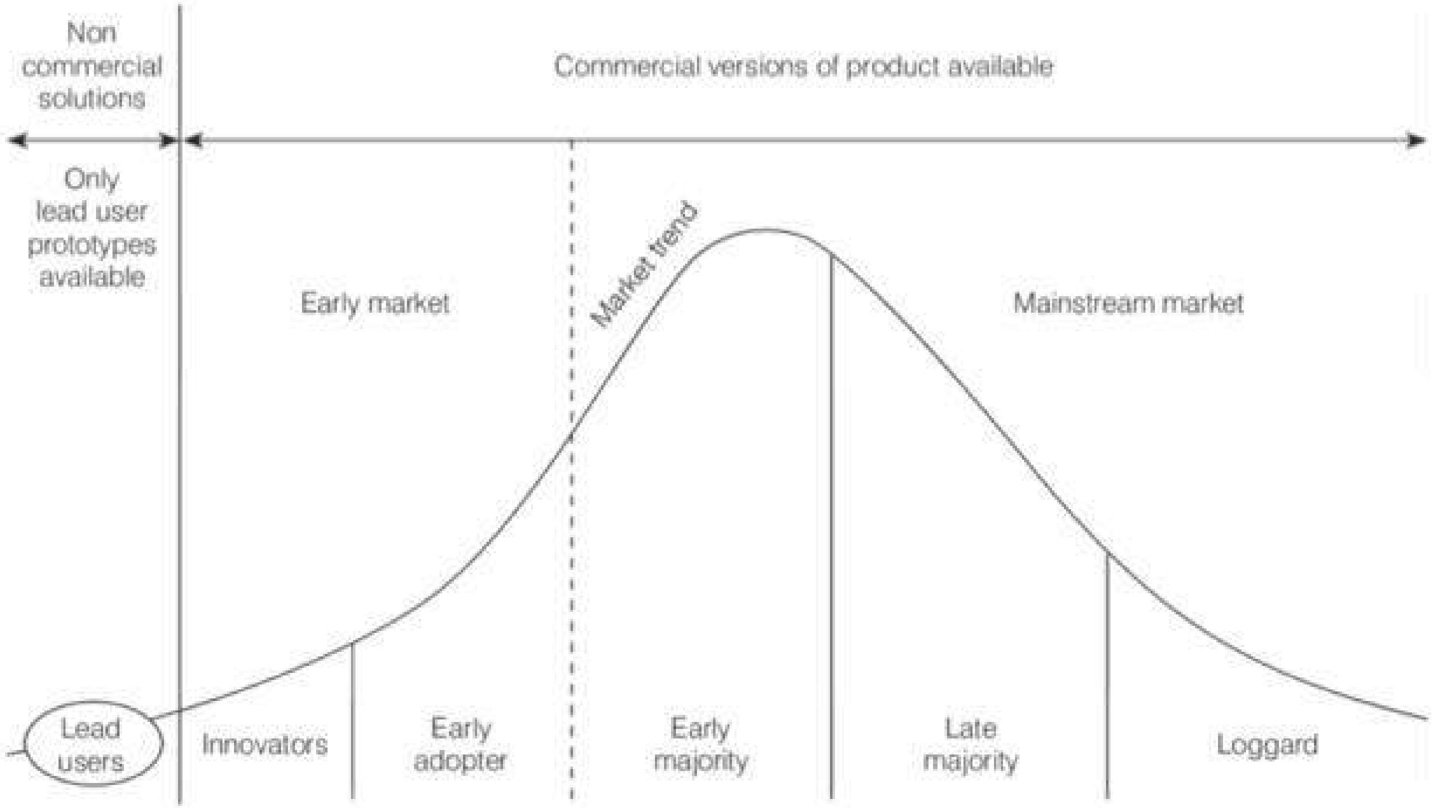


Figure 8: The lead user concept (von Hippel, 2005)

Knowledge externalities

The development of new technologies requires companies or businesses to make significant financial investments upfront. Moreover, whereas a single company might have financed the generation of new knowledge completely alone, it cannot then reap all of the financial benefits that this new knowledge creates. While patents are intended to protect innovations and intellectual property rights, they cannot fully exclude other companies from exploiting and benefitting from this new knowledge. Market competition will then further reduce the value of new technology, creating a positive externality in the form of lower consuming pricing. These "knowledge spillovers" disincentivize companies from investing in innovation or the development of new technologies (Jaffe et al., 2005).

Incomplete information

Information asymmetries between the developers of new technologies and investors can mean that insufficient money is allocated to the research and development of these new products and services. Developers, generally, have a greater understanding of their own new technologies, and the potential that it might have on the market. However, since they are often in a position of trying to generate funding for their project, they have an incentive to overstate either the value or the expected success of their product (Golove & Eto, 1996). For investors, it can then be difficult to judge whether these expectations are realistic, causing them to either underinvest or to demand a premium for their investment, which negatively influences the development of new technologies (Jaffe et al., 2005).

Adoption externalities

Adoption externalities do not refer to the development of new technology, but instead to its subsequent diffusion. The Theory of Technology Diffusion identifies three stages: "invention" – the first technical implementation of an idea; "innovation" – the first commercial introduction of a new product or business method; and "diffusion" – the gradual adoption of a new way of doing things by multiple actors (Schumpeter, 1942). At the diffusion stage, technology develops as more users adopt it, as initial previous users share information on its existence and its usage. As this process develops, and as new compatible products are developed, the value of the technology increases. These adoption externalities are important to understand the market diffusion process of a new product or technology (Jaffe et al., 2005), and Box 4.5 introduces the concept of diffusion of innovation in greater detail.

Coordination Failures

Coordination within and across sectors and industries is essential when new technologies attempt to change entire socio-technical systems. Companies and businesses will not financially commit to major projects unless related investment needs can be guaranteed. For instance, the development of offshore wind-farms requires the construction of underwater steel structures, the presence of electricity grids, and a synchronized outlay of wind turbines. In the absence of such coordination, companies and businesses will not commit to investing in the development of the necessary technology (Altenburg & Pegels, 2012).

In addition to these market failures, environmental externalities (see Chapter 1) also have the effect of distorting financial markets. In order to achieve a socially optimal level of green technology development, both kinds of market failures therefore have to be addressed. While environmental regulation works to internalize the effects of environmental externalities, policy instruments that promote both the development

Box 4.6: Case study: Green innovation in the United Arab Emirates

In October 2014, the United Arab Emirates' Government launched its National Innovation Strategy with seven innovation priority sectors (The United Arab Emirates' Government, 2018): Renewable energy, transport, education, health, technology, water, and space.

Within the renewable energy sector, the UAE has since made great progress, recording an astounding 29-fold increase in renewable energy investment of US$2.2 billion in 2017. This investment was concentrated on two Photovoltaic (PV) projects, the two largest such projects developed anywhere in the world: Sheikh Mohammed Bin Rashid Al Maktoum Solar Park Phase III installation, at 1.2GW and US$899 million, and the Marubeni JinkoSolar and Adwea Sweihan plant, at 800MW and an estimated US$968 million (FS-UNEP Collaborating Centre, 2018).

In order to guide the formulation of its national innovation strategy, as well as the activities of both the private sector and civil society in advancing the UAE's Green Economy transition, a number of initiatives were established. The UAE Green Business Toolkit is one such example. The Toolkit is intended to inspire the private sector to make their businesses eco-friendlier and more socially responsible, and to guide them in this process. The Toolkit provides guidelines on how to green existing businesses, or to start your own business as a green entrepreneur, focusing on three key areas:

- Green office: Focusing on typical office uses of energy, water, and other material goods and resources, the Toolkit presents examples of how to green offices by making small changes in how these goods and resources are used.
- Green procurement: This area focuses on procurement practices, including improving energy efficiency, lowering emissions, avoiding hazardous materials, and increasing recyclability. It also takes social aspects into account, such as ethical conduct and community development.
- Green products: This area focuses on enhancing the sustainability of produced goods and services, through reducing the use of resource materials, energy, and water at the input stage, and then by minimizing waste and emission outputs (UAE Ministry of Climate Change and Environment, 2018).

Dubai, as a leading smart innovative city both within the UAE and the wider Middle East region, has also developed a number of green technology initiatives. For example, in November 2015 His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai launched the US$27 billion Dubai Green Fund in November 2015, as part of its broader Dubai Clean Energy Strategy 2050. The strategy aims to provide 7 per cent of Dubai's energy mix from clean energy sources by 2020, 25 per cent by 2030 and 75 per cent by 2050, eventually making it the city with the smallest carbon footprint in the world (UAE Ministry of Climate Change and Environment, 2017).

and market diffusion of green technology need to be implemented and applied.

4. Transition management

While the development and implementation of a supportive policy framework is essential to promoting green technology, a single policy instrument alone will not be sufficient to bring about the desired economy-wide changes. Instead, the development and adoption of a set of coherent and harmonized policies is required to steer the economy in the right direction. The transition management approach can be used to coordinate such policies, and to overcome any market failures which limit the development and market diffusion of green technology. Transition management is a governance approach that aims at "accelerating structural transformation of the whole economy or of important sectors by utilizing innovation opportunities and designing policies that foster private investment into those opportunities" (Never & Kemp, 2017, p.89). The transition management approach can thus accelerate the transition towards an IGE.

In this context, Box 4.6 introduces the integrated national innovation strategy of the United Arab Emirates (UAE), within which key priority sectors were identified and a number of innovation initiatives developed and applied.

In order to effect economy-wide changes, it is first necessary to analyze the dynamics of the overall economic system that you wish to change. By examining the behavior of the economic actors that are involved in its processes, it is then possible to develop an understanding of any possible opportunities and limitations for directing this change. Once this analysis has been undertaken, the actual implementation of strategies to guide the transition towards a new economic model is based on the transition management cycle, which is provided in Figure 9 overleaf (Loorbach, 2010).

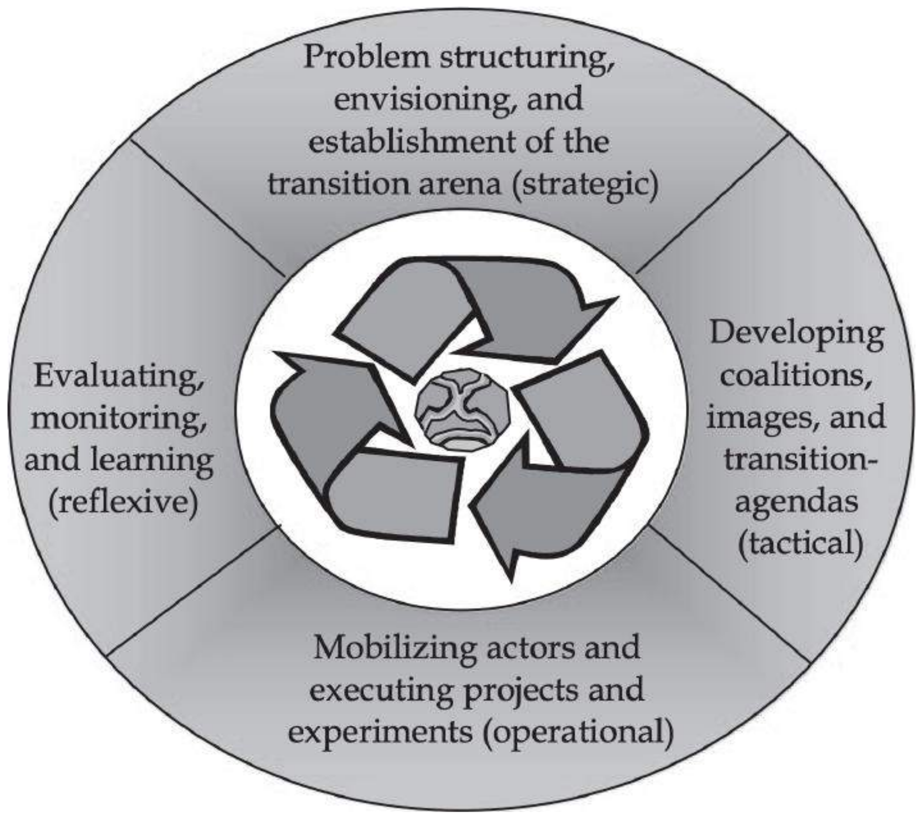


Figure 9: The transition management cycle (Loorbach, 2010, p.173).

According to Loorbach (2010), the transition management cycle takes place in a transition arena. This arena is first established as an innovation network, comprising of fifteen 'frontrunners' representing different societal institutions. These can be companies, non-governmental institutions, governments, knowledge institutions, and intermediaries (e.g. consulting firms). 'Front-runners' can then be experts or thought leaders, who are committed to investing time into the innovation process. Once a concrete transition issue has been identified, these front-runners develop a shared transition agenda with objectives, projects, and instruments, with the final outcome being a jointly agreed transition vision. Within the context of this vision, projects and experiments designed to give effect to this transition are then carried out.

Successful experiments and projects repeated and scaled up. In this regard, each phase of the transition management cycle is to be thoroughly monitored and evaluated; first, to capture new knowledge that has been created within the process, and then to both identify which projects have been successful and which elements of the process need to be amended in order to achieve the transition vision within a continuous policy learning cycle (Loorbach, 2010). In this respect, one significant challenge lies in the ability of institutions, within the transition management cycle, to carry out such projects and experiments independently and outside the scope of vested interests (To understand how institutions can be reformed to support the green economy transition, see Chapter 6).

4.1 Policies promoting innovation

The transition management approach requires the implementation of harmonized policies which promote innovation. Market-based environmental policies, such as cap-and-trade, are designed to internalize the true costs of environmental externalities such as by increasing the prices for environmental inputs. This then sends a price signal to consumers and companies, which can indirectly support the adaptation or development of green innovations (Jaffe et al., 2005). While this is indeed beneficial, such policies alone are not sufficient to ensure the research and uptake of green technology. In addition, targeted policies that promote green innovation are required on both the supply and demand sides of the market in order to correct market failures, redirect public and private investment into green technologies, and to understand the impact different environmental policies have on green technology diffusion.

Supply side

On the supply side, policies designed to foster green technology share the same characteristics as those that promote technology in general. Policy environments that promote and protect innovation, such as through patents and clear intellectual property rights, will similarly facilitate the development of green technology (OECD, 2012). As Figure 10 overleaf serves to illustrate, in most countries there is a positive correlation between the number of technology patent applications made and the number of applications that relate to green technologies; as one increases, so does the other (as shown by the green lightbulb).

In building an enabling policy and innovation-friendly environment, intellectual property rights represent a key and central element. Intellectual property laws give value to intellectual products which, in turn, provides an incentive for the development and diffusion of technology. They also protect the transfer of technology and innovation, which is particularly important in the context of small and medium-sized enterprises (SMEs) dealing with large corporations. In doing so, this protection facilitates the development of joint inventions (Brant, 2014).

Policies which strengthen entrepreneurship, and the ability of smaller and local firms to innovate also encourage new knowledge creation as well as its subsequent commercialization. Which sectors should be the focus of such policies is country-specific, and dependent on factors such as its level of technological sophistication and capacity to implement such policies.

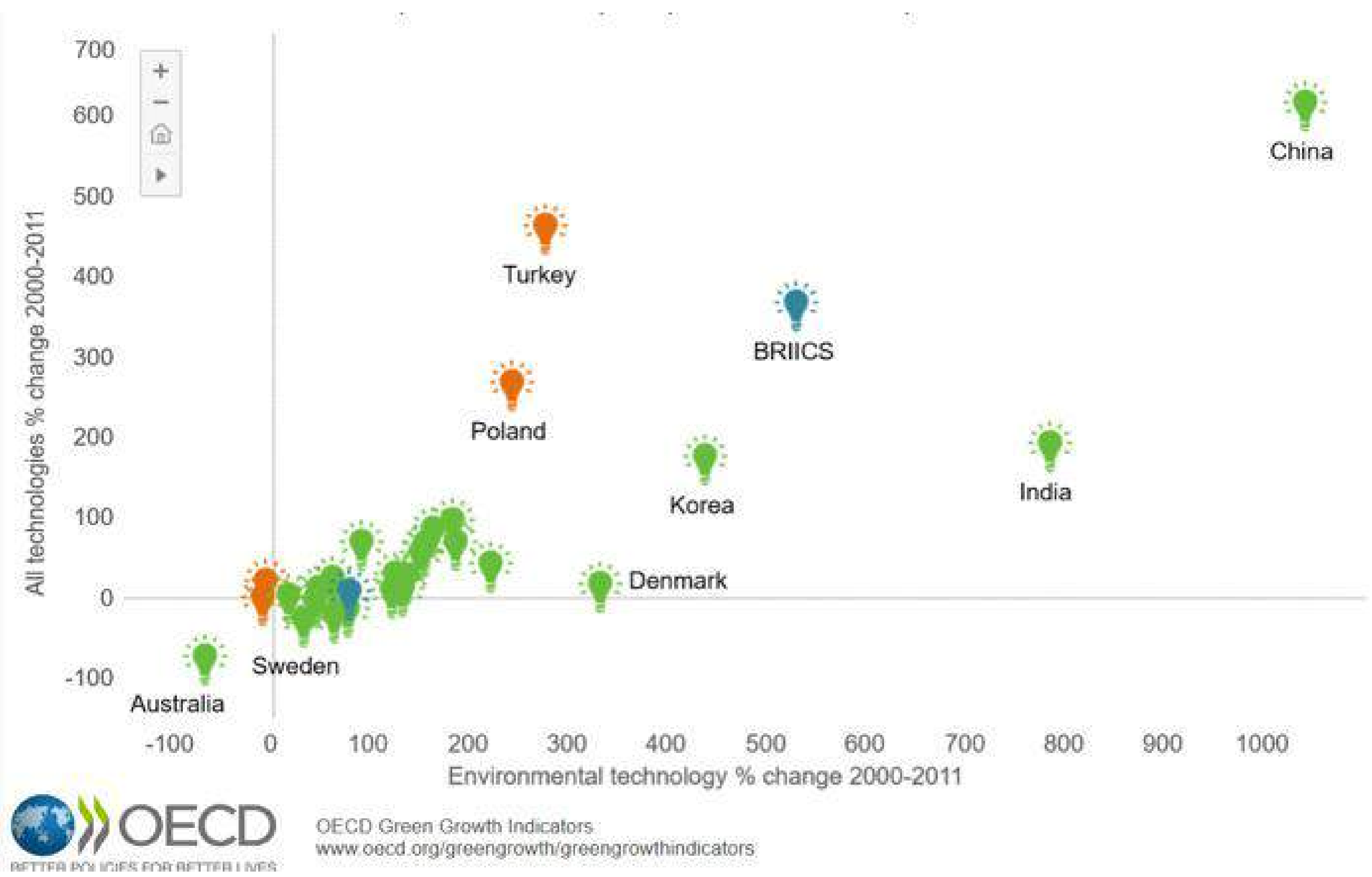


Figure 10: Technology development by country (Source: OECD, 2015)

According to the OECD (2012), common supply side policies and measures to promote green technology include:

- Public funding for R&D,
- **Venture capital** funding for green start-ups,
- Investment in research infrastructure, and
- Investment in higher education facilities and human resources.

Box 4.7: Support for small and medium-sized enterprises

In high-income countries, SMEs generate approximately 50 per cent of national Gross Domestic Product (GDP) and employ 60 per cent of the national work force. In low-income countries these numbers are slightly lower, with SMEs contributing 40 per cent towards GDP and 50 per cent of the employment (OECD & EU, 2014). Besides the creation of jobs and wealth, SMEs also play a valuable role in fostering innovation and social inclusion. However, the World Bank has estimated that 19 to 23 per cent of SMEs in developed countries, and between 26 to 32 per cent in developing countries, are either unable or only insufficiently able to acquire funding from the formal financial sector (Stein et al., 2013). This lack of funding significantly limits their ability to invest in R&D. To address this, Verdolini et al. (2018) propose a trilogy of measures that can be employed to both engage SMEs in the green innovation process, and to reduce the financial risks of investing in SMEs. These measures are:

1. A reporting system that can help monitor the scale-up of green-technology SMEs;
2. The use of public funds to signal innovative green-technology SMEs to investors; and
3. The inclusion of SMEs in the design of green finance platforms.

Key term: Venture capital
When investors provide financing or perhaps expertise to companies/businesses that are starting up and that have the potential for growth in the long term. Adapted from: https://www.investopedia.com

In this regard, funding and investment should be spread across the board. No single field of science can be identified as being a sole driver for the development of green technology, and public funding is thus best directed towards investments to enhance scientific research in general and to develop quality education facility and research centers. In terms of the actual R&D process, interdisciplinary teams from different societal institutions are generally better suited to identifying problems and creating novel solutions (OECD, 2012). This is a particular focus of the transition management approach (Loorbach, 2010).

In order to encourage the development of such partnerships and interdisciplinary teams, policymakers must create an enabling environment where regulation and intellectual property rights clearly facilitate the transfer and sharing of knowledge (the importance of intellectual property rights in this process was considered above). Policy environments that force the transfer and sharing of knowledge have a counter-productive effect, because it removes the incentive for companies to invest in R&D and discourages collaboration (Brant, 2014). In this respect, Box 4.7 overleaf introduces possible measures designed to engage SMEs in the green innovation process

Cooperation between public and private investors, sometimes in the form of public-private partnerships, also play a key role in this process. While an important source of investment, public funding for public research facilities can have the effect of crowding out private investment opportunities. With up to 80 per cent of global R&D funding in green technology development currently coming from the private sector, ensuring that there is sufficient incentive for companies to innovate is crucial (Brant, 2014).

Investment in education and human resources is another crucial component in the development of green technology R&D. High levels of knowledge and professional competence are key in this regard, enhancing the ability of R&D ‘staff’ (i.e. researches and developers) to learn, digest, and innovate, as well as their efficiency during the R&D process. Possessing strong R&D staff is important, as it often corresponds to a company’s ability to technologically innovate.

In this context, Song et al. (2018) have established modalities by which to improve staff quality as a means to enhancing company R&D performance. First, they suggest that R&D training activities should be practical, combining a formal technical education with practical experience acquired through on the job training. Second, R&D activities should encourage collaboration across different divisions, information communication, and the sharing and transmission of ideas; improving company efficiency and fostering the development of knowledge and experience. Third, the R&D process should be considered as a continuous learning process, and one in which knowledge is accumulated over time. This can be fostered by continuous on-the-job education and training. Finally, while stressing the importance of confidentiality, companies should not close themselves to developments in the outside world. Current advancements in technology, and the competitive advantage that is enjoyed by firms that hold these technologies, often means that internal R&D is driven by external developments and the activities of competitors.

Demand side

Demand side measures are designed to increase the market diffusion of green technology. This diffusion can be achieved indirectly, such as through market-based environmental policies as mentioned above, or through the implementation of direct policies. According to the OECD (2012), common direct demand side measures to increase the diffusion of green technology include **green public procurement**, regulation, and standards.

Key term: Green public procurement
Refers to the power that purchasers have in contributing to sustainable development through choosing to buy environmentally friendly products or services. Adapted from: http://ec.europa.eu and https://www.youtube.com/watch?v=7c-gmt6MSWg

Public procurement refers to the purchase of goods and services by the government or other public sector entities (Hommen & Rolfstam, 2009). In OECD countries, public procurement accounts for up to 15 per cent of total GDP, and thus plays a significant role in R&D and the diffusion of green technology. In this respect, the internet and the Global Positioning System (GPS) are just two examples of technological innovations that were originally developed for use by the public sector – in these cases, for the US military (OECD, 2012).

Green public procurement can stimulate green innovation by shaping market competition and, with the government or other public sector entities as a powerful lead-user, both drive the development of new technology and establish early markets for its diffusion, overcoming an otherwise fragmented demand (Hommen & Rolfstam, 2009, Rainville, 2017).

Research has shown that green public procurement can also engender positive spillover effects to private markets: the Leadership in Energy and Environmental Design (LEED) standard in public procurement, for example, has now been taken up by the private sector (Simcoe & Toffel, 2014). In this example, public procurement has led to the development of a technical standard. However, in most instances governments and public sector entities have limited autonomy to do so, with most of these being set and agreed at the international level. And even if they did have such autonomy, the rate of development within the green technology sector would raise questions regarding the suitability of governments or other public sector entities to determine future technological development paths. The effects of regulation, meanwhile, are not as straightforward, and more industry and sector-specific. Energy efficiency regulation in the EU, for example, has catalyzed huge progress in the development of energy-efficiency technology. Indeed, compulsory energy efficiency targets have had the complimentary effect of reducing prices for kitchen appliances while increasing their energy efficiency (Pelkmans, & Renda, 2014). However, this is an individual case, and Pelkmans and Renda (2014) have found that, in general, “more prescriptive regulation tends to hamper innovative activity, whereas the more flexible […] regulation is, the better innovation can be stimulated” (p.1). On the other hand, the OECD has concluded that when applied within an enabling policy environment alongside green public procurement policies, environmental regulation can help to establish customer confidence in new technology, as well as the development of minimum performance standards among producers (OECD, 2012).

5. Summary

Innovative green technologies and products represent an essential component in advancing the transition towards green economies. They satisfy both personal and company needs without causing irreversible harm to the environment, and they can therefore increase the speed with which economies become more sustainable. In this regard, they do not only make prevailing sectors more environmentally friendly, but can also lead to the establishment of completely new industries, as was the case with renewable energy. However, due to a number of market failures (such as knowledge externalities, incomplete information, adoption externalities, and coordination failures), the fact remains that both the public and private sectors are failing to sufficiently invest in the R&D of green technology. The adoption of a transition management approach by policymakers can play a key role in addressing these failures, and in directing the transition towards a green economy. Within such an approach, the development of harmonized policies on both the supply and demand sides can foster an enabling policy environment which promotes the development of innovative green technology and facilitates its market diffusion.

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CHAPTER 5: A JUST TRANSITION TO GREEN ECONOMIES: EMPLOYMENT AND SOCIAL ISSUES

CHAPTER 5: A JUST TRANSITION TO GREEN ECONOMIES: EMPLOYMENT AND SOCIAL ISSUES

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Articulate the importance of the labour market for a green transition and the resulting implications and effects on employment; and
- Formulate strategies and policies to overcome negative developments in the labour market to enable a just transition.

Moustapha Kamal Gueye et al[1]

Location and affilitation

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[1] This chapter is largely based on an ILO technical paper titled “A just transition to climate-resilient economies and societies: Issues and perspectives for the world of work”, prepared by the author with contributions from Claire Harasty, Olga Strietska-Ilina and Mito Tsukamoto (ILO, 2016).

CHAPTER CONTENTS

1. Introduction

This chapter discusses the importance of human capital and a proactive labour policy in the transition towards greener economies (ILO, 2016). Human capital can be defined by a broad interpretation of the labour stock, which includes skills, knowledge, education and research. In the pursuit of more environmentally sustainable economies and societies, human capital, on the one hand, acts as an 'enabling condition' and, on the other hand, as a 'parameter of adjustment' to achieve fair and acceptable social outcomes.

The enabling dimension can be thought of as a required input in green economic transformation and production processes, whereby its absence can become a constraint for green growth. For example, unless investment is made to build skills, retrain and requalify workers, the potential for growth in environmental goods and services industries can be hampered.

The adjustment parameter reflects policy objectives that recognize that the structural, economic and social changes that green economies entail will benefit some, while impacting negatively on others. Unless deliberate social policies are put in place to minimize negative social impacts, green economies will not be inclusive or just. Of equal importance, concern about the implications for jobs can be a powerful factor of resistance with far reaching political consequences. In some cases, countries have lowered, limited or simply cancelled environmental policies, including international commitments, on the grounds of the negative effects that these policies have on employment.

The chapter sets out by examining the consequences that degradation or loss of natural capital has on employment. It focuses on phenomena such as climate change, natural disasters and heat waves, as environmental impacts that bring shocks to the economy and have immediate consequences for enterprises and workers.

Secondly, it discusses how a transition to greener economies and subsequent structural changes in the economy and technology-related developments will have various effects on labour markets. The chapter will then discuss four principles channels of change, which may be observed in the literature and via country experience.

Finally, the chapter discusses why investing in human capital is not only a condition for success, but also a required building block in the shift to a greener economy. It does so by articulating the concept of a 'just transition' as a principle of social justice and a practical guiding framework to connect growth and economic policies with social objectives.

The chapter highlights that while most research suggests that the potential job creation of a transition to a greener economy outweighs the risk of job losses, and positive labour market outcomes can be expected overall, specific policies to ensure an active engagement in the world of work, social dialogue, and social protection are indispensable for a just transition that leaves no one behind.

2. Natural capital degradation: Risks to decent work

The risks arising from environmental degradation, and climate change in particular, range from economic and welfare losses, damage to health and labour productivity, and forced labour migration (Jessoe et al., 2018). The interrelation of these various types of risk translates into significant challenges for decent work. It is estimated that 1.2 billion jobs depend on a stable environment and ecosystem services. Therefore, a healthy planet and a stock of natural capital are necessary conditions for decent work, productive enterprises and sustainable livelihoods (ILO, 2018). In many instances, jobs in sectors characterised by informality and deficits in decent working conditions are further undermined by climate impacts due to higher vulnerability of workers and communities in sectors such as agriculture.

2.1 Economic losses

Current resource and energy-intensive economic growth models combined with the increased frequency and intensity of natural disasters have economic costs. Although debates about the **scale economy** remain open, there is growing evidence that uncontrolled climate change, scarcity of vital resources, such as fertile land, clean air, and water may have negative impacts on the economy and jobs. For example, a decade ago, the Stern Review (Stern et al., 2006) suggested that in a business-as-usual (BAU) scenario, long-term climate change would reduce welfare by an amount equivalent to a reduction in consumption per head between 5 and 20 per cent globally. Economic sectors most impacted by climate change include agriculture, forestry, energy, transport, manufacturing and building and construction (Planet Forward, 2014). Together, these employ more than half of the global workforce. For instance, agriculture alone provides jobs to 1.3 billion people, most of them working poor, which is close to 40 per cent of global employment (ILO, 2016).

Key term: Scale economies
Microeconomic concept that describes a reduction of production costs due to an increase in the produced quantity. Adapted from: https://dictionary.cambridge.org

One billion people live and work in low-lying flood prone areas directly affected by the rising sea-level and flooding. The World Bank estimates that due to global flooding, damage and loss of life will increase from US$6 billion in 2005 to US$52 billion a year by 2050, causing massive labour migration. For example, in 2014, Typhoon Hagupit hit the Philippines, affecting 800,000 workers, many of whom were forced to migrate (see Box 5.1, right, for more detail). Also, the 2011 drought in East Africa affected 13 million people, mainly farmers and pastoralists, with devastating impacts on local incomes, jobs and livelihoods (ILO, 2016).

Box 5.1: Physical impacts of climate change on jobs

Facing an average of 20 typhoons a year, the Philippines is the third most disaster-prone country in the world. Storms have been getting stronger and more deadly in recent years. In 2014, Typhoon Hagupit, locally known as Ruby, damaged and interrupted the livelihood of 800,000 workers overnight. About 370,000 of these workers were in vulnerable employment, living in poverty and accepting whatever work was available to them.

In response to the impact of Typhoon Hagupit, development cooperation agencies such as the International Labour Organization (ILO) provided emergency employment and sustainable livelihood support. Emergency employment programmes guarantee a minimum wage, extend social security, health and accident insurance coverage, and ensure safety at work through the presence of on-site medical support and provision of personal protective equipment, such as masks, helmets, gloves, boots and protective clothing.

Apart from bringing much-needed cash into the affected areas, this support helps workers to develop new skills, earn a decent wage and access better working conditions, including social protection coverage. These are not just labour rights but also basic human rights, which need to be taken into account in times of crisis and disaster. Such programmes are designed and implemented in close cooperation with national governments, employers' and workers' organizations and the Humanitarian Country Team of the United Nations (ILO Newsroom, 2014).

2.2 Impacts on labour productivity

Labour productivity is usually understood to mean the quantity of production obtained per unit of labour. This can be represented by the number of hours worked or the number of employees. Improving labour productivity has been a key focus of economic productivity. Resource productivity measures the efficiency in using natural resources when producing goods and services. A recent study by Stocker (2015) examined the relationship between resource and labour productivity with a conclusion that resource productivity and employment are strongly linked. High levels of employment tend to also be accompanied by high levels of resource productivity (Stocker, 2015).

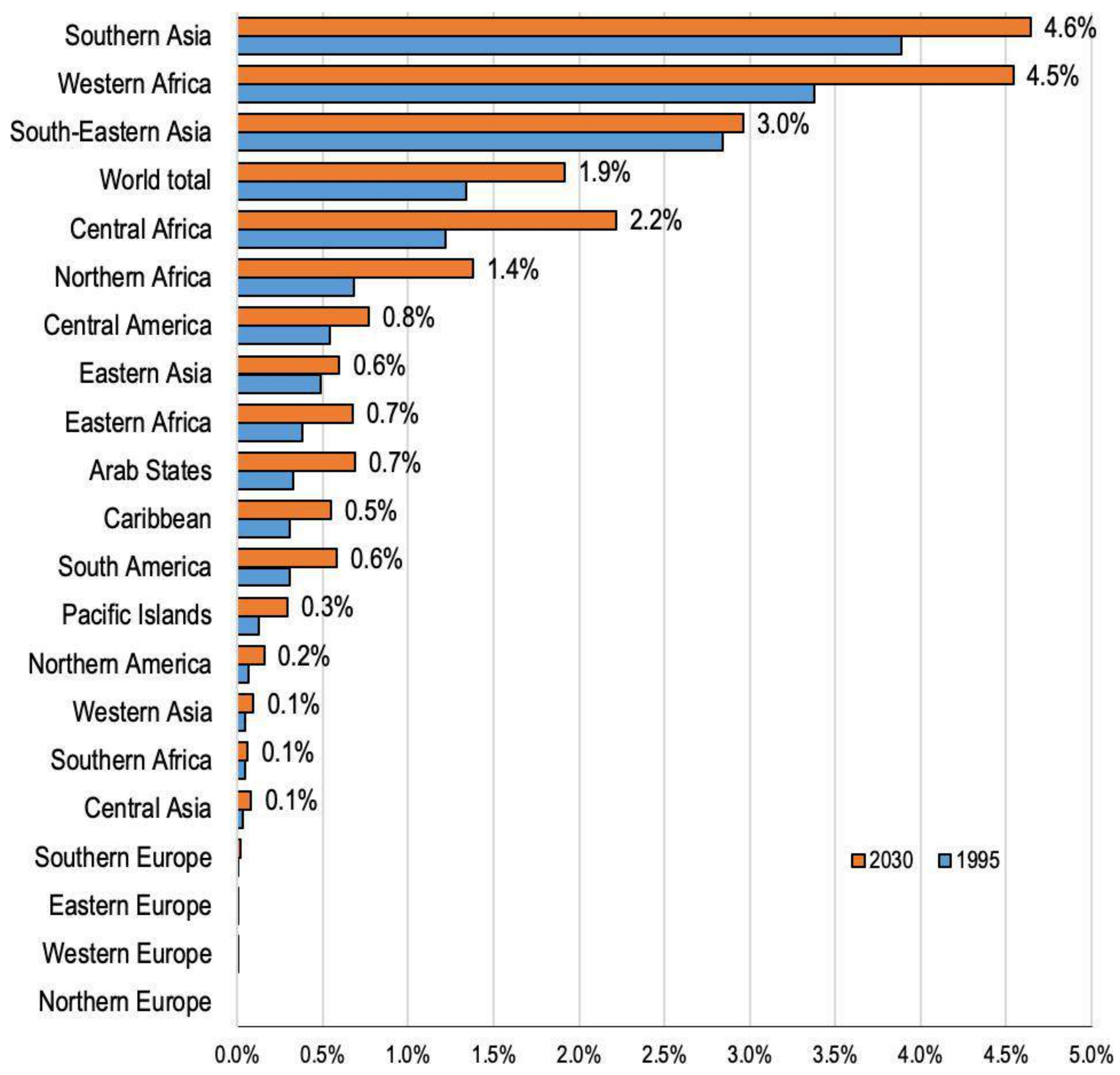
Studies by the ILO have suggested that the resource-intensive development model of the past will result in rising costs, loss of productivity and disruption of economic activity. Estimates based on the ILO Global Economic Linkages (GEL) model suggest that productivity levels in 2030 would be 2.4 per cent lower than today and 7.2 per cent lower by 2050 in a business-as-usual scenario. This is in line with the findings of a number of studies, which analyse economic damages because of environmental degradation and loss of basic ecosystem services (ILO & IILS, 2012).

Generally, economics has historically focused on improving labour productivity rather than progress on energy and resource productivity. For example, it is estimated that in Europe, over the past 50 years, labour productivity has grown nearly four-fold while energy productivity increased by less than 25 per cent. Achieving a circular economy will require bridging this

Figure 1. Percentage of working hours lost due to heat stress under a 1.5°C scenario, 1995-2030

Note: Due to warming temperatures, some areas will become too hot to work. Under a conservative scenario of warming at 1.5 degrees, 1.9 per cent of work hours will be lost by 2030 (up from 1.3 per cent in 1995). Agriculture and construction will be hit the hardest.

Source: ILO calculations based on ILOStat and HadGEM2-ES and GFDL-ESM2M climate models.



gap between labour productivity and resource productivity (see Chapter 1, Annex, for more information on circular economy).

One dimension of environmental change, which is likely to have significant consequences on employment and productivity, although it receives little attention in policy and science, is the rise in global temperatures and its impact on the workforce. Excessive workplace heat is a well-known occupational health and productivity danger: high body temperature or dehydration causes heat exhaustion, heat stroke and in extreme cases, death. A worker's natural protection is to slow down work or limit working hours, which reduces productivity, economic output, pay and family income (Kjellstrom et al., 2016). The IPCC's 5th Assessment Report confirmed that labour productivity impacts could result in output reductions in affected sectors exceeding 20 per cent during the second half of the century. Overall, the global economic cost of reduced productivity may be more than US$2 trillion by 2030 (Kjellstrom et al., 2016). As the IPCC report suggests, "Particularly at risk are agricultural and construction workers as well as children, homeless people, the elderly, and women who have to walk long hours to collect water." (IPCC 2014, p.71) Beyond productivity losses, there are also impacts on human health. These effects are dominated by malnutrition, diarrhoea, malaria and heat-related cardio-respiratory disease. A more recent study by the ILO found that heat stress would increase with projected temperature-rise particularly in agriculture, which can result in several medical conditions, including exhaustion and stroke. The report calculates that 2 per cent of hours worked globally will be lost due to sickness from heat stress (ILO, 2018).

2.3 Employment shifts in the transition towards a greener economy

A global transition towards a low-carbon and sustainable economy entails both positive and negative impacts on employment. Generally, output and employment in low-carbon industries and services will grow, while energy and resource-intensive sectors, on the other hand, are likely to stagnate or contract. Yet, evidence suggests overall job growth resulting from the transition process (ILO, 2016).

From a conceptual perspective, employment will be affected in four different ways as green economy policies reorient the economy toward greater environmental sustainability.

Firstly, the expansion of greener products, services, and infrastructure will translate into higher labour demand across many sectors of the economy, thereby leading to the creation of new jobs (ILO, 2016). Examples include: jobs in renewable energy and energy efficiency (in manufacturing, transportation, building construction and operations); organic agriculture; various employment-intensive adaptation measures intended to protect and restore ecosystems and biodiversity; and in infrastructure and green (public) works, intended to adapt to climate impacts and build resilience.

Improving rural infrastructure, through the development of irrigation schemes, flood prevention measures, soil stabilization, reforestation works, rural transport maintenance and improved land tenure may enhance agricultural productivity and contribute to the world's food supply and local energy production. In addition to direct jobs are those in the supply chain (indirect jobs). As the incomes generated are spent across the economy, they create further employment (induced jobs).

Secondly, some existing jobs will be replaced as a result of shifts in the economy from less to more efficient, from high-carbon to low-carbon, and from more to less polluting technologies, processes, and products. Examples include a shift from truck-based transportation to rail, from internal combustion engine manufacturing to electric vehicle production, or from landfilling to recycling and refurbishing. These shifts can be gradual or sudden, and will likely take place both within and across different industries.

Thirdly, certain jobs may be eliminated, phased out or massively reduced in numbers, without direct replacement. This may happen where polluting and energy- and materials-intensive economic activities are reduced or phased out entirely. The continuation of large-scale mining and the burning of coal, in particular, are both incompatible towards a stable climate. Greater energy, materials, and water efficiency (along with boosts in recycling of materials and reusing of products) could lead to substantial job losses in the primary sector. As is the case with job creation, there are indirect and induced effects.

Finally, many, and perhaps most, existing jobs (such as plumbers, electricians, metal workers, and construction workers) will simply be transformed and redefined as day-to-day workplace practices, skill sets, work methods and job profiles are greened. For instance, plumbers and electricians working in the 'brown economy' can, in principle, be reoriented to carry out similar work in the green economy. Automobile workers will produce more fuel-efficient (or electric) cars. Farmers will apply more climate-appropriate agricultural methods, and therefore have a lesser impact upon natural capital such as fresh water, or a lesser impact upon global greenhouse gas emissions.

Predictions of positive net effects are often based on assumptions of perfect labour markets, where workers are mobile between jobs and locations and where there is sufficient supply of labour with the necessary skills. But this is not the case in the real world. In reality, workers are not always mobile and do not necessarily have the right skills. Without policies to address these issues, net employment effects of the transition to a green economy may be negative.

2.4 Job gains and substitutions

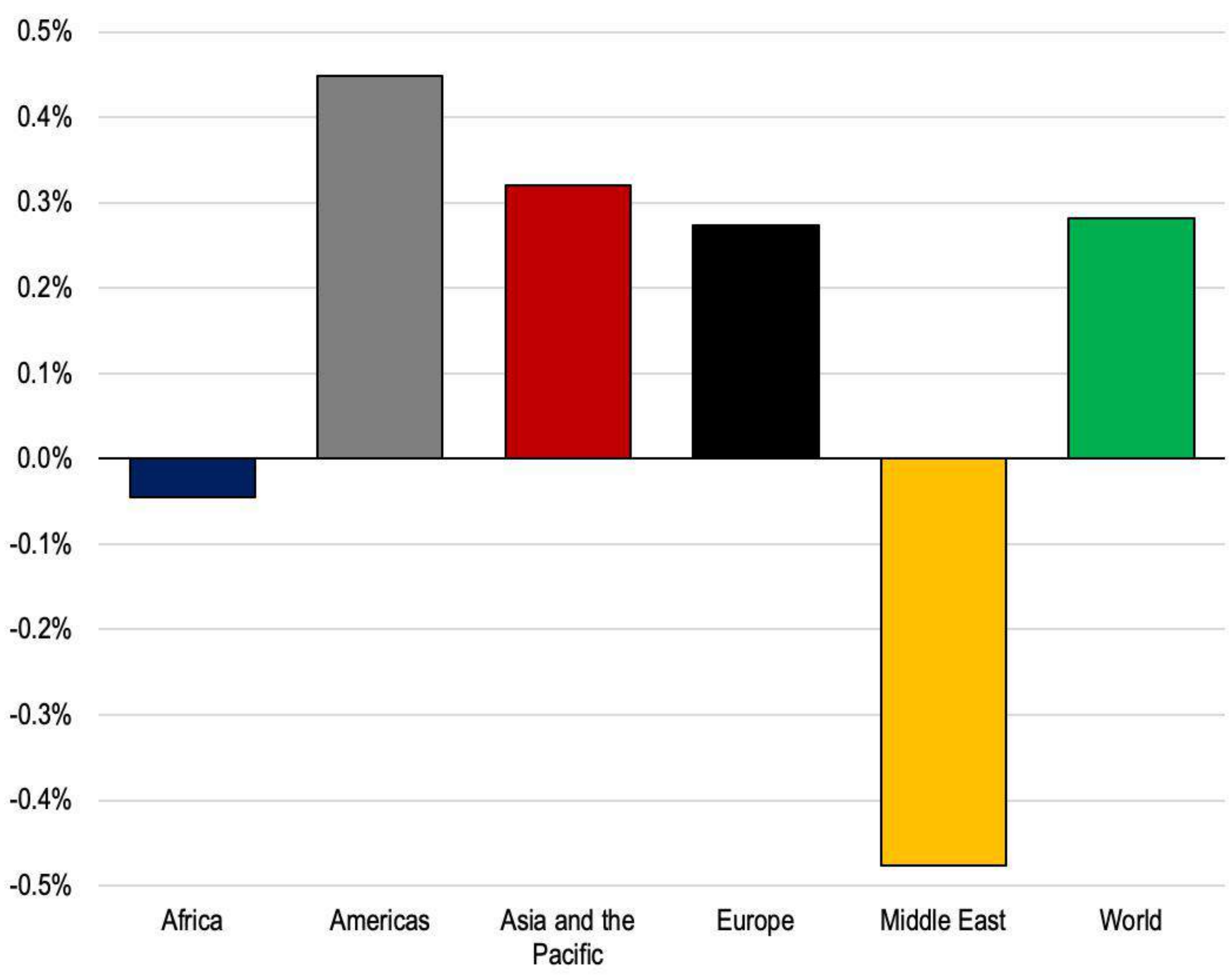
Most studies that have investigated the net impact on employment of environmental policy measures suggest it is positive. A review of 30 studies (covering individual countries and economic regions) finds that meaningful employment gains have either been achieved or are possible through the pursuit of climate policies (ILO & IILS, 2012). Most of the studies indicate net employment gains of 0.5–2 per cent, or 15–60 million additional jobs globally.

A more recent study by the ILO examines the potential jobs implications of pursuing the goal of the 2015 Paris agreement on climate change to limit global temperature increase (ILO, 2018). The report finds that with the right policies to promote a greener economy in place, 24 million new jobs will be created globally by 2030. In the process of limiting global warming to 2 degrees Celsius, the report estimates that the jobs created will more than offset job losses of up to 6 million, and generate a net gain of 18 million jobs globally.

The report further projects that, at the regional level, changes in the production and use of energy will lead to a net job creation in the Americas, Asia-Pacific, and Europe, representing some 3 million, 14 million, and 2 million jobs respectively. However, regional differences do exist:, a dependence on fossil fuel and mining may lead to net job losses in the Middle East (-0.48 per cent) and Africa (-0.04 per cent), if current trends continue (see also Figure 2, overleaf).

The energy sector stands out with rising investment and falling costs that have been the drivers behind an expansion of renewables, with wind power and solar PV being the most dynamic sectors. Global employment in the renewables energy sector has grown substantially in

Figure 2 – Employment in a green energy scenario, 2030, compared to BAU, by region (ILO calculations, based on Exiobase and IEA scenarios (ILO, 2018))



recent years; reaching an estimated 8.1 million jobs[1] in 2015 (IRENA, 2016).

Most renewable energy employment is found in China, Brazil, the United States, India, and members of the EU. It is important to note that this growth has, to date, supplemented jobs in the fossil fuel sector, due to the additional energy needs of emerging economies, rather than replacing them. This may well change if GHG emissions are cut as strongly as called for by climate science, in other words, if there is a comprehensive transition from fossil fuels to renewables (and to energy efficiency) (UNFCCC, 2016)

The potential for jobs creation is not confined to the energy sector. Agriculture, the biggest employer in the world, offers many opportunities both in the context of mitigation and adaptation to climate change, through **climate smart agriculture**. Evidence from various countries strongly suggests that low-impact (organic) farming methods tend to be more labour-intensive than conventional farming, opening an opportunity for new workers to be absorbed into agricultural jobs at least in the short to medium term. At the same time, agriculture and forestry also open up opportunities to build on traditional knowledge and empower communities that face several socio-economic vulnerabilities, including indigenous and tribal peoples. For example, as part of a global assessment, Herren et al. (2011), ran a **macroeconomic model** simulating green investments in the agriculture sector and concluded that the transition to sustainable agriculture could create over 200 million full-time jobs across the entire food production system by 2050. Another study by (Morison et al., 2005), with a sample of 1,144 organic farms in the United Kingdom and the Republic of Ireland, concluded that organic farms employ 135 per cent more full-time equivalent jobs per farm than conventional farms

Key term: Climate smart agriculture
'Climate smart agriculture' (CSA) incorporates a combination of traditional and modern techniques, which is one of the most cited and promoted techniques aimed at mitigating, and adapting to, climate change. See FAO: Climate Smart Agriculture: Sourcebook (Rome, 2013).

Key term: Macroeconomic model
Analytical tool describing the behaviour and operation of the aggregate economy within a country or a region. Adapted from: https://en.wikipedia.org

1 The estimates reflect annual data collection efforts based on a wide range of sources, including government agencies, industry and NGO studies, academic reports, and interviews with experts. Inevitably, the underlying methodologies vary, however, and data gaps remain.

2.5 Job transformation and redefinition

The majority of jobs will neither be lost nor newly created but redefined in terms of their occupational qualifications and profiles. This highlights that the greening of economies through public and private investment in the context of sustainable development and poverty eradication will rely on a mix of macroeconomic, industrial, sectoral, labour market, and skills policies (ILO, 2016).

One example is the buildings and construction sector, which is already experiencing job transformations on a large scale. Buildings are among the biggest users of energy, water, and materials, and they are the single largest emitter of GHGs. the same time, the sector has an enormous potential to improve energy efficiency, which lends it a leading role in the green transition (see also Box 5.2). Worldwide, building construction employs at least 110 million workers in formal jobs, plus an unknown but much larger number of informal labourers, including migrant workers (ILO, 2016). The renovation of existing structures and the construction of new energy-efficient buildings will require a significant number of workers with additional new skills in green technology practices to realize the large potential of economic and employment benefits. For example, the benefits of enhancing skills in plumbing for solar water heater installation, masonry for using alternative construction materials (such as compressed earth blocks), and the installation of rooftop photovoltaic panels In addition, building renovation will not only directly create and transform jobs in the construction sector, but also in supplier industries that produce insulation materials and energy efficiency equipment and materials, as well as in energy services requiring additional skills (Syndex, S. Partner & WMP, 2009; Trabish, 2011).

Employment dynamics in the building and construction sector are mainly driven by government incentives and policies. China achieved significant improvement in energy efficiency leading to important reductions in energy-related emissions (IEA, 2014). China’s 13th Five-Year Plan for 2016-2020 seeks a further 18 per cent reduction in carbon intensity compared with 2015 levels by 2020 (Climate Home, 2016). These measures point to a growing realization that **decoupling** economic growth from pollution is possible while creating jobs along the way. To achieve high-performance efficiency goals for buildings, working conditions and skill levels need to be improved for the construction sector to create decent, well-paying jobs (ILO, 2016).

Box 5.2: Energy efficiency in buildings in Europe and the United States

In the EU, an assessment of the potential impacts of the 2010 Energy Performance of Buildings Directive for the period 2011–2050 concluded that an accelerated pace of renovation could generate 0.5–1.1 million jobs annually (Buildings Performance Institute Europe, 2011). A US study found that energy efficiency retrofits of pre-1980 building stock could reduce electricity use by 30 per cent and create more than 3.3 million cumulative job-years of employment (Deutsche Bank Climate Change Advisors & Rockefeller Foundation, 2012).

Key term: Decoupling

The separation of the rate of resource productivity from the economic growth rate, meaning that more can be achieved with less resources. Adapted from: http://www.resourcepanel.org

2.6 Job losses

It is important to note that changes due to greening initiatives and climate change policies make up only some of the several factors that can lead to job losses. In fact, to date, greening initiatives for example has actually been a minor factor (ILO and IILS, 2012). The principal causes of declining employment in industries such as mining, fossil energy, or iron and steel have been relative; absolute price changes, increasing automation, and rising labour productivity have been occurring over several decades. For example, hard coal mining in France, Germany, Poland and the UK simply became too costly to be profitable (see Box 5.3).

An expansion of green economy and climate policies will need to bring about a fundamental change in the global energy mix in coming years and decades. The result will be further job loss in the fossil fuel sector—in coal mining, exploration and production of oil and gas, and among fossil fuel-powered power plants. Coal, as the dirtiest and most CO_2-intensive fuel, will need to bear the brunt of the changes to come along with the implementation of the Paris Agreement (see Box 5.3, overleaf).

The experiences of countries undergoing job retention in the coal sector highlight obstacles but also encouraging policy lessons.

2.7 Job quality

As noted by the ILO (2016), a dimension that is equally important as the number of jobs created, lost, or

Box 5.3: Transition in the coal mining industry: Germany

The case of the German coal mining industry underlines the need for well planned, well designed and socially fair transition strategies, including active labour market policies, social protection, retraining efforts, and economic diversification of regions most dependent on the coal industry. Total employment in Germany's coal mining industry has dropped from about 753,000 in the late 1950s to about 33,500 in 2014, an astounding 96 per cent decline. From the 1950s to the 1980s, automation eliminated jobs even while production held roughly steady. But the plunge in production from the 1990s and beyond accelerated job loss (Statistik der Kohlewirtschaft, 2015).

Galgóczi (2014) examines the transformation of the Ruhr region, Germany's prime hard coal-producing area, for general lessons in managing the transition challenges inherent in such a steep drop in coal employment. Even though resource depletion, automation, and rising competition from imports were the main driving factors, the lessons of dealing with this crisis are useful to consider in the context of climate-driven transitions. A key lesson that emerges is that a successful transition takes time, a strong vision of the future, and adequate resources. Worker co-determination (as part of a cooperative tripartite structure) has been an important factor in the coal sector, facilitating solutions that embrace a range of labour market policies.

For instance, for thousands of coal workers an early retirement plan was developed by the state government of North Rhine-Westphalia (NRW) in 1972, with transition payments for up to 5 years, to bridge the time until workers became eligible for pension payments. For younger workers, efforts were undertaken to find other jobs, with the help of personnel development centres and agencies specializing in employment promotion and training. As a result, in establishing higher-education institutions and technology centres, the region did manage to lay the foundations of a **knowledge-based economy** as an alternative to the coal- and steel-centred economy (UNFCCC, 2016).

Key term: Knowledge-based economy
Economy that heavily relies on knowledge and information as catalysts for growth and productivity. Adapted from: https://www.oecd.org

transformed, concerns the quality of employment. Jobs that do not offer **decent work** today, may or may not become more decent or greener with the structural transformation. Again, policies are critical in this respect. For instance, construction workers generally face poor working conditions that are among the most hazardous in terms of work accidents and occupational diseases, even in the formal sector. Jobs are often temporary rather than permanent and frequently filled by migrant workers who lack social protection. There are often complex subcontracting arrangements, particularly among informal workers, which makes for extremely hazardous employment conditions (Poschen, 2015).

Key term: Decent work
Decent work means opportunities for everyone to get work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration. Adapted from https://un.org

The ILO (2016) also notes that a shift in economic practises will affect a variety of areas linked to employment, including social protection, safe working conditions, workers rights, and the ability of workers' to assume a meaningful voice in decision-making. Generally, research indicates that effects will be positive. For example, occupational health and safety risks tend to be lower with a move towards a low-carbon economy (Poschen, 2015; Renner et al., 2008). An example of such risks is the shifting towards renewable energy which would avoid many of the severe health dangers associated with coal mining, even though some new hazards need particular attention. For example, workers producing solar PV panels are exposed to a number of toxic substances and electrical hazards; thin-film and emerging nanotech-based solar technologies may prompt health and safety-related concerns that will need to be addressed proactively. (SVTC, 2009 & 2014; EASHW, 2011).

2.8 Drivers of change: Technology and other factors

Transitions towards a greener economy are driven by a variety of factors. Some drivers relate to environmental and resource constraints that gradually lead to the integration of such dimensions in economic and growth policies. Other drivers are related to innovation and technological developments that enable economic growth to continue while the pace and scale of environmental impacts are minimised. Yet other drivers are purely linked to policy goals and objectives that aim to redirect investment and growth trajectories towards greater environmental sustainability.

Among these drivers, technology plays a central role in the transition to greener and more resource efficient economies (please refer to chapter 4 for a detailed discussion on the role of innovation and technological change for a green economy). **Digitally enabled automation** and **artificial intelligence** (AI) bring significant benefits in the form of new jobs and increased

Key term: Digitally-enabled automation
Digital transformation process which describes the incorporation of digital innovation and supporting infrastructure within existing business processes with the purpose of increasing efficiency. Adapted from https://www.techradar.com/news/what-is-digital-business-automation

Key term: Artificial intelligence
Simulated intelligence in machines which are designed to think like human beings while rationally taking the most plausible actions to achieve a specific target. Adapted from https://www.investopedia.com

Key term: Labour market polorization
Simultaneous increase in high-skilled and low-skilled jobs combined with a decreasing share of employment in middle-skilled occupations. Adapted from http://blogs.worldbank.org

productivity (McKinsey Global Institute, 2017). However, the shift to a new economy also calls for large-scale reskilling and a socially responsible transition, which poses challenges to employers, employees, and policy makers alike. Among these challenges is the increased **labour market polarisation**, where low and middle-skill jobs are more likely susceptible to automation while digital, entrepreneurial skills will be in high demand in the labour market of the future.

Digitalisation affects existing organisational and management structures in companies and touches on issues related to legal responsibility, data protection and work safety rules.

From the perspective of employment, technological change raises many questions that have yet to be answered: The first concerns its effect on employment, of course. Another question relates to its implications considering substitutability with other forms of capital. In particular, a key question that arises is to what extent technology can and will be substituted for human capital in the transition to a greener economy. The nature and scale of the technological development and its impact on employment have been studied for many decades.

A common assumption has long been, for the right or the wrong, that technological progress, by gradually leading to a substitution of human labour by machines, will translate into an overall loss in employment. A review of the literature (ILO ,2016), reveals that a simple answer does not exist.. The empirical evidence finds that impacts vary, depending on the waves of technological change (see also chapter 4). Based on an extensive literature review on technological progress and employment, Nübler (2017) observes that technological change is inevitably a dynamic process, which involves: (a) both job destruction and creation; and (b) transforming existing jobs, particularly in how work is organized, supporting Schumpeter's notion of 'creative destruction' (Schumpeter, 1942).

Nübler (2017) argues that debates on the impact of technology on jobs, which started as early as 1930 when John Maynard Keynes introduced the concept of technological unemployment, are still relevant today. This is owing to the fact that "unemployment, due to our discovery of means of economising the use of labour… is…outrunning the pace at which we can find new uses for labour," (Keynes, 1930, quoted in Nübler, 2017) – still persists today. She concludes that historical experience to date tends to discredit arguments of **techno-pessimism** when it comes to the overall employment outcome. The question that arises, subsequently, is whether, in the context of what has been labelled "the Fourth Industrial Revolution," (Schwab, 2015) there is an accelerated automation of occupations.

Key term: Techno-pessimism
The overestimation of security threats and risks associated with technological developments. Adapted from https://scholar.harvard.edu

A new dimension in the debate on technology and jobs, are environment-related technological innovations and their impact on employment. This question may be approached through a variety of angles. This chapter considers two aspects: job displacement and job creation.

In South Africa, for example, some 70,000 jobs in the electricity-power generation sector were lost between 1980 and 2000, at the same time electricity generation increased by more than 60 per cent. Similarly, in the European Union, an estimated 300,000 jobs in the electricity-power generation sector were cut between 1997 and 2004 (ILO & IILS, 2012). Overall, evidence points to the fact that technological innovations have played a much more significant role as a driver of job displacement than green-economy-relevant policies (ILO & IILS, 2012).

With regard to job creation, there is also evidence to suggest that innovation in the environmental sector has stimulated job creation. For example, in the case of the European Union, 'eco-industry' companies were found to employ over 4.2 million people in 2013, a figure well above car manufacturing, textile or chemical industries.

3. Investing in human capital for a just transition to a greener economy

The concept of human capital has become an accepted concept among economists following early writings by authors such as Gary Becker (2013). Human capital describes the stock of knowledge and attributes, including creativity, that materialize in the ability to perform labour in order to generate economic value. It is also referred to as the stock of skills possessed by the labour force encompassing the notion of investments in people (e.g., education, training, health), which increase an individual's productivity (Goldin, 2016).

3.1 Conceptualising Human Capital in the Inclusive Green Economy

In the context of the green economy transition, two observations can be made. First, the transition to green economies affects labour as an input to production, by way of a change in aggregate demand that leads to more demand for green products. This will require enterprises and a labour force to obtain the right skills and qualifications to deliver such goods and services. As discussed in the sub-section on training and skills development below, the availability of a skilled workforce contributes to the expansion of the environmental goods and services sectors, whereas skill shortages or inadequacy can hamper such expansion (ILO, 2016).

Second, the greening of economies will engender both job creation and job losses, although most studies point to a net job (ILO & IILS, 2012). However, the picture is much more complex as a result of factors due to delays in time and geographical shifts of industries - new green jobs are not necessarily created where other work is lost, or maybe provided right when new employment opportunities may be required.

In addition, it is essential to look at the underlying assumptions that scientific studies employ. Some economic models assume perfect labour market dynamics whereby labour mobility enables those who lose jobs to immediately enter occupations in growing green sectors. In reality, transitions in labour markets are more complex than economic models make appear. Environmental Goods and services industries that might be expanding do not necessarily require the same qualifications as declining, 'brown' industries, and workers who have lost jobs may have neither the skills nor the means to take up new job opportunities in new locations.

Investing in human capital and social policies is essential to bridge this disconnects. Transition policies can support workers and enable them to take advantage of new jobs created. That calls for coordinated and integrated approach to a just green transition, which includes social protection measures. This, of course, relies on appropriate planning and investment of financial resources. For example, Pollin and Callaci (2016) have estimated costs of a programme to support workers and communities that depend on fossil fuels in in the United States. They concluded that a rough high-end estimate for such a programme would require a relatively modest US$600 million per year, to pay for income, retraining and relocation support for workers facing retrenchments; pension guarantees for employees in affected industries; and effective transition programs for communities depending on fossil fuels (Pollin & Callaci, 2016).

Responding to the need to identify and create appropriate and integrated solutions for a green transition, the International Labour Organization (ILO) has formulated a guiding framework for a just transition, which will be discussed below.

3.2 Policies for a just transition

A green economy transition implies important structural transformations that will affect national economies, enterprises, foreign and domestic workers and their communities, thereby inherently creating (new) winners, but also potential losers. To respond to potential adverse impacts of the green economy transition on some, the notion of a 'just transition' aims to ensure that the transition is fair and maximizes opportunities for economic prosperity, social justice, rights, and social protection for all, and leaves no one behind.

At the International Labour Conference in 2013, governments, workers' and employers' organizations discussed and adopted the key guiding principles for a just transition towards environmentally sustainable economies and societies (International Labour

Box 5.4: Guidelines for a just transition

Policy coherence and institutional arrangements for mainstreaming sustainable development and ensuring stakeholder dialogue and coordination between policy fields;

- Establishing mechanisms for social dialogue throughout policy-making processes at all levels;
- Employment-centred macroeconomic and growth policies;
- Environmental regulations in targeted industries and sectors;
- Creating an enabling environment for sustainable and greener enterprises;
- Skills development to ensure adequate skills at all levels to promote the greening of the economy;
- Occupational safety and health policies to protect workers from occupational hazards and risks;
- Social protection policies to enhance resilience and safeguard workers from the negative; impacts of climate change, economic restructuring and resource constraints;
- Labour market policies that actively pursue job creation, limit jobs loss and ensure that adjustments related to greening policies are well managed.

(ILO, 2016)

Conference, 2013). The conclusions and resolutions on sustainable development, decent work and green jobs, adopted by the Conference, lead to a framework that could be used by policy-makers. In October 2015, a tripartite meeting of experts produced draft guidelines for a just transition towards environmentally sustainable economies and societies for all, with the ILO Governing Body successfully adopting a decision on the guidelines in November 2015 (ILO Governing Body, 2015). The Guidelines cover a broad range of policy areas, as also shown in Box 5.4, above.

The concept of a just transition has been particularly prominent in the context of global negotiations and policy addressing climate change. The Paris Agreement on Climate Change adopted in December 2015 recognizes “the imperative of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities”. In addition, the 21st Conference of the Parties (COP21) in Paris, adopted a work programme on the impact of the implementation of response measures (to climate change), comprising two areas: (1) economic diversification and transformation; and (2) just transition of the workforce, and the creation of decent work and quality jobs (UNFCCC, 2018).

In the sub-sections below, a few employment and social policies based on the ILO Guidelines are discussed with illustrative country applications (please note that material not cited specifically is based upon (ILO, 2016).

Labour market policies

Labour market policies are critical to ensure that the employment effects of the transition to climate-resilient economies are positive for everyone: the workers negatively affected by green economy policies linked to labour market restructuring, communities affected by climate change and other environmental disasters, and population groups disadvantaged by green policies (ILO, 2016). According to the ILO (2016), labour market policies are comprised of regulations and policies that influence labour demand and supply, and the interaction between the two. These regulations and policies influence the conditions of the labour market, upon which the employment effects of the transition to a low-carbon economy depend. Whereas ‘passive’ labour market policies are concerned with the provision of replacement income during periods of transition, i.e. joblessness or the search for employment, ‘active’ labour market policies refer to labour market integration through demand- or supply-side measures (Auer et al., 2008). Active labour market policies encompass five broad types of measures:

(i) Training schemes that consist of vocational and on-the-job programmes that target the long-term unemployed, laid-off workers, youth and other vulnerable groups along with special incentives for apprenticeships;

(ii) Job subsidies, which include measures to protect jobs, such as work-sharing schemes and interventions that promote hiring, including social security exemptions and one-off payments for hiring long-term unemployed;

(iii) Public employment programmes that cover not only traditional public works programmes, but also the new generation of public employment schemes and employment guarantees;

(iv) Entrepreneurship incentives that typically consists of a combination of entrepreneurship training and **microcredit**; and

Key term: Microcredit
Small financial loans granted to impoverished borrowers who strive to start their own business. Adapted from http://www.businessdictionary.com

(v) Job search assistance and other intermediation services that are provided by public and private employment agencies.

(ILO, 2016)

Job search assistance and job counselling aim at improving the match between demand and supply of labour and preventing long-term unemployment. They are relatively cost-effective, but require efficient employment services, are difficult to implement in times of crisis and are more suitable for formal jobs. Public employment services (PES) can inform and stimulate interest in green careers among future workers and the unemployed by providing information on vocational training and study routes, businesses and professions in green sectors, as demonstrated by the project "Meine Energie hat Zukunft" (My energy has a future) in Germany [available online]. In this project, the PES of the German town Bielefeld joined forces with a network of 120 companies, higher education institutions and learning providers, as well as the Association of German Engineers to lead experiments and workshops on solar energy, designing virtual wind farms, as well as taster events in physics (offering an insight into university life). Question and answer sessions were then provided between industry specialists and pupils as well as information events within the local schools. Another trend is the emergence of web job platforms for green industries, such as the renewable energy industry platform.

Training schemes aim at improving employability and reducing skill mismatches between the skills of workers (supply-side) and the requirements of the job market. Whereas such training schemes are important, as they build the human capital required for the transition to be successful they must be matched by appropriate short-run support schemes that can support workers in times of crisis (such as passive employment schemes). This may also mean that short-term skill gaps are difficult to address. Whereas longer-term planning would, of course be desirable, forecasting job skills which will be needed in the future is challenging.

Generally, however, longer-term trends like an economy-wide transition from fossil fuels can already be anticipated by regulators and supported. For example, a number of training centres are delivering vocational training for workers in targeted green industries, such as the China Wind Power Center. Dismissed workers from disappearing industries are retrained in order to place them in green industries. This retraining is happening at the initiative of local public employment services in cooperation with local businesses. This was also the case of the Le Mans region in France where workers, who were dismissed from the declining car industry, were retrained as mechanics and electro-mechanics - so that they could work in the newly created wind construction and maintenance industry. Around 95 per cent of car industry skills are transferable, which shows that building upon existing human capital can be very successful in developing new industries. In this case, the retraining helped foster the development of a cluster of industrial maintenance industries in the region (ILO, 2016).

Job subsidies aim at supporting labour demand by preventing lay-offs or encouraging hiring. They can be effective in encouraging green job creation in locations with high levels of unemployment and/or low levels of activity. They are, however, expensive and can have **deadweight**/substitution effects.

Key term: Deadweight effects
Cost to society which arises due to an inefficient use of resources. Adapted from https://www.investopedia.com

Typical examples of those effects include cuts to social security contributions for green start-ups.

Entrepreneurship incentives aim to promote entrepreneurship as a way out of under- or un-employment. They are an effective means of targeting poor, vulnerable groups, however only a minority of new enterprises are usually successful (Patel, 2015). In the United States, a growing number of **business incubators** are specifically designed for green start-ups. For example, the Green Exchange in Chicago provides retail, office

Key term: Business incubator
Organisation that aims at boosting the growth of start-ups and early stage companies, i.e. through supporting access to capital. Adapted from https://www.entrepreneur.com

and live-work space as well as a variety of marketing services for green businesses.

Public Employment Programmes aim to provide income to the poor/vulnerable while increasing employability and supporting labour demand by creating direct jobs. These programmes can be effective in situations of effective post-crisis, disaster, and measures linked to season-specific risks, to protect incomes and prevent poverty. As such, Public Employment Programmes offer indirect benefits to households, but they do not provide long-term employment. Green works refer to either both infrastructure and related employment-intensive approaches that have direct environmental benefits or as a response to a specific environmental context, including changes in climate and extreme weather events. They focus on forestry, irrigation, soil and water conservation and flood protection.

The transition to low-carbon and climate-resilient economies and societies is best conceived as a driver of structural economic change. This process of structural transformation is likely to involve imbalances in the number and types of jobs available. Labour market policies play an active role in addressing these imbalances and ensuring a just transition for all. They help workers and employers to make the transition with a smooth reallocation of workers from declining to growing firms/sectors, to reduce the adjustment costs for displaced workers, and to foster **eco-innovation** and diffusion of green technologies through technical education and vocational training (ILO, 2016).

Key term: Eco-innovation
Innovative business approaches that foster sustainability along the entire life cycle of a product while promoting a company's competitiveness and overall performance. Adapted from: https://www.unenvironment.org

Training and skills development

Skill shortages already pose a major problem for the transition to greener, climate-compatible economies and thus for job creation. Moreover, this is a problem that is likely to grow in the coming years. Poschen (2015) warns that with a lack of skilled and motivated workers in green growth sectors, hopes for creating a climate-compatible economy may not materialize. Shortages are the result of a number of factors, including: underestimation of the pace at which certain green sectors grow; a general shortage of scientists and engineers; a low reputation or limited attractiveness of some economic sectors; and shortages of teachers and trainers proficient in fast-growing sectors such as renewable energy and energy efficiency (Strietska-Ilina et al., 2011).

Strietska-Ilina et al. (2011) explain that "the challenge for skills development policy is to integrate environmental awareness and the right technical training for green jobs into education and training provision". Marrying these two objectives is essential, but difficult. Country studies compiled by the global report on skills for green jobs revealed that while coordination between climate/environment and skills policies can be comprehensive in some country cases, it is fragmented or practically non-existent in others. One observation made was a lack of cross-ministerial coordination (for more information on institutional challenges and reform, see Ch.6). Efforts by educational authorities to anticipate, identify, and provide skills do not typically include inputs from environment ministries and vice versa, education and training institutions are typically not involved in shaping climate policies. Safety and health issues are typically addressed separately, as well.

Besides the need to ensure that enough labour market entrants acquire the skills needed in the economy of tomorrow, retraining of existing workers provides another challenge. Retraining may be difficult for older workers and especially for low-skilled workers, or also migrant workers (again linked to skill-level or language), due to their challenge to 'skill-up' and compete for new jobs. Another challenge is linked to spatial shifts, in that green economy jobs may be created in locations very different from those suffering job losses.

National education and training efforts therefore need to be linked with a regional (development) approach to ensure a just transition policy. Disadvantaged workers and communities require targeted assistance, which can encompass the integration of skills building, vocational training and retraining into regional economic development strategies. This also applies to larger socio-cultural perceptions and systems of thought: For instance, with regard to agriculture and forestry, indigenous peoples' traditional knowledge is increasingly being recognized for effective climate action and livelihood security, but non-recognition of traditional skills continue to be an important challenge.

A number of efforts have targeted the renewable energy sector, motivated by the desire to overcome problems linked to the crises in older industries or a lack of economic diversification. Examples include the United States, where wind energy development has been seen as a way to inject new life into many abandoned "rustbelt" industrial facilities in Pennsylvania and Ohio, though with somewhat mixed results.

Critical to the success of education and training efforts is effective coordination and constructive dialogue between all actors, including the government, trade unions, and employers. Whereas countries' education and training systems in different countries face varying challenges and some may incorporate climate and environmental considerations into training programmes more readily than others, a multi-layer approach, with action taking place at the levels of enterprise, industry, nation and region, is essential for success.

Social protection and security

Social protection constitutes one of the pillars of a just transition framework. Only around one quarter of the world's population has adequate social security coverage and more than half do not have any coverage at all. A majority of the world's **economically active** population do not benefit from any protection in cases of unemployment, work-related injury, or maternity. Nearly half of all people over pensionable age do not receive a pension, and for those who do, pension levels are often inadequate (ILO, 2016b).

> **Key term: Economically active**
> According to the definitions of the International Labour Organisation (ILO) for the purposes of the labour market statistics people are classified as employed, unemployed and economically inactive. The economically active population is the sum of employed and unemployed persons. Inactive persons are those who, during the reference week, were neither employed nor unemployed. Adapted from https://ec.europa.eu

> **Key term: Informal employment**
> Employment in the informal sector includes all jobs in informal sector enterprises or all persons who, during a given reference period, were employed in at least one informal sector enterprise, irrespective of their status in employment and whether it was their main or a secondary job. Adapted from https://www.ilo.org

Informality, is common in the majority of the sectors most affected by climate change impacts, such as agriculture, fisheries, forestry or tourism. Migrant workers are overwhelmingly represented in these sectors, as are low-skilled national workers, and vulnerable groups, such as indigenous and tribal peoples, which makes them exposed to discrimination and exploitation. This is also a very frequent phenomena in economic sectors that are essential to achieve a low-carbon development, such as waste-management and recycling, construction and small-scale industries in all industrial sectors. Thus, providing access to social protection measures to these workers should be an integral part of any climate change policy.

The fifth IPCC Report (2014) highlights the importance of assessing the synergies between social protection policies, social development strategies, disaster risk reduction strategies and climate policies. In addition, there is a growing body of evidence that linking social protection and climate change policies plays a double role of enhancing the resilience of workers and their families in times of climate disasters and facilitating the ability to cope with climate consequences.

In addition, mitigation policies may have a negative impact on businesses and workers in highly emitting sectors such as coal mining, fossil fuel energy production, industry that currently feature a low-level of energy efficiency, while new green low-carbon sectors may benefit. In these cases, formulating accompanying policies through social protection, including unemployment insurance and benefits, social security portability, skills training and upgrading, **workforce redeployment** and other appropriate measures to support enterprises and workers in sectors negatively impacted by the transition should be part of the policy mix.

> **Key term: Workforce redeployment**
> The act or strategy of reassigning employees to a new position, for example in another geographical location, within a different work unit or by changing tasks and responsibilities. Adapted from: https://www.ofm.wa.gov

Another example where social protection policy is instrumental is in the field of fossil fuel subsidy reform. According to ILO (2016) estimations, between 2010 and 2015 overall, 100 governments in 78 low-income and 22 high-income countries reduced or removed subsidies, predominately on fuel, but also on electricity, food and agriculture. These adjustment measures were implemented at a time when food and energy prices were hovering near record highs; if basic subsidies are withdrawn from beneficiaries without adequate social protection mechanisms in place, this can lead to a situation in which food and energy become unaffordable for many households, in particular, but not only, the poorest ones.

In low and middle-income countries, public and private financing that supports national public employment schemes are not only extending the social protection floor, but in some cases, they are also contributing to restoring and protecting the productive capacity of lands, building resilient infrastructure, and at the same time, creating livelihood and income security for the most vulnerable often particular at risk of being impacted by climate change. Investment in physical, financial, natural and social capital is not only necessary, but also has a significant potential to contribute to climate resilience and disaster risk management.

To design successful climate related social protection systems, it should be considered that:

(i) Developing a social protection system takes a long time, particularly in countries where **institutional capacity** is limited. Therefore, mitigation actions with potential social impact, should only be taken once the potential affected population are protected and compensation through adequate social protection measures are in place;

> **Key term: Institutional capacity**
> Generally referring to the capability of institutions to perform effectively and efficiently, for instance through adequate management of shocks or through skills of human resources.
> Adapted from: http://www.undp.org

(ii) The large cost savings resulting from mitigation policies should allow countries and regional bodies to develop comprehensive social protection systems and agreements;

(iii) Mitigation policies may have complex social impacts that need to be properly assessed and discussed within the framework of national dialogue. Involving **tripartite** constituents in the definition and implementation of social protection measures is a key element to ensure a fair and efficient policy result, where negative socio-economic impacts are addressed;

> **Key term: Tripartism**
> Refers to a form of economic policy which relies on tripartite collaboration between employers, unions and the government. Adapted from: https://en.wikipedia.org

(iv) Taxing natural resource extraction offers great potential for many developing countries. Norway's approach of taxing oil profits and storing the revenues in the Government Pension Fund Global is perhaps the best-known case (see Chapter 8, Section 1.2.2).

Consultation and social dialogue

Consultation and social dialogue among those who are most affected by climate change impacts and policies that attempt to tackle these impacts are at the core of the just transition framework.

The role of dialogue to reach decision by consensus, identify new business and employment opportunities, and the potential challenges, as well as adaptation of current skills and retraining, has placed consultation and tripartism as an essential element of labour relations around the world. In the context of climate change, social dialogue has been identified as an essential tool for anticipating and managing the effects of greening on quality of work and employment (Aumayr-Pintar, 2015).

Social dialogue can take place at the regional level, at the national level, through cross-industry consultation or at the sectoral and company level. It also varies in terms of the purpose of the dialogue, from merely consultation to coordination of the implementation of a specific policy, to reaching binding agreements.

It can be noted that for social dialogue to be effective, two elements should be developed (ILO, 2016): 1) providing technical capacity and adequately updated information to stakeholders taking part in the dialogue process; and 2) ensuring that consultations take place on an on-going basis.

According to the *Guidelines for a Just Transition* (ILO, 2015), governments should actively promote and engage in social dialogue to discuss the best means to implement social, economic and environmental goals. The Guidelines also recommend for social partners "to promote active participation in social dialogue at enterprise, sectoral and national levels to assess opportunities and resolve challenges posed by the transition" (p.10).

4. Conclusions

Natural capital supports jobs in many economic sectors such as agriculture, forestry, tourism and industry. The degradation of natural resources and changing climatic and environmental conditions represent threats to employment, while resource and energy intensive forms of production will result in declining productivity over time. This makes climate change and environmental degradation a topic that relates directly to jobs. By tackling these structural problems, a transition to an inclusive green economy can secure and safeguard jobs.

More than that, the transition to green economies interacts with jobs and employment policy in various ways: First, a successful transition relies on the availability of a workforce that has the required skills and qualifications, for example to enable the production of environmental goods and services. Labour can thus be understood as a required 'input' and 'condition' for a successful transition to a green and sustainable economic structure. At the same time, green growth by default is not sufficient to deliver social inclusion and positive labour market outcomes. Dedicated investment in human capital along with social policies is needed to manage distributional impacts of green growth and ensure a just and fair transition for all.

As noted in the ILO (2016) analysis, for a transition towards greener and climate-resilient economies to be successful it requires accompanying and enabling policies that address the social and employment dimensions in order to maximise the positive employment effects of the transition.

Assessing the labour market implications at macro and sector level can provide a very solid knowledge base to inform the policy making process. It is essential that policy coherence is promoted at all levels so that greening policies are integrated in other policy areas and efforts are coordinated amongst different stakeholders through effective social dialogue. Indeed, social dialogue is a fundamental pillar of the just transition policy framework that brings together the actors of the world of work to identify new green business and employment opportunities and the means to address any challenges in the transition process.

Promoting labour market policies is critical to ensure that the employment effects are positive for everyone. Enhanced training for skills building and retraining, including better management and more efficient use of energy and material resources, is key in order to fully take advantage of the opportunities presented through economic and industrial changes and unleash employment potential, notably by supporting entrepreneurship development. Besides, social protection policies should not be overlooked as they can enhance the resilience of communities most dependent on natural capital for their livelihoods, and safeguard workers from the negative impacts of environmental change, economic restructuring and resource constraints.

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CHAPTER 6: INSTITUTIONAL REFORM FOR INCLUSIVE GREEN ECONOMIES

CHAPTER 6: INSTITUTIONAL REFORM FOR INCLUSIVE GREEN ECONOMIES

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Appreciate the institutional challenges of assessing, planning and implementing inclusive green economy approaches;
- Articulate the institutional spectrum of organizations, rules, and norms that are needed to sustain and grow green economies, and the change processes needed to arrive at them; and
- Apply practical frameworks to analyse the institutional reforms required for inclusive green economy.

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CHAPTER CONTENTS

1. Introduction: Why institutions matter for inclusive green economies

Institutions - a major component of **social capital** - are a significant determinant of national success. They have at least as much impact on GDP and the **Human Development Index** (HDI) as a country's resource endowments and geography (Rodrik & Subramanian, 2003, Acemoglu & Robinson, 2012). Good institutions make investments attractive, enable participation, recognition representation, and distribution among different groups, and ensure that environmental sustainability is considered. As such, we rely on institutions to demand, deliberate, decide on and deliver a green economy.

> **Key definition: Social capital**
> Networks together with shared norms, values and understandings that facilitate co-operation within or among groups. Adapted from: https://www.oecd.org

> **Key definition: Human Development Index**
> index developed by the United Nations Development Programme (UNDP) to provide an alternative measurement of development alongside economic growth. It includes key human dimensions such as health, knowledge, and standard of living. Adapted from: http://hdr.undp.org

> **Important note:**
> There has been earlier academic work. A notable example is Daly's propositions for three institutions needed for a steady-state economy that would reconcile efficiency and equity: (1) an institution to stabilise population; (2) an institution to stabilise the stock of physical assets and keep throughput below ecological limits; and (3) a 'distributionist' institution to limit inequality in distributing constant stocks among the constant population (Daly 1992).

In spite of a proliferation of debates, initiatives, and projects related to green economy, to date, institutional issues have been somewhat neglected and there is **little recent literature** on the subject. International support tends to focus on national green economy plans and projects, and globally, 65 national strategies or plans have already been developed. This is good progress, but most of the plans assume that the institutional setting and capabilities to create and implement them are effectively in place; at best they may provide for capacity building, but not structural reforms. Yet, without reforming or strengthening institutional and legal frameworks, the green economy transition is likely to be slow or uninspiring in terms of its outcomes (UNECA, 2016).

For example, a national green economy strategy might be developed without being integrated into the existing institutional structures. Any national plan for a transition towards a green economy initiated by a country's environmental authority needs to be able to influence economic and social behaviours governed by the Department of Trade and Industry or the National Chamber of Business. The people who have prepared these plans often privately admit that the biggest barriers to their implementation are institutional – at many levels, from fundamental beliefs to political will to practical issues of capacities and incentives.

Much more attention needs to be given to identifying, mobilizing, and investing in quality institutions to drive wide-ranging green economy reforms. The principle of "strong institutions that are specifically geared to safeguarding social and ecological floors" has become established as a central pillar for the design of an inclusive green economy or IGE (UN Environment, 2015, p.19) but institutions that can 'do more good' and not only 'do no harm' are also needed. As the challenges facing countries become increasingly complex, achieving success becomes a tougher task and institutions need to evolve, or indeed transform. This requires a much more nuanced understanding of the complexity of the existing institutional landscape in a country, region or sector, recognising that there is no single institutional blueprint for a green economy transition. It is important to understand why the prevailing institutions are often not up to the task, and how they can change. It is also a question of identifying which institutions, perhaps the least-usual suspects, are best placed to make the transition towards a green economy.

This chapter explores the institutional spectrum of **organizations**, rules, and norms that are needed to sustain and grow green economies, and the change processes

> **Key definition: Organization**
> A group of people, typically in a given sphere such as government, business or civil society, who are bound by a common purpose.

required to arrive at them. It describes the characteristics of the institutions that we should be looking for and encouraging. As green economy is not yet fully mainstreamed in a large number of countries – i.e. there is not yet a clear institutional landscape emerging – we draw on evidence from the evolution of sustainable development and its growing legacy of institutions that integrate economic, environmental, and social objectives.

While institutions have often been neglected on the level of national strategies, in principle "strong institutions that are specifically geared to safeguarding social and ecological floors" have been established as a central pillar for the design of an inclusive green economy or IGE (UN Environment, 2015, p.19). From a theoretical perspective, it is thus clear where the journey will go, but with regard to practical implementation, the reasons for institutional reform and how it can be achieved, too often remain in question. The chapter aims to clarify such issues.

2. The definition and scope of 'institutions'

Academic disciplines vary in what they consider to be institutions, but there is a more common interpretation of the term (Leftwich & Sen, 2010). Institutions, as defined in economics, are the 'rules of the game' and include formal legal rules as well as informal social norms that govern individual behaviour and structure social interactions (North, 1991). Efforts towards green economy to date have addressed institutions mainly with a technocratic focus, hence viewing institutions as formal structures, rules and regulation and pinning hopes on specific models and capacity development-oriented towards these specific models (Section 4.1.4. provides more information on capacity development). Those promoting the transition to a green economy have thus often focused on finding the 'magic bullet' – the one, promising model of how institutions should look like for bringing about the necessary change. However, institutions must be understood within, and indeed cannot be neatly distinguished from, their context. As a result, it is useful to conceive of institutions in relation to the 'institutional spectrum', ranging from individual through to society. This spectrum includes specific organizations, formal and informal 'rules of the game', **meta-institutions** such as 'economy' or 'government' and underlying norms, values and beliefs. Taking into account the entire institutional spectrum is useful in mobilizing institutions in the transition towards a green economy.

> **Key definition: Meta-institutions**
> Meta-institutions: Set of organizations together with a range of formal and/or informal rules and norms that determine social and economic interactions at a broad level. Examples: government, economy, media, civil society.

Figure 1 represents a nesting of elements of the institutional spectrum, which range from individuals to specific organizations, right up to the broader concept of social capital. Institutions occupy a central, mediating position between the individual and society as a whole. Used in a broad sense, the term 'institutions' includes other elements of the institutional spectrum, most frequently meta-institutions and organizations (the orange circles in Figure 1). When we speak of 'institutions' in this chapter, we refer to this broader definition, which includes both formal and informal structures, both organizations and rules, both government and non-government spheres, both traditional and modern approaches, and both new institu-

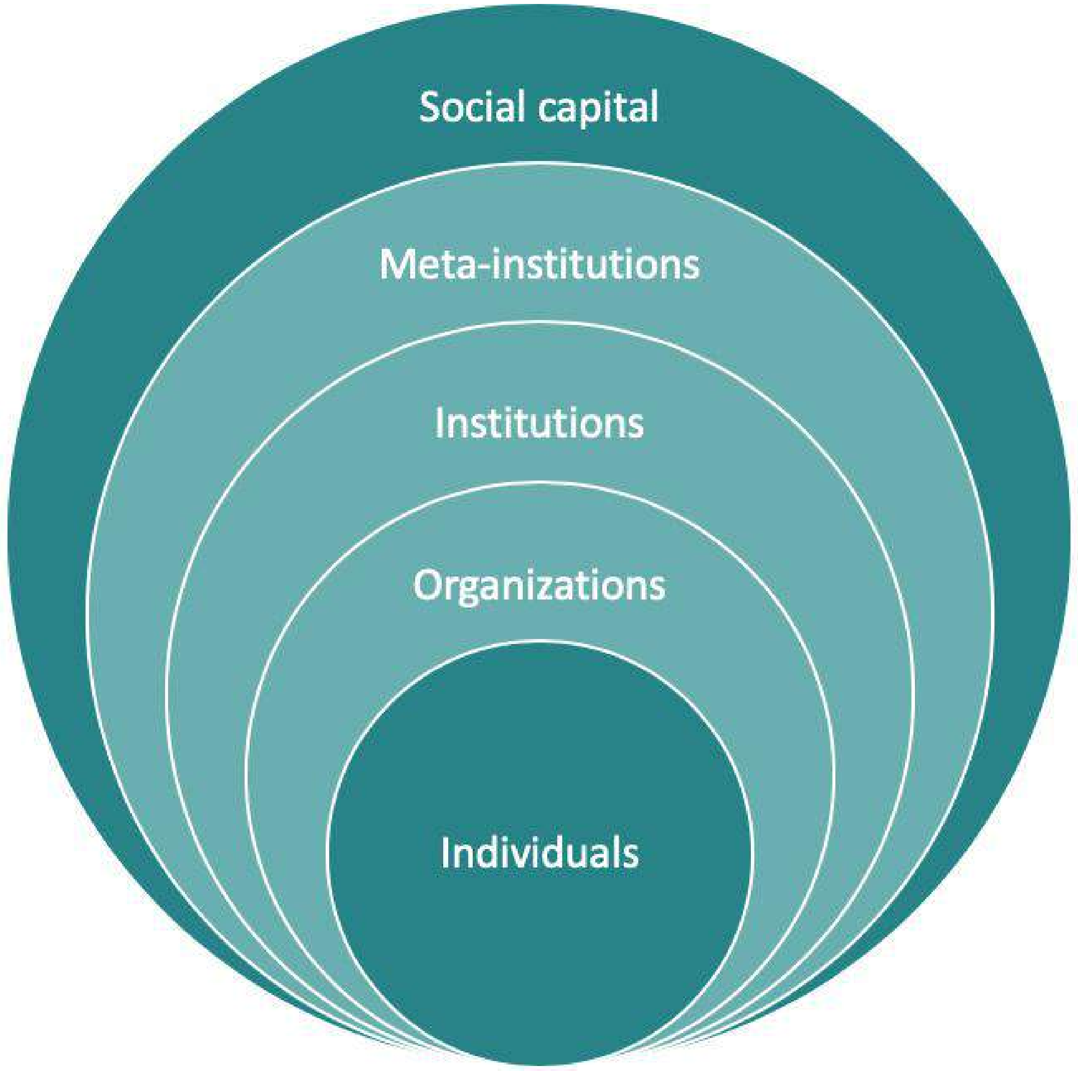

Figure 1: The institutional spectrum

Box 6.1: Descriptions of key institutions

- *Central government* – ministries of finance, development, planning, productive sectors, social sectors and environment; statistics and **audit authorities**
- *Local authorities* – municipalities, devolved natural resource authorities, traditional authorities
- *Economic organizations* – fiscal, banking and investment, insurance, **commodity markets**, **stock exchanges**, resource-mobilising institutions
- *Resource management organizations* – producer associations e.g. in agriculture, forestry and mining, comprising community members and/or businesses
- *Businesses* – companies, associations, finance and service providers, informal producer and resource management organizations
- *Civil society* – environment and development Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs), campaigning groups, consumer associations, watchdogs
- *Academic and professional bodies* – universities, think tanks, professional associations, training institutes
- *Media* – news and entertainment, public and private
- *Political institutions* – parliamentarians, parliamentary committees and audits
- *International organizations* – development, environment, aid and trade

Key definition: Audit authority
A national, regional or local public authority bodies which are in charge of evaluating and verifying the effective and proper functioning of a system based on given standards and rules. Adapted from: http://ec.europa.eu

Key definition: Commodity markets
trading place, either physical or virtual, for hard commodities (typically natural resources like oil or gold) and/or soft commodities (typically agricultural output or livestock) Adapted from: https://www.investopedia.com

Key definition: Stock exchanges
Strictly regulated financial markets for bonds, notes and shares. Stock exchanges follow the law of supply and demand. Adapted from: http://www.businessdictionary.com/

tions designed specifically for green economy and existing institutions that may evolve towards a green economy.

Organizations receive significant attention in discussions on institutional reform toward a green economy, in part due to the number and variety of organizations involved in the transition process (Wiggins & Davis, 2006, Carter, 2014a). Box 1 provides a list of the most relevant ones. These organizations are shaped by institutions and in return propose changes to ‘the rules of the game’, thereby influencing institutions.

Whenever we consider the role of organizations, we must bear in mind that organizations themselves are shaped by the institutional spectrum and that informal social norms shape the functioning of organizations at least as much as formal rules and procedures. This becomes clear when we contemplate questions such as:

- How are organizations defined by social context?
- How do wider laws and norms impact upon the functioning of organizations?
- In what ways does the underlying organizational culture and the wider societal context limit or enable organizational change?

Such questions reveal the necessity of considering informal social norms and the broad institutional context when considering the role of organizations in institutional reform.

The part of the spectrum most pertinent to institutional reform towards a green economy are meta-institutions or institutional frameworks, underpinned by societal values, shared narratives, beliefs and culture that can appear quite distinctive and fixed, changing only slowly over time. While the drivers of transition to a green economy are found among individuals, organizations, and institutions, these agents are not always aligned. To aspire to an IGE is, in practice, to take on the challenge of meta-institutional alignment and change at the level of the economy.

Institutions are an important component of social capital. Social capital interacts with other forms of capital to enable society to develop and function effectively; it both alters these other capitals through interactive influence, in our case potentially mobilising them for a green economy, and as a result, is shaped by them.

Several observations can be made about institutions (defined in the broad sense) that are relevant for green economy.

First, there is no ‘magic bullet’ institutional solution. Institutions are shaped by their historical, geographical, political, cultural and other contexts and can be very diverse. For example, French and British colonial influences remain strong in the institutions of government and law in ex-French and ex-British colonies and they are quite distinct from each other. Chinese historical and cultural references are extremely strong in the institutions that are now driving green economy in China – ancient traditions of harmony with nature and circularity, and more recent policy initiatives, have become married in the notion of '[ecological civilisation](...)' (Weng et al., 2015). Effective institutions, therefore, draw from the wider context and fit well with it. Their function matters most, but their form may differ widely, hence it is impossible to find a 'one size fits all' institution, instead 'second-best', 'good-fit' approaches are better suited to find customized solutions (World Bank, 2017).

Second, three characteristics of institutional function determine the effective delivery of any policy (such as IGE), according to the World Development Report 2017: (a) enabling credible commitment, consistency and continuity of policy over time; (b) inducing coordination through aligning beliefs and preferences; and (c) enhancing cooperation through good uptake and reducing **free-riding** – any gaps among these 'Cs' constrain progress (World Bank, 2017). In development work, however, it is common to look at institutions simply in terms of their technical mandates, i.e. what they should do rather than how they do it and with *whom*.

Key definition: Free riding
A person who, or organization which, benefits (or seeks to benefit) in some way from the effort of others, without making a similar contribution. Adapted from https://en.oxforddictionaries.com/

Third, informal institutions can matter as much as formal institutions. Modern economies are characterised by formal institutions for fiscal, banking, investment, insurance, commodity market, stock exchange, and resource-mobilising purposes that are explicitly set forth with relevant authority. Yet even here, what governs actual decisions and behaviour are **informal institutions**. They reflect human psychology, culture, habits, and customs – and so can often be more efficient for achieving certain social purposes. For example, pastoralists understand natural cycles and the need to move livestock and temporary settlements according to changing water and grazing availability – their rules are often more nuanced and effective than – though sometimes in conflict with – the formal 'fixed fences' rules of land use planning.

Key definition: Informal institutions
Socially-shared but generally unwritten societal rules, norms, and traditions that tend to be created, communicated, and enforced outside of officially sanctioned channels (Helmke and Levitsky 2004).

Fourth, institutions arise, develop and function through **social self-organization** that may well be beyond the conscious intentions of the individuals involved. They are social constructions, artefacts of a particular time, culture and society that are produced by collective human choice. Any significant distinction between periods of history tends to be associated with systemic changes in the institutions governing a society, e.g. from monarchy to republic (or in a green economy context, perhaps the shift from the fossil fuel age to the age of renewables).

Key definition: Social self-organisation
A complex, dynamic, productive, evolving process that links human actors and social structures. Definition adapted from: Fuchs, C. The self-organization of Social Movements, Systemic Practice and Action Research, Vol. 19, No. 1. Available at: http://fuchs.uti.at/wp-content/uploads/SM1.pdf

Fifth, institutions evolve to suit the changing context, but can find it difficult to change fast enough when the context changes significantly. **Active harm** or **disruptive change** may be required to achieve a meta-institution that is 'fit for the future' (Lustick, 2011). Scoones (2016) notes that today's hybrid, multi-level governance in the sustainable development field has experienced a quiet evolution, including by way of gradual institutional displacement, layering, drift, conversion, and exhaustion or redundancy, but fundamentally meta-institutions have not yet changed. The World Development Report (2017) suggests that institutions tend to change most significantly through three distinct types of stakeholder involvement – elite bargains, citizen engagement, and international influence (World Bank, 2017).

Key definition: Active harm
For example, to return Japan's economy back to prosperity from its decline in the 1990s, policymakers would have had to adopt policies that would cause short-term harm to the Japanese people and government. Japan had become stuck on "local maxima," by gradually increasing its fitness level to suit the economic landscape of the 1970s and 80s. Without an accompanying change in institutional flexibility, Japan was unable to adapt to changing conditions, and even though experts knew what changes the country needed, they were powerless to enact those changes (Amyx 2004).

Key definition: Disruptive change
A reference to ground-breaking technologies, processes or strategies that lead to substantial and innovative improvements of both efficiency and efficacy. For example, 3D printing is disrupting the production industry by lowering the demand for global transportation of goods, thus, reducing CO_2-emissions. Adapted from OECD (2018). Financing Climate Futures: Rethinking Infrastructure. http://www.oecd.org/environment/cc/climate-futures/synthesis-financing-climate-futures.pdf

In conclusion, institutions currently have multiple dimensions in place, which are imperfect in a time of significant change.

There is a need to identify and mobilize the critical social capital for the transition towards an IGE such as:

- Catalytic organizations, networks and alliances that can drive institutional change – which may come from government, business, or civil society;
- Coordinating institutions that can ensure coherence across separate endeavours – which may be governmental, professional or multi-stakeholder;
- Mandated authorities responsible for sustainable development and/or green economy – which are principally central and local government.

We explore these further in Section 3 below.

3. Institutional progress to green economy – baseline, drivers, barriers

This section takes stock of the 'meta-institutional' context, the key institutional components, their readiness for the transition to a green economy, the institutional barriers to this transition, and the kinds of institutional reform that have already taken place. This section begins by depicting three decades of institutional evolution for sustainable development, followed by the more recent and rapid development of several international initiatives that have been influential in researching, promoting and planning for a green economy. The extent to which issues related to green economies have been mainstreamed at national and local levels is explored in several case studies from Germany, Brazil, South Africa, and India.

3.1 An overview of institutional progress towards green economy

Green economy is a relatively new policy goal, following three decades of endeavour aimed towards sustainable development (UN Environment, 2008). There is a growing understanding that the 'engine' of sustainable development will be inclusive green economies. (see Chapter 1). It is, therefore, instructive to examine the institutional foundations that have been deployed, strengthened or built for sustainable development. Building on an earlier twenty-year stock-take of the sustainable development legacy (Bass, 2007), we can point to several core institutional innovations leading the way. Many will prove to be important institutional assets, which will enable countries to develop a green economy.

Firstly, a recognised body of sustainable development law has been built (see Box 6.2). Brundtland's report (1987) identified 22 sustainable development principles, many of which have come to be widely adopted in legal form. Initially embodied in multilateral environmental agreements, this body of sustainable development law has come to be interpreted and enacted in most national jurisdictions, together with the **three pillars** of sustainable development concept, – which offered principles for building institutions for sustainable development, and now for an IGE. Among the more influential examples are legal principles such as **Polluter Pays**, **Precaution**, and **Free Prior Informed Consent**, which are now applied routinely and effectively.

> **Key definition: Three pillars**
> More properly expressed today as three indivisible, interwoven strands rather than pillars – reflecting the 'indivisibility' now asserted by the SDGs.

In addition, some countries have enshrined sustainable development into foundational national documents (see innovation 2 in Box 6.2). The 2012 synthesis of national reports to Rio+12 revealed how

> **Key definition: Polluter pays**
> This principle entails the responsibility of polluters to pay for the environmental degradation they cause. Adapted from: http://www.lse.ac.uk

Box 6.2: Institutional innovations for green economies

1. Sustainable development law
2. Revision of constitutions or national statements
3. Environmental authorities
4. Increasing market acceptance
5. Holistic frameworks
6. Multi-stakeholder development processes
7. Sustainable production codes and standards
8. Interdisciplinary approach for sustainable science
9. Recognition of holistic institutions
10. Future-facing mechanisms
11. Development of sustainability networks

Key definition: Precautionary principle
This approach underscores the importance of preventing serious or irreversible environmental damage. The principle, which is enshrined in the Rio Declaration on the Environment and Development (1992) asserts that cost-effective measures shall not be postponed in the face of potentially irreversible damage, even in if absolute scientific evidence is lacking. Adapted from: https://www.cbd.int

Key definition: Free, prior, informed consent
This principle is derived from the Declaration on the Rights of Indigenous Peoples. It provides a legal framework requesting states to inform, consult with and cooperate with indigenous people in good faith before taking any decision that may affect indigenous groups. Adapted from: https://www.ohchr.org

countries such as Bolivia, Ecuador, Costa Rica, and Nepal, had "gone so far as to integrate sustainable development into their constitutions", while many others have incorporated sustainable development into national visionary statements, including Tanzania, Zambia, Vietnam, Jamaica, Bangladesh, Mauritius, Pakistan, and Timor-Leste. However, institutional fragmentation has been noted as a common barrier (UNDESA & UNDP, 2012).

More commonly, environment authorities, or sometimes even dedicated sustainable development authorities, have been established (see innovation 3). For instance, the National Council on Green Growth (NCGG) has become the fundamental mechanism in Cambodia, contributing to the implementation of Global Green Economy Principles (GGKP, 2013). Whereas only a few countries had a central environment authority at the time of the first UN conference on environment and development in Stockholm in 1972, practically all countries now have ministries of environment. Their mandates have become increasingly clear and often overloaded. Although their power does not often match their wide mandate, most environment authorities have developed cross-sectoral mandates with powers to demand information and to enforce environmental safeguards. In some countries, the environment lead is now taken by a sustainable development ministry with a cross-cutting mandate in addition to an environment sector mandate, as in Malta, Mauritius, St Kitts Nevis and Sri Lanka – perhaps reflecting island governments' acute awareness of environmental and social limits to growth (Grove, 1990). Colombia, the DR Congo, France, Georgia, and Montenegro, among others, have also made similar progress in establishing sustainable development ministries (UNDESA & UNDP, 2012).

While these environmental authorities first had to 'push' green issues, finance and development authorities, as well as market players, have increasingly leaned towards 'pulling in' green institutions (see Innovation 4 in Box 6.2). The introduction of green economy potentials has hastened this, as financial institutions are attracted by the notion of green jobs (see Chapter 5) and revenues and the opportunity to access climate funds. Institutionally, the planning and finance authorities in many countries have, as a result, included the environment in national development planning, budgeting and expenditure reviews (PEI, 2015). However, the practice of isolating an economic process from its wider impacts – or an economic institution from the wider institutional framework – is still widespread (Confino, 2015).

With this growing involvement of ministries of planning and finance, national plans are increasingly based on more holistic frameworks (see innovation 5 in Box 6.2). National sustainable development strategies from the early 2000s were idealistic and isolated planners' exercises, lacking clear priorities, with little influence on budgeting, investment and public institutions (Dalal-Clayton & Bass, 2009). Nowadays however, sustainable development strategies are experiencing a revival through the imperative to implement the sustainable development goals nationally. This large-scale - implementation calls for accompanying mechanisms to gain societal support, to budget for, implement and monitor them. For example, most of the twenty countries supported by the UNDP-UN Environment Poverty-Environment Initiative have seen close involvement of finance authorities, at least in asking questions about relative costs, benefits, and risks of environmental management and tackling climate change (PEI, 2015, Westman et al., 2017).

The increasing involvement of a variety of authorities and market actors has made multi-stakeholder development processes the norm (see innovation 6). In most countries, it is now considered unthinkable that development decisions should be the preserve of experts and bureaucrats and made without involving affected stakeholders. Initially, governments led the way to sustainable development, but the notion of the 'sustainable development triad' of government, civil society, and business actors jointly leading change has since taken root. Examples include **Community Based Natural Resource Management** (CBNRM) and **National Sustainable**

Key definition: Community-based Natural Resource Management
A scheme based on the transfer of ownership or user rights of natural resources or wildlife resources from the government to local communities. Through economic incentives for these communities, CBNRM promotes the sustainable management of local resources. Adapted from: http://wwf.panda.org

Key definition: National Sustainable Development Councils
Bodies that serve as promoters of sustainable development at the national level. NSDCs typically reunite leaders from civil society and other groups with the government to generate discussion and collaboration for sustainable development policies and practices. Adapted from: https://www.ncsds.org

Development Councils (NSDC), which represent major groups, but still often lack representation of smaller groups such as workers and trade unions, parliamentarians, indigenous people, farmers, women's organizations, and youth groups.

Furthermore, sustainable development production codes and standards are increasingly influencing business practice, investment, and policy in many sectors (see innovation 7 in Box 2). The food, forestry, energy, and latterly mining sectors, for example, have developed sustainability schemes to address social and environmental concerns. Motivation to develop and implement those schemes may be attributed to different factors, including management of reputational risk, enhancing resource security, or in anticipation of wider legal changes. Examples of such schemes are the Forest Stewardship Council (Cashore et al., 2004) and the Marine Stewardship Council (Blackmore et al., 2015). Although these codes and schemes do not yet dominate the markets for some commodities, and have so far failed to transform sectors as a whole (IISD et al., 2014), they still have the potential to influence public policy on production, and consumption, and improve practices in niche markets. Despite a lack of transparency in the reporting of sustainability practices, it is promising that some businesses have begun to incorporate analysis of their dependence on natural capital and associated risks into their decision-making (NCC, 2018) – a higher level of interest than purely assessing their environmental impact. For example, the Social Capital Protocol, a new initiative by the World Business Council for Sustainable Development (WBCSD), aims to mainstream the measurement of social impacts.

Recent experience of tackling complex 'wicked' global problems, along with government's greater openness to **evidence-based policy** is also encouraging scientific innovation (see innovation 8 in Box 6.2). At the international level, the Intergovernmental Panel on Climate Change (IPCC) and the 2005 Millennium Ecosystem Assessment (MA) enabled economists and natural scientists to work together on major issues and the results are starting to influence development decisions, in spite of their apparent complexity to policy-makers and the lack of academic incentives. Interdisciplinary science for analysing linked environmental, economic and social issues has become increasingly recognised and deployed. Government research and policy are discovering interdisciplinary approaches and, as an example, seven UK research councils have jointly launched a £1.5 Billion Global Challenges Research Fund. The 8-year Ecosystem Services for Poverty Alleviation Programme (ESPA) has attempted to bridge the science-policy gap in many low-income countries, offering practical frameworks that demonstrate the links of environmental, social and economic systems (Schreckenberg et al., 2018).

Key definition: Evidence-based policy
Set of methods that strive to inform policy making through rational analysis and scientific evidence. Evidence-based policy making fosters a more analytical and systematic approach to policy design rather than directly influencing policy goals. Adapted from: https://www.odi.org

In some cases, a greater recognition of traditional holistic institutions can go a long way (see innovation 9 in Box 2). In the quest for efficiency and effectiveness, western societies developed through separating complex societal goals into individual sectors, disciplines and institutions. This was successful until increasingly global limits and scarcities demanded more integrated approaches. In contrast, many traditional societies have retained a sense of the whole, as in their stewardship of the land. Interdisciplinary science has recognised this and embraced anthropologists and others who understand the holistic realities of many traditional institutions. It is no surprise that the first major global science initiative to follow the IPCC and the MA – the International Assessment of Agricultural Science and Technology for Development (IAASTD, 2009) – emphasised the importance of embracing local technical knowledge and traditional institutions.

Looking forward is equally important: future-facing mechanisms are evolving, to come to grips with multi-variate and non-linear futures (see innovation 10 in Box 2). Whereas climate and geology used to be considered 'fixed', today there is recognition that even these "fixed" factors are changing, less to say factors such as societal preferences. Using approaches that anticipate futures is increasingly the norm and promises to nurture institutional resilience. Scenario development, invented by Shell for the oil industry, has been deployed by the IPCC and the MA and is now *de rigueur* for exploring systemic change. Modelling has become more sophisticated, with technology now enabling real-time manipulation of factors to explore the best way to achieve synergies between economic, social and environmental objectives, as in the case of the Millennium Institute's T21iSDG simulation model.

So, where there was once a primacy of single organizations in centralised roles, the system is changing into multiple **networks** of players working together towards sustainable development (see innovation 11 in Box 6.2). Networks are characterised by many nodes and links (actors and relationships), but they also maintain the autonomy of the actors (the network partners). Although these networks are diverse, there are certain standards or common practices that they share, notably: a clear internal purpose stemming from the collective aims of partners, an organizational structure that is proportionate to this purpose but in which decisions can be taken and implemented effectively, and a stable income that does not depend on one single funding source. A truly resilient and adaptable network is not taken over by a 'hub' but uses the combined strength and knowledge of all its nodes, possibly facilitated by such a hub. The Green Economy Coalition example is an effective demonstration of such a hub and is discussed later in this chapter (Box 6.4).

Key definition: Network
Here a network refers to voluntary (formal) multi-organizational arrangements for collaboration on collective goals.

Some of the above innovations have become part of mainstream policy, planning, budgeting and investment in certain countries and sectors. However, they are rarely the rule, demonstrating that most countries and sectors are still dominated by the 'brown economy'. Nevertheless, in cases where these innovations have prevailed, it can be seen as the beginnings of a sustainable development 'meta-institution'.

This has not only been achieved through the overt promotion of sustainable development as a concept. Instead, it's also the outcome from people's shift in perspectives on the relationship between development and environment. A meta-analysis of the evolution of the mainstream environment agenda alongside the mainstream development agenda reveals their increasing convergence. In essence, both environment and development agendas no longer avoid one another, but are beginning to **feed back into each other**, when human or environmental limits respectively are breached. There is an increasing sense of convergent agendas, at least in progressive quarters, towards environment with people, alongside development with nature. In many ways, green economy is the logical next step – where integrated economic institutions also now provide for both of these agendas. Figure 2 indicates the variety of 'institutional connectors' that have enabled this gradual congruence to date: we suggest that many of them offer potential for achieving green economies.

Key note
As an Oxfam Malawi officer revealed to the author, where once Oxfam delivered seeds and implements to farmers, they now have to invest in soil and water conservation.

3.2 Institutional barriers to inclusive green economy

In spite of the progress described above, there is not yet a robust, resilient and mainstream institutional landscape that supports green economy. At the international level, there is the set of intergovernmental sustainable development and environmental conventions referred to above. Yet there are major institutional failures in mainstream trade, financial, and global public goods regimes. For example, international norms and governance structures for rapid and effective green technology transfer will be crucial building blocks for sustainable development, but are fragile at best (UN Environment, 2015). While current efforts to pursue green economies are rightly focused on at the national level, ultimately the global green economy needs to be addressed.

There are institutional barriers at the national level, too. The sustainable development 'legacy' built up over recent decades within most countries is a disparate set of agreed vision statements, niche plans, isolated projects and some capacities. There has not been broad-scale institutional reform. One notable phenomenon is that peoples' jobs within institutions have very rarely changed. Additionally, some sustainable development plans run parallel to mainstream economic and development plans and may be upstaged by them. As seen in the previous chapter, mainstream institutions in many places still remain structured around the brown economy and resist change. Enthusiasm to support the growth of particular green projects should not blind us to this reality. We therefore need an institutional reform

Box 6.3: Summary of the barriers to institutional reform for green economies

Poverty, environment and climate problems are the result of deep structural failures (GGGI, IIED & GEC, 2016). Not surprisingly, most barriers to green economy are institutional in nature and are often the main reason for a lack of progress or poor decisions made in pursuit of green economy. Institutional barriers specifically associated with green economy initiatives to date include:

- Overly technocratic scope and lack of inclusion – too many initiatives have focused on projects and technologies, as opposed to 'tougher' structural/institutional reform. Due to the technical nature of the initiatives, often only environmental and economic objectives have been factored in. Considering social capital is necessary to reap support and to ensure that institutions are capable of delivering the envisaged projects. Without structural reform, social objectives can easily be overlooked and thus lead to low societal support and a 'green economy owned by the few'.
- Lack of overarching national green economy policy and/or strategy –an overarching strategy is needed to improve the coordination and implementation of all related activities, from field to policy. Without a comprehensive green economy strategy, national institutions lack a mandate to lead the transformation across all sectors.
- Driven by external organizations – rather than by national, local and sector stakeholders who have a record of effective structural change in their fields (including major mainstream players who are open to green economy).

approach that is informed as much by the barriers that it will face, as by the potentials of its realization. We summarize the main barriers to institutional reform towards green economies in Box 6.3.

3.3 Recent case studies of catalytic institutions driving reform

'Green economy' was barely spoken of before the 2008-9 financial crisis, and since then, it has put the challenge of reforming fundamental economic rules onto the political agenda. The 2009 Commonwealth Heads of Government meeting, for example, had as its theme 'The Road to Recovery' and the heads of states' private meeting was on green economy prospects (IIED, 2009). Proliferating projects and enterprises, for example, that promote low-carbon technology, **sustainable agriculture** or **eco-tourism**. In addition, increased availability in financial incentives to carry out such activities, have begun to impact the products and services offer provided by the market, and public services offered by the government, and raise civil society expectations on the availability of such goods and services. This proliferation has been enabled by diverse innovations in international, national and local institutions. New kinds of institutions and institutional mechanisms have begun to improve mainstream actors' awareness, incentives and commitment to act, as well as their behaviour.

Key definition: Sustainable agriculture

Sustainable agriculture describes the incorporation of economic, environmental, and social considerations within agricultural practices in order to avoid compromising future generations' ability to meet their needs. Adapted from: http://asi.ucdavis.edu

Key definition: Ecotourism

Eco-tourism is defined as a form of tourism that encompasses the principles of sustainability. It does not only strive to minimize detrimental effects of traveling on the environment, but it also aims at fostering interpretation and education as well as the social well-being of local communities. Adapted from: http://www.ecotourism.org

A principal influence in this early stage of institutional change towards a green economy were international initiatives, for instance, the Green Economy Initiative launched by UN Environment in 2008 that aimed to support the transition; (see also Chapter 1). In this section we will discuss salient issues concerning some of the major international institutions that promote an IGE. Changes, however, would not have taken off without a diversity of national and local institutions driving in similar directions. For this reason, we will also explore a selection of such cases. These cases are principally catalysts that have begun changing the overall institutional landscape (i.e. the meta-institution). Each case has overcome some, but by no means all, of the barriers to institutional change, which are identified in Box 6.3. They have emerged from their specific contexts (e.g. PAGE from several UN agencies), have become embedded to varying degrees (e.g. Amazonas Sustainable Foundation in the sustainable development landscape of Amazonas and Development Alternatives (DA) Group in India, which will be introduced in section 3.3.3).They play different roles in catalysing the transition to green economies (top-down, bottom-up, bridging, and validation). Most are innovative cases – new institutional innovations rather than stories of the evolution of existing institutions. Given they are relatively new; the literature on most of these cases is scarce.

3.3.1 International green economy institutions

Chapter 1 introduced several international institutions for an IGE, including United Nations Partnership for Action on Green Economy (PAGE), Global Green Growth Insti-

Environmental / nature institutions *How do they treat development?*	Institutional integration approaches	Development institutions *How do they treat nature?*
4. Nature *with* people Resilient and adaptive landscapes, from 2010s	4. Structural reform for sustainable development Transform institutions for well-being of people + nature	4. Development *with* nature Resilient systems; natural capital; Sustainable Development Goals: from 2010
3. Nature *for* people Ecosystem services approach, CBNRM; 1990s – 2000s	3. Synergies Aim for win-wins where possible	3. Nature co-benefits from development Sustainable land/NR/livelihoods, MDG7; from 2000s
2. Nature *despite* people Tackling habitat loss/pollution; 1970s-90s	2. Safeguards Aim to avoid damaging trade-offs	2. Development '*doing no harm*' to nature Land/NR management, EIA; from 1990s
1. Nature *without* people Species and protected areas;1950s-70s	1. Silos Separate, unlinked agendas, often in conflict	1. Development by *converting* nature Land and NR 'development'; from 1950s

Drivers of integration

Increasing feedbacks between environment and development: both positive and negative effects become apparent

Limits of institutional silos become apparent: people find they cannot achieve desired outcomes through one agenda alone

Societal demand for integration: people campaign on issues with linked causes, e.g. health, pollution, jobs; concern for 'just transition' to minimise 'losers' (see Chapter 5)

Top-down drivers of integration: states need public goods, efficiency and effectiveness; businesses need to secure scarce resources; some political leaders champion sustainable development

Institutional 'bridges' that enable integration

Plural policy processes: that pull agendas together e.g. GE strategies, 'reciprocal mainstreaming' connecting env and dev plans; policy coherence e.g. PC sustainable development

Networks and coordination: that link env and dev communities: sustainable development Councils and Accords; cross-ministry planning groups; sustainable development units; communities of practice

Integrated planning tools: sustainability assessment (SESA), environmental expenditure reviews, capital accounting, sustainable development foresighting, modelling tools e.g T21 iSDG

Integrated metrics: multi-dimensional poverty, ecosystem services/wellbeing, resilience, footprints

Localisation processes: decentralisation, participation, landscape/nexus approaches that highlight cross-issue local realities.

Figure 2: The institutional integration of environment and development over time – towards a truly inclusive green economy?

tute (GGGI), Green Growth Knowledge Platform (GGKP) and the Green Economy Coalition (GEC). This sub-section discusses these institutions, vis-a-vis the innovations, as well as the barriers identified earlier. Together with the national and local level case studies in the following sub-sections, these discussions are intended to provide a few pointers to the direction of institutional reforms required to deliver an IGE.

Partnership for Action on Green Economy (PAGE)

PAGE, by drawing several UN agencies together in response to country demand, has contributed to multi-disciplinary approaches coupled with in-country deliberation of diagnostics and optional pathways to green economy. UN Environment's early work on the mutually reinforcing relationship between environmental investment and economic prosperity (UN Environment, 2008) plus ILO's work on green jobs (ILO, 2013), form an evidence- and skills-based core of this partnership, enriched by UNDP's integrated in-country policy and programme work, UNITAR's capacity development expertise, and UNIDO's promotion of innovation and green industry. This "One-UN" collaboration is conducive to ministerial commitment and the mainstreaming of green economy strategy into national development planning. Its primary focus is to engage national governments in a productive dialogue. Nevertheless, tackling institutional barriers remains challenging.

Global Green Growth Institute (GGGI)

GGGI is innovative in at least three aspects. First, it has an integrated delivery model for technical and advisory services in green investment, policy, and knowledge-sharing. Second, it employs national teams, often with national officers who are on secondment to improve the chances of a demand-led approach rooted in a country's institutions and aspirations. Third, it helps countries to be able to attract their own finance rather than providing limited finance itself. While GGGI is quite a traditional development assistance organization, its increasing tendency towards engaging in partnerships, rather than relying entirely on in-house capabilities, means it has been open to others' influences- for example working with the GEC and IIED to explore evidence of inclusion in green growth approaches (Bass et al 2016).

Green Growth Knowledge Platform (GGKP)

GGKP collates publications on a website organised around sector, theme, country, project and best-practice bases. GGKP research committees review the evidence available and identify knowledge gaps, proposing future research. Fifty-eight 'knowledge partners' have so far joined GGKP (GGKP, 2019). Its institutional model is consistent with the requirements of IGE: it is an accessible, organised platform and network for international green economy research that encourages collaboration among actors in generating and using knowledge for the green economy transition.

These international institutional arrangements for green economy initiatives reflect the more than usual level of collaboration. The availability of information, social media and numerous methods for people to connect with each other have in part enabled this. The main elements of a global institution for catalysing green economy may already be in place: a cross-UN programme in the form of PAGE; a 'go-to' information source that also identifies research priorities in the shape of the GGKP collaboration; an independent GGGI to complement them and improve the finances flowing to IGE; and a dialogue and consensus-building platform open to civil society in the Green Economy Coalition, which is discussed below.

Perhaps the main advance made by these and other international green economy initiatives has been the recent emphasis on 'inclusive' and 'pro-poor'. This was a reaction to earlier efforts that focused on least-cost carbon abatement, but excluded many players and their needs. Consequently, several international initiatives are now actively trying to ensure that they serve a majority in low-income countries.

Green Economy Coalition (GEC)

GEC is a new kind of institution that is designed to catalyse the transition to green economies: holistic and inclusive, future-focused and adaptive, values- and evidence-based. Established in 2009, initially as a time-bound partnership for three years between a few founding members (like the GGKP), its membership has grown to include international organizations, business and civil society, as well as large and small organizations across 20 countries. Its role is to facilitate multi-stake-

Box 6.4: Green Economy Coalition - paving the way for new GE institutional norms

The GEC grew from the shared concerns of several international groups, initially including IUCN, IIED, WWF, UN Environment, WBCSD, among others, each concluding that the environment and the economy need to be more closely aligned for a sustainable future. Together, they proposed a 'Global Coalition for a Sustainable Economy' as 'the sustainability challenges are too big for one sector, organization, or strategy to address alone' (IUCN, 2009).

GEC's power lies in its ability to bring together the stakeholders needed for change, to give them the space to exchange experiences and develop solutions together. Its position as a platform not only generates "informational power", but also "political power" to drive policy decisions for green economies. Its approach is based on dialogue with diagnostic to help stakeholders scope what a green economy means for them, modelled after existing dialogue-based models such as the Forests Dialogue and the Poverty Environment Partnership. However, this concept also has downsides: diverse approaches are compatible with convening, but are challenging for achieving clarity of position. The centrality of a positive, engaged secretariat, while helpful for mobilising and building trust among members, also means that members can rely on the secretariat too much without making their own tough changes.

The Coalition has been careful to avoid single issues, but rather showed how the different parts of the agenda link up, such as fairness, inclusion, ecological limits and natural capital. The GEC works through an issue, generates consensus among its diverse members, and moves on. To keep people focused on the prize of transition, building a compelling narrative has been central to the GEC's work with devices such as 'glimpses of a green economy', 'stories of change', and a 'barometer' of progress.

GEC now includes both international members and national NGOs large and small, forming national hubs that reach out to hear the 'voices of the poor'. It has upheld high aspirations for inclusive GE, conferring the credibility to critique some of the intergovernmental work (e.g. too many initiatives were focused on carbon, large companies, big infrastructure and high technology, risking green economy being owned by elites) (GEC, 2014). As its work plan and funding expands, the GEC intends not to build a large central secretariat but to mobilise best-placed members to act, increasingly those based in different continents.

holder dialogue at national, thematic and global levels, sharing experience and knowledge, and building a shared narrative that makes a strong case for change. There is much to learn from the evolution of the GEC and its network: Box 4 is the first attempt to draw out institutional lessons and principles from the GEC.

As the GEC case study suggests (see Box 6.4), the 'safe space' that it has created has encouraged collaboration between the international green economy initiatives – with the GEC helping participants under the initiatives to come together, to get to know one another, mutually recognise strengths and weaknesses, learn and adjust. This collaboration has already broken-down apparent barriers between narrow definitions of green economy and green growth and developed shared principles, priorities and pathways towards an IGE (GEC 2019 forthcoming).

3.3.2 National green economy institutions

The existence of a national green economy strategy or plan is still taken as a primary indicator of progress in green economy rather than any institutional or behaviour change. So, for example, the existence of a national green economy strategy or plan was obliged to be considered in a recent assessment of progress across 21 Mediterranean countries. However, the conclusion of this assessment indicates that even countries with good strategies 'still lack concrete implementation mechanisms, stakeholders' commitment and systematic follow-up and evaluation' (eco-union et al., 2016).

Globally, over sixty-five countries had some type of green economy strategy or plan by the end of 2016 (GEC, 2017). In the African context, UNECA (2016) suggests relative strengths and weaknesses of the various institutional arrangements for these strategies and plans. It concludes: 'What is emerging is that countries are either building on existing institutional frameworks and reformulating sectoral and national development strategies, e.g. Ethiopia, Rwanda and South Africa; or anticipating a gradual but eventual introduction of new institutions and mechanisms to take over the implementation,

Box 6.5: Lessons from African approaches to IGE planning

While African governments have employed a variety of approaches to IGE planning, the most successful ones are characterized by:

- Strong, high-level leadership, which links long-term national goals with environmental risks and opportunities and builds winning coalitions; examples include Ethiopia and Morocco;
- Clear economic, environmental, and social objectives reflected in outcome-based mandates supported by strong institutional governance, such as in Rwanda and South Africa;
- Robust and adequately resourced planning and coordination processes, designed to generate compelling evidence, overcome barriers, and manage conflicting interests; such an approach characterized the development of Kenya's Low Carbon Climate Resilience Plan;
- Active and strategic processes of stakeholder engagement with clear roles and well managed expectations, exemplified in the inclusive green growth process of Mauritius;
- Well-governed institutions able to manage a predictable long-term cycle of planning, implementation and review, which aligns with other activities and protects against political change and interference by interest groups. Ethiopia is doing well in this respect.

Source: UNECA (2016)

and oversight role, e.g. Mozambique.' UNECA is equivocal about which institutional approach is best, but helpfully postulates five factors that contribute to the success of planning for IGE (Box 6.5).

Of these, coordination of national organizations is particularly important from a practical perspective. No single institution can tackle the interlinked challenges of inclusive and green economies, yet each institution wields the power of its mandate, planning system and budget. Therefore, the ability of many institutions to work systematically together in 'vertical' (across levels of government) and 'horizontal' (across sectors) coherence is important. As noted before, the best arrangements will fit the national context well – with function mattering more than a particular institutional form (World Bank, 2017). Many inter-ministerial mechanisms, however, are connected to one-off projects and do not last long, posing problems of institutional memory and legacy. Others are limited by a lack of interdisciplinary understanding and methodologies (UNDP, 2017; UN-PAGE, 2016).

Effective coordination mechanisms are characterized by: a clear vision and scope, a related planning and monitoring framework, high-level and centrally-located leadership that has the independence to raise challenges and help push through substantial reforms, a secretariat to organise dialogue and work plans, a planning division to help with comprehensive strategy, and an implementation division to ensure coordinated delivery. In this subsection, we examine two cases of this below. One is a green economy 'accord' between diverse stakeholders, enabling recognition of multiple strands of work, experimentation and adaptive strategy (South Africa). The second is a multi-agency programme aiming to embrace all stakeholders in making a system-wide energy transition (Germany).

Case study: South Africa – the Green Economy Accord as a multi-stakeholder platform for adaptive strategy

Approaching green economy as a multi-stakeholder process, not just a plan. South Africa signed its Green Economy Accord in November 2011 (Economic Development Department of South Africa, 2011). Recognising that there is much to learn and a lack of precedent for green economies, the government agreed that a fixed plan or 'predictive strategy' would not be appropriate. Instead, an accord was adopted to encourage action research, convene regular stakeholder meetings to review progress, and to apply 'adaptive strategy'. The Accord formed part of a set of multi-stakeholder initiatives in support of the country's 'New Growth Path', which aims to create 5 million new jobs by 2020 and to cement a 'national partnership' between the Government and social partners (organised labour, businesses and community constituents). The Accord brought together 12 government departments, three major labour federations, and diverse business and community organizations, to design and implement major programmes of public and private green investment.

An OECD peer review mission to South Africa in 2012 noted that the Accord had gained the public interest, but recommended it be brought together with several other institutional innovations to improve momentum towards a green economy (OECD, 2013). These other innovations include, among many, the National Climate Change Response, National Sustainable Development Strategy 2011-14, Clean Technology Fund and Green Fund, and South African business leadership.

There have also been several institutional challenges that need to be addressed. The Accord's eclectic approach means there is not yet a common view on what a green economy would look like. It has been criticised for focusing on an 'add-on' green sector or 'green' niche (with 300,000 jobs), as opposed to an economy-wide transformation (all 5 million jobs envisaged under the New Growth Path). Because of this confinement, commitments are heavily focused on energy-related issues. Water, waste, biodiversity and ecosystems, however, are of significance to a majority of population and could bear high potential from an IGE perspective.

Additionally, there are challenges of inclusion in a country where resource rights and their allocation have been pre-defined in a non-participatory way. Inclusion is difficult in practice where populations are often scattered and informal economic actors are not well organised. This often means that the **transaction costs** of moving onto green economy paths hold back progress.

> **Key definition: Transaction costs**
> Costs incurred by market exchanges such as costs for the formation of contracts or those related to research on market prices. Adapted from: https://stats.oecd.org

Despite bringing a number of different government departments together, the lack of capacity, expertise and political influence of the lead agency, the Economic Development Department of South Africa, the absence of an implementation plan, and the failure of other departments (responsible for implementation) to take ownership of the commitments, have somewhat undermined the Accord. Additionally, there is not yet an integrated information and monitoring system or a set of standard metrics to link the various pieces and to assess added value.

Thus, it remains to be seen whether the voluntary, collaborative Green Accord institutional model will be able to drive coherence and systemic change across all institutions, investment, and behaviour.

Case study: Germany – the Energy Transition (Energiewende) uniting policy and public incentives

One of the most significant challenges in Germany is decarbonising the economy (UNFCCC, 2016). As in all countries, the prevailing energy system has a pervasive influence: throughout history, the transition from the woodfuel era, to the coal and steam era, then to the prevalent oil-based era, and currently to direct electricity have marked major changes in the way economies and societies are organised.

Germany's Energiewende programme recognises that a shift in the country's energy supply requires significant institutional change, one that supports economic growth, inclusion and environmental protection at the same time. Energiewende exists to shape Germany's transition to a low-carbon, environmentally sound, and affordable energy system. Launched with legal support in late 2010, Energiewende is driving renewable energy, energy efficiency, energy demand management, decommissioning nearly all coal-fired generation, and phasing out of nuclear reactors by 2022 (Buchan, 2016). It includes ambitious targets by 2050: greenhouse gas (GHG) reductions of 80–95 per cent compared to 1990, when emissions were 1,248 million tonnes total emissions of CO2 equivalent; 60 per cent renewable energy in the energy portfolio; and 50 per cent reduction in consumption (Agora Energiewende, 2013).

Energiewende presents an extensive institutional reform agenda – shifting energy policy from demand-driven to supply-driven, from centralized to distributed generation (e.g. combined heat and power in small units), and from overproduction and overconsumption to energy-saving and increased efficiency. Together with a commitment to greater transparency in energy policy formation, this can amount to a greater democratization of energy.

The reform was designed to combine national-level political ambition with societal demand – marrying a top-down, legislated mandate for change and programme coordination with ensuring widespread local ownership. There is significant participation of the German public, building on long-standing German traditions of collective civic action in, for example, guilds and cooperatives. So the public benefits from Energiewende as not only energy consumers, but also as investors (private households, land owners, and members of energy cooperatives) and sometimes as employees of decentralised energy generating companies. To this end, central authorities engage with local governments (Länder).

While the overall shift to renewable energies has been a success: about 36 per cent of electricity came from renewables in 2017 (BMWI, 2018) and 88 per cent of the general public support the energy transition (IASS, 2017), the results are not as clear for other targets. The abundance of cheap energy has, for example, crowded out relatively clean, but expensive energy forms, such as natural gas, and given rise to cheap, polluting lignite, hampering the reduction of emissions (Pegels, 2017). Favourable energy prices for energy-intensive enterprises were financed by shifting the burden onto households and small and medium enterprises, making two thirds of the population agree that the burden for the Energiewende is not shared equally (IASS, 2017). To embrace all stakeholders, institutional change, therefore, has to be combined with continuous public feedback.

As we have stressed, effective institutions often grow organically from their context, and become fit for that context. In this respect, the exact Energiewende model is unlikely to translate to many other countries, especially those with weaker social institutions.

3.3.3 Local green economy institutions

For green economies to achieve scale – to become the norm rather than isolated 'green' projects and businesses – the focus must be on inclusion (Benson 2016). However, it is not easy to involve large numbers of excluded people without engaging with the institutions that represent, serve and regulate them. This points to the importance of municipalities and other local authorities, producer associations, community natural resource management associations, chambers of commerce, and others in shaping and delivering green economies. The institutions that are directly formed by local people – as rights-holders, producers, consumers and citizens – will be particularly important, and will include institutions at village level. These are all potentially parts of the local institutional landscape of a green economy.

Governments differ in how far they are decentralised to local levels. But local authorities almost everywhere are no longer merely service providers. They are also highly complex systems that can play a central role in an interdependent world. In Western European, North American countries, and Japan, between 40 and 60 per cent of all governmental spending takes place at the subnational level, while in the economically less developed parts of the world, the figure ranges from 3 to 30 per cent. (ECOSOC, 2017a).

Key note:

In addition, in North America and Europe, 57 per cent of all public sector employment is at the subnational level, while in Africa the figure is 6 per cent; in Latin America, 21 per cent; and in Asia, 37 per cent.

Although local authorities have significant influence, except perhaps on elites, they are not uniformly supportive of inclusive and green approaches. Satterthwaite and Sauter (2008) lay out the local government institutions needed for sustainable development (in education, health, environmental services, natural resource regulation, business development and legal enforcement) and give examples of both supportive and unsupportive types. Those that are supportive are characterised by:

- High levels of transparency and accountability to local groups;
- Well-established work programmes with low-income groups;
- Giving such groups central roles in defining priorities and undertaking initiatives;
- Mobilising resources to build the local economy– skills, natural resources and finance; and

- Openness to influencing central government policy based on the above.

In poor countries, there is a further challenge: up to 80 per cent of the workforce may work and live in the informal economy (IIED, 2016a). There are over 500 million smallholder farms around the world supporting over 2 billion people, many operating in the informal economy – clearly one of the world's most significant bases for local green economies. There are many types of community or communal natural resource management regimes producing a mix of public and private benefits – institutions could drive local green economies. Yet the potential of informal actors is not yet realised. They cannot easily be reached by formal organizations such as local government. Instead, their inclusion relies on a much broader range of women' groups, religious organizations, social enterprises and others, that also need to be considered as part of the institutional landscape for green economies.

In the context of global economic, political and cultural processes, it is essential to consider the impacts these processes have at the local level. Indeed, there is some consensus that the nation-state as the predominant system of public governance, as it stands today, has become increasingly incompatible with contemporary realities. Those realities are increasingly characterized by the emergence of multi-stakeholder and multilevel institutions (ECOSOC, 2017a).

"Establishing institutions that are effective, accountable and open to all, means moving more and more towards a "helmsman" State, with a central Government that performs the tasks that only it can perform and that it is best placed to perform. It delegates the other tasks to other stakeholders and intermediaries such as local and regional governments and business and community processes, and intervenes — and only in a secondary capacity — only when an issue cannot be resolved or best resolved by such intermediaries."

(ECOSOC, 2017a)

In conclusion, considering the significant role local and subnational stakeholders are playing in constructing green economies, the institutional landscape is not yet conducive and is difficult to navigate. Two examples are offered to illustrate the kinds of organization that can catalyse change at subnational levels. Approaches like these will be increasingly important if inclusive, and local green economic activity is to achieve scale.

Fundação Amazonas Sustentável (FAS, the Sustainable Amazonas Foundation) was created in 2007 by the State of Amazonas in Brazil and Bradesco Bank as "a meso-level institution between government, communities and businesses that catalyses the local green economy". Its developmental and environmental activities are substantially supported by both Brazilian and global corporations. The FAS's mission is to improve the riverine communities' quality of life in the State of Amazonas, helping them to grow their economies by mobilising capital assets within social and environmental limits (FAS, 2016). Its slogan – 'making forests worth more standing than cut' – is illustrative of its approach of ensuring local people can make a good living in the forest environment. Its principal work includes: Bolsa Floresta (conditional payments to farmers for forest conservation), Education and Health, and Innovative Solutions (with an emphasis on business development and training for indigenous groups using the Amazon's natural resources and drawing on best local practices).

Since 2008, FAS's institutional mandate to implement the Bolsa Floresta state policy has helped to confer the power to bring together all state departments that are relevant to local economies, livelihoods and environmental conservation, and to catalyse action partnerships. There are now over 100 partnerships, many focused on nine regional Centres for Conservation and Sustainability, which involve FAS's with the state health authorities, local government, and local NGOs. Today, these Centres support professional qualifications, entrepreneurship, knowledge exchange, waste recycling and sustainable agriculture. Its growing institutional mandate has helped FAS to reach nearly 600 communities in the Amazon, including some of the most isolated, remote, and poor (which often take many days to reach by boat from the capital, Manaus).

After 10 years, FAS's institutional mechanisms have taken off because they are simple to understand by all, attract the interest and excitement of stakeholders, build trust, and realise synergies. For example, Bolsa Floresta gives farmers a regular income for practicing farming without fire; just one criterion. This has greatly reduced consequent deforestation, boosted the local economy, saved on government environmental protection costs and enabled many other co-benefits for farmers from the registration process. All of this helps to establish FAS as a 'meso' level institution that connects others and – critically – engenders trust, a core characteristic of catalytic organizations (FAS, 2016).

Development Alternatives (DA), India is one of the Social Enterprises (SEs) that are being built at a rapid rate in India around previously unnoticed opportunities in conservation, renewable energy and clean transport (Box 6). Currently, private companies provide a significant proportion of India's public services; their primary motivation is profit – not justice, collective security, clean air, or other social goods that people need in order to face emerging challenges and opportunities. SEs can fill the gap by providing the motivation, ingenuity and customer focus (characteristics shared with successful private companies), while aligning their services much more closely to the needs of local producers, consumers and citizens. At the same time, they avoid the simplistic 'one size fits all' public services that are provided either directly by governments or through contracts with private businesses (Palwa, 2012).

DA – claimed as the world's first social enterprise dedicated to sustainable development - has been behind much of this. It serves the innovation, incubation and implementation of enterprise development and has shown that small technology investments through SEs can contribute to big gains in terms of job creation, mobilising local capitals, and improving the quality of services delivered. For example, DA has facilitated the establishment of more than a thousand businesses and over a million green jobs since its inception, spearheading low-carbon pathways and inclusive growth in rural housing, renewable energy, water management, sustainable agriculture, waste management and recycling. DA's lessons on effective SEs are summarised in Box 6.6 (right).

Box 6.6: Social enterprise - a promising driver of green economy at local levels

The experience of Development Alternatives and other social enterprises (SEs) suggest that effective SEs are characterized by:

- Locally relevant innovation of products, services and business models: SEs respond to basic needs of the local poor by improving the understanding of, and access to, local resources and technologies. They can also generate goods and services in ways that reduce the environmental or social problems that private businesses usually create. This is very difficult for large businesses, research institutions or Government agencies to achieve alone.
- *Creating jobs at low cost:* Green jobs produce the goods and services required to fulfil everyone's basic needs in ways that regenerate – rather than destroy – the environment. At the same time, they generate the wages that help people to access these goods and services, and confer the financial security that empower people within their communities. SEs can create jobs at much lower financial and energy cost – perhaps $100 and 0.1KW/hr compared to $100,000 and 10 KW/hr in corporate job creation.
- *Mobilisation and investment in local capital assets*: SEs put local human and material resources at the centre of their operations, often combined with innovative knowledge or technology to establish efficient and competitive business models. The results create markets for other local businesses. This may compare favourably with external models, such as development assistance, which brings external financial and technical resources and hopes for the maximum '**trickle-down effect**'.
- *Incubation of business models to a viable scale:* 'Network enabler' organizations provide integrated services to make the local ventures profitable and, crucially, to scale them up.
- *Investment in 'undesirable' sectors:* SEs are increasingly able to draw investment into sectors that had been considered undesirable by business. They are able to demonstrate – at least to social investors – how financial returns can be obtained both from the delivery of goods and services (selling to often poor consumers) and from purchasing goods and services made locally (buying from the poor).

Key definition: Trickle-down

This effect is derived from the trickle-down theory in economics, which argues that tax benefits and other economic benefits for corporations will eventually lead to economic gains for the entire society. In other words, economic growth will be boosted and the benefits will "trickle down" to other groups in society. Adapted from: https://www.investopedia.com

Principal source: Palwa, 2012.

4. Analysis – Institutional reform for inclusive green economy

In section 3, we described how we have begun to see a 'wiring together' of existing and new institutions to better support IGE. We noted how some catalytic institutional innovations at international, national and local levels have helped, along with deploying existing institutional coordination mechanisms at the national level. However, we also emphasised how many of the main barriers to a green economy remain institutional in nature. Hence the importance of system-wide institutional reform.

In this section, we offer an empirical overview of the typical processes of institutional reform that can overcome the barriers (4.1) and the characteristics of effective integrated institutions that emerge from – or are strengthened by – such processes (4.2).

4.1 The process of institutional reform towards a green economy

There is no blueprint for how particular institutions move towards a green economy; there is a large diversity of contexts. The process is a political and societal one, at least as much as a technocratic one. It can be expected to take considerable time, over which the institutional dynamics will include: growing pressures to change norms, exhaustion of some institutions that become unfit in new circumstances, 'unfreezing' of other institutions to become more responsive to pressures to change, redeployment of some institutions and spinning-off of new ones, and eventually meta-institutional regime changes including umbrella coordinating institutions (see e.g. Scoones, 2016).

Many are searching for a more deliberative and accelerated approach to institutional reform, given the institutional barriers to inclusive and green economies (UNDP, 2017). It can be considered, that progress should be evident in four areas:

(i) Pathway: an institutional transformation pathway – progressing from **institutional silos** towards integration.

(ii) Processes: multi-stakeholder processes involving alliances and leadership – creating political and practical reform 'space' to embark on this pathway.

(iii) Communications: including agreed metrics and tools to adapt – helping stakeholders to navigate the pathway.

(iv) Capacity: mobilisation and development of capabilities – to undertake all tasks involved.

Key definition: Institutional silos
Approach which tackles problems in an isolated manner instead of looking at the whole system (see chapter 1).

Each element on its own is not sufficient for 'rewiring' or 'retooling' the institutional landscape for inclusive green economies. Too often, only a narrow form of the last element – capacity development through short-term training – is relied on, even where major institutional changes are required. While some elements can be formulated in advance, the institutional transformation pathway itself is not predictive and cannot be planned in a definite manner. Nevertheless, it is of fundamental importance, the stage a country or sector reaches is, in large part, a strong determinant as to what type of intervention will work, as we will explain below.

4.1.1 Pathways of institutional transformation – four basic stages:

Building on the historical observations summarised in Figure 2, we can identify four typical stages of progress towards integrating inclusion, green and economic objectives in a typical country or a sector. **These stages** are illustrated in Table 1 below, which implies that certain policy ambitions and/or instruments will be better suited to one stage more than others. One problem is that particular narratives are used, business cases are made, or instruments used, which do not suit the stage that the country has reached (e.g. countries at the 'do no harm' stage are unlikely to be interested in full natural capital accounts or green fiscal reforms). Interventions must match the stage a country's institutions have reached, though this can be complicated when a country's business institutions may be more or less progressive than its government.

Key note
This broadly corresponds to the three orders of change noted in Chapter 10 on financial system reform (Hall 1993): our Stage 1 is a 1st order change, where assumptions and paradigms remain fixed. Stages 2 and 3 are 2nd order or incremental changes, through new instruments rather than overarching policy. Stage 4 is a 3rd order major paradigm change.

While a system-wide transformation (i.e. something like stage 4) may seem a far away reality, much can be achieved through smaller steps, which should be determined with consideration of sequencing and priorities at the national level. Such a process could come, for example, in the form of an institutional reform roadmap, starting with assessing the stage(s) already reached. While progression is commonly observed towards integrated approaches, this does not mean that full integration of all institutions into a monolithic green economy institution is the most effective or efficient approach to stage 4.

Instead, the ability to engage and mobilise all institutions with relevant mandates can be useful (e.g. Involving various policy-relevant institutions in finance, trade, labour, and environmental policy-relevant institutions). A national institutional framework that embraces many institutions, taking advantage of multiple network effects but ensuring coherent vision and coordination, can be more effective than comprehensive replacement institutions (Nilsson, 2017).

Table 1: Institutional reform towards integrated objectives (sustainable development, GE): a 4-stage empirical framework. Developed from Raworth, Wykes & Bass (2014)

Stages in institutional reform	Level on integration at this stage	Current status	Catalysts that help this stage
1. Silos - 'do nothing'	*Separate* – institutions work separately; and social, environmental, and economic objectives are not integrated in practice.	Very few countries are still at this stage. But prevailing incentives can be hard to shift.	Prevailing institutional incentives – incumbent regimes, professional disciplines and elite bargains maintain (and often robustly defend) silos.
2. Safeguards - 'do no harm'	*Checks and balances* – between social, environmental, and economic objectives seek a minimal 'do no harm' outcome, with minor institutional cooperation.	Most countries have achieved this stage, with many provisions in legislation. But provisions are often misunderstood and ignored in practice. Safeguards do not enable the major leaps forward that are required.	Citizen engagement has often pushed for safeguards. Tools include: Environmental impact assessment; Social Impact Assessment; 'alternative livelihood' schemes; cash transfers or compensation.
3. Synergies - 'do good win-wins and co-benefits	*Win-wins* – between social, environmental, and economic objectives are sought, but are limited in extent – to where current institutional and finance rules allow.	Many countries are at this stage Policy discussion is constructive and focused on integrated schemes. But win-wins are elusive – just as important is to consider 'losers' as well, with 'just transition' (see Chapter 5) or at least compensation mechanisms.	International engagement has often catalysed win-win strategies. Tools include: Strategic environmental assessment; Payments for Ecosystem Services and conditional cash transfers; joint env/social protection schemes e.g. jobs through land restoration; certification of production; and Public expenditure reviews on environment, climate, sustainable development.
4. System-wide reform - 'do more by changing the rules'	*Full integration* – of sustainability, efficiency, equity and long-term orientation. A truly inclusive, green economy draws on relevant concepts of circular economy, bio-economy, etc. Addresses structural barriers to scaling/speeding up the transition towards green economies.	Few countries are at this stage yet. However, the need for an inclusive green economy is understood by many – institutionally this means: • Much better trade-off decisions – with mechanisms to analyse and resolve • Changing economic structures so they are inclusive and green	Multi-stakeholder policy/oversight bodies Primary empowerment e.g. rights reforms and redistributing assets Inclusive formalisation of informality Fiscal reforms pro-green economy, anti-brown economy Wealth/natural capital accounting and other means for better decision-making.

What, then, helps countries or sectors to progress between the stages? The following section will elaborate on a number of important factors.

4.1.2 Stakeholder interactions and leadership:

Financial, juridical, organizational and mental space is needed for the kind of adaptive strategy required to drive the transition from siloed organizations to full integration (GGGI et al., 2016), i.e. from stage 1 to stage 4 in Table 1. Multi-stakeholder processes (MSPs) provide this space. The value of MSPs lies in their potential to achieve consensus and pool the necessary resources for the institutional reform that no one stakeholder alone could achieve (or even envisage). MSPs confer legitimacy by virtue of whom they involve and the kinds of information they uncover. Many national and municipal sustainable development councils and green economy cross-ministerial groups attest to this. Indeed, it is no longer considered acceptable to proceed with any major policy change without them. IIED and GEC (2013) offer guidance on effective national dialogues for stakeholders to address green economy at various levels – vision, purpose, principles, policies, and precise targets for getting there.

However, there are limits to MSPs, which must be managed. At some point in the encounter between MSPs aiming for green economies and mainstream institutions that may perpetuate brown economies, something tends to give way. There have been too many instances of the MSP being ignored, annihilated, co-opted, dropped, or at best being absorbed, e.g. NCSD (Dalal-Clayton & Bass, 2009). Additionally, there are too few instances where the MSP's legitimacy is complemented through gaining an independent power base, or changing the way that prevailing power is exercised. While prevailing powers very often find a good reason to entertain holistic MSPs initially (they can gain intelligence and sometimes influence from them) they can unfortunately 'turn off' the MSP if it becomes threatening. Hence there is a need to institutionalise MSPs' mandate as a continuing process of dialogue and review, for example through national sustainable development or green economy councils, steering groups, accords or parliamentary committees.

Green economy partnerships and networks also provide the required space. According to the report published by 3GF (Global Green Growth Forum) in 2016, which brings together business-focused partnerships in support of green economy, 'Partnerships have a positive impact […] through trust-based relationships with the right people, using the right language, to tackle the right issue, at the right time [...] These intangible ingredients are often the most important and we need to get better at understanding this chemistry and how to make it work quicker and at scale' (3GF, 2016). It concludes that platform organizations are helpful in scaling up and increasing the number of such partnerships. 3GF itself is one such platform for the business world; the Green Economy Coalition (Box 4) for civil society; and the Green Growth Knowledge Platform (GGKP) for the research and knowledge community. All of these help to encourage a 'thick soup' of partnerships and networks aimed at green economy that is accessible to many: this model is in direct contrast to prevailing models of centralised institutions.

The institutional landscape evolves in large part because leaders push existing institutions into new territory, or spot an important gap that leads to the establishment of new institutions. This leadership may come from political, economic, civil society, technological, or business spheres, and often across these spheres, such as the South African Green Economy Accord and the global Green Economy Coalition, thereby widening the 'ownership' of the new institutional ideas. One example is the African Leadership Group on Biodiversity Mainstreaming, which includes people from conservation, development and finance authorities within and across eight African countries (Musasa, 2017).

However, there are also limits to relying on leadership. 'Top-down' decisions alone do not always result in the scale and speed of uptake that we need – hence the need to secure societal demand as a countervailing force to shape green economies. The likely demands of future generations also need to be taken into account in political and economic context that tends to often act on short-term incentives. One example of how such longer-term thinking can be incentivized is the Wales' Well-being of Future Generations Act, which requires named public bodies to ensure this by vesting power in a Future Generations Commissioner that provides future generations a stake in today's decisions (Welsh Government, 2015).

4.1.3 Tools for institutional reform

Good communication is an especially important quality that enables institutions to be effective in their own work and in their cooperation with others. One barrier to institutional reform in the green economy context remains the lack of a common narrative for the IGE. Green economy, green growth, green prosperity, low-carbon development, and sustainable development need some sort of common messaging if confused stakeholders are to become more confident to commit. The GEC organised an informal institutional collaboration group, which has prepared a common narrative that will best engage the public and subsequently politicians (GEC 2019, forthcoming). In addition, establishing new metrics of progress is a tough institutional nut to crack (see also Chapter 10 of this book). Statistical authorities in particular are the 'guardians' of definitions – of what is included, and what is not, when it comes to key measures such as economic success or wellbeing. While there are multiple alternative measures out there, none has yet become mainstream, and are unlikely to become so until the green economy narrative enters day-to-day business.

Another tool for institutional reform towards an IGE is information and communication technology (ICT) (see also Chapter 4 of this book on innovation). While the role of ICT has not yet been fully exploited, it holds the promise to support multi-factor decisions, enable citizen engagement in generating and using data, drive new spatial/resource modelling that green economies need, and do so increasingly in 'real time'. The qualities inherent in ICTs that support effective institutional arrangements for green economies have been spelled out by ECOSOC in the following way: "ICTs enable collaborative, integrated and coordinated action across public sector agencies and between the public sector and other actors. ICTs make governments transparent and accountable; harness and distil vast amounts of data to assist with policy planning; and (promote) data and analytical tools for measuring progress" (ECOSOC, 2017b), and further, Electronic governance helps to ensure institutional transparency and improve service delivery and is becoming a 'must-have' even in poor countries (ECOSOC, 2017a). Thus, it can be subsumed that ICTs are increasingly a central part of democratic and public administration reform with high relevance to the transition to an IGE.

Apart from communication and informational tools for driving institutional reforms, many analytical instruments play an important role, as shown in the right-hand column of Table 1. They include public environment and climate expenditure reviews, Strategic Environmental Assessment (SEA), sustainability reporting protocols for the private sector, environmental economic analyses, and Natural Capital Accounting (NCA). There have been positive feedbacks between some of these instruments. For example, the findings of a one-off environmental expenditure review can create demand for an NCA system, so that a continuing track can be kept of stocks and flows of natural capital.

4.1.4 Capacity development

A country may have changed its policy, but often this is not matched by investment in the social and human capital needed to carry it out. Green economy will require new organizational capabilities to plan, implement and review reforms – and thus also new skills and behaviours among the many professionals who work in government as well as those across the business and financial sectors.

Capacity development is a huge subject, outside the scope of this chapter. It begs the question 'capacity for what?' In brief, this means capacities to operate the entire 'institutional cycle', i.e.:

- Data and knowledge access
- Analysis, learning and review
- Participation among stakeholders
- Policy dialogue and formulation
- Law and standard-setting
- Planning and coherence
- Resource and financial mobilisation and management
- Oversight and redress
- Transparency and accountability

A second question that needs to be asked is 'whose capacity?' We propose that capacity is needed for the functions lined out above at three levels (see also OECD, 2012; UN-PAGE, 2016): Firstly, individual capacity - knowledge and skills that help people to build relationships, trust and legitimacy ('soft capacities') and interdisciplinary technical and managerial skills ('hard capacities'). Secondly, organizational capacity - organizational structures, systems and teams that bring individual capacities effectively together, preserving continuity through staff turnover. And thirdly, institutional or enabling environment capacity - cross-sectoral policy, legal, regulatory, economic, scientific, information and social support systems to encourage and require individuals and organizations to contribute to sustainable development.

4.2 Characteristics of enabling institutions

This chapter has demonstrated that there is much to learn about the kinds of institutions that are needed for an inclusive green economy. Based on the initial synthesis of literature and case studies to date, and taking into account SDG16, which addressed institutional challenges (Box 6.7), we can propose a dozen tentative characteristics of institutions that are 'fit' for green economies while acknowledging the large diversity of institutional contexts and needs (Box 6.8).

Box 6.7: Social enterprise - a promising driver of green economy at local levels

SDG 16 includes several targets that suggest the qualities that institutions should have if they are to be effective in the transition to sustainable development (our emphases in italics):

16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all;

16.5 Substantially reduce corruption and bribery in all their forms;

16.6 Develop effective, accountable and transparent institutions at all levels;

16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels;

16.8 Broaden and strengthen the participation of low-income countries in the institutions of global governance;

16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements ;

16.b Promote and enforce non-discriminatory laws and policies for sustainable development .

Whereas not every characteristic will be a prerequisite for every institution, organization, rule or norm (and instead might pull the former in too many dimensions) – their absence across the national institutional landscape can make the reform process very fragile. However, overall, the outline characteristics remain quite general, and a wide variety of institutions in government, business or civil society could achieve and demonstrate those. Nevertheless, it is useful to emphasize that many different types of institutions may be selected or developed successfully, and that no ‘standard’ form of institutional set-up exists.

Instead of using the above criteria in a prescriptive manner, Green economy strategies at various levels may use the above characteristics as diagnostic criteria for institutional reform.

5. Conclusions

Although many countries have to date developed green economy transition plans, the lack of efficient, capable institutions is one of the persistent obstacles to IGE progress. Only transparent, competent, resilient and enabling institutions can ensure that sustainable development is taken into consideration in the decision-making process, and that all societal groups are represented and participate. grant representation and participation to all societal groups. Developing such institutions will not follow a single model in all countries. Institutions are complex and diverse and shaped by their historical, geographical, political and cultural contexts. If new institutions gain commitment from stakeholders, to coordinate effectively among them and to increase cooperation for an IGE, they will need to be tailored to local needs and circumstances. They will build on what works in context.

This chapter has explored promising institutional various reforms and innovative measures in diverse contexts including new regulations for sustainable development, the establishment

Box 6.8: Tentative characteristics of institutions ‘fit’ for green economies

1. *Voice and inclusion* – participatory, trust-building and empowering – especially of poor and marginalised groups; demonstrating clear social purpose and participation in governance.

2. *Rooted* – in local contexts, capabilities and needs. Embracing domestic cultural, political, economic and social processes that support GE, and thus ‘owned’ by stakeholders.

3. *Future-oriented* – clear vision, long horizons. Responsive and adaptive, not only focusing on short-term stability but also long-term wellbeing of future generations.

4. *Holistic and systemic* – integrated, interdisciplinary, and internalizing externalities. Respecting both ecological and social limits in planning, incentives and implementation.

5. *Networked* – linking actors horizontally and vertically, and across knowledge systems. Supporting coherence, collaboration and coordination, and not overly centralized.

6. *Wealth-building* – helping stakeholders to understand, manage, grow and track the capitals needed for inclusive green economy, and make sustainable trade-offs.

7. *Resilient* – effective means for feedback, learning, adaptation, prioritization and resourcing.

8. *Legitimate and clear mandate* – rooted in the constitution and legal regime, accepted as right and proper, reflecting societal demand and consensus, and autonomous from short-term political pressure and vested interests.

9. *Upholding the rule of law* – protecting rights and fundamental freedoms, reducing bribery and corruption, and promoting informed consent and the body of sustainable development law.

10. *Evidence-based and -sharing* – founded on sound science and local knowledge; ensuring access and welcoming and responding to diverse information and learning loops.

11. *Accountable and transparent* – institutions are able to account for performance, transparent and open about the quality of that performance, and subject to independent oversight.

12. *Competent and adequately resourced* – finance and expertise are secure but responsive to need, with mechanisms to mitigate risks and avoid performance dropping off.

of national environmental authorities and cross-sectoral authorities and international green economy institutions, including PAGE, GGKP, GGGI, and GEC. But there is more to be explored and achieved beyond the scope of this chapter, especially to foster capacity for implementing and delivering IGE objectives- the long term ‘messy business’ of changing the way core economic sectors such as construction or agriculture reform their planning, procurement, production methods, training and marketing.

From successful examples of institutional reform the chapter has derived characteristics to build institutions for inclusive green economy. We have also learned why careful planning is necessary, which lays out concrete processes to implement for institutional change. The chapter has furthermore demonstrated the need for all stakeholders to be involved in such processes.

In summary, this chapter aimed to convey that it is time to identify and invest in institutions that are ‘fit’ for driving and delivering inclusive green economies. They will be especially critical for shaping local and national economies in which people and nature thrive together. And they will embrace the objectives and demonstrate the characteristics that may eventually inform a global meta institution- a common global IGE.

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CHAPTER 7: INCLUSION, POVERTY REDUCTION & GENDER EQUITY FOR A GREEN ECONOMY

CHAPTER 7: INCLUSION, POVERTY REDUCTION & GENDER EQUITY FOR A GREEN ECONOMY

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline the main challenges facing humanity and analyse their drivers;
- Articulate how the inclusive green economy model seeks to address these challenges; and
- Understand the major characteristics that underpin national strategies on inclusive green economy, the related analytical tools, key actors and initiatives as well as the critical role of public policy in turning the inclusive seen economy model into practice.

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CHAPTER CONTENTS

Foreword

This chapter will begin by discussing the status and trends of the key aspects of inclusion, focusing on poverty, equality, and gender equality in developing countries. Section 2 introduces the intrinsic case for establishing the links between inclusion, poverty, and gender equality in the context of a green economy transition (a case which has recently been strengthened by the Sustainable Development Goals), and examines the instrumental case for why this transition will improve the health, livelihoods, and vulnerability of poor women and men. Section 3 then presents economic theory, modelling statistics and empirical studies to demonstrate the links between green economy transition and poverty reduction, income, and gender equality. Section 4 considers the trade-offs between inclusion and a green economy transition, as well as how these might be addressed (such as through price increases for fossil fuels).

By doing so, the chapter aims to enable the reader to better reflect upon the fact that a green economy transition does not automatically enhance social justice in developing countries. Indeed, social justice cannot be enhanced unless the transition is complemented by integrated policies that ensure that the externalised costs of greening the economy do not fall on those that are living in poverty. Finally, Section 5 presents illustrative examples of how inclusion, poverty reduction, and gender equality can be improved under a green economy transition, focusing on four main approaches: empowerment, integrated institutions, inclusive finances, and metrics.

1. Poverty, inclusion, and gender equality: status and trends

This section will examine and review the global status and trends on poverty, inclusion, and gender equality. For these purposes, inclusion is defined as the processes of overcoming social exclusion through poverty reduction, or of addressing discrimination against a disadvantaged social group, such as women.

At the global level, absolute poverty (using the international poverty line of US$1.90 per day) has fallen considerably over the past 15 years – both in terms of numbers, and as a percentage of the world's population. Almost 1.1 billion people were lifted out of poverty between 1990 and 2013. However, still 766 million of people were living on less than US $1.90 a day in 2013, as estimated by World Bank (2017). However, the remaining poor population is often difficult to reach. Many of them live in remote rural areas with little access to share the common wealth achieved by their city or country. They are frequently living on poor quality land and far from formal markets, generally find themselves to be politically invisible, in some cases. Only a deliberately inclusive approach will succeed in reaching them.

In addition, the advancements to fight poverty have been predominately driven by pro-poor growth in both China, and more recently, in India. Due to the huge size of their populations, improvements in these two countries mask underperformance elsewhere, and particularly in some African countries. In addition, there are still hundreds of millions of people that continue to live just above the official poverty lines with few safety nets, low job security and limited physical and social infrastructure. These people therefore remain highly vulnerable to the effects of conflicts, economic shocks (as in the 2008 global financial crisis), or climate impacts (such as

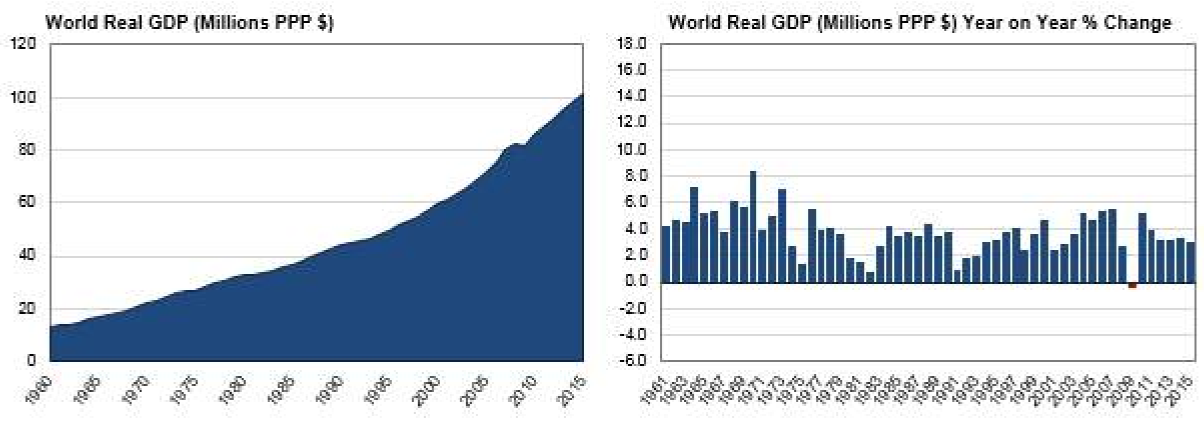

Figure 1: Paradox of global GDP growth alongside persistent poverty. (Left-hand figure of World real GDP based on Tani, 2016 and right-hand figure from Chen and Ravallion, 2012).

floods and droughts), each of which can cause them to fall back below the poverty line.

The geography of poverty is also changing. Already, more than half of the world's poor now live in Sub-Saharan Africa, and this number is set to increase further by 2030 (World Bank, 2016). Out of the eighteen countries in which the number of people living in absolute poverty is rising, fourteen are located in Africa (Kharas et al., 2018). These countries also represent some of those most at risk to challenging social and political conflicts, and climate extremes. And, while poverty remains primarily rural, urban poverty has now also increased to 20 per cent of the total poor. This is due in part to increasing rural-urban migration, with it being estimated that up to 80 per cent of the total population in some cities now living in slums (World Bank, 2016).

The challenge of tackling relative poverty now also takes place in a global context or rising and widespread *inequality*. While wealth is expanding *between* countries (with some emerging economies experiencing rapid levels of growth), wealth *within* most countries is becoming increasingly concentrated in the hands of just a few individuals. Indeed, a recent study conducted by Oxfam found that just eight individuals now possess more wealth than the 3.5 billion people living in the "bottom half" of the global population (Oxfam, 2017). Rising inequality is often accompanied by polarised levels of education, health, and mobility, each of which further exacerbate the imbalances of power – fuelling exclusion at the cost of future economic growth. Indeed, the 2013 UNDP Human Development report found that countries with high inequality suffer from slower growth rates than countries in which incomes are distributed more equally (UNDP, 2013). There is now growing political momentum in many countries to address inequality, even if it is phrased in more politically acceptable terms, such as 'inclusion'.

Gender inequality also remains a stark global issue. In this regard, data shows that women complete at least twice as much unpaid domestic and care work as men. Even where women provide more agricultural labour, most agricultural land is still owned by men: in India, Nepal, and Thailand, for example, less than 10 per cent of women farmers own the land that they farm, while in Kenya this figure is only 1 per cent, despite women providing 70 per cent of the agricultural labour (IFAD, 2008). However, some improvements have been made and provide hope for the future: 20 per cent of parliamentarians worldwide are women, and many countries now have almost 100 per cent enrolment of girls in primary education (IPU, 2014). However, other indicators, such as estimates of female infanticide, gender-based violence, and cases of child marriage, show that women and girls still remain seriously vulnerable in many countries.

Another area of exclusion that has been receiving increasing recognition is disability. Estimates of its prevalence are challenging due to the lack of uniform understanding on, or definition of, what disability is, as well as a lack of national data allowing for international comparison. The most comprehensive estimate of global prevalence is from 2011, when the WHO/World Bank's World Disability Report synthesized data collected from 59 countries through the World Health Surveys from 2002 to 2004, and which was based on a 'functioning' approach. From this, the 2011 report estimated the global prevalence of disability to be at 16 per cent, with a lower prevalence of 12 per cent in higher income countries and a higher prevalence of 18 per cent in lower-income countries (WHO/World Bank, 2011).

2. Green economy transition's contribution to inclusion, poverty reduction & gender equality: Intrinsic & instrumental approach

There are both intrinsic (i.e. moral) and instrumental arguments for the transition to a green economy to address poverty and inclusion issues.

- First, the intrinsic argument views inclusion, poverty reduction, and gender equality as fundamental underpinning of a green economy transition. This position is supported by the UN's Declaration of Human Rights and many other UN Conventions related to development and poverty reduction, which explicitly call for these to be prioritised within national policies.
- Second, the instrumental view submits that if complemented by targeted, integrated policies, the transition to a green economy will contribute to poverty reduction and enhance inclusion.

Our focus here is primarily on the instrumental view, as the intrinsic view is determined by definitional considerations. For instance, if by definition a green economy is required to contribute to poverty reduction then the transition will necessarily be inclusive. In this regard, it is important to note that the intrinsic view recognising the interlinkages between green economy, poverty, inclusion and gender equality has recently been endorsed under the 17 Sustainable Development Goals (SDGs), which were formally agreed and launched by all countries at the United Nations General Assembly in September 2015.

Up to this point, progress on issues of poverty, the environment, and economic growth had largely been pursued independently. Indeed, certain SDGs (see Box 7.1 below), whilst not being without their critiques, do provide a platform for joint action on poverty reduction, inclusivity, and environmental sustainability, based on the high degree of consensus between countries and stakeholders that the SDGs represent.

Box 7.1: Selected SDGs will drive some aspects of an inclusive green economy

SDG 1: End poverty in all its forms everywhere.

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

SDG 5: Achieve gender equality and empower all women and girls.

SDG 6: Ensure availability and sustainable management of water and sanitation for all.

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all.

SDG 8: Promote sustained, inclusive and sustainable economic growth.

SDG 10: Reduce inequality within and among countries.

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable.

SDG 16: Promote peaceful and inclusive societies for sustainable development.

The 17 goals and 169 indicators may be complex, but sustainable development (SD) is inevitably a multi-dimensional endeavour, and especially when applied to all countries and all people. Importantly, equity and inclusion are central components to half of the Goals shown in the box, and the SDGs commit countries to end extreme absolute poverty by 2030: a global commitment that would have seemed naïve even a decade ago. In this regard, the SDGs aim to drive inclusive green growth at the national level, since the 2030 Agenda applies universally and equally to all countries across the globe.

On the other hand, the instrumental view of the interlinkages between poverty, inclusion, gender, and a green economy transition focuses on 'cause and effect'. In this way, the transition to a green economy can contribute to the 'effects' of poverty reduction, inclusion, and gender equality by first reviewing which environmental issues this transition will 'cause.' Then those that are most likely to threaten the health and livelihoods of poor women and men can then be addressed on this basis (DFID et al., 2002).

2.1 Environmental health of poor people and transition to a green economy

While the provision of water and sanitation has improved, many poor people still lack regular and safe access. In 2012, 89 per cent of the world's population had access to an improved drinking water source (up from 76 per cent in 1990), which still left almost 750 million people exposed to, and relying on, unsafe water sources (UNDP, 2014). And while sanitation coverage increased from 49 per cent to 64 per cent over this same period, over a third of the world's population, almost 2.5 billion people, continue to live without sanitation, with one billion of these still forced to resort to open defecation (UNDP, 2014). Moreover, these water and sanitation metrics are often inadequate, with "improved" water sources and sanitation types not reflecting real needs observed on the ground — a reflection of the failure to include people when defining the targets.

In addition, deaths from the effects of air pollution continue to rise, with indoor air pollution, which affects the very poorest members of society. In 2012, around 7 million people died as a result of air pollution exposure – one in eight of total global deaths,: 4.3 million from indoor air pollution, mostly resulting from cooking with biomass, and 3.7 million from other effects of outdoor air pollution (with 1 million deaths being attributed to overlapping causes) (WHO, 2014). Of the 4.3 million deaths attributed to indoor pollution, most of the victims are women and young girls, who spend most of their time with the 'killer in the kitchen.' (WHO, 2004).

Since 2012, the proportion of the world's population living in slums, and specifically urban residents in developing regions, has fallen from 40 per cent to 33 per cent. However, the rapid rate of urban population growth has meant that the actual number of people living in slums has risen considerably, from 650 million in 1990, to 760 million in 2000, and reaching 863 million in 2012 (UNDP, 2014). These slums are known for having poor environmental conditions which have a corresponding negative impact on human health, such as poor water and sanitation, indoor air pollution, exposure to vector-borne diseases (such as dengue fever) from a lack of drainage, and vulnerability to climate change-related flooding.

2.2 Livelihoods of poor people and transition to a green economy

The poorest members of society disproportionately rely on available natural assets such as forests, fisheries, and farmland for their livelihoods, nutrition, health, and employment, and this is especially the case in rural areas. Some 2.6 billion people are either partially or fully dependent on agriculture; 1.6 billion rely on forests; and a further 250 million on fisheries (Lee, 2012). Natural capital is therefore critical for low-income countries — forming 25 per cent of national wealth, compared to just two per cent in those countries which are members of the Organisation for Economic Co-operation and Development (OECD) (World Bank, 2006).

This explains why farming, forestry, and fisheries make up 57 per cent of what has been called 'the GDP of the poor' in India, even if they contribute just 7 per cent to India's formal national GDP. It is also why forest communities choose to invest an estimated US$2.5 billion of their own labour and inputs each year into sustainable forestry — a figure that is higher than the combined yearly contributions of all international organisations put into forestry aid (ITTO & RRI, 2007).

In this regard, many poor groups have developed the skills to successfully manage natural capital, and numerous examples of community managed natural resources in drylands, croplands, forests, and fisheries have been well-documented by anthropologists. Initially, economists focused on the so-called "tragedy of the commons," which undermined the effectiveness of community management approaches. More recently, however, this narrative has changed, and the "tragedy of open access" now acknowledges the inefficiencies of open access approaches, with the collective management of natural capital serving to address these. **Elinor Ostrom**, the Nobel Prize-winning economist, focused her work on documenting what made these collective management schemes successful (Ostrom, 1990), and her theories have now been applied to both older and more traditional resource management approaches (such as small-scale irrigation and traditional fishery management regimes in South Asia), as well as those that are more contemporary (such as community management forestry in Nepal and elsewhere) (Ghate et al., 2008). In this respect, the adoption of collective management approaches under a green economy transition can contribute to poverty reduction by increasing the social and institutional capital of poor women and men.

Key concept: Governing the commons

Good examples from Ostrom's 'Governing the Commons' (https://wtf.tw/ref/ostrom_1990.pdf) are: Torbel in Switzerland (p. 61), Hirano, Nagaike and Yamanoka villages in Japan (p. 65), Spanish Huerta irrigation institutions (p.69) and irrigation communities in Philippines (p.82). Further resources: https://www.youtube.com/watch?v=Qr5Q3VvpI7w
Switzerland: https://houseofswitzerland.org/swissstories/environment/swiss-village-changed-ecology-twice Japan: https://www.youtube.com/watch?v=GFVwm3earxU
Spain: https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/10135/ORTEGA.pdf?sequence=1&isAllowed=y Philippines: https://www.youtube.com/watch?v=yNQcOvnQY4g

2.3 Poor people vulnerability and transition to a green economy

Climate change is now almost universally recognized as posing a huge short-term threat to poor economies, and particularly to the very poorest members of the population. This discourse has shifted from concern over impacts on future generations to the realisation that climate change is already having significant impacts – increasing the intensity and frequency of natural disasters, the economic damages from which exceeded US$380 billion in 2011 alone. While the financial impacts of these are greater in emerging economies, the toll on society and human life hits small, low-income countries the hardest (World Bank, 2012a).

Within this context, evidence increasingly suggests that women and other excluded groups are particularly exposed to the effects of climate change. The Inter-Governmental Panel on Climate Change (IPCC, 2014) concluded that: "Differences in vulnerability and exposure arise from non-climatic factors and from multidimensional inequalities often produced by uneven development processes (very high confidence). These differences shape differential risks from climate change. […] People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change and also to some adaptation and mitigation responses (medium evidence, high agreement). This heightened vulnerability is rarely due to a single cause. Rather, it is the product of intersecting social processes that result in inequalities in socioeconomic status and income, as well as in exposure. Such social processes include, for example, discrimination on the basis of gender, class, ethnicity, age, and (dis)ability."

3. Theory and data of how green economy transition matters for inclusion, poverty reduction and gender equality

This section presents economic theory and data from modelling and empirical studies which consider the links between a green economy transition and poverty reduction, income, and gender equality:

Section 3.1 presents the proponents and critics of the theoretical linkages between growth and development, in the context of a green economy transition in low income and least developed countries. The proponents of these linkages focus on the instrumental justifications that were briefly introduced in Section 2. Critics of these, on the other hand, tend to focus on shorter-term green economy issues, while ignoring the effects of distribution and equality over time. Section 3.2 presents some of the data that is available for these linkages, with a focus on modelling and some empirical data taken from Ethiopia and Uganda. In this regard, the limited observable empirical data is highlighted. Section 3.3 then presents the linkages between a green economy transition and income inequality, with a focus on equality of incomes, natural resource access, and climate vulnerability and emissions. Finally, Section 3.4 considers a green economy transition in the context of gender equality, and examines both the traditional literature focusing on the unequal burdens of environmental degradation, as well as a more radical feminist interpretation of a green economy transition being needed to free women from patriarchal economic systems.

3.1 Theoretical literature on a green economy transition in low-income countries

There is now emerging theoretical literature on the effects of a green economy transition within low income and less developed countries. This literature has been produced both by international organisations such as the World Bank and the United Nations, and by more academic economists (Scott et al, 2013; Barbier, 2013; Dercon, 2011; Hallegate et al., 2012). The only applied work to have been conducted tends to be advocacy analysis, made by green growth exponents such as the New Climate Economy (eg. NCE and GoU, 2016).

It is submitted that the literature that has been critical of a green economy transition is constrained by seeing the goals of economic policy (i.e. to deliver growth and employment) in the aggregate and over relatively short term periods, while generally ignoring the long-term effects of distributional issues or other social goals. As such, some of the critiques in this section are limited and partial when considering poverty reduction and inequality as explicit long-term goals and objectives.

Some publications, by international organisations such as the OECD and World Bank, have argued that a green economy transition in developing countries is 'necessary to achieve sustainable development' (World Bank, 2012). This core argument, as Resnick et al. submits, is based on the evident failings of following the 'conventional development theory' path (Resnick, 2012). Indeed, upon reviewing publications by the World Bank, ADB, ESCAP, UN Environment, and OECD, and based on hypothetical and empirical analysis, Scott et al. (2013) argue that green economy can bring ‘poverty reduction, economic growth, reduced vulnerability to climate change and natural disasters, greater energy security, and more secure livelihoods for those directly dependent on the use of natural resources’.

However, at least two main economic critiques to the literature relating to development and poverty reduction have been put forward. As a sceptic of the green economy model, the economist Dercon (2012) argues that ’conventional growth may provide a more rapid route out of poverty.’ Dercon further argues that given their level of poverty and high dependency on natural resources and natural capital, the ‘poor are likely to suffer most due to their low resources for mitigation and for investment in adaptation’ (2011). In addition, concerns have been raised regarding the trade-offs that must be taken for advancing green economy transitions within national development strategies. As Resnick et al. (2012:1) argue these pose ‘more trade-offs than is readily acknowledged’. Here, it is submitted that the focus of green growth strategies essentially remains to reduce carbon emissions, and that doing so requires that countries deviate from both the prescriptions of conventional development theory, as well as their current development trajectories. Therefore, while the long-term environmental benefits in this context could be sizeable, the initial short-term societal and economic costs are likely to be particularly felt by the poorest members of society. These trade-offs are explored further in Section 4.

A second critique raises the opposite concern – that green growth is too closely linked to the earlier economic models of neoclassical growth (see Chapter 2). For instance, Becher (2012) argues that ‘the assumption underlying economic policies – that growth automatically brings prosperity, or for that matter, greater justice – has proven to be false’. These arguments similarly oppose the financialization of natural capital, which is framed within the traditional neo-liberal economy mode of thinking (Scott et al., 2013:5; McAfee, 2012).

The emerging theoretical literature also focuses on two necessary components for a green economy transition: state capacity and sufficient finance. A green economy often requires, at the initial stage, state structural transformation and huge capital investment. However, challenges regarding the ‘absorptive capacity’ for innovative green technology among developing countries is evident, and the transition may be ‘too costly for LICs and potentially a constraint on their economic development’ (Scott et al., 2013:10-12). The question of affordability then, with many developing countries already facing overstretched public finances, is important.

In this regard, there have also been huge disparities between the levels of climate finance awarded to developing continents, with Asian and Latin American countries receiving a significantly greater amount than their African counterparts do. It is therefore submitted that, in Africa, the proposed economic transformation under a green economy can potentially be an obstacle for growth and poverty reduction. Indeed, in the cases of Malawi, Mozambique and South Africa, Resnick et al. (2012) conclude that green economy ‘may be inconsistent with their comparative advantages and past investments, economically costly and face popular resistance’.

This literature also considers the potential impacts a green economy transition can have on jobs in developing countries. A green economy requires low-carbon climate resilient investments and investments in natural capital to create green jobs (Bowen & Kuralbayeva, 2015). Green livelihoods therefore depend on the creation of entrepreneurial opportunities and decent jobs, and to this end a green economy can influence the labour market by creating new employment opportunities where previous jobs had been lost (see Chapter 5 for a full discussion of the impact of Green Economy on labour). In this regard, the proponents of green economy argue that the overall net expansion of jobs would have a positive effect (OECD, 2013). This is particularly important when taking into account the high youth unemployment rates in most low-income countries. However, countering this position, some writers contend that the technological advancement and mechanisation of several economic sectors, as part of a green economy transition, can lead to unemployment among the poor who live in both urban and rural areas. These economists argue that a green economy is anticipated to be highly based on certain technology and industrialisation processes, and that these may benefit more educated, skilled workers; and this can negatively affect the millions of poor people whose livelihoods depend on labour-intensive employment, especially in agriculture (Barbier, 2015).

Finally, the literature also speaks about the need to ensure that natural resource revenues are carefully managed in order to benefit the poor and to sustain future finance flows — maintaining these as a resource 'blessing' rather than a resource 'curse' (Auty, 2001). Revenue flows from natural resources — such as minerals, land, forests, and fisheries — are more critical to low-income than to high-income countries, a dependency that has increased with commodity price booms (Isham et al., 2005). It is therefore vital that these revenues are used in ways that benefit the poor, both through revenue-sharing schemes, and to secure future revenue streams through the management of the natural resource base (Ploeg, 2011; OECD, 2008).

3.2 Applied economic literature on a green economy in low-income countries: Country data

There is limited data from modelling or actual empirical work conducted on the interlinkages between poverty reduction, development, and the transition to a green economy in low-income countries. As Scott et al. (2013) pointed out, macro-level 'research on the costs and benefits' of a green economy transition has not yet been carried out within many developing countries. This lack of a green economy 'champion' for a model transition within a developing country context, and the subsequent unproven results (Jacobs, 2013) is creating uncertainty and deterring many developing countries from pursuing this approach. Developing countries are struggling to find a showcase "green economy country" with a similar initial level of economic development but reaching a high degree of economic growth with the transition. The 'lack of a model' is indeed creating uncertainty for developing countries in pursuing a green economy transition.

However, some countries are nevertheless making attempts to seize opportunities that might be presented by pursuing a green economy transition, and reviewing some of these national initiatives can provide a basis for developing corresponding activities. Some of the countries that have taken these steps include Columbia, China, India, Ethiopia, and Uganda. For now, our focus here is on Uganda and Ethiopia, and the green economy transition in an African context. Sub-Saharan Africa had the biggest group of people in extreme poverty compared to other regions in the world in 2015 and the World Bank (2017) projected the trend to continue until 2030.

Advancing the green economy agenda is seen, for governments of the global south, to be part of their foreign policy and diplomatic efforts to create a positive state image or brand at the global level (Death, 2011). Ethiopia, while representing African interests at COP15, took on a leading role in elaborating the common position of the African countries and, in doing so, served to create a new state brand at the global stage. Indeed, while Ethiopia is a low-income country, it decided to be a leader in the global and national greening agenda by launching its Climate Resilient Green Economy (CRGE) Strategy in 2011. The following quote, made by the late Prime Minister Meles Zenawi, reflects the new ambitious direction that the country decided to pursue.

> *"We have therefore embarked upon the development of a CRGE strategy addressing both climate change adaptation and mitigation objectives […] which will be fully integrated into our five-year Growth and Transformation Plan. Our goal is quickly to improve the living conditions of our people by reaching a middle-income status by 2025 based on carbon-neutral growth."*
>
> (FDRE, 2011: 5)

To this end, it is stated that the CRGE, which deploys a 'sectoral approach' and identifies more than 60 prioritised national initiatives for advancing the green economy transition, can enable Ethiopia to become a middle-income country 'while limiting 2030 GHG emissions to around today's 150 Mt CO_2e – around 250 Mt CO_2e less than estimated under a conventional development path' (FDRE, 2011).

In line with the theoretical literature examined in Section 3.1, these country modelling calculations conducted at the national level highlight the need for major financing, often with huge external investment, to unlock the full potential of a green economy transition. For instance, in Uganda it is estimated that an annual investment of US$1.8 billion is needed until 2020 to meet its green economy objectives (NCE & GoU, 2016). In the case of Ethiopia, initial estimates for achieving a green economy detailed a total expenditure requirement of around US$150 billion over the next 20 years, 'with around US$ 80 billion of required funding estimated to be capital investment and the remaining US$70 billion assessed as being necessary to cover operating and program expenses' (FDRE, 2011). The CRGE, recognising this huge financing gap, calls for the mobilization of additional resources from both international climate finance and the private sector, requiring additional state capacity and the development of a CRGE Facility to oversee this project preparation. To this end, the CRGE Strategy reformed the Environment Protection Authority to give it the status of an executive body with a ministerial mandate – making it the Ministry of Environment, Forestry, and Climate Change.

However, despite the initial investment required, Ethiopia's transition to a green economy is expected to provide significant positive pay-offs. Indeed, 'for more than 80 per cent of the abatement potential, abatement costs are less than US$15 per Mt CO2e. Many of the initiatives offer positive returns on investments, thus directly promoting economic growth and creating additional jobs with high value-added' (NCE & GoU, 2016). The ambitious strategy to transform Ethiopia to a middle-income status, and in a short timeframe, has prioritised the forestry, agriculture, energy, and transport sectors for investment. For instance, the huge hydropower potential of the country, demonstrated through megaprojects like the Renaissance Dam (with about 6,000 megawatt capacity), is expected to positively contribute towards the country's generation of clean energy.

Similarly, Uganda's national green strategy aims to make it an upper-middle income country by 2040, and 'a green growth leader in the region' (NCE & GoU, 2016: v-vi). To this end, its recently developed Green Growth paper, entitled *Achieving Uganda's Development Ambition – The Economic Impact of Green Growth: An Agenda for Action* and published in November 2016, aims to accelerate the country's economic development in a way that ensures 'growth is socially inclusive and that the protection of the environment is upheld' (NCE & GoU, 2016). This document is intended to complement and enhance Uganda's Second National Development Plan and its Vision 2040 strategy. This strategy estimates that a 3 per cent increase to the annual public budget, financed by the development and climate communities, will bring an economic benefit of 'US$3 for every dollar invested, even excluding wider benefits'. With full implementation of its green strategy, Uganda expects to experience a 'boost to economic activity, worth around 10 per cent of GDP by 2040 compared to business as usual (BAU) deliver employment of up to 4 million [green] jobs; and reduce future greenhouse gas (GHG) emissions by 28 per cent relative to a conventional growth pathway' (Ibid). For instance, Uganda plans to create up to 4 million green jobs by 2040 (NCE & GoU, 2016). While some of these green job opportunities are projected on the basis of future initiatives, there is evidence of some progress already being made in Uganda, such as in the sector of organic agriculture (see Box 7.2).

Box 7.2: Organic agriculture in Uganda

Inclusive green economy within the agriculture sector would entail an increase in sustainable farming practices, including organic production, and an increase in food productivity. Agriculture is a dominant sector in most African economies, accounting for 32 per cent of Africa's GDP and supporting about 65 per cent of the labour force (AGRA, 2013). As such, targeted green investment in the sector could yield long-term positive results and generate the highest social impacts with regards to the economy and food security.

In Eastern Africa, the amount of land under organic production has been expanding. Between 2000 and 2012, land under organic production grew more than 20-fold (UNECA, 2016). Uganda currently has the biggest proportion of land under organic cultivation (Willer and Lernoud, 2014), and accounts for 16 per cent of Africa's total. Ethiopia and the United Republic of Tanzania also have significant areas of organic agricultural land, with 13 per cent and 12 per cent respectively.

In Uganda, organic products represent an important source of export earnings for the state, and provide revenue for smallholder farmers. Certified organic exports increased from US$3.7 million in 2003-2004 to US$6.2 million in 2004-2005, before jumping to US$22.8 million in 2007-2008.

Through organic farming, Uganda not only gains economically but also contributes to mitigating the effects of climate change, as greenhouse emissions per hectare are estimated to be on average 64 per cent lower than emissions produced on conventional farms. In sum, Uganda has taken an apparent liability – limited access to chemical inputs – and turned this into a comparative advantage by growing its organic agriculture base, thereby generating revenue and income for smallholder farmers.

Source: UN Environment, 2010 and UNECA, 2016

To conclude, modelling data is starting to emerge on how a green economy can contribute to development in low-income countries, but this is still primarily based on hypothetical modelling promoted by exponents of a green economy transition. Meanwhile, critics of this transition focus primarily on the possible imposition of short-term societal and economic costs on the poorest members of society. However, it is argued that these critics fail to properly consider long-term sustainability of traditional growth models, and whether these will lead to lasting poverty reduction. This dichotomy arises from a lack of observable empirical data and actual experience over time. While this section has identified some exceptions to this, such as the growth of organic agriculture in Uganda, contributing to poverty reduction in the short-term, generally it will be some time before independent and observable macro-economic empirical data will allow the impacts and effectiveness of a green economy transition in low-income countries to be assessed.

3.3 Economic literature on green economy transition and inequality

Inequality is important because of its fundamental associations with income or wealth, ethnicity, gender, and the power to access or control natural resources. Inequality can also determine vulnerability to the effects of climate change, the capacity to respond to green growth benefits (such as green jobs), and the impacts of green policies (UNRISD, 2012). More recently, the economist Thomas Piketty has argued that inequality is deeply rooted politically and thus cannot be determined or dealt with by economic mechanisms alone; rather, that knowledge and skills diffusion are the two converging forces essential to economic growth and the reduction of inequality (Piketty, 2014).

The identifiable links between economic growth and the social pillars of sustainable development have generally shown to be positive and complimentary (Hallegate et al., 2012; Dollar & Kraay, 2002), and even more so in the presence of policies that reduce inequality. In economic theory, wealth inequality is directly related to the capacity to invest in physical or human capital, which in turn affects the long-term growth rate (Aghion et al., 1999). However, this conclusion has been challenged by recent 'degrowth' literature (Jackson, 2017), which argues that beyond a certain level of income, growth may in fact have negative impacts – in particular, by increasing inequality, as will be seen below.

The question as to whether income growth causes inequality continues to be contested both theoretically and empirically. Theoretical relationships between economic growth and income inequality can be neutral, positive or negative (Chen & Guo, 2002), or take the shape of an inverted U (Kuznets, 1955,). In this regard, the 'Kuznets Curve' submits that inequality is low (negative) at initial levels of growth, increases (positive) as income levels increase, before falling again once an average level of income is reached. Aghion et al. (1999), based on cross-country empirical studies, found a negative correlation between the average rate of growth and measures of inequality. The compilation of household-level data from developing countries also suggested little or no correlation between growth (and indicators of growth promoting policies) and its effects on inequality across countries (Ravallion, 2001), and this reaffirmed the conclusions of Dollar and Kraay (2000) that economic growth has a low direct impact on inequality (UN Environment, 2011).

With regards to other aspects of a green economy transition, such as access to natural resources and vulnerability to the effects of climate change, the links to inequality is much clearer. Firstly, it has been shown that more equal access to natural resources promotes economic growth, and that inequality of access has the opposite effect. High levels of inequality in the distribution of income and tenure to land appear to slow economic growth and restrict the opportunities for pro-poor growth (Aghion et al., 1999, Ravallion, 2001). Studies of post-war land reform in Korea and Taiwan, on the other hand, showed that a reduction in inequality helped to foster rapid and broad economic growth. In addition, the natural resource 'curse' (as considered in Section 3.1) submits that where certain natural resources (particularly hydrocarbons, but also hard rock mineral and forests) are very inequitably distributed and controlled by certain elites, the overall economic growth rate is reduced (Auty, 2001).

Increasing evidence also suggests that climate change has a direct 'cause and effect' relationship with inequality – that the effects of climate change can be a cause for income inequality, while income inequality itself increases vulnerability to climate change, creating a reinforcing circle. Indeed, a recent study in *Nature* by Burke et al. (2015) found that unchecked climate change is likely to reduce global average incomes per capita by roughly 23 per cent by the year 2100, but that this figure will vary considerably depending on where a country is located. According to Burke et al. (2015), climate change will reduce average incomes in the poorest countries by 75 per cent in the year 2100, while the richest countries may actually experience slight income gains. Climate change is therefore predicted to significantly increase global patterns of inequality.

In this regard, inequality of income can also exacerbate climate change as high-income individuals are much more likely to emit greenhouse gases. To this end, a recent article by Piketty and others found that "Global CO_2e emissions remain highly concentrated today: top 10 per cent emitters contribute to about 45 per cent of global emissions, while bottom 50 per cent emitters contribute to 13 per cent of global emissions. Top 10 per cent emitters live on all continents, with one third of them from emerging countries" (Chancel & Piketty, 2015).

Box 7.3: Green economy investments in energy for gender benefits

A pioneer in renewable energy production and distribution, Grameen Shakti has been operating in Bangladesh for the last 20 years. The not-for-profit organization provides renewable energy services, such as solar energy or biogas, to households for electricity generation and cooking.

This benefits women in two respects: 1) Women are able to reduce the time-consuming, tiring, and often unpleasant and even dangerous work of gathering biomass fuel; and 2) Grameen Shakthi has trained a growing pool of female energy technicians, allowing women to benefit from the production side of renewable energy. There is now a network of 'Grameen technology centres' (GTCs), with most of these being managed by women engineers. These GTCs train other women as technicians through a two-week course, in which they learn to assemble equipment and how to install and maintain solar home systems. Some women are then given further training on how to repair these. As of 2008, 20 GTCs had trained over 1,000 technicians; with at least 300 of these technicians working either for the GTCs or on their own.

Source: Ashden, https://www.ashden.org/winners/grameen-shakti

3.4 Economic literature on green economy and gender equality

The emerging literature on the relationship between a green economy transition and gender equality highlights the strong linkages between the two. Traditionally, this literature has focused on how a green economy will provide benefits to poor women in terms of health, livelihoods, and vulnerability. For example, in most developing countries women bear the principal responsibility for collecting and then using household forms of energy – often generated from biomass – and thus spend much of their time not only travelling to collect the biomass, but also facing harmful smoke exposure when cooking indoors. Green economy initiatives that promote the use of cleaner energies can therefore have positive corresponding effects on gender equality (see Box 7.3 - example from Bangladesh).

Another linkage between gender equality and green economy relates to job creation. Globally, while the generation of green jobs is expected to create a wide array of opportunities for women, this can go both ways. As ENERGIA et al. (2011:2) point out, greening initiatives that aim to generate 'green jobs' in the informal sector can in 'some cases even be a threat to women's livelihoods'. There is also the question as to whether informal jobs, such as domestic work and the engagement of women in agriculture and food production, can be considered 'decent jobs' under a green economy transition. For example, some jobs involve the use of harmful chemicals – 'women in the flower industry are exposed to pesticides, and women hairdressers use chemicals linked to breast cancer,' meaning that women often 'have different health risks from working with chemicals than men' (ENERGIA et al., 2011:5). Green jobs therefore need to be introduced in ways that do not undermine employment opportunities for women.

Finally, the literature on gender equality and a green economy transition has given rise to a more radical critique: that in order to become more effective within a green economy context, women first need to be freed from current patriarchal systems. This includes economic, legal, and political constraints which limit their ability to own and control land and, restrict their rights to access natural resources, and often prevent them from obtaining necessary training, to access information, raise financing, and acquire relevant technology. Therefore, it is submitted that gender needs to be central in developing 'environmentally friendly technology' (ENERGIA et al., 2011:3). In many developing countries, women are often unable to seize the new benefits associated with green economy, including 'improved agriculture management […] due to patriarchal attitudes and social conditioning' (ENERGIA et al., 2011:3). This critique also contends that 'a gender-equality perspective is still missing from the mainstream understanding of the concept, which is based on a traditional interpretation of the economy, focusing on growth while ignoring the value of care work' (2012:20). On this basis, it is submitted that a green economy transition that fails to value the care and domestic contributions of women does not fully depart from conventional economic approaches.

4. Managing trade-offs: Why inclusion, poverty reduction and gender equality are not inevitable outcomes of a green economy

The previous sections have served to demonstrate that by placing green growth at the heart of their development objectives, governments can generally achieve sustainable economic growth and social stability (OECD, 2013) and bring long-term sustainable benefits to the poor (Raworth et al., 2014). However, emerging theoretical literature by Dercon, Hallegate and Barbier highlight a number of potential trade-offs to these benefits, as initially considered in the previous section. If not complimented by integrated policies, these trade-offs can have negative impacts on the poor:

- Increases to fossil fuel prices, if not complemented by other policies, can strongly affect those poor consumers who have no alternative but to continue to purchasing fossil fuels.
- The closure of coal mines, often found in the poorer parts of a country, can have significant impacts on coal miners who have limited employment alternatives.
- An increase in biofuel production, intended to reduce greenhouse gas emissions, can displace land for food crops, negatively impacting poor rural food producers. Indeed, "land grabbing" for biofuel production by corporates and state-led mega-investments has, in many cases, driven Indigenous and rural communities off of their own land, leading to an increase in conflicts in many communities.
- The use of scarce natural resources for green, non-poverty reducing investments. For instance, climate proofing (e.g. protecting against floods and storms) public infrastructure such as roads, ports and industrial estates is more likely to benefit the wealthier members of society. To this point, the focus of climate proofing physical infrastructure has generally been for the economic benefits to the economy as a whole, with only a limited consideration of the distributional and poverty reduction benefits (UNDP, 2011). However, there are now programmes to climate proof capital that are important for poor people, such as low-income settlements or rural houses in Bangladesh and other climatically vulnerable locations. This is an area where further attention is required.
- Moving from labour intensive, more poverty-reducing technology to more capital intensive and less poverty reducing technology, such as the development of high-tech, clean technology for energy, agriculture, and transport, may potentially reduce job and employment opportunities for the poor.
- Green economy initiatives, which carry high health costs, such as rare earth metal mining (e.g. cobalt) for renewable technologies and batteries, often disproportionately affect the very poorest members of society. For instance, artisanal miners in many African countries are exposed to serious pollutants on a daily basis, as well as the conflict and negative social impacts experienced in mining regions.

An IGE does not operate in a vacuum (UNECA, 2016). The green economy does not automatically increase social justice, and must be complemented by integrated policymaking processes and a holistic outcome framework which combines environmental, social and economic objectives, so that the costs of greening the economy do not fall on women and men living in poverty (Raworth et al., 2014). Thus, as the trade-offs above serve to illustrate, green economy policies do have the potential to cause inequalities (Barbier, 2015) and their ultimate effect is dependent on them being complimented by other integrated policies.

Indeed, green economy policies can have both negative and positive impacts – for instance, the internalization of environmental externalities (e.g. through a 'Carbon tax') may lead to higher energy prices for consumers. They may also have income and distributive effects – a 'Carbon tax,' for example, is likely to reduce the number of jobs in the polluting, fossil fuel industries (Hallegate et al., 2012). However, green economy policies can succeed if the external costs of these policies are contained, ensuring that they do not disproportionately affect the poorer members of society (Huberty et al., 2011). For example, removing fossil fuel subsidies and providing direct cash transfers to low-income households (as in the case of Indonesia), or promoting higher government spending on other public development objectives such as health and education (as in the case of Ghana), has shown that such policies can significantly improve the living conditions and wellbeing of the poorest (OECD, 2013).

To this end, Dercon (2011) conducted a study in 2011 in which he deployed a number of stylized examples of green growth initiatives, assessed their effects and impact on the poor. His analysis focused on three main categories of green growth policies (environmental pricing and regulation, low-carbon investments, and adaptation investment), and he tested these in four spatial and sectoral dimensions. These dimensions are now crucial in understanding the dynamic relationship between economic growth and the inclusiveness of growth in low-income and least developed countries.

First, he found that environmental pricing and regulation intended to internalise environmental costs (such as fuel or water pricing at full cost) might impact poor people (as consumers and producers) through rising prices, while the wealthy could circumnavigate environmental regulations by simply displacing pollution to low-income areas. The design and enforcement of regulations as part of green growth policies is therefore central to determining whether these will benefit the poor. Second, Dercon found that low-carbon and other environmentally friendly investment strategies could promote and mobilize investment at a local level (such as by supporting growth-focused on local linkages, such as agriculture close to cities). However, such strategies could also discourage investment in more rural, marginal areas from common shared development as the cost of long-distance transport could be a factor holding back the investment, which may lead to geographical imbalance. Finally, his study found that adaptation measures generate the strongest trade-offs for the poor. Instead of encouraging economic transformation and migration, rural adaptation measures may actually encourage the rural poor to invest in low-return livelihoods. In addition, investments in public infrastructure may be centred on the most economically valuable assets at the expense of poor communities based in marginal and unsuitable areas, making them increasingly vulnerable to climate shocks.

As earlier sections have demonstrated, the medium and long-term benefits of a green economy transition are clear and, if implemented correctly, can provide tangible benefits to the excluded and poor. However, the transition may also carry many costs, and these are essentially the costs of moving from unsustainable production and consumption processes to ones that are sustainable. It is therefore vital that these transition costs are not borne by the excluded and poor.

Box 7.4: Successful energy subsidy reforms in Kenya

In Kenya, energy subsidy reforms were made under a new energy policy in 2004. The policy increased power tariffs in 2005 to reflect long-term marginal costs, introduced an automatic pass-through mechanism to adjust tariffs for changes in fuel costs, and reconstituted the Electricity Regulatory Commission as an independent energy regulator.

The new policy led to significant improvements in the electricity sector as power generation steadily increased, distribution losses declined, and the number of customers served by grid-supplied power expanded substantially. In the post-tariff increase period, the average annual increase in national power supply was over 5 per cent. Line losses declined from 18 per cent in 2005 to 16 per cent in 2011, and the collection rates increased from 85 per cent of total power bills in 2005 to 99 per cent in 2011. Indeed, electricity access in Kenya increased by almost 140 per cent between 2005 and 2011.

Political support for the process was achieved through prior consultation with trade unions, which helped to mitigate potential job losses. On the basis of these reforms, the increase in revenues would also be used to expand energy access, with the newly reconstituted Electricity Regulatory Commission to promote integrity and more transparent processes.

Source: IMF (2013)

One common example of a trade-off would be any short-term increases in energy prices before renewable energy prices can compete with the lower market rates for fossil fuels. In many cases, this will bring immediate benefits to the poor. First, renewables are now price-competitive (half the new energy-generating capacity installed in 2014 across the world was renewable). Second, poor people in remote locations often live too far from the grid to utilize traditional power supplies, and thus decentralized renewables may represent a more convenient option. Finally, when the external costs of coal are included (such as its negative impacts on health and outdoor air pollution), renewables can be seen to be the more cost-effective option. At the same time, however, increases to fossil fuel prices (e.g. through the removal of fossil fuel subsidies) could also potentially have negative impacts on the poor. As such, it is important for governments to be aware of these transition costs and to ensure that they favour the excluded and poor, as shown by the example of energy subsidy reforms in Kenya (see Box 7.4). This can be achieved by shifting the savings made by removing fossil fuel subsidies into social programs and initiatives that benefit the poor. Such initiatives have been successfully introduced in Indonesia, Ghana, Mexico, and Germany, where the costs under a green economy transition have been cushioned by social protection reforms and programs.

A second, important trade-off is the use of greener, cleaner technology, which can potentially produce more (energy) outputs while using fewer polluting and/or natural capital inputs. However, it will also have impacts on other types of assets and may, for example, require more or less labour or capital inputs. Again, this may negatively impact poor women and men, and the impacts of these technologies therefore need to be carefully assessed before being introduced to a country. Indeed, while internet connectivity and high-tech approaches will always be important aspects of a green economy transition, it does not require only imported or high-cost high technology. Instead, an inclusive approach to a green economy transition will aim to identify and support local technical knowledge, as well as innovations compatible with informal economies. Energy-efficient cookers made from local materials, bicycle-based transportation, and local mobile phone apps are good examples of affordable technologies that can directly benefit poor groups. In this regard, social enterprises can be good brokers for finding, testing, and extending appropriate technologies that produce the inclusive and green outcomes that are sought by these groups. For example, the solar water heater program in Bangladesh, as detailed in Box 7.3, is supported by social enterprises and aims to maximize benefits for the excluded and poor: low-income women act as producers and distributors and, as a result, thousands of female jobs have been created.

A third and final trade-off may occur when prevailing governance and fiscal rules for access to and control over natural resources work against the social and institutional capital of the poor. It is often mistakenly assumed that simply increasing the value of natural assets and capital, such as through increasing land prices for biofuel production or receiving, will benefit the excluded and poor. Instead, these higher prices may lead to higher demand and 'land grabs' and 'green grabs' that subsequently exclude the poor from accessing natural capital. Greater resource and tenure rights must therefore accompany these increases in natural resource prices for the poor (Cotula and Mathieu, 2008). Improvements to land governance are especially important for women who, while often being the primary farm workers, have limited land and tenure rights (Kisambu, 2016).

5. How to increase inclusion, poverty reduction, and gender equity as outcomes of green economy transition

This final section reviews the existing literature on recommendations for advancing a green economy transition that increases inclusion, poverty reduction, and gender equality. These will be considered under the following four main areas (which need to be pursued together):

(i) Empowerment

(ii) Integrated institutions

(iii) Inclusive finance; and

(iv) Metrics

5.1 Empowerment

Increase empowerment and rights: recognising, empowering and engaging poor women and men — so that they can be effective agents and rights-holders in their own future

Poor people are actors for, and the holders of, universal human rights. They also possess the most credible voices in terms of drawing the world's attention to the poverty, environmental and climate agendas – these are all issues that disproportionately affect their livelihoods. However, prevailing dialogue and decision-making structures are often closed to this group of population and their lack of a political voice on the global stage is seen as being a cause of these wider problems. As such, it is submitted that a systematic change, with new governance institutions, is required at the global level (Action 2). As rights-holders, poor women and men must be able to hold duty-bearers accountable for their actions (MRFCJ, 2015). These duty-bearers are those acting at the governmental or state levels, who have a legal obligation to protect, respect, and fulfill the rights of the rights-holder (UN, 2016). To this end, it is contended that an empowerment and human rights-based strategy, consistent with the UN Declaration of Human Rights, should be pursued as part of the broader SDG implementation process at the global level.

In many developing countries, marginalized producers who operate through micro/small enterprises within the informal economy still form the backbone of that country's economic activity. Smallholder agriculture remains the principal form of employment in many countries, with women often being the main source of agricultural labor. Meanwhile, the non-agricultural informal economy continues to grow and now accounts for 82 per cent of the total non-agricultural employment in South Asia, 66 per cent in sub-Saharan Africa, and 51 per cent in Latin America (ILO, 2014). Indeed, the informal economy is now encouraging innovative developments in a range of sectors, including energy, water, sanitation and transport provision.

Poor women and men, then, can be a central component in advancing the transition to a green economy – as empowered citizens able to upgrade slums, as custodians of natural resources, as labour intensive producers, and as distributors of low carbon technologies and products. Informal labour markets should therefore be supported (e.g. to achieve higher wages), and governments should resist attempts to criminalize or close them. Instead, in those cases where informal labour markets do have negative environmental and health impacts on the poor (such as in some small-scale mining, and waste recycling and disposal), the provision of technological and training support can help to shift informality along the spectrum from 'dirty' and 'illegal', to 'professional' and 'efficient'.

Doing so requires a formal, institutional process and, when organized by governments or state/private corporations, these can be (inadvertently) exclusionary or environmentally ineffective. Such processes, if prompted by small producers or traders based on their own capitals, knowledge and organization can be more sustainable; however, these are likely to miss out on other technological, skills-based and market opportunities. Instead, through a better understanding of these informal actors, as well as the power and agency that they hold, it is submitted that innovative hybrid approaches can promote rewarding livelihoods and create decent jobs within these informal environments. In the long-term, education and training programs should complement these, in order to build a workforce suited and prepared for an inclusive, green future.

5.2 Institutions

Developing integrated, inclusive and transformative institutions — including for collective action on multiple systemic risks and opportunities

Poverty, environmental and climate issues affect stakeholders across a variety of different sectors, and solutions to these problems accordingly require collection action from a wide range of organizations. On this basis, the international community needs to build more and stronger bridges between these individual organisations, and to promote synergies and collaborative practices, which benefit the poor. These bridges need to be built deliberately and systemically — developing integrated institutions with common rules, knowledge bases, and norms that achieve a better balance between sustainability, growth, and equity.

Two decades of mainstreaming the environmental and climate agendas at the international level have generated enough theoretical experience to consider how this institutional restructuring may be achieved. On this basis, three key opportunities may be identified. First, the 2030 Agenda requires governments to generate national plans for implementing the SDGs within their respective countries. Second, there is now an increasingly imminent need for the international community to make decisions on issues that will help shape the futures, one way or another, for poor people and the environment (e.g. whether to exploit new fossil discoveries, or where to focus climate change adaptation plans). And third, these decisions are to be facilitated by the availability of new information and communication technology and 'big data,' with magnified citizen engagement and new landscape/spatial modelling providing clearer ideas on the consequences of multi-factorial decisions – and all increasingly in real time.
If the work completed to date has focused on integrated assessments, plans, and projects, this should now be expanded to encompass the development of integrated governance frameworks and institutional capacities. This is certainly an ambitious aim, given that poverty, environmental and climate problems are themselves the result of deep structural failures. So while systematic, institutional reform may at first appear daunting, a lot can be achieved in smaller steps. Moreover, to begin this process, sequencing and priorities should first be determined at the national level, and perhaps in the form of a poverty, environment, and climate institutional change roadmap.

5.3 Finance

Inclusive finance and business: reforming private and public investment — to better engage with the people and environments marginalised by current policy

Together, the 2015 Paris Agreement and 2030 Agenda for Sustainable Development, promote the need for huge new investments in energy, transport, and urban infrastructure across the world. If done correctly, these investments have the potential to make real progress on poverty, environmental and climate issues.
However, for these investments to achieve the requisite scale, the current financial rules need to be changed. These must recognize the interests of all stakeholders

Box 7.5: Social protection schemes starting to address climate and environmental objectives

Brazil: The national Bolsa Verde program provides cash payments to low-income families who adopt practices that conserve trees, fish, and other natural resources. The scheme targets people in extreme poverty, and particularly forest-dependent communities in the Amazon region. The program distributes more than US$40 million dollars each year to more than 69,000 families, and the quarterly payment of 300 Reais that these receive is nearly double the average quarterly income.

Ethiopia: The Productive Safety Net Project provides 7 million people, who are chronically food insecure, with a predictable transfer of cash or food, in return for labour on schemes that benefit vulnerable communities. These work schemes include tree planting, water harvesting, and the construction of health centres. The project enables vulnerable people to resist shocks, accumulate assets and, most importantly of all, to feed themselves. The project aims to encourage households to engage in production and investment promotes market development by increasing household purchasing power.

India: Each year, the Mahatma Gandhi National Rural Employment Guarantee Scheme provides tens of millions of people with 100 days of paid manual work. The scheme creates a legal right to employment, and anyone who applies and is not given work within 15 days is entitled to an unemployment allowance. Since 2006, when the scheme began, US$25 billion has been distributed. Participants work on projects that benefit their local communities, such as creating infrastructure for water harvesting, drought relief, and flood control.

Source: Steele et al. (2015b)

and not just shareholders, and should consider long-term outcomes as well as share prices. There is a need to engage those who, while not having contributed to these issues, can nevertheless play a powerful role in addressing them. Finance mechanisms will therefore need to be more accessible, integrated, and supportive of innovation, and should prioritize investment quality as well as quantity.

Microfinance, local funds, and social protection schemes can provide targeted financial instruments that reach those who need it most and so get money to where it matters (IIED, 2017). Where new finance is brought into the economy as a measure to drive green growth, it often fails to consider the benefits that this may provide to poor women and men. Indeed in many cases, the poor and excluded are not able to access formal credit markets, general financial instruments, or even basic banking loan facilities due to their lack of collateral and low income earnings, for instance, only a quarter of adults of sub-Saharan Africa have access to a formal bank account (Demirgüç-Kunt el al., 2017). Microfinance, local funds, and social protection schemes can therefore expand this access to financial capital for the excluded and poor (Steele et al., 2015a).

Social protection can also be designed in a way that is adaptive. In this way, social protection and climate resilience objectives are linked and targeted towards those households that are most vulnerable to income and climate shocks. Other social protection schemes are now also starting to address ecological rehabilitation through afforestation and water management initiatives (Porras et al., 2016). Examples of these schemes in Brazil, Ethiopia, and India are provided in Box 7.5, while in South Africa's "Working for…" programs, public works schemes for cleaning up the nation's river basins and water bodies are targeted at single-parent female headed households — including those affected by HIV.

Box 7.6: Support for SMMEs in Nepal

In Nepal, the Alternative Energy Promotion Centre has developed a targeted subsidy model to enable the most vulnerable households to adopt renewable energy technologies. Forty per cent of Nepal's National Rural Renewable Energy Programme's US$170 million budget is being disbursed as grants to these households and, depending on the circumstances, these grants can cover between 30 and 50 per cent of the cost of buying and installing renewable energy technology (with the remainder coming from concessional loans). These grants are delivered in accordance with Nepal's Subsidy Policy for Renewable Energy (2013), which promotes the targeting of poor, vulnerable, and socially marginalized households.

Source: Rai et al. (2015) and Steinbach et al. (2015)

Financial mechanisms should also look to prioritize the informal economy and Small, Medium and Micro-sized Enterprise (SMMEs). In terms of inclusive consumption, the exploration of major, "bottom of the pyramid" markets can better align these mechanisms with the needs of poor consumers who, as was detailed in Section 5.1, often operate within informal markets. In order to mobilize green production, jobs, livelihoods and SMMEs within informal economies should be recognized as being potential drivers of, IGE growth and especially in those countries where 'job creation' represents a primary political concern. Start-up grants provided to SMMEs can be a useful tool in this regard (as shown in Box 6), and these work well for projects that may not generate revenue, but are otherwise ideal for promoting green growth. However, these grants should be aligned with other investments to ensure that first; they do not increase government expenditure over investments and, second, do not provide false market signals. The long-term effects of these grants and subsidies should also be monitored, and subsidies should be phased out once markets have been developed.

5.4 Metrics

New messages and metrics: improving and aligning poverty, environment, and climate messages, narratives, and metrics – to inspire widespread understanding of poverty, environment, and climate issues, and to galvanise and measure progress

A positive narrative promoting the poverty-environment-climate nexus is now needed. A narrative that is based on enduring prosperity, and perhaps on joint human and ecosystem wellbeing, could have increasing political traction as extreme poverty declines but climate change and ecosystem degradation impacts really begin to 'bite'. New players, such as BRICS (New Development) Banks, locally controlled development funds, and domestic markets, now need to work alongside the UN and other development agencies that have until now led the poverty, environment, and climate agendas to establish a clear and coherent set of poverty, environment, and climate planning and performance standards.

These standards will require cross-disciplinary collaboration, and must engage multiple stakeholders from all (and not just developing) countries in order to produce a message that is universally acknowledged and accepted. This message should include:

- Communication strategies that can successfully influence positive decision making regarding poverty, environment, and climate (such as the judicious use of economic information, but also incorporating ethical arguments, people-centred stories of change, 'wellbeing' measures, and ways to 'brand' poverty, environment, and climate).
- A conceptual framework that best expresses the links between poverty, environment, and climate, and which is scientifically credible, robust to diverse biophysical, social, and economic realities, policy-influencing, and can be used throughout the whole policy cycle (from assessment to debate, modelling, planning, and accounting). This framework could be based on two reviews:
  - A review of existing frameworks, including the steps countries have taken to implement the SDGs (and especially the nine poverty, environment, and climate related SDGs noted in Table 2);
  - A review of how the Millennium Ecosystem Assessment's ecosystem service-wellbeing framework has been adopted and adapted by different disciplines, from economists, to statisticians, to natural scientists.
- Rolling out the System of Environmental Economic Accounts. Under the auspices of the UN Statistical Division, the System of Environmental Economic Accounts has now been agreed at the international level, with the Wealth Accounting and Valuation of Ecosystems (WAVES) initiative, led by the World Bank, providing support to countries for implementation. Yet more is still needed to generate the necessary physical and economic data for the system, and to create the necessary demand among policymakers and the general public to use the system to inform national decision-making and transparency.
- Today's 'data revolution' provides many opportunities that are yet to be harnessed. Information and communication technology and 'big data' can help us build a picture on how poverty and the environment relate in specific cases, as well as the effects and impacts that previous interventions have had. This will help the international community to progress from the drawing of crude trade-offs between poverty, environment, and climate, to achieving better distributional results and correlations which can optimize synergies and integration. In addition, new technology, such as mobile phones, can enable poor people to become powerful data producers and receivers. They can bridge the disconnect between global and very local, service providers and service demanders, and thus enhance learning and accountability.

6. Conclusion

This chapter provided an understanding on the linkages between inclusion, poverty and gender equality, and the transition to a green economy. It demonstrated that poverty reduction is not an automatic outcome of green economy interventions and that trade-offs do exist. However, the recommendations put forward in this chapter can provide a guidance for learners and decision makers on research, evidence and best practise, and thus help maximising identified links and synergies between inclusion, poverty reduction, and gender equality. A careful consideration of inclusion, poverty and gender equality, and their fully integration into policy-making may thus help ensure that the transition to a green economy promotes social justice among the poorest members of society.

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CHAPTER 8: FISCAL POLICY FOR AN INCLUSIVE GREEN ECONOMY

CHAPTER 8: FISCAL POLICY FOR AN INCLUSIVE GREEN ECONOMY

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline a number of fiscal policies that can be considered when an inclusive green economy is sought.
- Assess trade-offs between environmental and fiscal impacts, as well as discuss distributional consequences.
- Review frameworks for public expenditures and public environmental expenditure reviews (PEERs), to help assess the efficiency and effectiveness of government resource allocations across environmental priorities.
- Explore and understand the relevance of carefully designed fiscal policies that stimulate green innovation and investment and take into consideration environmental externalities and the distributional implications of taxes, subsidies and government spending, for advancing the inclusive green economy.

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Environment for Development Initiative

Thomas Sterner, a Professor of Environmental Economics focuses on the design of policy instruments to deal with resource and environmental problems. Sterner has published more than a dozen books and a hundred articles in refereed journals, mainly on environmental policy instruments with applications to energy, climate, industry, transport economics and resource management in developing countries. With Gunnar Köhlin, he has founded the Environment for Development Initiative. Sterner is the recipient of the Myrdal Prize and past president for the European Association of Environmental and Resource Economists. During 2015-16 he was guest professor at the Collège de France.

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Gunnar Köhlin is the Director of the Environment for Development Initiative – a global network of environmental economics' centers. He is also an Associate Professor at the Environmental Economics Unit, Department of Economics, University of Gothenburg. He has spent 30 years working with applications of environmental economics in developing countries including the development of a dedicated PhD program in environmental and development economics. His research interests focus on natural resource management and environmental policy analysis in developing countries. The applications have been focusing on forestry, energy and sustainable agriculture as well as environmental strategies at the country level.

Kirstin Seyboth

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Kristin Seyboth is an independent consultant with more than a decade of applied expertise in climate change mitigation and renewable energy. Prior to founding her private practice, she led, co-authored and managed reports for the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency. The IPCC's 5th Assessment Report on Climate Change Mitigation, which Seyboth co-authored and co-coordinated, is considered by many to be a landmark report – it provided the scientific basis for the Paris Agreement. Seyboth received her Master of Science in Environmental Management and Policy from Lund University, Sweden and her Bachelor of Arts in Biology from Bucknell University, USA.

CHAPTER CONTENTS

1. Introduction and overview of green fiscal policies

1.1 Fiscal policies in context

As described in Chapter 2.5, an inclusive green economy (IGE) is characterized by methods and patterns of production and consumption that are low, or even zero, in carbon emissions, that are resource efficient and are waste minimizing. These activities should remain within the planetary and local boundaries critical for natural and environmental resources. The transition toward an IGE is characterized by increasing the share of green activities in each of the components of aggregate demand: household consumption, government expenditure, investment and net exports. The role of green fiscal policy is therefore to shift consumption, investment and the government's own expenditure in a way that stimulates innovation and green investments and dissuades activities with negative environmental effects.

Key term: Taxonomies
System according to which things, in particular animals and plants, can be sorted into groups that share similar qualities. Adapted from https://dictionary.cambridge.org/

A number of **taxonomies** exist to categorize policy instruments, each with its own pros and cons and usefulness in different contexts. Based on field experience, one useful typology applicable to natural resource management and pollution control (based on World Bank, 1997) breaks policy instruments into four categories: 1) using markets; 2) creating markets; 3) environmental regulations; and 4) engaging the public (Sterner and Coria, 2012), see Table 1. This chapter focuses primarily on the first category, 'using markets'. Fiscal policy, which makes use of government revenue collection (e.g. taxes) and expenditure, falls largely in this category. Market-based approaches can both be seen as a complement and a substitute for command-and-control regulation. Market-based approaches are not only interesting to policy makers as a means to increase incomes, they often increase both static and dynamic efficiency as compared to command-and-control environmental regulation.

Table 1: Classification of instruments in a policy matrix (Source: Sterner and Coria, 2012)

Using markets	Creating markets	Environmental regulations	Engaging the public
Subsidy reduction	Property rights and decentralization	Standards	Public participation
Environmental **taxes** and **charges**	Tradable permits and rights	Bans	Information disclosure
User charges	International offset systems	Permits and quotas	
Deposit refund systems		Zoning	
Targeted subsidies			

Key explanation: Taxes
Taxes must go through a relatively complex legal process that involves passing and modifying tax law which can make them difficult to implement.

Key explanation: Charges
Charges may be levied by the administration and may be earmarked for local or sectoral use and are typically more readily accepted.

A comprehensive green fiscal policy is therefore an essential ingredient to ensuring that an appropriate incentive structure is in place to achieve an inclusive green economy. Through the design of government revenues and expenditures, signals can be given to consumers and producers that ensure efficiency in resource use, discourage environmental pollution (static efficiency), and encourage innovation in new products, processes and technologies (dynamic efficiency). In other words, taxing externalities can incentivize the investments and technological progress upon which a green economy is dependent – it may also increase resource efficiency and reduce environmental problems and welfare losses.

1.2 Fiscal Policies Important to Green Economies

In this section, we provide a brief overview of a few of the most prevalent green fiscal policies, including Pigouvian taxes, resource rents, subsidies and subsidy removal. Pigouvian taxes include a number of different categories of taxes that attempt to correct negative externalities, such as carbon taxes, fuel taxes and taxes on sulphur and nitrogen. For each category of policy, an introduction to design features is provided, unique features are discussed, and a general summary of existing policies worldwide is presented. Each sub-section concludes with a brief review of experience with those policies.

1.2.1 Pigouvian Taxes

The most fundamental challenge for a green economy is that there are plenty of instances when producers and consumers of goods and services do not fully consider how their production and consumption affect the environment and thus the welfare of people. Such environmental externalities are not only a violation of the Polluter-Pays Principle, but lead to inefficiencies throughout the economy. An optimal policy for a government is therefore to identify such negative environmental externalities, estimate the negative welfare implication each externality has and then impose a tax that is exactly as large as that negative welfare effect so that the producers and consumers fully internalize the cost – a Pigouvian tax. For example, such taxes can be placed on greenhouse gas emissions, pollution and environmental degradation.

Key term: Pigouvian taxes
A pivougian tax sets out to internalize externalities, such as pollution, and prevent market failure. Adapted from https://www.investopedia.com

Pigouvian taxes raise revenue while at the same time reducing the negative environmental impact by taxing the negative environmental externality. These taxes have been criticized due to their inherent tax base erosion effects (See Box 8.1). However, since an environmental tax is not an end in itself, but a means, such considerations are not actually problematic. The positive effects on the environment offset the reduced income from taxation. It might be tempting to see Pigouvian taxes primarily as a tax base, but it is better to see them primarily as environmental taxes that just happen to give a positive effect to the budget and allow other taxes to be somewhat lowered.

Box 8.1: Tax base erosion

Each environmental tax will normally affect behaviour by consumers and input choice by firms. This is the purpose of the tax. The size of the reaction will depend on the relevant price and substitution elasticities. If elasticities are high, there will be a big behavioural change. If elasticities are low, the response will be smaller. Often the behavioural response increases over time so that the short-run elasticity is low while the long-run response is higher. This means that over time the tax will tend to diminish the pollution or resource use even more than the initial response. From an environmental viewpoint, a more rapid response may be desirable if the environmental problem at stake is urgent.

Another aspect of the decrease in pollution (or resource use) is that tax revenues will tend to fall - at least compared to a simplistic calculation that fails to take the demand response into account. For some time tax revenues may be stable or may even increase, depending on income elasticities and on whether the tax level is raised over time. Eventually, however, tax revenues will often fall quite considerably – particularly if the optimal solution involves zero or near zero emissions. This is sometimes referred to as tax base erosion. If the item that is taxed has very high demand elasticities, its use will be reduced very quickly. The high elasticity shows that as soon as there is a tax in place, people will substitute away from the polluting good or input and thus the problem is readily solved.

If the government officer in charge did not realize this and instead counted on a long-run stream of tax revenue – and if the government prematurely abolished other (e.g. labor or VAT) taxes – then a problematic budget deficit could be created.

In the case of carbon emissions, the response to taxes can be significant, but takes time as adaptation is rather slow. Eventually it would be ideal if taxes on fossil fuels were to reduce fossil fuel use so much that revenues become negligible. However, this is still decades away, due to a multitude of factors. One factor is that carbon taxes are generally not high enough to be reflective of the 'real' cost of the negative externalities produced by polluters, and that no coordinated, global approach to a carbon tax or a cap-and-trade system exists, which captures the entire global economy. Another factor is inertia and path dependency, which ranges from earlier investments in the fossil-fuel based infrastructure with a long lifespan, risk aversion of private and corporate actors, such as banks, which often lead to hesitance to trust and thus finance new technologies, such as solar or wind power. When that time comes, the missing environmental revenue is not a serious problem. Taxes could be applied to new (environmental) problems or could revert to be based on labour, capital, property, VAT, etc. to face the tax base erosion problem that is created. In the long-run, continued automation and artificial intelligence could reduce the importance of labour as a production factor, which would create a much more serious problem of tax base erosion rather than the end of the fossil fuel era.

The difference between taxes and charges (terms that are sometimes – here and in other texts - used interchangeably) should be noted, largely for the differences in their ease of implementation. Taxes must go through a relatively complex legal process that involves passing and modifying tax laws that can make them difficult to implement (See Section 9.2 for more on political economy of fiscal reform). Tax revenues go to the central treasury - money that goes to the treasury is often perceived as being 'lost' (Sterner & Coria, 2012). Charges, on the other hand, may be levied by the administration and may be earmarked for local or sectoral use and are typically more readily accepted.

Careful valuation of the negative externality is needed in order to set an optimal Pigouvian tax. In theory, the optimal levels of a Pigouvian tax are equal to marginal damages at the optimal pollution level (i.e. at the intersection of the marginal damage and the cost curves), but these are difficult to estimate for a number of reasons. These reasons include a lack of understanding of the multiservice and public good characteristics of ecosystems, the potentially large slope of the damage curve, and (e.g. in rapidly growing economies) there is a fundamental challenge of estimating the cost of damages at a hypothetical optimum to which a society hopes to move toward (Sterner & Coria, 2012). While optimal taxation preferably should affect behaviour as little as possible (a reason why e.g. property taxes are preferred to labour taxes is to minimize such a **deadweight loss** to welfare), this is not true for taxation of negative environmental events (e.g. pollution or resource depletion).

Key term: Deadweight loss

A loss that occurs because the government raises taxes to increase its income, but thereby loses money instead. Due to increased taxes, a company might have to cease operations, for example, and will stop paying taxes completely. Adapted from https://dictionary.cambridge.org

The design of an environmental tax must carefully consider competitiveness and social consequences. In practice, many environmental tax reforms have had positive effects on competitiveness, though negative effects on individual industries are possible (UN Environment, 2017). Reduced tax rates for industry (particularly those that are energy intensive or subject to intense international competition) are a widely applied protective measure and a major element of many reforms. Such exemptions and reductions may be unattractive in that they reduce the incentive to adapt behaviour toward protecting the environment and may also increase administrative costs (UN Environment, 2017).

An additional design consideration lies in the inherent difference between point (e.g. a specific industry) and non-point (e.g. from mobile sources and agriculture) pollution. The effectiveness of environmental taxes can be assessed more easily for point sources where emissions can be measured directly. While taxes may be the most efficient policy to address some non-point pollution (e.g. cars due to the handling of fossil fuels), changes in emissions cannot be measured directly and must therefore be estimated. This makes the effectiveness of the policy less certain than for point-source pollution (See for example, NOx emission discussion below).

Empirical evidence suggests that levying an environmental tax while reducing taxes on labour, corporate or income taxes – called revenue recycling – can increase economic efficiency and can also produce positive employment effects (UN Environment, 2017). For example, in Germany green taxes were recycled to cut pension contributions and thereby lowered labour costs. In British Columbia, green taxes were accompanied by cuts in corporate and personal income taxes. Lump-sum payments were also made to low-income households. Revenue recycling in such ways may help to enhance the political acceptability of green tax reforms (See Section 2), although the demand elasticity of the taxed item must be carefully considered such that a tax base erosion problem is not created (See Box 8.1).

Earmarking (designating funds for a specific purpose) is used widely (e.g. in the United States and many other industrialized and developing countries), for major undertakings such as road construction, though it is considered by economists to constrain optimal governmental allocation of taxes and expenditures. According to that theory, all revenues should go to the treasury and compete equally for public funds (Sterner & Coria, 2012). Due to earmarking, many argue that funds should also be designated for environmental fees, even if sub-optimal from a broader economy perspective. If so, economists argue that earmarking of environmental tax returns for environmental public projects should ideally be limited to cases in which such spending would generate efficiency gains comparable to those from cutting distortionary taxes (Bird & Jun, 2005 in Heine, Norregaard & Parry, 2012). Earmarking could also increase the feasibility of implementing a tax or charge

Box 8.2: Green bonds

Increasingly, government agencies are issuing so-called 'green bonds' – bonds that are identical to traditional bonds, but with an additional step that tracks, monitors, and reports on the use of proceeds for dedicated green projects. These projects can be related to climate (e.g. renewable energy or energy efficiency) or sustainable waste management, land-use, biodiversity, clean transportation, clean water, etc.

Green bonds appeared on the securities market at a time when there was a great need for large infrastructural investments for a sustainable future, e.g. in renewable energy and climate change adaptation. At the same time, large investors – not least pension funds - were looking for secure investment opportunities. The green bond market can therefore be expected to grow rapidly in the years to come. A striking example is the French government, which raised US$830 million for projects that included renewable energy in schools and energy efficient social housing (UNDP, 2018). Similarly, the U.S. State of Hawaii, through a Green Energy Market Securitization program, issues bonds to provide low-cost capital to finance solar photovoltaic systems and other clean energy improvements for Hawaii consumers. (Hawaii State Energy Office, 2018).

The municipal bond market is particularly attractive as it is the local authority's typical responsibility for overseeing water, waste, and transport services (See UNDP, 2018). The municipal bond market funds large-scale, long-term capital-intensive projects in states and cities, along with their operational expenses. It predominantly attracts individual investors, either directly as retail investors or through mutual funds, mostly because municipal bonds tend to be issued as tax-exempt instruments. The first municipal and city bonds were issued in 2013 by the U.S. State of Massachusetts and the Swedish city of Gothenburg. Since that time, local green government bonds have continued to grow (Climate Bonds Initiative, 2018). Johannesburg was one of the first cities to issue a Green City Bond (worth approximately US$143 million). Funding through the bond will be provided to biogas and solar projects, dual-fuel buses and others that are dedicated to reducing the city's greenhouse gas emissions (UNDP, 2018).

by increasing its acceptance among the general public. Recently, an innovative financial instrument – green bonds – has been increasingly used by government entities to 'earmark' bond proceeds to green projects that generate climate or other environmental benefits (See Box 8.2).

To what extent have environmental taxes been used? Answering this question is complex since one of the goals (at least in the long run) of the environmental taxes is to reduce the negative externality being taxed. If they are successful, revenues will decrease over time. As such, comparisons of revenue as a measure of how environmental policy is implemented in a particular country or year will be inherently inaccurate. An example of this is Sweden, which has record high tax rates but little pollution. As a result, the overall share of pollution taxes is moderate, as seen in Figure 1 (overleaf) and Box 8.1.

Figure 1 provides an overview of environmental taxes in place for the past twenty years (1994-2014), across a number of countries. In the OECD, the use of environmental taxes is still relatively limited in many countries. The share of generated revenue (equal to 1.56 per cent of GDP in 2014) has been declining. A closer look at many developing countries reveals that they also have decreased their environmental taxes in 2014 compared to 1994.

Carbon Taxes

Carbon taxes put a price on CO_2 or other GHG emissions, ensuring that different fossil fuels are taxed in a 'neutral way' according to actual emissions. For an overarching environmental bad, such as climate change, carbon taxes have a number of attractive features. Carbon taxes are economy-wide, and thereby provide an incentive to reduce emissions across sectors. Emitters are heterogeneous in terms of technology, size, and organization – a carbon tax addresses this heterogeneity by allowing emitters to direct efforts toward their distinct **marginal abatement costs** (these abatement costs typically differ greatly between sectors). In other words, emitters may choose to invest in those abatement efforts that are least costly first. This ultimately minimizes the cost of pollution control, thus enhancing economic efficiency. It also contributes to dynamic efficiency, stimulating research and development, innovation, and adoption of new technologies that emit less carbon. It also provides a financial incentive to invest in technologies that reduce emissions.

Key definition: Marginal abatement cost
The cost of abating one additional unit of carbon emissions.

There are a number of design considerations that are important to consider when implementing a carbon tax. These include: the tax rate, whether certain sectors should be exempt, how revenues are to be used, how to assess distributional impacts (e.g. impacts especially on low-income households – see Section 3.1) and how to ensure that the tax reaches its emission reduction goals (NREL, 2009).

Around 4 per cent of global GHG emissions are currently covered by carbon taxes (World Bank, 2016). Figure 2 (below) shows the levels of carbon taxes in those countries that had adopted a policy by 2016. Though some countries (e.g. Sweden, Norway, and more recently France) have significant carbon taxes, there are exceptions for

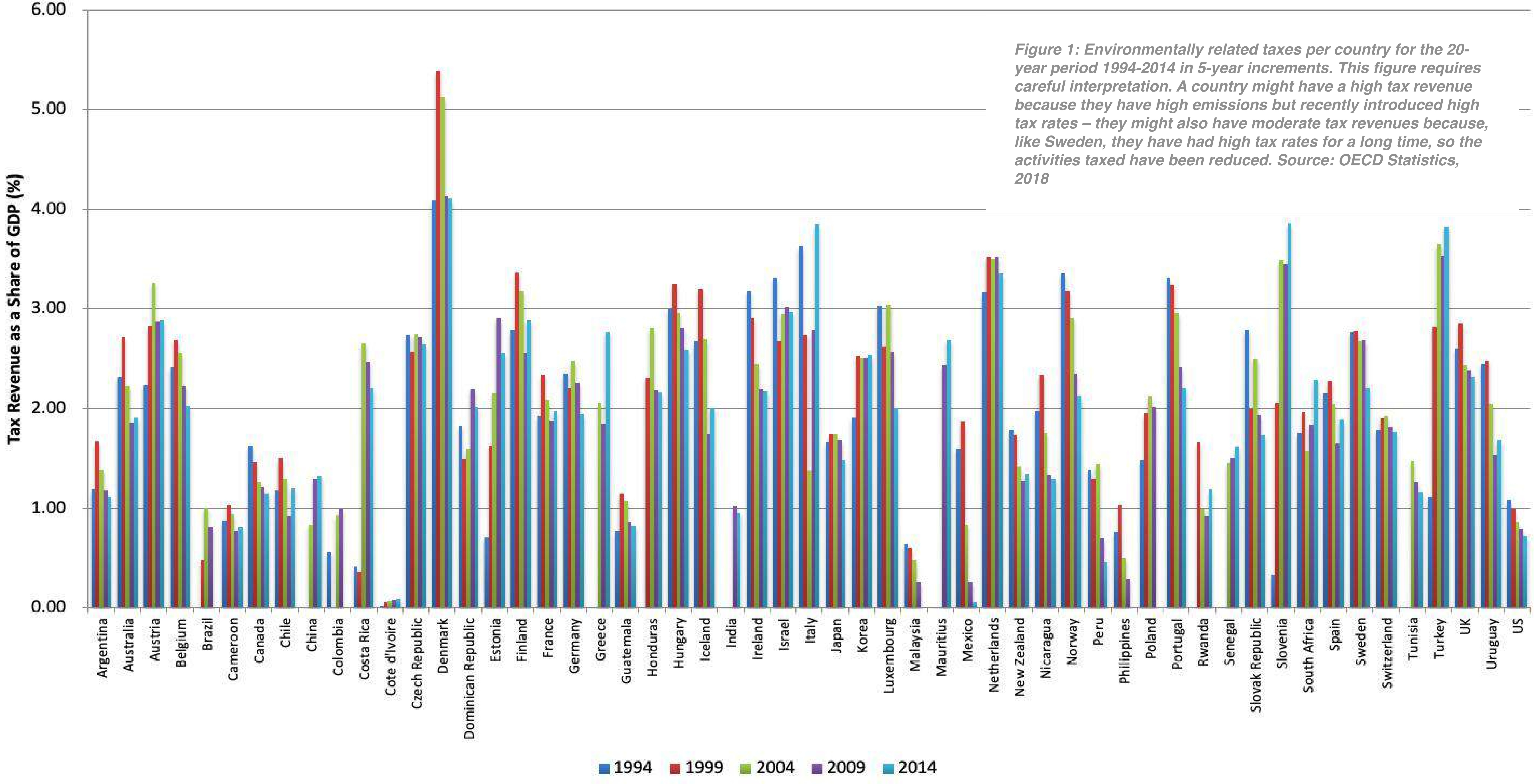

Figure 1: Environmentally related taxes per country for the 20-year period 1994-2014 in 5-year increments. This figure requires careful interpretation. A country might have a high tax revenue because they have high emissions but recently introduced high tax rates – they might also have moderate tax revenues because, like Sweden, they have had high tax rates for a long time, so the activities taxed have been reduced. Source: OECD Statistics, 2018

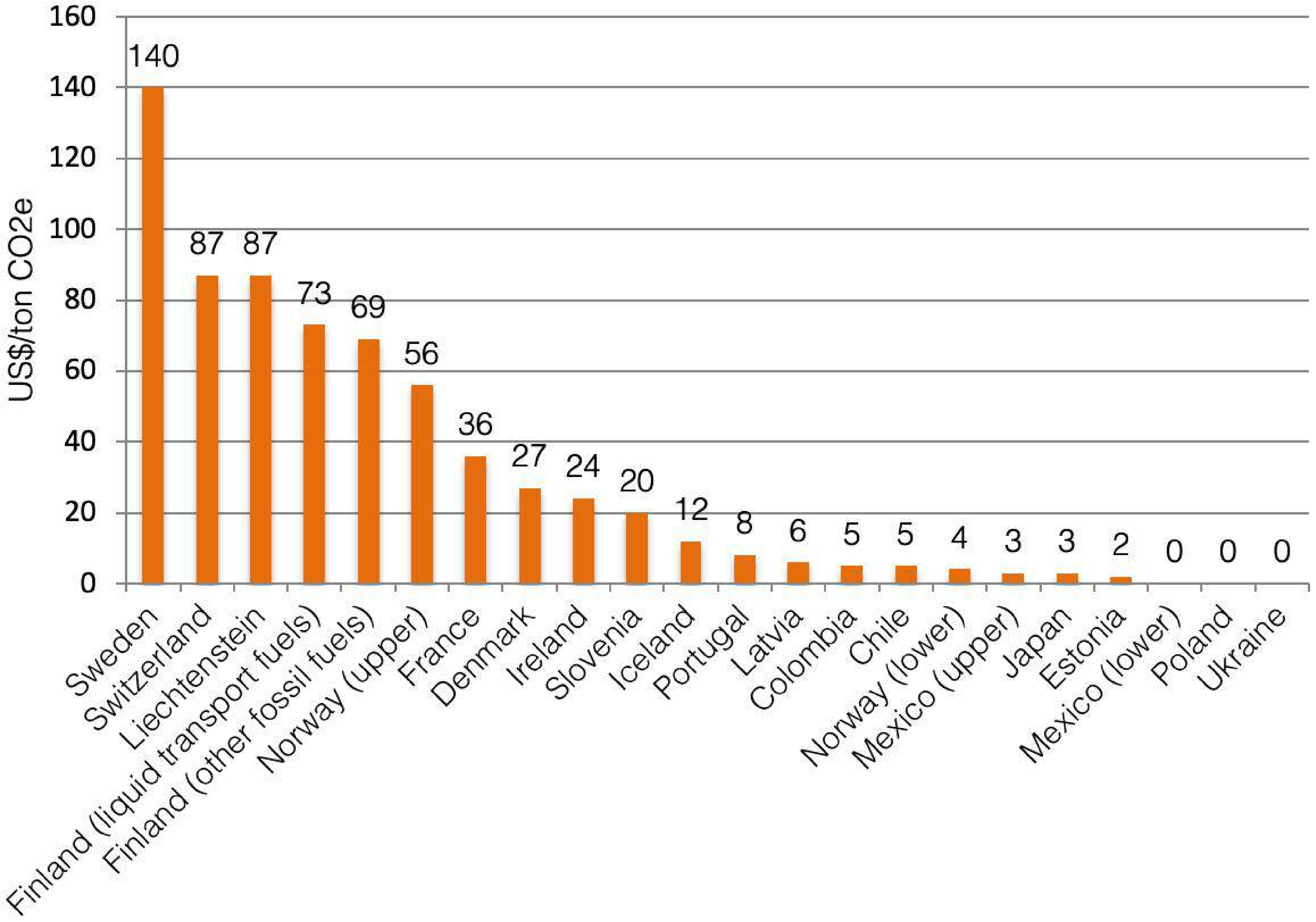

Figure 2: Levels of carbon taxes across countries (Source, World Bank, 2017, Carbon Pricing Trends)

certain sectors (e.g. production of electricity), meaning that there are no countries that have truly overarching carbon taxes in place. Sweden does, however, come fairly close as the tax is applied not only to transport fuels but also heating and some industrial use. It should also be noted that while some countries do not formally have carbon taxes, they do have gasoline or diesel taxes that serve roughly the same purpose (see next Section).

It is challenging to draw firm conclusions about the effects of carbon taxes on emission levels by assessing individual countries. This is the case as many additional factors come into play which would need to be considered by research, such as economic growth levels or parallel programs that address analogous environmental issues. Nonetheless, some studies (Sumner et. al.,2011), find real reductions in carbon emissions in those countries that have carbon taxes. This appears to be supported by other studies that have found effects albeit not always significant or large, such as two studies on Norway by Bruvoll and Larsen (2004; 2006) and a study by Cambridge Econometrics (2005) on *Modelling the Initial Effects of the Climate Change Levy* for the UK. Also, Berkhout et al. (2004) conclude that the energy tax in Holland had a small yet significant impact on household energy consumption. Likewise, Martin et. al. (2011) find strong impacts on energy intensity of the UK's Climate Change Levy (CCL), introduced in 2001, on manufacturing plants. A paper by Lin (2011) that estimates the mitigation effects of the carbon taxes of five European countries (Denmark, Finland, Sweden, Netherlands and Norway), also provides evidence that CO_2 taxes proved effective in reducing CO_2 emissions. However, several of these papers also suggest that desired mitigation effects are reduced due to tax exemption policies for energy intensive industries (see also Hammar et al. (2013)).

Many debate the pros and cons of carbon taxes versus cap and trade policies. On the positive side, carbon taxes continuously encourage emission reductions (at least as long as the tax is high enough to provide an adequate incentive to reduce emissions), whereas cap and trade policies encourage reductions only to the point of the cap (although the cap can be lowered). Taxes are straightforward to implement, they create revenue and they are viewed to be transparent because the price is known (in cap and trade policies, prices may be volatile). Another important advantage of carbon taxes (as compared with a cap and trade programme) is that the tax works well in combination with other instruments of climate and energy policy, such as green certificates, subsidies to renewables and regulations that have been introduced after (or in some cases before) the tax. With cap and trade policies, on the other hand, because of the absolute 'cap' of emissions, an additional policy may yield no further reduction in emissions. This is because the additional policy yields reductions in emissions by some facilities, causing the demand for and price of allowances to fall. An additional policy in the presence of a carbon tax, on the other hand, can lead to an overall reduction in emissions

(Goulder and Schein, 2013). See Chapter 9, Box 9.4, for a discussion of policy alignments of cap and trade programmes and feed-in tariffs. Carbon taxes can be viewed as less politically acceptable, and do not necessarily guarantee a certain level of emission reductions, as do permit schemes (NREL, 2009).

Fuel Taxes

Fuel taxes, generally and simply, are taxes imposed on the sale of fuel such as gasoline, jet fuel and diesel. Fuel taxation policy differs considerably across countries, which is a large part of the reason for widely different domestic fuel prices. Fuel taxes are generally not imposed for environmental reasons, though they currently have the largest impact on revenues. The practice of earmarking fuel taxes also differs across countries and may influence the support for or against such a tax. For example, in the United States most fuel taxes are earmarked for highway construction.

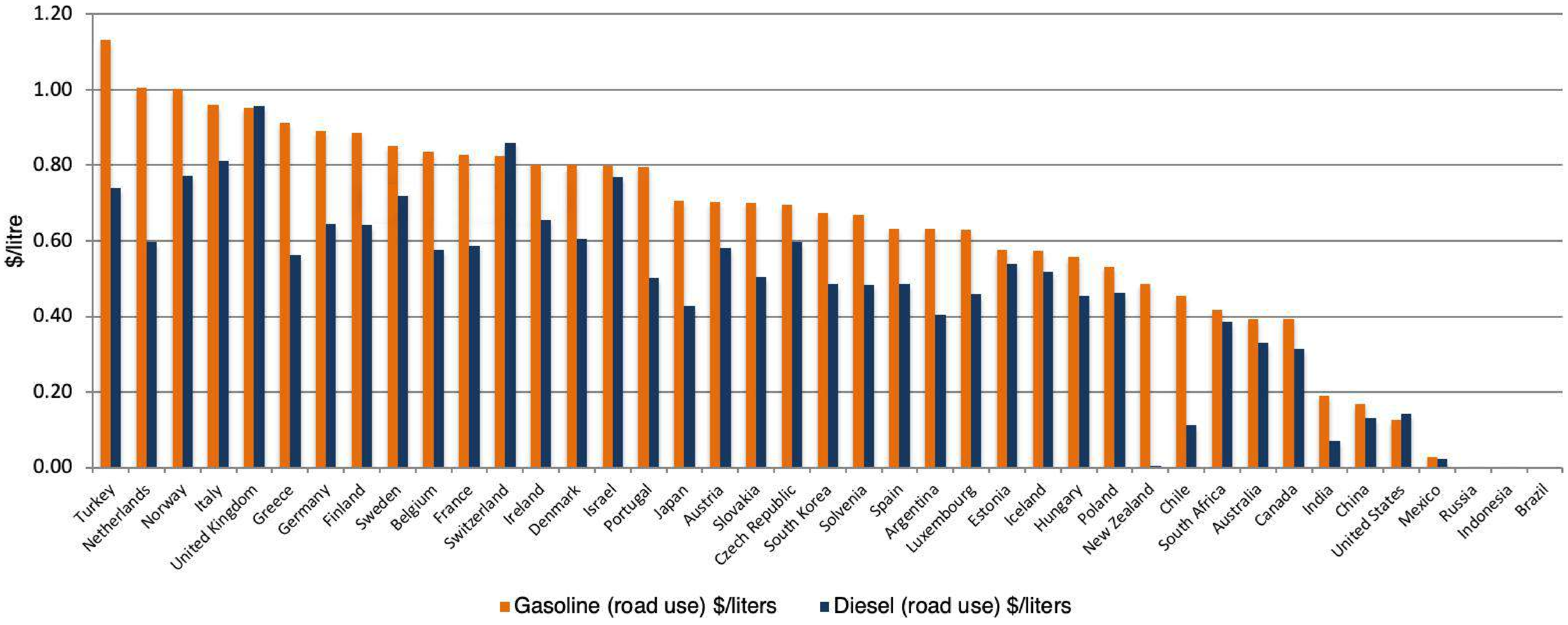

Figure 3: Overview of tax rates on gasoline and diesel motor fuels (USD/litre). Source: OECD, 2015, Taxing Energy Use

Diesel and gasoline often face quite different taxes. At one time, diesel was preferred over gasoline because it is generally more energy efficient and it was believed to create less toxic exhaust emissions. As a result, until catalytic converters reduced the emissions from gasoline engines, diesel was preferred. Diesel is also much cheaper than gasoline in many countries, and is used heavily in both transport (buses, trucks and cars) and non-transport machinery, such as agricultural equipment, heating, light industry and diesel generators. The role of particulate matter and the dangers of diesel to human health have recently become more important concerns, suggesting that diesel may receive more attention moving forward.

Figure 3 gives an overview of total tax rates on motor fuels across countries. Fuel taxes are high in almost the entirety of Europe and in Japan. Other countries (such as the US) have low levels of taxation, and yet others (such as Australia, Canada and New Zealand) have somewhat intermediate tax levels. Prices in most European countries are more than twice as high as US prices (see e.g. Sterner (2007)).

The level of fuel taxes across countries seems to be affected by a number of socio-economic factors, which in turn influence the costs and benefits of such a policy, as well as political attitudes toward the policy. For example, the presence of an oil industry tends to lead to lower gas taxes and high consumption levels. This has

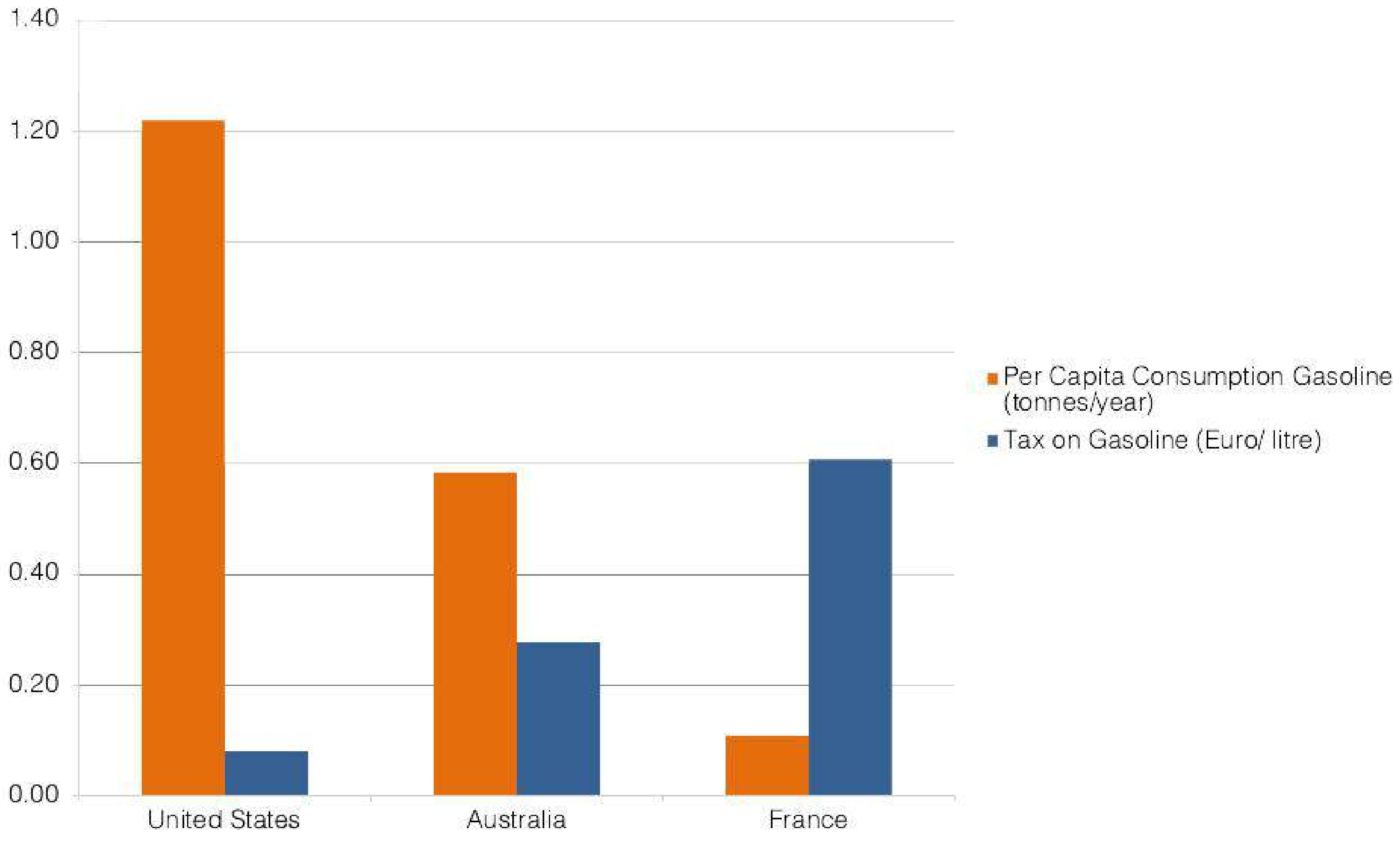

Figure 4: Prices and consumption of fuels in selected countries in 2014. Source: Gasoline Prices IEA (2009) and IEA (2018), Consumption IEA (2017), with population data from UN (2017).

been shown in the United States, Mexico, Venezuela, and some countries in the Persian Gulf. Also, low population density generally results in a higher dependence on individual transportation, leading to lower taxes, whereas high population density countries tend to have higher taxes. Higher highway tolls are also associated with lower taxes (Sterner and Coria, 2012).

Countries with low or negligible fuel taxes (resulting in cheap fuel, e.g. the United States) tend to have much higher consumption rates than countries in which fuel taxes are higher (resulting in more expensive fuel, e.g. in Europe, see Figure 4). In most European countries, per capita consumption of fuel is less than half of that in the US.

As a result of the fuel policy in the EU and Japan, some econometric studies show that fuel demand has been cut so dramatically that it has had a large and significant effect on the carbon content of the atmosphere (Sterner, 2007). In general, fuel demand is quite price-elastic – at least in the long run – and therefore fuel taxation can be an effective long-run instrument to lower demand and thereby emissions.

Sulphur and Nitrogen Taxes

In the 1970s acid rain was a major environmental problem – it is an interesting case demonstrating the successful use of market-based instruments. Acid rain is caused by emissions of sulphur dioxide (produced in the combustion of fossil fuels such as coal, oil and natural gas) and nitrogen oxide (produced by nitrogen fertilization of soils, and fossil fuel combustion largely in mobile sources), which react with water. The acid produced damages plants, organisms and infrastructure. There are several differences between sulphur dioxide and nitrogen oxide that necessitate a differentiated policy approach.

Most policies addressing sulphur dioxide are regulatory. They include performance standards on the sulphur content of fuels or design standards that prescribe certain technological requirements (Sterner and Coria, 2012). In addition, a number of countries have used differentiated taxes on energy or fuel to target sulphur reductions. The level of these taxes range widely, from under US$50 /tonne in Italy, France, Switzerland and Spain, to higher levels in the Scandinavian countries Sweden (US$3,000/tonne), Norway (US$2,100/tonne) and Denmark (US$1,300/tonne), where local ecosystems are very sensitive to acidification (Sterner and Köhlin, 2003). In countries with high taxes, sulphur emission rates have generally fallen dramatically. For example, between 1980 and 1997 substantial reductions were seen in Austria and Sweden (86 per cent), Finland (83 per cent), Germany (80 per cent), Norway and Switzerland (both 78 per cent) (Sterner and Coria, 2012). In the USA, a trading scheme was established for SO_2 among electric utilities in 1990, and is considered a success for achieving environmental goals at comparatively low costs (Sterner and Coria, 2012).

Countries with a tax on nitrogen have levied between US$30 and US$100 /tonne. Unlike SO_2, NO_x does not result from a fuel impurity, and therefore cannot be easily predicted. As a result, expensive monitoring equipment is required (Sterner and Coria, 2012). It follows that these taxes are most often levied on the basis of estimated pollution. Inherent technical difficulties to monitoring and enforcement have made NO_x emission reduction less successful than that of SO_2.

1.2.2 Resource Rents

The sustainable management of natural resources such as oil, minerals, forests, hydropower, etc. is central for an inclusive green economy. This is due to their importance for livelihoods, labour opportunities, contribution to GDP and exports and, not least, due to the disastrous effect that mismanagement can have on the people that are directly affected.

Empirical evidence has shown that countries endowed with richer natural resources systematically grow more slowly than resource-poor countries, creating a so-called 'resource curse' (Frankel, 2010). A number of possible reasons for this curse have been proposed. One such reason is that often resource-rich countries develop their economic activity along a narrow geographic and material base, focusing on the abundant resource. The inflow of foreign currency that results from the resource export can become so great that it leads to a distortion of the economy, making other sectors uncompetitive. This phenomena is sometimes also called the 'Dutch disease' (named after the problems created in the Netherlands after discovery of natural gas in the North Sea). In a country afflicted by the resource curse, the booming sector is more profitable than other sectors. As a result, talented entrepreneurs and workers flock to this sector, depriving other, established sectors of suitable resources. Politicians vie for the attention of this sector and neglect others. Since these natural resource sectors are profitable, salaries tend to increase and naturally rising salaries in one sector will have at least some tendency to spread to other sectors. The ease of exporting and earning money in the profitable sector will tend (through various mechanisms) to encourage an overvalued exchange rate that makes it even harder for the country's industries to export in any other sector.

Thus, exports from the more profitable resource sector make other sectors less competitive. Generally, the resource curse is also strongly associated with weak public institutions which in turn slows growth and affects institutional capacity to handle shocks (Isham et. al., 2005). It is also quite common for lobbyists from the booming sector to have undue influence over governments. Corruption and policy capture can arise in this setting more easily, creating a situation in which decisions over policies are directed away from the public interest towards specific interest due to lack of transparency, accountability and information (OECD, 2017).

For economies based on exhaustible resources, the Hartwick rule offers a prescription for maintaining sustainable and constant levels of consumption. This rule prescribes reinvesting resource rents in reproducible capital such as machines. It argues that the value of investment should equal the value of rents on extracted resources at all points in time. (Hartwick, 1977; Asheim, 2013).

The strength of a country's institutions is a critical consideration in whether the resource curse can be countered (Ploeg, 2011). For example Chad, a country highly dependent on oil revenue (which constituted 70 per cent of government revenues in 2013), since 2003 has been plagued by conflict and internal instability. Poor state legitimacy and a highly fractured society have retarded the emergence of solid accountability systems and have contributed to a deterioration of the country's external competitiveness and non-oil trade balance, exposing the county to oil shocks and increasing the number of poor households (World Bank, 2015b).

Where institutions are strong, one approach to counteract the difficulties inherent with the 'resource curse' is to neutralize excess earnings by, for example, creating a sovereign wealth fund. Such a fund can invest in other activities that can continue to provide wealth even after the boom. They may help to smooth volatile revenues and provide a buffer to maintain public spending in times of low commodity prices. There are relatively few countries that succeed with such policies, though Norway is sometimes cited as a developed country example, and Timor-Leste as a developing country example. In the 1990's in Norway – following previous legislation granting ownership of all of the nation's resources to the state - a Government Pension Fund, informally known as the Norwegian Oil Fund, was created to manage the revenues generated by its fossil resources. Today, this fund is worth more than US$1 trillion – one of the world's largest investors. Withdrawals from the fund were capped at 4 per cent annually to help ensure security should the petroleum resources expire. In sum, Norway has succeeded in transforming its petroleum wealth into financial assets. The 2005 Petroleum Fund in Timor-Leste has helped control phase-in of petroleum income into the country's economy with a diversified investment strategy and transparency requirements. A share of revenue and investment returns (approximately 3 per cent) is transferred to the state budget and is dedicated to investment in economic affairs, public services, education, social protection and other programs (GIZ and UN Environment, 2016).

Public funds, such as Norway's Government Pension Fund, may also contribute to green investment and thereby a green economy. Such funds can gain exposure to green assets by committing to green debt platforms, investing in renewable energy companies and projects or participating in green infrastructure funds. To date, green investment strategies by sovereign wealth funds are still relatively nascent, though there has been some investment in green infrastructure assets (e.g. by funds in China, Morocco, Saudi Arabia, and the United Arab Emirates) (UN Environment, 2017).

Charges such as mining royalties, stumpage fees, user fees, and land taxes, on the extraction of various natural resources have become increasingly prevalent. They may be charged because of negative external effects (e.g. environmental externalities) or because the government (as is the case in Norway and many other countries) owns the resource and thus could and should charge a scarcity rent (Sterner and Coria, 2012). Even in the case of ill-defined property rights, the state can apply this right. Quite a few countries have a law stating that all forests or lands that are not explicitly the property of other individuals or entities, automatically belongs to the state.

Resource rents theoretically can belong either to owners of land, to citizens or to polluters, depending on the legal philosophy of the country/region, on tradition and on ideology. In some countries, rights (e.g. minerals or water) are associated with land ownership. In others, rights (e.g. water rights) belong to communities or may be grandfathered to historic users. One might say that we are in a constant process of creating land rights. Some refer to this as a process of enclosure. In medieval Britain, for example, public or common lands were open and private lands were 'enclosed' through some form of fence (usually a hedge). Naturally, in historic times there were no rights to the bottom of the deep seas, nor to radio frequencies, geo-stationary 'parking spots' for satellites, nor rights to emit carbon dioxide. Rights are created as scarcities develop and these rights can either be thought of as emanating from, and inherently belonging to, the state, the owners of adjacent land property, or customary users.

The importance of the design of resource rents is evident from the dependence that many, particularly developing, countries have on oil and minerals. Many African countries are particularly dependent on revenues generated by mineral and petroleum extraction. At least 70 per cent of total government revenues come from the petroleum sector in Algeria, Angola, Democratic Republic of Congo, Equatorial Guinea, Libya, and Nigeria (Jones, 2011). Minerals are also important for a number of African countries as a proportion of GDP, for government revenues and for export, and thus foreign exchange earnings (see Figure 5, overleaf). While minerals may be important in terms of contribution to GDP and export earnings, this does not automatically translate into government revenues. In Cameroon, and in particular in South Africa, the governments have been unsuccessful in ensuring that returns from minerals contribute proportionately to government revenues. It is in the design of contracts for resource concessions and other tax policies that countries can ensure a fair share of the resource rent from their natural resources. Successful design and implementation of such a contract or policy will typically depend on the strength of the institutional environment in which it is implemented.

1.2.3 Subsidies and Subsidy Removal

Subsidies may range from tax expenditures to direct budget-financed payments in support of certain activities believed to be environmentally friendly. Rather than charging a polluter for emissions, subsidies offer a reward for reducing emissions, thereby providing an incentive to reduce polluting emissions (Coria, 2018). They are typically (partial) payments for verified abatement costs (e.g. fixed capital costs for a filter, catalytic converter or other), and may come in the form of grants, low-interest loans and favorable tax treatment. For example, subsidies may be used to do the clean-up if the polluter cannot be identified or is bankrupt, (the most famous example being the 'superfund' sites under the Comprehensive Environmental Response, Compensation, and Liability Act in the United States)

Subsidies may also be provided to actors that help avoid external environmental costs (e.g. by generating cleaner electricity). The idea behind such subsidies is that society would have to bear a given cost if a given quantity of energy was produced by a conventional energy plant – the level of subsidy paid to renewable energy plants/producers would be based on this calculation (Coria, 2018). By supporting adoption of better

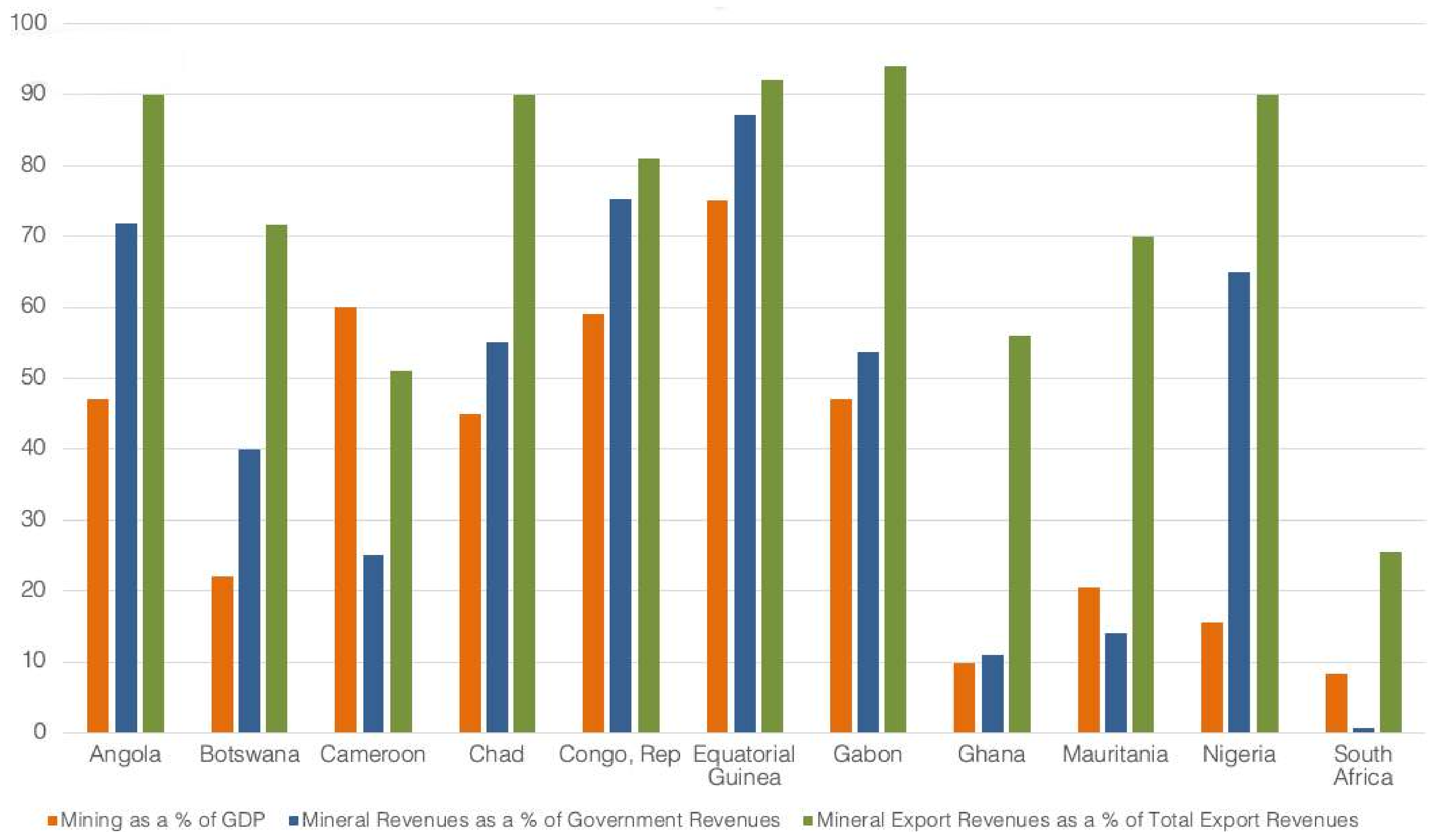

Figure 5: Mining Revenue - Selected Sub Saharan African Countries (2009-2015) Source: Information drawn from Sopp and Leiman, 2017. (Incl data from IMF International Financial Statistics, Primary Commodity Prices, Government Financial Statistics, World Economic Outlook Database. Country specific data sources vary.

practises by way of different financial support schemes, such subsidies can incentivize the adoption of sustainable technological innovations. The additional demand creates economies of scale, again, providing impetus for technological learning effects. For this reason, subsidies to renewable energy production can have large and far-reaching implications when it comes to setting the future structure of the energy and transportation systems.

Subsidies are often popular with polluters (as it does not fulfil the polluter pays principle), which may make them more feasible to implement politically than other fiscal policies. Once introduced, however, subsidies are difficult to phase-out, and may create vested interests and clientelism. This also makes it challenging to phase out subsidies that have negative environmental consequences and that drain the government budget, as part of green fiscal reform. By making resource use cheaper, subsidies may contribute to higher consumption and thus resource depletion. For example, subsidies for fossil fuels encourage excess energy consumption, artificially promote capital-intensive industries, reduce incentives for investment in renewable energy and accelerate the depletion of natural resources (IMF, 2013). The IEA estimated the value of global fossil fuel consumption subsidies in 2016 around US$260 billion, with vast differences by country (see Figure 6). Estimates vary widely by organization, however, depending on the methodology and whether externalities are included. For example, in 2015, IMF estimated that energy subsidies would incur costs of US$5.3 trillion, or 6.5 per cent of global GDP (IMF, 2016). Most of this arises from countries setting energy taxes below levels that fully reflect the environmental damage associated with energy consumption, such as by global warming and local air pollution (IMF, 2016).

There are potentially substantial benefits to fossil fuel subsidy reform, which include increased government revenue, a reduction in global CO2 emissions, and in pre-mature air pollution deaths, though the exact quantification of such impacts is subject to debate. An IMF report estimates, through a partial equilibrium analysis, that eliminating subsidies could raise government revenue globally by US$2.9 trillion (3.6% of global GDP) (IMF, 2016).

A number of countries have embarked on fossil fuel subsidy reforms; however, efforts have been both successful and unsuccessful. Reforms have addressed fuel subsidies, the electricity sector and in isolated cases, the coal sector (IMF, 2016). In some countries (e.g. in Turkey, Brazil, Chile and South Africa), reforms have led to a permanent and sustained reduction of subsidies, whereas in other countries subsidies have either (temporarily) re-emerged (e.g. Indonesia, Peru and Iran) or price increases were rolled back soon after the reform began (e.g. Mexico).

A number of key elements have been identified for fossil fuel subsidy reform, based on experience in countries in which such reforms have been implemented. These elements include: 1) a comprehensive plan for energy sector reform including analysis of impact and consultation with stakeholders; 2) an extensive communications strategy;

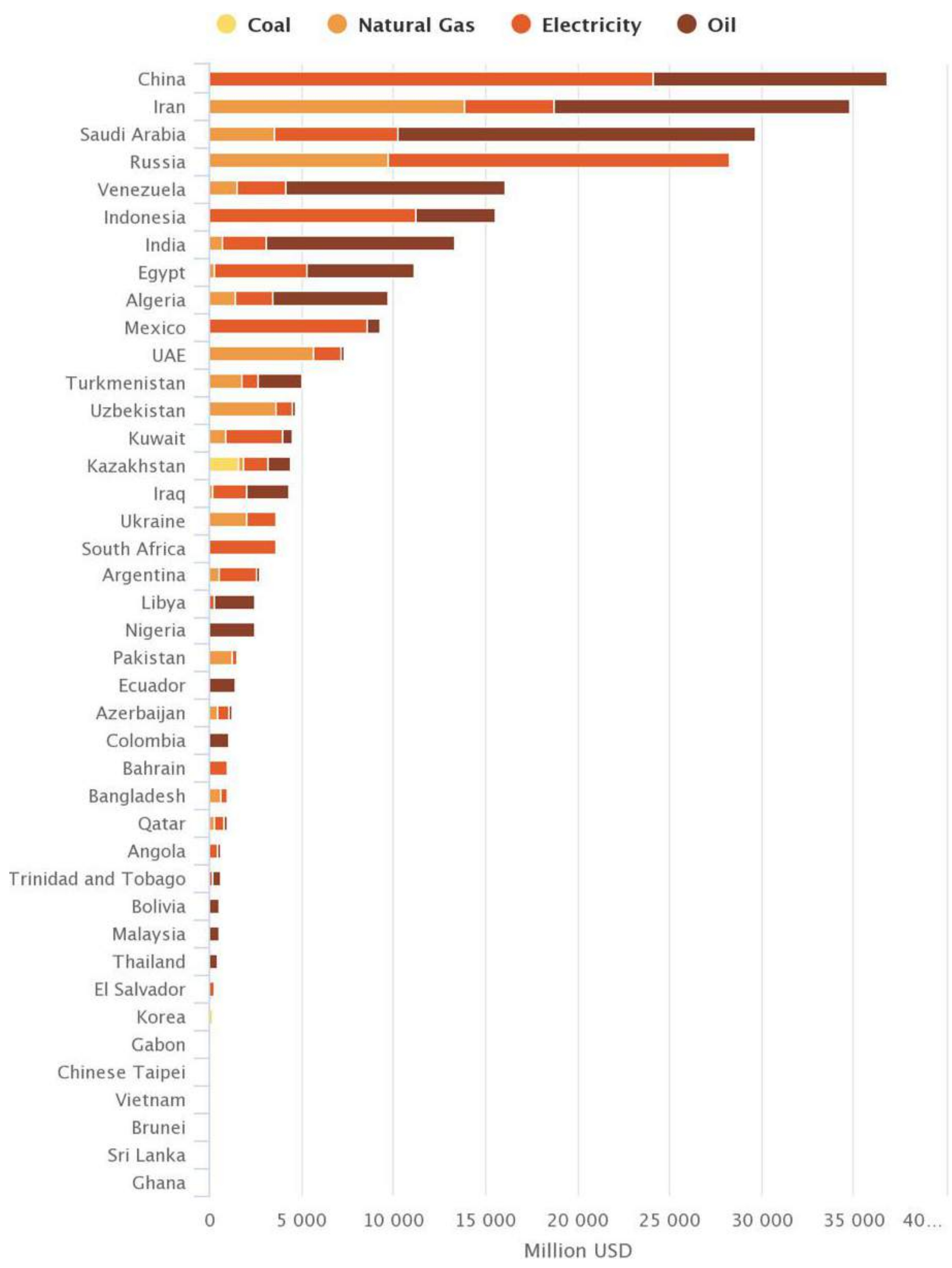

Figure 6: Energy Subsidies by Country (2016). Source: IEA, 2018b.

3) appropriately phased price increases, which may vary across energy products; 4) targeted measures to protect the poor; and 5) institutional reforms that depoliticize energy pricing, such as the introduction of automatic pricing mechanisms (IMF, 2013).

Targeting measures to protect the poor may be particularly relevant in developing countries, where households may spend as much as 10 per cent of their income on energy (World Bank, 2010). Reforming subsidies for energy in such countries could make modern energy unaffordable if not accompanied by, for example, cash transfers to the relatively poor. Such pro-poor policies can be financed by funding streams previously spend on the energy subsidy. (See Iran case study (Section 2.2.1) below).

Another example of subsidies with negative environmental consequences are those in the fishing industry. The difficulty with a majority of fisheries subsidies is their capacity enhancing effect: subsidies result in more and bigger boats, and longer nets. While this may increase fish yields in the short term, this practise exacerbates the depletion of fish stocks in the long run (in turn leading to a reduction of economic benefits over a longer period of time). Subsidies also lower retail prices, which increases consumer demand for resources that are already under pressure (Markus (2010); See also Sanchirico and Wilen (2007); Khalilian et al. (2010); and Costello et al. (2016)). Some positive efforts have been made to counter such policies. For example, in 2002 and 2007 the EU amended its European Common Fisheries Policy to phase out support previously provided for the construction of fishing vessels. In addition, support for the modernization of fishing vessels to improve safety, working conditions, hygiene and product quality was limited and provided only on the condition that such aid did not increase catch capacity (Markus, 2010).

2. The political economy of green fiscal reform

As discussed in the previous section, there are many strong arguments for environmental taxes, which include increased revenues, the polluter pays principle and the opportunity to offset other distortionary taxes. Such attractive features would suggest that green fiscal reforms have the ability to easily gain wide public support and to be successfully implemented. However, environmental policy instruments are not selected based on academic merit or how good they would be at allocating resources – enlightened civil servants cannot implement optimal green taxes without political backing.

Environmental policy instruments are inherently part of a political struggle between different interest groups and other political factions and will naturally be a product of such circumstances, as well as of the institutional and cultural features of a country's public sector. If not taken properly into consideration, these factors may obstruct implementation and/or make the final outcome of a certain policy deviate from expectations. One country's fruitful introduction of a certain environmental policy does not guarantee success in other contexts. This means that the design and implementation of a green fiscal policy needs to consider and be tailored not only to environmental and economics characteristics, but also to the political context.

The administrative feasibility of an environmental tax, vis-à-vis its closest substitute, is an important consideration. In many developing countries the tax base is small and it is difficult to implement efficient property taxes, labour taxes and value-added taxes. The feasibility of a tax, and the lower transaction costs of enforcing some environmental taxes make them particularly interesting for many developing countries with large informal sectors. As an example, a recent World Bank report (2015) notes that carbon sources are concentrated making carbon emissions straightforward to monitor and carbon or energy taxes difficult to evade. For such cases, as in Sweden and the UK, tax evasion has been shown as substantially lower than for value added tax and income tax respectively. For the many developing countries struggling with tax evasion, that is a substantial advantage (World Bank, 2015).

In terms of subsidy removal, the adjustment of subsidized energy prices has, in many cases, led to widespread public protests from those who benefit from the subsidy, followed by either a complete or partial reversal (IMF, 2013). A lack in public support for subsidy reform is often the result of distrust that the government can reallocate savings to benefit the broader population and that vulnerable groups will be protected. The inflationary effects of higher domestic energy prices and the possibility for adverse effects on international competitiveness are further concerns (IMF, 2013). See Section 2.2 for short summaries of subsidy removal in practice.

In the following section, we will have a closer look at some cases where green reform has either succeeded or failed, in an attempt to demonstrate political and institutional aspects that influence implementation and overall results in both positive and negative directions. If acknowledged and carefully incorporated in policy design, political and institutional characteristics may effectively support green fiscal policies' potential to achieve traction in the political system.

2.1 Experience in implementing carbon taxes

2.1.1 Carbon tax in Sweden

The long-term aim of the Swedish Government is a sustainable energy supply that makes efficient use of resources and gives rise to zero net emissions of greenhouse gases in the atmosphere by 2050 (Government Bill 2008/09:162). Sweden is a positive example of political opportunity and implementation of a CO_2 and energy tax. To ensure general acceptance, the country implemented exemptions and gradual changes to its policies.

In 1991, Sweden introduced a CO_2 tax on all major fossil fuels at rates equivalent to US$35/tonne CO_2 – a very high level of taxation on fuels compared to other countries. At the same time the energy tax rates were reduced by 50 per cent, which still meant a net increase for all fuels (although the increase varied in magnitude between fuels). The energy tax and CO_2 tax should be seen in combination, as two tax components rather than as two separate taxes. The energy tax targets other external effects than CO_2 emissions (such as noise, congestion and road wear from traffic) and also acts as a way of generally stimulating energy efficiency.

The significant aspect of the green tax reform was that it was introduced as part of a broad tax-reform with bipartisan support. The introduction of CO_2 taxation was just a small part of the funding of this reform that primarily involved dramatically lower taxes on capital and labour. The political opportunity to introduce this rather unique tax consisted of the confluence of two separate political processes. The predominant political pressure was a demand for a drastic reduction in marginal income tax rates that had reached very high levels. At the same time, there was an increasing interest in environmental issues. The CO_2 tax was thus introduced at a moment when there was a need to fill a gap created by reduced taxes on other factors of production. According to pre-reform estimates, the reform entailed a reallocation of revenue of approximately 6 per cent of GDP. Interestingly enough, at the design stage it was expected that the amount of carbon emissions would decline, meaning that the associated tax revenue would also be reduced (Swedish Green Tax Commission, 1997). In summary, transparency in shifting taxes on labour to taxes on pollution was an important factor to achieve popular support for the reform. It happened to also be a high political priority and made a lot of economic sense given the high marginal tax rates on labour at the time.

In general, the introduction of the carbon tax did not increase the tax burden on the public sector, while tax increases for companies and households in the energy and environmental areas were combined with general tax relief in other areas. This avoided increases in the overall level of taxation, addressed undesirable distributional consequences and stimulated job growth.

Over the years, the CO_2 tax rates gradually increased, with the purpose of achieving cost effective emission reductions. The tax changes were implemented stepwise so that households and companies had time to adapt. For example, in 2009, the Swedish Parliament adopted a number of tax changes in the climate and energy area that entered progressively into force (Government Bill 2009/10:41). The fact that the reform was gradual and predictable made it more acceptable to those affected, as well as the special concessions made to industrial emissions, as can be seen in Figure 6.

In 2017, the general CO_2 tax corresponded to around US$137/tonne CO_2 (1.13 SEK per kg CO_2). This is an order of magnitude higher than the price of permits within the EU Emissions Trading Scheme which laid at around US$6/tonne CO_2 for most of 2017, and US$15/tonne CO_2 in early 2018. In Sweden, the risk of carbon leakage was addressed through the use of somewhat lower tax levels (that are still high in an international context) for certain sectors. For example, ever since the introduction of the CO_2 tax, industry has

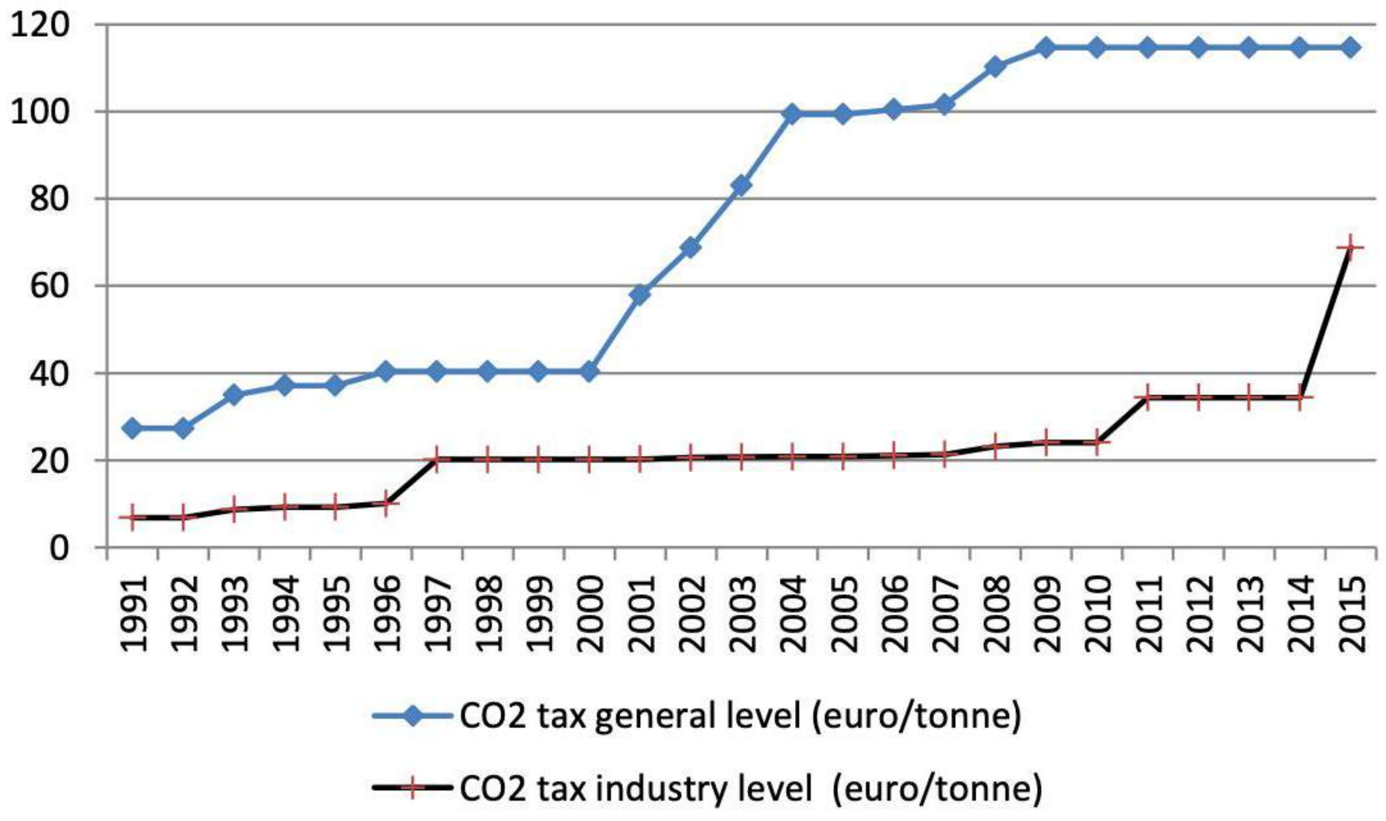

Figure 7: Development of the Swedish CO2 tax for different areas of use. Note that Nominal CO2 tax levels, for 2010-2015 the 2010 level is used. From 2008, level for industry outside EU Emissions Trading Scheme (EU ETS) is shown. Fuel used for stationary motors and for heating purposes in the manufacturing process in industry. Diesel as motor fuel in tractors and other agricultural and forestry machinery is not included. (Source Hammar et al 2013)

been subject to a considerably lower tax level than households (See Figure 7).

Another important issue when it comes to green tax reform is how it relates to international commitments. Since Sweden is part of the European Union, it had to balance its own policies with EU policies and in some cases also transition from Swedish policies to EU policies. In 2008, Sweden took a first step towards abolishing the CO_2 tax within the industries that are part of the EU ETS cap and trade program by reducing the CO_2 tax on fuels used in those industries, e.g. heavy energy-using installations such as power stations and industrial plants. In 2011 the CO_2 tax for industrial installations within the EU ETS was abolished. As for heating fuels that are used by industry not covered by the EU ETS, the lower level of the CO_2 tax was raised to 30 per cent of the general level in 2011 and further increased to 60 per cent in 2015.

While we cannot establish causality, we can point to the fact that Sweden has seen significant reductions in carbon intensity, particularly in the sectors where the full tax is applied. The CO_2 tax has had a major impact on fuels used for heating purposes, where biofuels and other non-fossil energy sources (such as energy from waste and surplus heat from industrial processes) have significantly increased their shares.

The Swedish experience also shows that emission reductions can be combined with economic growth. Between 1990 and 2010, CO_2 equivalent emissions were reduced by 8 per cent while at the same time economic activity increased by 51 per cent. This may be considered an 'absolute' decoupling (see Chapter 2) if examined from a territorial or production-based approach. Moreover, the total tax share of GDP actually fell, so carbon taxation did not lead to 'a bigger state'. The green fiscal reform and the high carbon taxes in Sweden managed to reduce an already low level of emissions of CO_2 per GDP to even lower levels. (See Figure 8, which compares Sweden to a number of other countries). This exemplifies both the potential of green fiscal reform to fundamentally affect the sustainability of an economy by decoupling emissions from growth, but also the extent to which policy makers need to go to achieve these objectives.

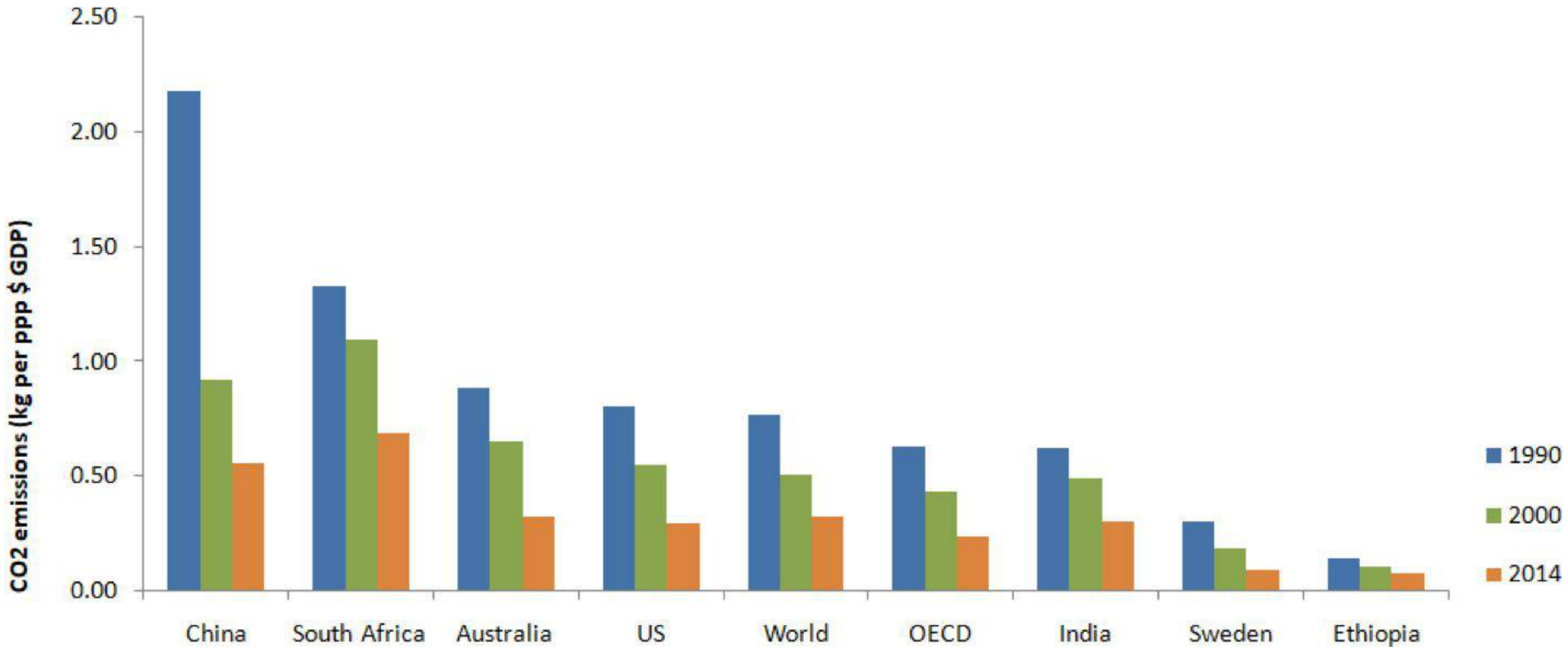

Figure 8: Carbon dioxide emissions per unit GDP in selected countries and regions. Source: Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States.

2.1.2 Australia's carbon policy reversal

Australia is another example of the importance of political feasibility for green tax reform, and in many ways is the opposite from Sweden. The Australian economy is tied closely to fossil fuels – coal and natural gas account for the bulk of the country's export income, fuelled largely by Chinese demand. It is the world's second largest coal exporter. The country also relies heavily on coal for domestic electricity generation. The strong connection to fossil fuel interests has made action on climate change the subject of a highly partisan debate between Australia's major political parties (Bailey et. al., 2012).

The political environment surrounding climate change mitigation policy has shifted starkly in the past decade, and continues to be volatile. Though the first blue prints for emissions trading were developed in the 1990's, the government refused to ratify the Kyoto Protocol in 2002. Following this decision, the incoming Prime Minister Kevin Rudd expressed strong support for climate change issues. While in office, Rudd's flagship climate change policy, the Carbon Pollution Reduction Scheme, twice failed to gain the support of the Australian Senate, and helped confirm climate change as one of the most controversial issues in Australian politics (Bailey, et. al., 2012). Since 2007, climate change policy has contributed to the downfall of a number of prime ministers and opposition leaders (Jotzo, 2012).

A growing awareness that Australia faces severe risks from climate change impacts helped propel broad bipartisan support for carbon pricing in 2007-2009. Then, in 2011, amidst policy uncertainty, Australia implemented a carbon pricing mechanism covering around 60 per cent of the country's greenhouse gas emissions. It went into force in 2012, and was first scheduled to operate with a fixed price model that continued until mid-2015. Then, beyond 2015, emission trading was to begin (Jotzo, 2012). Following the 2013 federal election, legislation was introduced to repeal the carbon price. It went into effect mid-2014, effectively ending Australia's carbon policy. Though emissions had in fact declined during the short life of the policy, public support for this move was provided by an increase in electricity costs for households and industry and a campaign that placed the economy against the policy (Baird, 2014).

Since its repeal in 2014, climate change policy has remained an issue on the Australian political scene. Australia did sign the United Nations Framework Convention on Climate Change Paris Agreement in 2016 and in 2017 the government completed a climate policy review that concluded in 2018 it would begin developing a long-term emissions reduction strategy. Nonetheless, Australia clearly demonstrates how a political environment can prevent the success of a carbon tax, no matter how well-designed.

2.2 Experience in fossil fuel subsidy reform

2.2.1 Steps toward reform in Iran

In Iran, the Targeted Subsidy Reform Law specified post-reform price targets with increases of up to 20 times for gasoline, diesel, natural gas, electricity, some foods, and air and rail transport with the aim of closing the gap between domestic and international prices. This policy made Iran the first major energy-producing and exporting country to drastically cut subsidies to fossil fuels.

To prevent opposition to the reform, the policy replaced subsidies with transfers to the population. Fifty per cent of the net proceeds from the price increase were allocated to households as cash and non-cash transfers. Thirty per cent of proceeds were allocated to enterprises, which were to receive subsidized loans for the adoption of new, energy-saving technologies and credit lines to mitigate the impact of energy price increases on their production.

As international prices were far out of line with domestic prices, few could argue that maintaining such a system was sustainable. Authorities made it clear from the outset that the purpose of the reform was to reduce waste and make consumption more efficient. In passing the reform, authorities reached out to more than 70 million citizens and engaged in a public-relations campaign that lasted for months. The purpose of the campaign was to educate the public on the growing costs of low energy prices and the benefits expected from the reform. Because close to 80 per cent of Iran's population was told that they would be eligible to receive significant sums of money, support for the reform was widespread.

Though the reform began smoothly in 2010, the second phase of the reform was postponed in 2012 following deterioration in economic conditions, increasing inflation and exchange rate depreciation. Large shares of the revenues expected from price increases failed to materialize, and as a result, revenues fell short of those promised to households. Though consumption of subsidized products declined in the early stage of the policy, once it was postponed the growth in consumption of subsidized products rebounded.

For a full discussion, see IMF, 2011 (Iran – the Chronicles of Subsidy Reform, International Monetary Fund, WP/11/167) and IMF, 2014 (Islamic Republic of Iran, International Monetary Fund, Country Report No. 14/94).

2.2.2 Early signs of successful reform in the Ukraine

Natural gas (most of which was imported from Russia) was heavily subsidized in Ukraine since its energy independence in 1991, with households paying 10 times below the market gas price (Nabiyeva, 2016).

Motivated in part by conditions required by the International Monetary Fund in 2014 for continued loan programs to the country, residential gas tariffs were raised by 470 per cent and district heating tariffs by nearly 200 per cent (Astrov, 2017; World Bank, 2017). In April 2016, another gas tariff was introduced. In sum, amid fiscal crisis, prices were substantially increased for consumers, stirring social protests. Nonetheless, several elements were included to help ease acceptance of the reforms: 1) the government committed to social safety nets with budget allocations – increasing the number of households covered by the social protection system from 1 million to 7 million to ensure that the most vulnerable were protected from the price increases; 2) people were allowed to apply to social assistance by mail, so asking to help was less public (World Bank, 2017).

As a result of the reduction of subsidies, gas consumption has been reduced by half in a period of just a couple of years (Nabiyeva, 2016).

For a full discussion see Astrov V. (2017) Nabiyeva, K. (2016) and World Bank (2017).

2.2.3 Slow reform progress in Vietnam

The IEA estimates that fossil fuel subsidies in Vietnam fluctuated between US$1.2 and US$4.49 billion annually between 2007 and 2012 (IEA, 2018b). Most subsidies are indirect and are not recorded as actual fiscal transfers, making them very difficult to quantify. The support comes in the form of control of prices for electricity and petroleum products, and provisions for energy producers and distributors, most of which are state owned enterprises (SOEs). SOEs receive, for example, discounted or even free resources and infrastructure, preferential loans from state-owned banks, loan guarantees or bail-out of loss-making units and a variety of corporate tax breaks and concessions. Similarly, state-owned Petrolimex, responsible for more than 50 per cent of Vietnam's retail petroleum supply dominates domestic fuel markets.

A brief survey of people's perspective on reform of the energy sector revealed a number of key concerns. These include a lack of transparency regarding the monopoly structure of SOEs and the perception of likely adverse impacts on household and enterprises, particularly during time of economic downturn. Households and small- and medium enterprises recent energy price has increased, in the face of what they perceive to be wasteful and inefficient energy SOEs.

Nonetheless, the government has committed to fossil fuel fiscal policy reform and a transition to green growth (see the Party Resolution on Climate Change, Natural Resource Management & Environment and the national Green Growth Strategy). Some preliminary steps have been taken in the direction toward green growth. For example, the government has instituted a small environmental tax and has started to raise electricity tariffs and prices for fossil fuels (e.g. prices for coal and gas for power production). The government has also agreed on a roadmap to restructure SOEs, scheduled to be complete by 2020, though progress has been slow for a number of reasons. These include vested interests, the complexity of SOEs' role within markets, and difficulty in tackling the scale of commercial and institutional issues existing within energy markets. For a full discussion and accompanying recommendations see UNDP, 2014.

3. Distributional consequences

The political feasibility of a green fiscal reform depends fundamentally on how it affects different groups in society. The cost distribution may have many dimensions – between owners of capital and labourers, between rich and poor people, between urban and rural, but also across generations and more categories that may be difficult to predict (Sterner and Coria, 2002). Ultimately, the consideration from the most influential group will matter, but it is also interesting to look for the distributional implications from an inclusive sustainable development perspective. Overall, the distributional effects of an environmental fiscal policy can vary significantly.

The impact of a reform in terms of 'regressivity' (i.e. the extent to which a policy imposes a proportionally higher burden on the poor) or 'progressivity' (which is what an inclusive green reform typically should aim for) of taxes has been shown in the literature to depend on a number of factors including the incidence of the policy vis-à-vis socio-economic conditions, as well as the nature of the goods and services affected (Aasness et al., 2002). This will be elaborated on in the following sections.

3.1 Carbon and energy taxes

The effects of a general carbon tax will depend on the mode of implementation with respect to different fuels and sectors, and will typically be more complex than for a single fuel (Somanathan et al., 2014).

Because lower-income households spend a larger share of their income on energy than higher-income households, a carbon tax could easily have a regressive impact, but that depends on the composition of fuels. Some studies (e.g. Smith, 1992, for the case of the UK, and Poterba, 1991, for the case of the US) confirmed this assumption. Others (e.g. Speck, 1999) have shown the distributive impacts of a carbon tax to be relatively weak, with only relatively moderate impacts on low-income households. Relative impacts would again depend on the type of fuel being taxed, but also on the distribution of benefits from improved environmental quality. In sum, the existing literature about possible adverse distributional implications of carbon taxes has largely yielded diverse conclusions. A recent overview study by Dorband et al. (2018), concludes that the distributional consequences of carbon pricing can be expected to be most adverse in countries with relatively high per-capita emissions, whereas in countries with low emissions, carbon pricing can be expected to entail less severe distributional implications, but as we will see below, other factors than emissions are also important.

In developed countries, carbon pricing tends to be regressive, which can be explained by the more carbon-intensive consumption patterns of poorer households (Dorband et al., 2018; Grainger et al., 2010). Direct energy consumption and private transport in these countries can be considered as necessities and exhibit decreasing expenditure shares with rising income.

In poorer countries, the level of greenhouse gas emissions as well as the breakdown of carbon emissions by sector looks quite different than those in high-income countries. For example, in Ethiopia, the level of overall greenhouse emissions is comparatively low and most emissions originate in the agricultural sector (e.g. livestock), land-use and forestry (land clearance and firewood). As a result, the implementation of a carbon or energy tax will affect these countries differently than

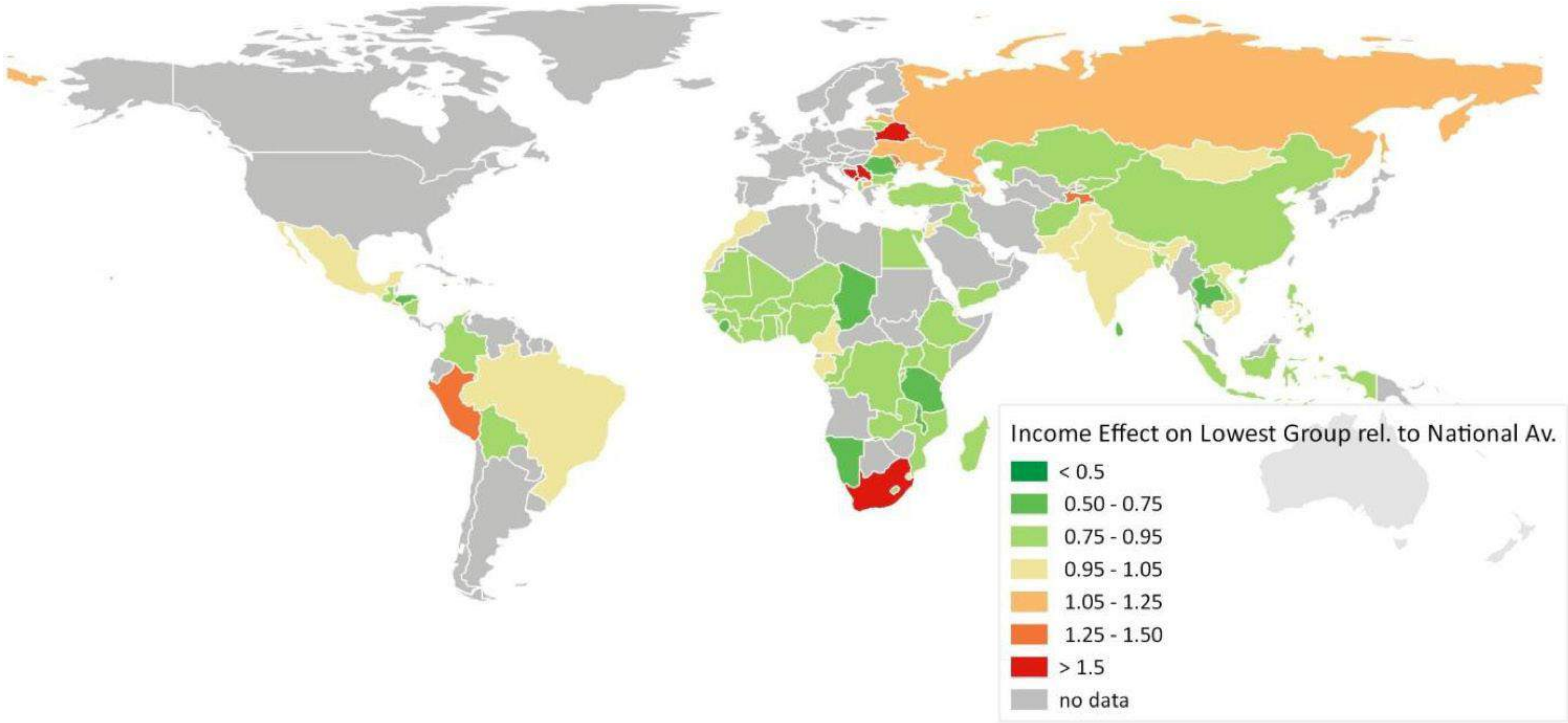

Figure 9: Distributional consequence of a carbon tax on the lowest income group relative to the national average in low-income countries. Values smaller than one indicate progressive distributional impacts, whereas those greater than one indicate regressive impacts. Source: Dorband et al., 2018.

high-income countries. In an overview study of 87 low and middle-income countries, Dorband et. al. (2018) found that for countries with per-capita incomes of below US$10,000 per year carbon pricing has, on average, progressive distributional effects (see Figure 9). In many low-income countries, energy and transportation access are still luxuries and expenditure on energy shares increase with rising income. This is partially due to the use of traditional biomass (which is collected rather than purchased) used as a primary fuel by the very poor.

The impact of a carbon tax on the distribution of income has been shown to be a fundamental factor in securing public support for such a policy and thereby also political acceptability (Baranzini, 1997; Zhang and Baranzini, 2004). There are, of course, design options that could help to mitigate any regressive distributional impact. Such options include setting a tax-free use for the essential use of energy (e.g. metered domestic energy), or redistribution of carbon-tax revenues. The 1996 Dutch regulatory energy tax, for example, set a tax-free allowance of 800 m3/year for gas and of 800 kWh for electricity to reduce its distributional effect on lower-income groups (Zhang and Baranzini, 2004).

In Europe, concerns about regressive effects of energy taxes have been addressed by various redistribution and compensation mechanisms. For example, exemptions have been made for some energy uses thought to be characteristic of low-income households (e.g. night storage heaters were exempted from German energy taxes), and higher tax rates have been imposed on energy uses characteristic of rich householders. Despite such efforts, the regressive effects often remain to some extent (Ekins et al., 2011). Similarly, Increasing Block Tariffs (IBT), with higher prices for large consumers, is the most common approach to ensure redistributive objectives when it comes to energy tariffs in low-income countries. Unfortunately, since poor families often share connections (and thus become "large consumers") this approach is seldom very effective (Whittington, 2000; Meles, 2017).

3.2 Fuel taxes

As described in Sterner (2011), fuel taxes are often criticized for being regressive, though a closer look at the empirical results shows that there are large variations in distributional impacts and effects ranging from regressive to progressive. The specific regressive effects of fuel taxes are also impacted by country and region-specific factors such as distribution of income, energy supply structure and energy efficiency characteristics of domestic fuel use, as well as on the specifics of the methods used (e.g. whether lifetime or temporary income, or substitution or other adaptations are allowed for in the analysis) (Ekins, 2011; Sterner and Carlsson, 2012). Nonetheless, the assertion that fuel taxes are regressive is often used as an argument against them and can make fuel taxes politically difficult to implement even if untrue.

In rich countries, fuel taxes may be neutral or weakly regressive, though the picture is somewhat mixed. While in Europe (see below), taxes tend to be neutral, in some richer countries, like the U.S., fuel taxes may be regressive (Sterner et. al., 2012). This is partly due to the absence of public transport, which makes people dependent on cars, and the sprawling character of cities, as well as distances between places that people live and work. These factors make many, in particular, poorer households dependent on cars and thus fuel, which may present a sizeable proportion of their income. In addition, poorer households tend to have older, cheaper, and more gas-guzzling cars.

In low-income countries, fuel taxes are generally progressive. In fact, in some of the countries with the lowest incomes, such as India, Indonesia, China and many African countries, the progressivity of fuel taxes may be quite strong. See, for example, the case of Ethiopia below. In China, very poor households cannot afford public transportation and the very richest households rarely use public transport. As a result, the fuel tax on public transport instituted in 2009 falls primarily on the middle-class, and is therefore progressive (Sterner et. al., 2012).

In general, revenues generated by fuel taxes can be used in a number of ways. In an 'income-based' recycling model, they could be allocated to households according to their aggregate income, in order to reach the intended distributive objectives (Sterner et. al., 2012; Bento et. al., 2009). If revenues are simply refunded on a per capita basis, the overall fuel tax reform may be made more progressive (Sterner et. al., 2012). In an additional model, revenues could be allocated as a lump sum according to each household's share of aggregate vehicle miles travelled. The government could simply mail rebate checks to households on an annual basis. (Bento et. al., 2009)

3.2.1 Fuel taxes in Europe

As discussed in Section 9.1.2, the average tax on gasoline in Europe is very high compared to the U.S and many other non-European countries. Nonetheless, the income distribution effects of fuel taxes in Europe have been shown, in general, to be approximately neutral (Sterner, 2012). With the exception of income, other variables such as population density, vehicle density and degree of urbanization do not tend to affect these results. In lower-income European countries, such as Serbia, the fuel tax is actually progressive (Sterner and Carlsson, 2012).
In general, the highest burden is placed on middle-income groups because the proportion of car ownership is lower in low-income groups, and households without cars are not much affected by transport fuel taxes (Ekins, 2011).

3.2.2 The case of Ethiopia

Ethiopia has had a package of fossil fuel taxes in place for nearly a decade. These include an excise tax, a value added tax, road funds, municipal taxes and a price stabilization fund applied to consumers of gasoline and diesel oil. The package of these taxes is an equivalent of around Birr 4.41 per liter (or US$0.16) on gasoline and around Birr 2.39 per litre (or US$0.09) on automotive diesel fuel (Mekonnen, Deribe and Gebremedhin, 2011).

In Ethiopia, private vehicles are used almost exclusively by the richest 10 per cent of the population – around 85 per cent of Ethiopians live in rural areas with limited use of modern modes of transport. In the poorer shares of the population, people prefer not to pay for public transport and tend to walk by foot or use non-motorized means of transport.

As a result of this split in transportation use, about 97 per cent of the expenditure on private transport fuel in the country is spent by the richest 10 per cent of the population (Mekonnen, Deribe and Gebremedhin, 2011). On average this population group spends around 0.8 per cent of their household budget on fuel – the rest spends nearly 0. Transport fuel taxes have thereby been shown to be clearly progressive in Ethiopia. If fuel taxes were to increase, the rich are likely to be impacted disproportionately – such a policy could be viewed as pro-poor and would fit well in an inclusive green growth strategy.

4. Public environmental expenditure reviews

As presented in Section 9.1.2, government expenditures can have important implications for the greening of an economy. Historically, public expenditures were focused on economic efficiency and macroeconomic stability, but often failed to incorporate environmental and social factors (Sheng, 1997). Public Environmental Expenditures (PEEs) is one framework that helps guide government spending designated for achieving environmental objectives.

4.1 An overview of public environmental expenditures and public environmental expenditure reviews

The PEE framework begins with the identification and ranking of environmental priorities, which may be done in a number of ways. One approach is to use a common and broad international list, and focus data collection and indicator selection on a country's specific circumstances. The World Bank (1995) developed such a list that could be used as a basis and expanded or amended accordingly:

(i) *Sources* (Water, Fisheries, Forests, Land, Sub-oil assets)

(ii) *Sinks* (Solid Waste, Toxics, Greenhouse Gases, Stratospheric Ozone)

(iii) *Life Support* (Biodiversity, Oceans & Coastal Zones)

(iv) *Human Health Impact* (Water Quality & Access, Air Quality)

Setting environmental goals must be incorporated in a process that considers other social and economic imperatives and trade-offs through a general equilibrium analysis to produce a balanced picture of overall public expenditures (Sheng, 1997).

In a next step, environmental expenditures should be classified in a system that can be related to environmental indicators, which can also be done in a number of ways and can be based on various definitions. This process helps to disaggregate environmental expenditure data in the existing national accounts to identify data gaps, indicate current priorities and provide an estimate of the costs of moving toward established targets (Sheng, 1997). It also provides a framework for cost-sharing between government, industry, households and non-profit organizations. The United Nations uses a Classification of Environmental Protection Activities (CEPA), to which countries may relate their expenditures (UN, 1993). These include the following:

(i) Protection of ambient air and climate

(ii) Protection of ambient water (excluding ground water)

(iii) Prevention, collection, transport, treatment and disposal of wastes

(iv) Recycling of wastes and other residuals

(v) Protection of soil and ground water

(vi) Noise abatement

(vii) Protection of nature and landscape

(viii) Other environmental protection measures

(ix) Research and development

Once decisions have been made on what types of environmental protection activities are to be financially supported by society, spending questions can shift to what specifically the government should spend on, how much to spend, and from where the funding comes (Sheng, 1997). PEEs are typically divided into two categories: capital expenditure and current expenditure (operation and maintenance or O/M). Particularly in difficult financial times, PEEs should focus on O/M - if O/M expenditures are not made a priority, much larger expenditures would have to be made at a later date on rehabilitation or replacement.

Once government resource allocations have been made within and among sectors, Public Environmental Expenditure Reviews (PEERs) help to assess the efficiency and effectiveness of those allocations in the context of environmental management frameworks and priorities (IIED, 2009). PEERs are typically prepared by economists and public finance professionals, with technical assistance from environmental professionals. Although international partners could give technical assistance (e.g. the World Bank), the usefulness and potential impact of the PEERs increase with the levels of government involvement (IIED, 2009; Swanson and Lundethors, 2003). PPERs highlight the mismatch between environmental policy and what may be low levels of government spending in those areas. Identifying positive and negative trends can be an important tool in holding governments accountable for the direction of public investments. PEERs require detailed budget and expenditure data, which in many cases may be lacking, making the task challenging and time-consuming.

4.2 PEERs in practice

Historically, PEERs have helped to redistribute spending toward institutions responsible for environmental priorities (IIED, 2009). There are a number of positive examples across Africa and Asia.

In 2004, Tanzania decided to implement a PEER to help establish the level of environmental expenditure required to meet the country's environmental priorities and poverty reduction objectives. Using data from 2000-2002 on government expenditure by central and local governments, the resulting PEER highlighted key problems in spending that included: 1) below-potential revenue collection; 2) low shares of revenue making it to districts (i.e. poor decentralization); 3) low environmental expenditure; and 4) procedural constraints. As a result of the PEER carried out in Tanzania, the environmental budget grew considerably and those sectors and local government authorities that deal with relevant issues have clarified responsibilities. (For more information see Paschal et al., 2007.)

Similarly, following a 2012 PEER in Mozambique that demonstrated insufficient funds to address economic loss due to environmental degradation and the inefficient use of natural resources, the government opened new budget classification codes related to climate change and appointed two environmental focal points within the Ministry of Finance to enhance the use of environmental codes in budget lines. In Malawi, a PEER showed that only 1 per cent of the country's environment and climate funds were allocated to districts in which people are most impacted by environmental degradation and climate change. Highlighting this information spurred the Government to explore how more funds can be allocated to the overlooked districts and to identify the major barriers (UN Environment and UNDP, 2017).
In Nepal, following a PEER instituted in 2010, the government created a new climate change related budget code to track climate related expenditures and results over time and also increased budget allocation to environment and climate related institutions (Government of Nepal, 2013).

5 Concluding remarks

Fiscal policy is an important tool in any economy and is therefore also essential to create a truly green economy. Through taxes and subsidies, signals can be given to consumers and producers to shift investments and ensure efficiency in resource use, discourage environmental pollution and encourage innovation in new products, processes and technologies. Similarly, careful targeting of government expenditures can effect both production and consumption patterns as well as the portfolio of government services, including environmental management.

This chapter has provided an overview of the most prevalent fiscal policies important to green economies: Pigouvian taxes, resource rents, subsidies, and subsidy removal:

Pigouvian taxes

The optimal fiscal policy for a green economy is most often implementation of Pigouvian taxes that correct market failures and enforce the Polluter Pays Principle. Most often these failures lie in pollution and resource misuse. An example is carbon taxation commensurate with the social cost of carbon emissions. This is also considered to be the most efficient policy instrument because it encourages both static and dynamic efficiency in carbon mitigation with far-reaching implications for both production processes and consumption patterns. The ambitious carbon taxes in Sweden were an important factor behind an 'absolute' decoupling of economic growth and carbon emissions. Fuel taxes are another example. In countries that have implemented more stringent fuel policy (e.g. several in the EU and Japan), fuel demand has been cut dramatically. Furthermore, the revenues from such taxation can be used to lower other distortive taxation, to achieve distributional objectives and to fund other prioritized government spending.

Resource rents

Economic theory suggests several reasons why resource rents should be taxed. One of these is simply the presumption of common or state ownership. If this is the case (which varies from country to country and resource to resource), then there is a clear case for government to maximize revenues by selling extraction rights (or setting the equivalent mining duties, stumpage fees, etc.). Since the income or rent is essentially windfall – or attached to immobile and naturally given resources such as land - there is no risk for deadweight loss in taxing. (The opposite applies to taxing labour, profits or innovation.) Large resource rents, however, are often characterized by quite severe lobbying and sometimes, institutional capture. Those countries subject to a resource curse – where discovery of significant natural resources leads to corruption, inefficiency, Dutch disease and sometime war - do not typically institute the ideal institutions or policies. Instead their governments are often beholden to the resource owners, and may therefore be opposed to instituting optimal rent capture.

Subsidies and Subsidy removal

Subsidies, which either offers a reward for reducing emissions, or for avoiding external environmental costs (e.g. for renewable energy investments) are often popular and more feasible to implement politically than e.g. Pigouvian taxes. However, subsidies can also become major burdens for government budgets and slow down necessary reforms (e.g. fossil fuel subsidies). Removal or reform of such fossil fuel subsidies with negative environmental consequences has begun in a number of countries with both successful and unsuccessful outcomes.

Green fiscal reform cannot be seen in isolation from the political realities of a country. In a democracy, there must be sufficient public and political support to carry out major reforms. This also explains why the distributional implications of green fiscal reforms are so important. After all, a partially implemented green fiscal reform is often preferred to an optimal reform that is stuck on the drawing board.

The increased attention to sustainable production and consumption, climate change and inclusive green growth created by the Sustainable Development Goals, the Paris Agreement and other international treaties generates momentum to look at the role of fiscal policy in achieving these ambitions. This chapter makes the case that carefully designed fiscal policies that take into consideration environmental externalities and the distributional implications of taxes, subsidies and government spending are critical to achieve these goals.

The fundamental premise is that if sustainability is to be achieved, we need to use our resources as efficiently as possible. For that to happen, all actors must be aware of the real social cost of resource use. Clear incentives are needed not only to reduce environmental degradation and resource use, but also to unleash both market powers and collective action to fundamentally transition our economy towards sustainable production and consumption. This will need dramatic innovations and investments. Green fiscal policies have a very important role to play in this transition since they can stimulate both static and dynamic efficiency. As the number of active green fiscal policies is multiplied, we can look forward to a rapid increase in renewable energy production, transportation solutions with a minimum environmental impact, circular systems for production and consumption of food, clothes and durable products and government spending that is consistent with an inclusive and green economy.

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CHAPTER 9: GREEN INDUSTRIAL POLICY: DIRECTING PRIVATE INVESTMENT

CHAPTER 9: GREEN INDUSTRIAL POLICY: DIRECTING PRIVATE INVESTMENT

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline the main challenges facing humanity and analyse their drivers;
- Articulate how the inclusive green economy model seeks to address these challenges; and
- Understand the major characteristics that underpin national strategies on inclusive green economy, the related analytical tools, key actors and initiatives as well as the critical role of public policy in turning the inclusive seen economy model into practice.

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CHAPTER CONTENTS

1. Green industrial policy: conceptual issues

This chapter addresses the concept, nature, and manifestations of green industrial policy and how it contributes to an inclusive green economy (IGE). Green industrial policy was implicitly the intellectual foundation of UN Environment's Green Economy Initiative launched in 2008, and called for directing investments in environmentally significant economic sectors. The term is relatively new and has found its way not only into globally negotiated commitments (Sheng, 2009) but also, in recent years, into mainstream economic literature (Pegels, 2014; Rodrik, 2014, 2016; Schmitz et al., 2013; Lütkenhorst et al., 2014; Schwarzer, 2013; Hallegatte et al., 2013). To fully appreciate the green industrial policy concept, it is necessary to understand its origin in industrial policy itself.

Section 1 will thus elaborate on the evolution and state of the debate on industrial policy in general, and subsequently explain the fundamental characteristics and distinct features of green industrial policy as a special manifestation of industrial policy. This will establish a methodological basis for the following more concrete and illustrative sections. Section 2 will address implementation issues of green industrial policy with an emphasis on different instruments and their interaction. The importance of defining policy packages that allow synergies, whilst also being in line with good practice principles of policy design and implementation, will also be discussed. Section 3 will draw key conclusions and deal with a number of open issues that should receive attention in the years to come.

1.1 The discourse on industrial policy

Green industrial policy is a derivative of industrial policy. Understanding the latter's rationale, evolution, and application is thus imperative for coming to terms with green industrial policy. This section will review how the concept of industrial policy has developed over time, where common ground has been established, and in what areas controversies have remained.

Industrial policy is all about structural change and its directionality. Arguably, for those parts of economics that deal with growth and development, the concepts of structural change and diversification have always been at the center of attention (for the main methodological implications of measuring and predicting patterns of structural change, see Altenburg et al., 2016). How the composition of economic sectors changes over time is a crucial determinant of productivity growth, technological upgrading, and hence long-term economic dynamism. Seminal studies have addressed this question in either historical or analytical approaches and most notably among them are the works of Clark (1940) and Lewis (1955), with their emphasis on what Polanyi (1944) labeled the "great transformation" from **agrarian** to **industrial societies**.

> **Key term: Agrarian society**
> A society based on producing crops and maintaining farmland. Adapted from: https://en.wikipedia.org/

> **Key term: Industrial society**
> A society which is using technology for mass production and can support a large population through the division of labour. Adapted from: https://en.wikipedia.org

> **Key term: Development economics**
> Development economics: Study field for economic improvement in low-income countries. Adapted from: https://www.worldatlas.com/

> **Key term: Industrialisation**
> The transformation from agrarian into an industrial society through social and economic change towards manufacturing. Adapted from: https://en.wikipedia.org/

> **Key term: Contoversy over services sector**
> The nature and extent of the services sector has remained a controversial subject in view of the fact that part of the growth in services is likely to be a statistical artefact (caused by outsourcing) while many services continue to be directly dependent on a manufacturing foundation (see e.g. the argument of Chang 2010, 88-101).

As Ranis (2005) points out, in those early years of **development economics**, **industrialization** was generally considered as a synonym for development. More recently, the transition to highly diversified manufacturing sectors as a source of rapidly growing intra-industry trade (initially demonstrated by Chenery, 1960) has become a dominant theme, followed by evidence of a general (**yet still controversially discussed**) trend towards service-dominated **post-industrial economies**. Thus, in general, structural change is considered "as a central feature of the process of development and an essential element

Key term: Post industrial
Phase during which an industrialized economy moves from manufacturing to services and information. Adapted from: https://en.wikipedia.org

in accounting for the rate and pattern of growth. It can retard growth if its pace is too slow or its direction inefficient, but it can contribute to growth if it improves the allocation of resources" (Syrquin, 2007, p.4).

Given the centrality of structural change and diversification for economic development, industrial policy has been geared towards a direction that - for a variety of reasons, including enhancing productivity, creating employment or stimulating innovation - may be considered desirable from a long-term societal perspective without, however, stifling market forces of efficient resource allocation. As such, today there is a stronger emphasis than before on using industrial policy as a tool to reach broader societal goals and thus to acknowledge its **normative orientation**.

Key concept: Normative orientation
Both aspects (innovative instruments and broader goals) were explicitly called for by Stiglitz already two decades ago as part of the then prevailing discussion on defining a 'post-Washington' consensus (Stiglitz 1998).

Key concept: Interventionist
Policy approach of intervening in economic affairs. Adapted from:chttp://www.dictionary.com

In both literature and practice, there has been a protracted debate on the rationale for industrial policy – defined here as deliberate measures taken by governments to drive structural change in the desired direction. This debate has seen pendulum swings towards either a more **interventionist** or a more **hands-off approach**. The evolution, and the twists and turns of this discussion have been described elsewhere (Altenburg and Lütkenhorst, 2015; Rodrik, 2007; Stiglitz et al., 2013; Naudé, 2010) and will not be revisited here.

Key concept: Hands-off
Approach characterized by non-intervening.

A certain degree of convergence, however, is striking and should be noted. Gradually, fierce ideological arguments have given way to a more balanced and nuanced assessment. The discussion's more constructive element has moved from the question of whether to engage in industrial policy, to how to apply it, and what policy instruments to select to promote structural change towards increased productivity and enhanced competitiveness. In this context, the recent debate between Ha-Joon Chang and Justin Lin is revealing, as it boils down to technical questions of just how far a deviation from an economy's comparative advantage should be targeted, i.e. whether to gradually build on latent advantages or to venture into entirely new industrial activities (Lin & Chang, 2009). Compared to earlier dogmatic arguments around industrial policy's potentials and perils, today's discourse focuses on empirical evidence and the appropriateness of different methodologies.

Thus, the time is ripe to build on this momentum, leave behind stereotypes and preconceptions, and take a constructive perspective towards industrial policy. In what follows, we stress five dimensions, which are also of particular relevance to green industrial policy.

(1) Industrial policy is more than correcting market failures

Key term: Market failure
Situations in which market outcomes are not providing maximized efficiency. Market failures can provide a reason for government intervention. Adapted from: https://stats.oecd.org

Key term: Imperfect competition
Market situation where there are many sellers selling goods, which are not completely similar, as they would be in a perfect competitive market scenario. Adapted from: https://economictimes.indiatimes.com/

Key concept: Asymmetric information
One agent in a trade possesses information while other agents involved in the same trade do not. Adapted from: https://siteresources.worldbank.org

Key concept: Coordination failures
A more desirable equilibrium could be reached but firms fail because they do not coordinate their decision making. Adapted from: https://en.wikipedia.org

Although various types of **market failure** have always been pertinent to justifying industrial policy, they are neither necessary nor sufficient. Making markets perform more effectively, removing or reducing externalities, overcoming **imperfect competition**, addressing **asymmetric information** or dealing with systemic **coordination failures** – these are all valid and legitimate reasons for policy interventions [1]. However, this is only part of the story. Above all, reducing industrial policy's role to correcting failures of market mechanisms creates an ideological framing that automatically puts the stigma of failure on **public policy-making**.

1 This applies under the assumption that the removal of market failure is not fraught with severe policy failure related to both the willingness and the capability of governments to act in pursuit of the public good (Altenburg & Lütkenhorst 2015, 45-53).

> **Key reference: Policy making**
> Similarly, Cimoli et al. 2009 argue that the market failure argument is not irrelevant but constitutes a "misleading point of departure" (p.20) for industrial policy.

Policies are fundamentally meant to contribute to achieving goals, to move 'something' (for instance a sector, an economy or a society) from the status quo to a desired state. They are about reaching outcomes and not just about optimizing a process. These two dimensions (process and outcome norms) are not equivalent but hierarchical: **outcomes yielded by market transactions** (even if resulting from perfectly functioning markets) must be subjected to an assessment based on broader societal goals, such as equality, inclusion or sustainability (Altenburg & Lütkenhorst 2015, p.10).

> **Key reference: Outcomes yielded by market transactions**
> The distinction between outcomes being normative and markets being a process or an instrument is in itself questionable. As Sandel has pointed out, "markets are not mere mechanisms. They embody certain norms. They presuppose – and promote – certain ways of valuing the goods being exchanged" (Sandel 2012, 64).

Based on the above, it follows that anchoring the case for industrial policy exclusively in market imperfections is insufficient. Doing so would reflect many economists' broader attempts to remain in an allegedly value-free space that deals with technical models and equations, and steer clear of normative considerations. In short, it would be an attempt "to separate efficiency from ethics" (Crespo, 1998, p.201). Recently, Sedlacek has drawn attention to the systematic elimination of values, normative judgement and social context from mainstream economics, with his apt conclusion being that "it is a paradox that a field that primarily studies values wants to be value-free" (2011, p.7).

As such, industrial policy must be more than just a tool to increase productivity, enhance competitiveness, and promote structural change. It is necessary that it becomes part of a normative societal undertaking to achieve and balance a variety of goals – from creating employment to ensuring equity and limiting climate change. Essentially, industrial policy needs to be embedded and discussed within an overall vision of the 'public good' of societal change.

(2) Industrial policy can avoid "picking winners"

Frequently, industrial policy is portrayed along the following lines: government policymakers define priority sectors for further development and accordingly, 'pick' companies (or groups of companies) worth being supported through special incentives. This can take the form of assuming direct ownership, for instance governments running **state-owned enterprises**, or offering various types of indirect support such as priority access to credit, preferential loan conditions or special tax privileges. The underlying assumption that governments possess superior knowledge compared to markets is challenged and seen to lead to a waste of public resources and to misguided development that later causes heavy readjustment costs.

> **Key term: State owned enterprise**
> A legal entity created by the government to carry out commercial activities on its behalf. Adapted from: https://www.investopedia.com

Indeed, examples of failed government interventions are abound and range from **import-substitution strategies**, which were applied in many low-income countries in the 1970s, to some more recent politically supported green technology projects in high-income countries (see the educational analysis of the US Solyndra case by Rodrik, 2014).

> **Key term: Import substitution strategy**
> Government strategy that emphasizes local production for local consumption, rather than producing for export markets. Adapted from: http://www.businessdictionary.com

This argument – apart from the methodological problems of counterfactuals, i.e. being unable to directly attribute impact to specific policy measures – used to be an important one. There is strong evidence for unsuccessful state interventions and severe policy failure. However, today's proponents of an active industrial policy are no longer calling for a heavy-handed state to decide on details of investments to be undertaken and seeking to replace market forces. Instead, they argue for a guided 'discovery process' (Rodrik & Hausmann, 2003), whereby markets are allowed to operate within a broader "directionality" (Mazzucato, 2014) that provides signposts to a politically desired development path.

Hence what is being 'picked' are not individual enterprises, but, for instance, types of technology (e.g. those which are resource-efficient and produce low carbon emissions) that are needed to accompany and reinforce long-term transition processes. "The history of technological change teaches us that choosing particular sectors in this process is absolutely critical… the **green revolution** will not take off until it is firmly

> **Key concept: Green revolution**
> The increase in crop yields based on cultivation of new varieties of wheat, rice, maize and millet, and intensive use of fertilizers, pesticides, irrigation and machinery. Adapted from: https://stats.oecd.org

picked and backed by the state," (Mazzucato 2014, p.27). Importantly, this does not imply excluding market-based decisions but defining development trajectories (sometimes also described as broader 'technology corridors') to enable competitive processes, consensus building among stakeholders, and the distribution of knowledge to feed into the targeted development path

(3) Industrial policy can guide private investment

It has long been customary to adopt typologies that classify industrial policy measures as being either functional (also termed: horizontal, cross-cutting or aimed at creating a conducive business environment) or selective (also termed: vertical or sectoral) - with the former being generally accepted and the latter subject to controversy (see for instance the taxonomy proposed by Weiss, 2011, p.18). However, there are valid reasons to call this distinction into question.

First, even allegedly functional policies impact differently on distinct economic sectors. This applies all the way from **exchange rate policies** (with their effects depending on the **export-intensity** of industrial sectors) to education policy (that can lean more towards vocational training or university education) and R&D support (that, outside very basic research, always implies choices on specifically what type of research to support). Thus, it would seem more appropriate to conceive a continuum of policy selectivity rather than a neat separation (Altenburg & Lütkenhorst, 2015, p.46).

> **Key term: Exchange rate policies**
> Policy a country uses to manage its currency with regards to other foreign currencies and the foreign exchange market. Adapted from: www.bankofbotswana.bw

> **Key term: Export intensity**
> Index of export activity to calculate the revenue generated from exporting domestically produced goods. Adapted from: http://www.jgbm.org

> **Key term: Feed-in tariffs**
> Payments to the producers of renewable energy for the electricity they generate and feed into the grid. Adapted from:http://www.fitariffs.co.uk

Second, in line with the earlier argument about directionality, an enlightened industrial policy builds a desired long-term development trajectory into the framework condition it establishes i.e. chooses a long-term 'policy path' that remains consistent over time. A government can create markets for green investments (for example, through **feed-in tariffs** for renewable energy), which trigger economies of scale, technological learning effects, and a decrease in unit costs. This, in turn, builds pressure on future governments to continue on the same path. In technical terms, this is referred to as enhancing the "endogeneity" (Karp & Stevenson, 2012) of future policies (see also Section 1.2).

Conventional wisdom suggests that business is interested in a state that leaves markets to work and does not intervene. Against this backdrop, it is intriguing to make note of the recent demand for active policies voiced by major European oil corporations. In a letter addressed to the UNFCCC during the run up to the Paris climate negotiations, these corporations requested "governments across the world to provide us with clear, stable, long-term, ambitious policy frameworks… We believe that a price on carbon should be a key element of these frameworks" (UNFCCC, 2015). This is a clear call for creating not just any business-friendly framework but one that sets a consistent long-term direction for technology choices and thus reduces investment risks for business players. Whether this is called functional or selective is a moot point.

(4) Industrial policy can be designed to minimise costly failures

Any industrial policy may fail to achieve its goals and, in the process, costs are incurred. At the same time, however, this argument should not lead to discrediting industrial policies altogether. It must not be forgotten that there are also heavy costs to policy abstinence. Preserving the status quo of an economy's structure instead of actively transforming and diversifying it can prolong the life span of incumbent **sunset industries** and cause even higher costs once adjustment becomes inevitable. In this sense, governments are "doomed to choose" (Rodrik & Hausmann, 2006) in the face of uncertainty.

> **Key term: Sunset industries**
> An industry which has already passed its peak and is now in decline. Adapted from: https://en.wikipedia.org

There can be different ways to design and implement industrial policy, establish goals, and select instruments.

The potential costs of failure can be minimised through full process transparency, participatory stakeholder involvement, continuous monitoring, and rigorous progress evaluation towards systematic policy learning (Lütkenhorst et al., 2014). Section 2 will provide examples of such approaches.

(5) Industrial policy can build on competitive mechanisms

The stylized contradiction between industrial policy and competition is a simplification that can be challenged. There is sound evidence of how industrial policy approaches can be designed to build upon competitive mechanisms. In various countries, feed-in tariffs are applied based on **competitive bidding procedures**; environmental product and process standards are determined from proposals and best practices from private industry; R&D subsidies are granted only after assessing competitive submissions from **industrial clusters** or entire regions. In a nutshell, smart industrial policy can be quite sophisticated and in harmony with private sector dynamism and competition. This differs fundamentally from earlier rigid, top-down policy approaches.

> **Key term: Competitive bidding procedures**
> Competitive bidding procedure: Selection process used in procurement to determine the best bid among competing suppliers and contractors. Adapted from: http://www.tendersinfo.com

> **Key term: Industry clusters**
> Groups of related firms in a certain geographic area that share common markets and technologies and are often connected by buyer-seller relationships. Adapted from: www.oregonbusinessplan.org

To sum up the above reflections: Industrial policy provides a set of instruments aimed at steering economic and technological choices towards achieving societal goals. To this end, a well-designed industrial policy establishes a directional framework that offers reliable signposts for long-term investment decisions by private actors, and does so within a process that stimulates competition and offers safeguards for corrective action.

1.2 Green industrial policy: key components

Based on the above stock-taking of the industrial policy discourse, we can now enter the green industrial policy space with a fresh perspective. In doing so, we slightly amend our general definition of industrial policy and define green industrial policy as “any government measure aimed to accelerate the structural transformation towards a low-carbon, resource-efficient economy in ways that also enable productivity enhancements in the economy” (Altenburg & Rodrik, 2017, p.11). As such, green industrial policy can also be understood as a driver or accelerator for a country’s transition to an inclusive green economy.

This calls for deliberate government action aimed at incentivizing and directing private capital into the green markets of the future. As will become evident from the various dimensions and trigger points of interventions elaborated below, green industrial policy seeks to raise the productivity of natural capital (e.g. through promoting renewable energy sources or a circular economy), human and intellectual capital (e.g. through R&D to promote new sustainable technologies and related skill upgrading programmes) and social capital (e.g. through strengthening transformative alliances among various stakeholders) (see Chapter 2 in this volume for a conceptual distinction between different forms of capital in green economy growth models).

With a long-term transformative goal at the core, green industrial policy must be able to respond to key global mega-trends that shape today’s development agenda. Within the broader framework of the SDG’s adopted by the international community in 2015, this relates specifically to:

- climate change, which is widely considered as a blatant case of market failure (Stern, 2007);
- rapidly widening income gaps leading to higher levels of inequality in high and low-income countries alike (OECD, 2011; Ortiz & Cummins, 2011) and thus forcing the green transformation to also aim at **social inclusiveness** and poverty reduction;
- the disruptive impact on employment in a range of new technologies, above all linked to robotics, the **internet of**

> **Key term: Social inclusiveness**
> Process of improving societal participation, especially for people belonging to disadvantaged and marginalized groups, through promoting opportunities, access to resources, and equal rights. Adapted from: http://www.un.org

> **Key term: The internet of things**
> System of interrelated devices and machines with the ability to transfer data in a network without human-to-human or human-to-computer interaction. Adapted from: https://internetofthingsagenda.techtarget.com

things and additive manufacturing (Brynjolfsson & McAfee, 2014);

- the need to safeguard and expand agricultural land with a view to providing sustainable levels of food for still rapidly growing populations in many low-income countries;
- the strong trend towards further urbanisation, which calls for the long-term planning of sustainable agglomeration infrastructures and transport systems (WBGU, 2016);
- changing consumer preferences of globally growing middle classes leading to new lifestyles, such as those visible in various strands of an emerging sharing economy (Rifkin, 2014), but also towards more resource-intensive consumption patterns; and
- the rise of the service economy accompanied by premature de-industrialisation in many emerging and low-income countries (Rodrik, 2015).

The fundamental challenges stemming from these (and further) global mega-trends have triggered a sense of a heightened policy responsibility to anticipate the implications, take advance action and where necessary, mitigate the negative repercussions on economic and social development. This is not trivial; it implies that the very raison d'être of green industrial policy is connected to fundamental, long-term societal goals that markets alone fail to achieve – a point that will resurface repeatedly throughout this chapter.

Applying industrial policy to the task of bringing about a green transformation towards sustainability does not necessarily change the entire policy landscape. Some challenges remain essentially the same - green industrial policy needs to address well known issues such as policy alignment, political capture, evasive behaviour of economic agents or deficient policy implementation capacities. However, some important additional characteristics need to be considered. In what follows, we emphasize seven defining strategic challenges of green industrial policy (a more detailed elaboration is provided in Lütkenhorst et al., 2014, on which this section partially draws):

(1) The reality of pervasive market failures.

(2) The need to define long-term development scenarios.

Key term: Stranded assets
Assets which have lost in value due to unanticipated write-downs or devaluations. Adapted from: https://www.oecd.org

(3) The creation of new pathways in uncharted territory.

(4) The disruption of old pathways with the risk of **stranded assets**.

(5) The need to address production and consumption.

(6) The crucial importance of co-benefits.

(7) The innovative nature of key policy instruments.

(1) The reality of pervasive market failures

As mentioned above, market failures are among the classical reasons evoked to justify industrial policy interventions. This line of reasoning applies all the more to the realm of finite resources, **environmental goods** and climate change (Stern, 2007; Nordhaus, 2013). Table 1 below provides a stylized typology of various types of market failures and highlights the importance of coordination failures, public goods and externalities for green industrial policy (more examples will be provided in Section 2).

Table 1: Typology of market failures. (Source: Lütkenhorst et al., 2014, p.11.)

Imperfect competition	Asymmetric information	Coordination failures	Public goods	Externalities
Market power resulting from non-atomistic structures and collusive behaviour	Superior information of some market actors (mostly on the supply side)	Obtainable benefits are not being reaped due to lack of coordinated action **Crucial for creating new and disrupting old techno-economic pathways**	Goods that are non-excludable and non-rival in consumption **Most severe in case of climate change mitigation suffering from 'free-riding'**	Deviation between private and social costs and benefits **Pervasive in environmental pollution, waste management and natural resource use**

> **Key term: Environmental good**
> Non-market goods, such as clean air, clean water, landscape, public parks, rivers, mountains, forests, and beaches. Adapted from: https://en.wikipedia.org

However, just 'getting prices right' by incorporating externalities into market prices as the conventional response to market failures is insufficient for a number of reasons. First, while the signals corrected prices send to market actors may trigger technological innovation and changes in behavioural patterns, these responses may be too slow and adjustment periods may have to be accelerated. As pointed out by Schmitz (2015), the transition towards sustainability must take place under extreme time pressure and as such, we are faced with an industrial revolution with a deadline. Second, even market-based instruments (e.g. cap-and trade-systems) are subject to political negotiation processes and often get diluted and lose effectiveness. Third, 'correct' prices may be met with low **price elasticities** or principal-agent-problems (World Bank, 2012a), which can reduce their impact. Fourth, new technologies require not only market prices that enhance their competitiveness but also the breaking up of deeply entrenched development paths and the complementary provision of new sustainable infrastructure (see the example of electric mobility in Section 2).

> **Key term: Price elasticity**
> The price elasticity in demand is the percentage change in the demand divided by the percentage change in price. Adapted from: https://stats.oecd.org

(2) The need to define long-term development scenarios

The green industrial policy challenge of dealing with long-term societal transformations is a defining element and cannot be overestimated in its implications. It calls for setting ambitious and coherent policy goals coupled with implementation trajectories that ensure stable framework conditions and thus inspire confidence among market players. Frequent policy shifts are counterproductive for putting an economy on the path towards sustainability. However, policy-making in the face of quantifiable immediate costs and less certain long-term benefits, is often challenged by both the pressures of short-term electoral systems and the tendency of citizens to put an irrationally high value on immediate costs/benefits. This often comes at the expense of their own and future generations' long-term interests, i.e. the tendency to excessively discount future gains (see Chapter 10 on discounting and the findings of behavioural economics, e.g. Phelps & Pollack, 1968; O'Donoghue & Rabin, 2000; Kahneman, 2003).

This harks back to the theme of policy endogeneity, i.e. the need to establish the commitment to staying the selected course of structural change which is binding and provides investment certainty also in the case of a change of government. A green transformation thus should ideally be translated into a national project with buy-in from all societal stakeholders (see the example of the German energy transition and a proposed coal exit strategy in Box 9.7). As pointed out by Karp and Stevenson (2012, p.26), "the endogeneity of future policy and the inability of current policymakers to make binding commitments regarding future policy, create a rationale for **green investment policy**".

> **Key term: Green investment**
> Investing capital in green assets, such as green funds, companies, infrastructure and projects. Adapted from: https://www.cisl.cam.ac.uk

For green industrial policy to promote long-term structural change towards sustainable development pathways, it also has to factor in global mega-trends (see Section 1.2 above) that are going to affect and interact with, the green transformation, which in itself reflects both the mega-trends of environmental impacts, and subsequent restructuring and adaptation efforts. To future-proof the economy against these trends, green industrial policy must address a multitude of dimensions encompassing infrastructure (transport, energy, recycling, water etc.), technological innovation, education (skills development), trade and many others. This raises issues of conceptual boundaries with many complementary policy fields that cannot be neatly drawn.

(3) The creation of new pathways in uncharted territory

Against today's deeply entrenched economic products and processes with large environmental footprints, such as the widespread phenomena of "**carbon lock-in**" (Unruh, 2000) with high levels of inertia, new

> **Key term: Carbon lock-in**
> If energy systems are largely based on fossil fuels, it is difficult for public and private actors to shift the system towards alternative energy technologies. Adapted from: https://en.wikipedia.org

environmentally friendly development trajectories need to be charted. This constitutes a formidable challenge given that the effects of lock-in stem from individual firms, technologies, and infrastructures as well as the co-evolutionary forces of social behaviour and institutionalised policy-making.

Technically, a country's environmental footprint depends on the level of economic activity (as conventionally measured by GDP) on the one hand, and the structural composition and efficiency of production and consumption (which defines the **environmental intensity** of the economy) on the other (Lin et al., 2018). Environmental sustainability can, therefore, be achieved by: (a) limiting or reducing economic output (see Chapter 2 in this volume for a more detailed discussion of the role of economic growth in the green transformation); (b) reducing the environmental intensity of production; and/or (c) lowering the environmental intensity of consumption, for example by promoting the circular economy, or setting incentives for changing consumption patterns.

> **Key term: Environmental intensity**
> Environmental impact per unit of economic output.

However, aligning the economy with environmental boundaries is not purely a technical issue. It is one of the most challenging and complex policy goals imaginable, including critical questions and a number of trade-offs between costs, benefits, distribution, fairness, and technological and behavioural change, at both national and global levels. Climate protection was initially treated almost exclusively in terms of an environmental policy issue before being considered as a multi-dimensional challenge of systemic transformation calling for new, sustainable development paths. Only more recently has it been looked at from a broader perspective, underlining the need for technological innovation as well as fundamental "social, normative and cultural innovations" (Messner, 2015, p.261).

Specifically, green industrial policy is faced with the task of encouraging broad technological experimentation and innovation (R&D incentives playing a critical role here), yet at some point having to choose specific technologies for upscaling and market creation. This often involves a trade-off and calls for taking well-calculated risks in moving from **strategic niche management** (Kemp et al., 1998; Unruh & Carrillo-Hermosilla, 2006) towards big-push investments and incentives targeting selected technology corridors [2].

> **Key term: Strategic niche management**
> Creation of protected spaces for the development of promising technologies, which are later phased out. Through experiments the desirability of the new technology and means to enhance its application rate are investigated Adapted from: https://repub.eur.nl

In this context, one thorny issue relates to the policy choice between creating a **lead market** or alternatively, relying on latecomer advantages.

> **Key term: Lead market**
> A market, which pioneers the successful adoption of an innovation Adapted from: https://en.wikipedia.org

2 On a methodological note, we would argue that in contrast to the sector focus of traditional industrial policy (e.g. textiles, electronics, automotive), green industrial policy should be targeting resource-efficient, low-emission technologies across the board.

For low-income economies in general, and low-income countries in particular, there are powerful reasons in favour of being an early adopter of low-carbon development paths, yet there are also arguments that could be used to decelerate such a strategy (see Box 9.1, overleaf). It would be naïve to assume that trade-offs can be ruled out altogether. However, an important argument developed by Porter and van der Linde (1995), challenges the conventional view of the cost-increasing effects of strict environmental standards, and stresses their positive impact on innovation and early investments into future green technologies.

(4) The risk of stranded assets from disrupting old pathways

As argued so far, green industrial policy is essentially challenged by future-proofing a country's economy, identifying and promoting innovative sustainable technologies, creating and upscaling pioneering markets and bringing about changes on both the supply and the demand side that can ensure a long-term uptake of new green technologies and products.

However, such a fundamental transformation of productive capacities is necessarily accompanied by adjustment processes caused by the gradual withdrawal – and ultimately complete exit – of the technologies of the past, i.e. the heavily polluting and high-emission industries. Inevitable adjustment processes in such sunset industries need to be addressed as the latter often employ significant parts of the workforce and can mount destructive political opposition against a green

Box 9.1: Low-carbon strategies for low income countries: Balancing development goals

Most research on decarbonization tends to focus on the larger industrial and emerging economies (see e.g. DDPP, 2015). This makes sense from a short- to medium-term impact perspective seeking to assess the implications of a sustainability transformation that is enacted now and can have tangible results in 10-15 years. However, there is a downside to this approach. The world's more than 70 low-income countries currently account for just 10 per cent of global CO2 emissions (Nordhaus 2013, p.253), yet it is now at the early latecomer stage of their industrialization process when key decisions on their development trajectory are being made. With only incipient industrial capacities in place, low levels of motorized private transport, poorly developed transport infrastructure and a high population share without access to modern energy, the critical challenge for these countries going forward is not to decarbonize existing economic structures, but to develop new productive capacities, while avoiding the build-up of high-carbon economies relying on unsustainable technologies. Moreover, in view of recent massive discoveries of coal and oil reserves in sub-Saharan Africa (SSA), their commercial exploitation may conflict with a limited global carbon budget as derived from a global 2°C warming scenario. The question thus emerges of how the legitimate economic development aspirations of low-income countries can be reconciled with global climate change boundaries and targets.

There is an urgent need to prevent low-income countries from locking themselves into high-carbon development trajectories that would create unsustainable production and infrastructural capacities for decades to come. This calls for early emphasis on the significant co-benefits, which can support the economic case for low-carbon development (see also Section 2.2 below). Among others, these range from job creation (UN Environment, 2011; ILO, 2012) to acquiring new skills in innovative technologies as well as educational benefits derived from rural off-grid electrification (Byrne et al., 2014; Guruswamy, 2011; Kanagawa & Nakata, 2008).

Recent research on sub-Saharan Africa shows that early transitions to low-carbon development are feasible and can yield both economic and social benefits. A methodology developed by the Overseas Development Institute and the German Development Institute includes four criteria (related to avoiding GHG emissions, averting lock-in risks, increasing productivity, and reducing poverty) and concludes that switching from coal to renewable energy sources, removing fossil fuel consumption subsidies, reducing demand for agricultural land, and promoting mass transportation systems are among the most promising avenues to promote (Hogarth et al., 2015). However, it remains important to acknowledge that environmental and climate objectives are part of a broader policy agenda that also encompasses goals related to equality and poverty reduction. Although the case for promoting low-carbon development is sound and strong, it needs to address a number of counter-arguments that cannot be readily dismissed.

Potential pros*	Potential cons
• Early acquisition of technological and managerial capabilities and skills related to sustainable technologies that will dominate in future • Investment into future export potentials: access to stringently regulated markets in terms of environmental footprints and various sustainability labels that increasingly govern global value chains • Access to dedicated green donor funds (bilaterally and in terms of global climate finance facilities) • Avoiding early lock-in of technologies that will decline and possibly be banned while new ones are rapidly phased in and becoming cost-effective • Significant co-benefits (e.g. health benefits from clean air and water as well as resource efficiency) that are key for policy management	• Overall scenario of tough trade-offs and exceedingly high opportunity costs (e.g. originating from critical investment needs in health, education, etc.) • Widespread poverty and high wealth aspirations of population put premium on growth objectives; widening access to energy valued higher than decarbonisation • High upfront investment costs coupled with backloaded and often uncertain benefits; limited green donor funding available • Awaiting impact of technological learning and cost curves to make new green technologies economically more attractive • Lack of green awareness among private sector players focusing on quick profits

* The juxtaposition of pros and cons are just a listing of relevant considerations on both sides. The arguments are not horizontally linked. Source: Altenburg & Lütkenhorst, 2015, p.89.

In view of the severely constrained financial and institutional capacities in low-income countries, there is a critical need for international funding frameworks (e.g. dedicated climate funds) as well as multilateral and bilateral cooperation to focus on support aimed at easing financial burdens, advising on appropriate long-term strategies and policies, and strengthening policy implementation capabilities. As low-income countries are not to be found at the technological frontier, emphasis must be placed on "utilizing the opportunities already present that coincide with development objectives" (Kemp & Never, 2017), such as capitalizing on available renewable energy sources.

Source: Pegels, Lütkenhorst

transformation. The twin challenge is thus to create incentives for green technologies while withdrawing support from, and ultimately actively discouraging, the continued use of polluting technologies.

The unavoidable aspect of devaluation of incumbent technologies and related assets has, in the context of climate change mitigation, become known as "stranded carbon assets", specifically in the energy sector in the form of "unburnable carbon" (Meinshausen et al., 2009; McGlade & Ekins, 2014) and of carbon-intensive financial assets. While it may be tempting for governments to delay the necessary adjustment in the polluting capital stock to avoid industry resistance, a more sudden devaluation at a later time can be all the more disruptive.

To avoid unilateral competitive disadvantages from early greening, unsustainable development trajectories must be addressed at different governance levels (see also section 3.2 below). This ranges from local action, such as on company or city level, to national policy-making, supra-national alliances (such as networks of cities or regions based on voluntary climate commitments), and ultimately, global action, as embodied in multilateral negotiations on measures to protect the climate, biodiversity, or phase out specific pollutants. In the latter context, the required responses are faced with the challenges of collective action (Olson, 1965; Ostrom, 1990). The success of the **Montreal Protocol** provides an example of effective collective action based on a clear goal of phasing out harmful substances backed up by financial commitments (Lütkenhorst et. al., 2014, p.31).

> **Key term: Montreal Protocol**
> Global agreement, finalized in 1987, to protect the stratospheric ozone layer by phasing out the production and consumption of ozone-depleting substances. Adapted from: https://www.state.gov

(5) The need to address production and consumption

As described in Chapter 2, both the supply and demand sides of the economy need to become sustainable, that is, low (or even zero) in carbon emissions, resource efficient, and with minimized waste. This requires addressing all components of supply and aggregate demand: consumption, investment, government spending, and trade.

As emphasized before, the policy-induced creation of new markets (be it in terms of using innovative renewable energy sources, relying on sharing approaches in individual transport or sustainable design principles for consumer goods) is key for putting a green economy on a growth trajectory that allows for upscaling innovations and for cost decreases along the technological learning curve.

More pronounced than in the case of conventional industrial policy, this implies that there is a challenge in not only changing modes of production, but also in promoting the broad acceptance of changes in patterns and preferences of consumption, and ultimately, in individual lifestyles. Entrenched habits and forms of behaviour need to be overcome with a view to breaking up existing **path dependencies** and the **bounded rationality** that often governs economic decision-making [3].

> **Key term: Path dependencies**
> Continued use of a product or practice based on historical preference, even if newer, more efficient products or practices are available Adapted from: https://www.investopedia.com

> **Key term: Bounded rationality**
> Limited rationality during decision making due to the tractability of the decision problem, cognitive limitations, and the time available to make the decision Adapted from: https://en.wikipedia.org

> **Key term: Social norms**
> Informal understandings that shape the behaviour of members of a society. Adapted from: https://en.wikipedia.org

Consequently, green industrial policy must tackle deep-seated **social norms** and standards of consumption behaviour. To this end (like technological lead markets), it can be effective to identify and showcase intrinsically motivated lead users who pioneer sustainable forms of consumption (Marechal & Lazaric, 2010) and who can serve as avant-garde role models. Generally, there is a strong case for green industrial policy to link up to new findings of behavioural economics within the attempt to influence consumption styles (see Box 9.2, overleaf).

(6) The crucial importance of co-benefits

Seeking co-benefits (in terms of collateral benefits on secondary or additional policy goals) is often critically important for the broader societal acceptance of green

3 Interestingly, this may apply even for supposedly rational corporate decision-making as has been shown to be the case in the so-called energy-efficiency paradox (Jaffe and Stavins, 1994): Investments into more energy-efficient production processes are often neglected despite their financial benefits.

Box 9.2: Evidence from behavioural sciences

Contrary to (neo)classical economics, behavioural sciences question the assumption that rationality is the sole basis of human decision-making. Behavioural sciences see the well-informed maximisation of utility, the determinant of decisions in rational choice theory (Olson, 1965; Becker, 1976), as only one subset of drivers of human behaviour, the others being social, ethical and psychological drivers. Simon (1957), also questions the unlimited ability of humans to obtain and process information in the pursuit of their goals ("bounded rationality").

Policy can use these insights to steer individual decisions towards a desired outcome – in our framework the outcome would be sustainability. Behavioural insights can, for example, be used to inform the design of behavioural nudges (World Bank, 2012a). Thaler and Sunstein define a nudge as "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid" (Thaler and Sunstein, 2008, p.6). Nudges, though an important policy component for the green transformation, have yet to be explored in any depth. As their aim is to change human behaviour rather than influence the rate or direction of technological progress, they are particularly suitable in areas that are difficult to tackle with technology alone, such as reduced and sustainable consumption and recycling.

One example of how to change consumption decisions informed by behavioural insights is to change the default options. Empirical studies show that people are more inclined to accept a pre-set default option than to opt out (see, for example, Pichert & Katsikopoulos, 2008; Center for Research on Environmental Decisions, 2009; Brown et al., 2012). Flight booking websites, for instance, can make the offsetting emissions option the default, forcing customers to take action if they want to opt out.

Source: Lütkenhorst et al., 2014, p.23-24 (adapted from Pegels & Becker, 2014).

industrial policy measures. In situations where the green transformation is perceived to take place at the expense of other economic or social goals it becomes imperative to identify tangible co-benefits that can help mobilize support from opposing stakeholders. Often such co-benefits are economic advantages, such as triggering innovation, enhancing competitiveness and creating new green jobs. In addition, they may also involve broader political benefits, such as the strengthening of decentralized, municipal-level energy provision (for an overview on the 'climate bonus' see Smith, 2013).

The long-term nature of a green transformation necessitates the mobilization of transformative alliances that are capable of and willing to take risks and stay the course (Schmitz, 2015). Here again, co-benefits are crucial for advocacy campaigns that may even unite traditionally antagonistic forces (e.g. trade unions and employers' associations) behind a common purpose (e.g. the creation of future-proof jobs).

(7) The innovative nature of key policy instruments

At the implementation level, green industrial policy frequently involves designing and applying innovative, hitherto untested policy instruments. This is true even for some instruments that by now have become part of the standard green industrial policy toolbox, such as feed-in-tariffs for renewable sources of energy or cap-and-trade systems for emissions trading. However, when these were pioneered, their impact in terms of stakeholder acceptance, effectiveness and efficiency was highly uncertain and it took a lot of risk-taking and experimentation to make them work.

2. Implementing green industrial policy

As has been argued throughout the preceding section, green industrial policy needs to initiate structural change of unprecedented scope and scale. To this end, it borrows some of its instruments from both industrial and environmental policy, but the conventional scope of instruments in these areas is not sufficient to meet the challenges posed by the green transformation. Green industrial policy may require additional and indeed unconventional instruments, such as mission-oriented R&D or consumer-oriented nudging based on behavioural insights.

2.1 Instrument categories and packages

Green industrial policy instruments can be grouped into four broad categories:

Regulation: Regulatory instruments can, for example, mandate the use of particular technologies or products, or prescribe performance standards, such as minimum levels of resource efficiency, maximum emission levels in production processes, or a ban of substances or products such as plastic bags (Goulder & Parry, 2008). Provided it is strictly enforced, regulation has a particularly strong steering impulse. The set of regulatory instruments has been well-tried in environmental policy, and their interaction with industrial policy aims has been analysed widely, not least since Porter and van der Linde (1995) developed the hypothesis that strict regulation can lead to **competitive advantages** arising from the pressure to innovate (for empirical assessments see, for example, Rubashkina et al., 2015; Cohen & Tubb, 2016; Ramanathan et al., 2016; Wang & Shen, 2016; Zhao & Sun, 2016; van Leeuwen & Mohnen, 2017).

> **Key term: Competitive advantage**
> A nation has a competitive advantage in an industry if it has sustained and substantial exports in that industry based on domestic skills and assets outperforming its worldwide competitors Adapted from: http://www.economie.ens.fr

Market incentives: Market-based instruments influence the elements of the market – price or quantity – to encourage a specific behaviour in market actors: for example, through subsidies, quotas for renewable electricity, or through carbon taxes. These instruments usually change the relative prices and hence investment incentives and can thus be avoided by economic actors at a cost. The category of market-based instruments as part of a green industrial policy package has seen the most policy innovation.

Information and voluntary agreements: Information instruments, such as disclosure requirements, are used to exert 'soft' pressure on polluters and to allow consumers to make informed decisions. Information and voluntary agreements rely on economic actors' willingness to cooperate. Voluntary agreements are less binding than regulation, but can, if ineffective, be made mandatory. This threat of turning voluntary into mandatory regulation, if credible, is aimed at increasing the effectiveness of voluntary agreements ("shadow of hierarchy", Héritier & Lehmkuhl, 2008).

Nudges: Using insights from behavioural sciences, choice design instruments influence the circumstances of choices to encourage desired behaviour (Thaler & Sunstein, 2008), for example, the prominent display of organic or local produce in cafeterias to encourage its consumption. Nudges are strong enough to alter collective behaviour in a predictable way, but weak enough to be easily avoidable, thus preserving individual freedom of choice. The use of nudges as green industrial policy instruments is still in its infancy.

In practice, the boundaries between instrument categories are not always clearly defined, and instruments may have features of more than one category. For example, governments may mandate emission quotas, but introduce market-based tradable permits to enhance efficiency. Voluntary standards with increasing degrees of compulsion over time may be part of the gradual introduction of regulation. The specific instrument choice and design will depend on a multitude of factors, such as the capacities of government and industry, interests and negotiating power, society's attitude towards the role of the state and the market, and on existing institutions. International learning about instrument choice and design needs to be a cautious process, always taking into account compatibility with the specific country background and with carefully chosen peer countries (World Bank, 2012b).

Furthermore, governments will employ not only instruments from one category, but a wide-ranging and coordinated mix of all instrument types (World Bank, 2012a). First, the policy instruments need to cover the entire **technology cycle**. Both green technology R&D and deployment support are integral elements of green industrial policy. Given the need for rapid technological advancements, direct government support of R&D, including through public institutions (e.g. basic, or upstream R&D), and incentives for private sector innovation are key (see Section 2.2.3). In addition to technology supply side measures, demand side measures need to bring the newly invented technologies rapidly to scale. For instance, one of the key challenges of promoting renewable energy sources is a skilful combination of R&D subsidies and market creation. R&D subsidies need to foster a variety of solutions suited to different renewable energy resource endowments, while market creation instruments (e.g. feed-in tariffs) are aimed at scaling up and bringing technology costs down.

> **Key term: Technology cycle**
> The technology cycle is made up of research, development, demonstration, market formation and diffusion. Adapted from: https://sustainabledevelopment.un.org

Second, policy packages need to consider the systemic requirements of new technologies and foster related complementary technologies. For example, in the case of renewables, these refer to electricity system management and storage technologies. For the large-scale deployment of electric vehicles, battery technologies and charging infrastructure are key. Both sectors (energy and transport) can – and indeed should

Box 9.3: Promoting electric mobility: A complex policy challenge

The transition from internal combustion engines to electrically powered cars is considered as a critical building block of any meaningful green transformation. However, progress to date has remained limited in most countries. So far, only Norway and the Netherlands have reached significant market shares of electric vehicles, with levels of 23 and 10 per cent, respectively, in 2015. This compares to a market share of well below 1 per cent in Germany and below 2 per cent in France (IEA, 2016, p.11).

The Norwegian success in pushing electric mobility owes itself to a comprehensive package of policy measures. This includes generous financial incentives, such as exemption from 25 per cent VAT on purchase; exemption from non-recurring vehicle fees and annual road taxes, and free use of toll roads and ferries. In addition, there are further incentives targeting convenience, such as preferential access to bus lanes, and importantly, the early build-up of an extensive charging infrastructure, which according to recent research is the dominant factor for purchase decisions by consumers (Sierzchula et al., 2014). At the same time, cultural factors play an important role (the population's high environmental awareness coupled with an almost fully renewables-based energy supply) as does the fact that Norway does not have a domestic automotive industry and as such there is little resistance from vested interests.

Other countries are gradually moving towards the Norwegian approach. For instance in Germany, the initial emphasis on promoting supply-side R&D efforts towards innovative technologies (easily explained by the presence of a powerful automotive sector invested in fossil fuel-based engines) is now complemented by demand side incentives ranging from general buyers premiums to special depreciation allowances for commercial cars (Altenburg, 2014).

In China, the government is currently considering the introduction of mandated automotive fleet quotas for zero-emission electric vehicles as a response to massive urban air pollution. Similar to schemes pioneered in California and meanwhile applied in several US states as well as in Canada's Quebec Province, this would call for gradually rising minimum sales shares of zero emissions vehicles, proposed to be set at 8 percent for 2018 and 12 per cent for 2020.

Source: Authors

– be linked, to power electric vehicles with renewable energy and use the vehicle batteries as storage for fluctuating renewable energy supply. These examples illustrate that green industrial policy needs to go beyond sectoral considerations and adopt a more holistic and interconnected view – and coordinated instrument packages – than conventional industrial policy (see the example of promoting electric mobility in Box 9.3).

Third, careful balancing and sequencing within well-designed policy packages aims at generating synergies between instruments within the package and between national policy aims and avoiding trade-offs or **crowding out**. In this context, the combination of renewable energy feed-in tariffs and emissions trading constitutes a potentially conflicting policy field, which has led to a contentious debate (see Box 9.4).

Key term: Crowding out
Expansionary fiscal policy by governments to boost the economic activity can result in increased interest rates. These can stop companies from investing and prohibit previously profitable projects which should have been financed through loans.Adapted from: https://economictimes.indiatimes.com

Regarding green industrial policy implementation in the real world where there are competing interests, the creation of co-benefits from greening will play a crucial role. It will necessitate close integration with more conventional industrial policy goals, such as those related to competitiveness, employment and innovation. At the same time, green industrial policy needs to find ways of balancing potential negative effects on incumbent industries – not only creating new groups of winners, but also dealing with those who stand to lose. This broader perspective on complementarities and trade -offs is key for green industrial policy acceptance in both the business world and society at large. Safeguarding social objectives such as poverty eradication and reduced inequality, as described in Chapter 2 and Chapter 7, is indispensable in this endeavour, as is dealing with powerful decision-makers.

At the same time, green industrial policy suffers from the same implementation issues as conventional industrial policy, but potentially on a larger scale. Since stronger intervention in current socio-technological pathways is necessary, the risk of government failure increases as well. The following subsections will discuss the interaction between green industrial policy measures and conventional industrial policy aims, typical implementation issues, and key general principles of good practice in green industrial policy making. A select number of successful real-world policy packages will also be presented.

2.2 Interaction between green and conventional industrial policy aims

Many governments, recognizing the sustainability challenge and the economic opportunities of greening, are exploring synergies between green industrial policy and the more conventional aims of industrial policy, such as competitiveness, employment, innovation, and income distribution (Pegels, 2017). Even low-income

Box 9.4: Feed-in tariffs and emissions trading: Complementary or incompatible

Both the feed-in tariff (FiT) instrument and various emission trading schemes are applied increasingly worldwide to push private investment into low-carbon technologies. In the EU, their simultaneous use poses problems of policy alignment. Sinn (2012), sees the European Emissions Trading System (EU ETS) as the only instrument needed to reduce carbon dioxide emissions in the European Union and criticizes the use of feed-in tariffs as having a distorting effect. In principle, this is true – in a world with perfect markets and without political capture, a stringent emissions trading scheme would suffice to induce the green transformation.

Any FiT-induced lowering of CO2 emissions reduces demand for emission certificates traded under an ETS, cuts their price, and thus discourages investments in further emission reductions (Böhringer & Rosendahl, 2010; Böhringer & Rosendahl, 2011). The parallel operation of FiT and ETS will thus crowd out the former's emission reduction benefits – at least for those emissions traded under the ETS.

However, in a more realistic world of uncertainties, information asymmetries and interest groups, more targeted technology support may be necessary. Although an ETS may crowd out the emission reductions of FiT systems, literature finds various arguments for complementing ETS with additional support for low carbon investments. Vogt-Schilb and Hallegatte (2014) argue that the long-term nature of developing low carbon technologies requires looking beyond the cheapest short-term mitigation options; Jenkins (2014) and Rozenberg et al. (2013) emphasise the **political economy** aspects of ETS, such as difficulties to set sufficiently strict caps to spark investment in low carbon technologies.

> **Key term: Political economy**
> Looking at both political and economic factors, political economy is the study of how a country is governed. Adapted from: https://www.britannica.com

Lecuyer and Quirion (2013) stress that additional support instruments can create the required investment certainty for low carbon investments where fluctuating certificate prices fail, and Fischer and Preonas (2010) state that cost reductions through learning and spill over effects can be an argument for parallel instrument use. Gawel et al. (2013) and Gross et al. (2012) thus argue for realistic pragmatism. They recommend that as stringent cap and trade systems as possible should be established and complemented by targeted support for specific technologies where necessary. The lower price of certificates opens political space for tighter emissions caps without threatening the competitiveness of companies. Targeted technology support may be second best in a completely transparent and efficient textbook situation, but in its absence, it may be the best available.

Source: Authors, adapted from Pegels & Lütkenhorst, 2014

countries, although having little historical responsibility for greenhouse gas emissions, can find it economically beneficial to start implementing green industrial policies for several reasons (see also Box 9.1):

- Many measures to increase resource efficiency either pay off immediately or after short amortisation periods. Producing with fewer resource inputs is the easiest win-win option, and a lot of efficiency potential in industry, buildings, agriculture etc. is still underdeveloped. Although cost effective, these opportunities often require additional government interventions. For example, information campaigns and labelling, developing a market for environmental service companies, and subsidised credit lines to enable households to invest in buildings insulation.
- Many forms of environmental damage immediately undermine agricultural productivity, for example by soil erosion or water pollution. As most low-income countries are highly dependent on agriculture, any negative effects on agricultural productivity undermine the potential for future growth. In addition, these negative effects can disproportionately affect the poor whose livelihoods often depend on agriculture. Protecting the environment can, therefore, directly contribute to economic growth and social inclusiveness.
- Reducing environmental hazards, such as air pollution, can lead to a considerable reduction in health costs. Air pollution, as found in many megacities, has been shown to increase the risk of stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma, and a reduction in life expectancy by several years. As such, air pollution has a strong negative effect on wellbeing and economic development. The OECD (2016) calculates that in 2015, annual healthcare costs related to air pollution amounted to US$21 billion, with the number of work days lost to air pollution-related illness standing at 1.2 billion. Should no further measures be taken, the OECD further estimates a rise of health costs to US$176 billion annually by 2060, and a jump of 3.7 billion a year in lost work days. These calculations do not account for indoor air pollution. The World Health Organization estimates that while ambient air pollution causes 3 million premature deaths every year, indoor air pollution, mostly from the indoor use of biomass and coal, is responsible for 4.3 million premature deaths annually (World Health Organization, 2014; World Health Organization, 2016).
- Switching to green pathways now may be much easier than switching in the future. If, for example, a city like Addis Ababa follows the development of other African megacities, it may get locked into

> **Key term: Sunk investments**
> An investment that has already been incurred and cannot be recovered. Adapted from https://en.wikipedia.org

unsustainable pathways due to **sunk investments** in infrastructure development – such as allowing urban sprawl which leads to high mobility requirements, an energy inefficient building stock, and transport infrastructure oriented towards individual motorised mobility. The relative lack of existing infrastructure in low-income countries can, in this respect, turn out to be an advantage, since they can avoid the costly misinvestment in unsustainable infrastructure and 'leapfrog' into sustainable and efficient alternatives.

- Long-lived infrastructure in particular needs to be planned with a long time horizon, since it can even become stranded when stringent sustainability policies or changes in demand patterns lead to its devaluation. Coal fired power plants built today, for example, may have to be decommissioned within the next 20 years, which makes full **amortisation** difficult. This further tips the cost scale towards renewable energies, whose cost structures have developed favourably over the past years.

> **Key term: Amortisation**
> The payback of debt with a fixed repayment schedule in regular instalments over time. Adapted from:https://www.investopedia.com

- The cost advantage of renewable energies particularly applies to the electrification of remote rural areas where grid expansion is costly and renewable stand-alone or mini-grid solutions could offer viable alternatives. Renewable energy technologies are thus often cheaper and faster to deploy than conventional fossil options, especially in countries with abundant renewable energy resources, such as solar irradiation and wind.
- Fossil fuel importing countries can reduce their dependency on these imports and vulnerability to oil price shocks by investing in renewable energy and energy efficiency. Exporters of fossil fuels need to prepare for a possible devaluation of their fuel resources through decreasing demand from an increasingly decarbonised world. They can use the remaining time to diversify their export structure and develop competitive advantages in up-and-coming green technologies.
- Many green technologies and practices are relatively labour intensive, such as distributed renewable energies and organic farming practices. Accordingly, green industrial policies can have positive net employment effects when juxtaposing employment gains in the new green sectors to losses in incumbent industries (see Chapter 5 for more information on employment effects).
- Trade is increasingly organised in global value chains in which large transnational companies impose standards and traceability systems. These include more and more sophisticated environmental standards, for example, organic labels for agricultural produce, or a ban on carcinogenic hexavalent chromium in leather products. Low-income countries which fail to comply with such standards are bound to lose their export markets. Conversely, if they succeed in taking the lead and building the necessary quality infrastructure (such as test laboratories and traceability systems) earlier than their competitors they may capture larger market shares.
- Lastly, high-income country donors increasingly commit to phasing out investment in environmentally harmful infrastructure in low-income countries. In the climate change negotiations, high-income countries committed to scale up climate related financial transfers and enhancing the transfer of environmental technologies to low-income countries. Such transfers will not be spread evenly among recipient countries, but foremost to those which can show **absorptive capacity** and political ownership for a green agenda.

> **Key term: Absorptive capacity**
> Capacity of a country to learn and to apply knowledge.

However, existing trade-offs between environmental protection and economic development should not be denied, and they need to be managed carefully (Scholz, 2012). In their early stages, most clean technologies are more expensive than conventional alternatives. These upfront costs need to be bridged before benefits can be reaped. At a national level, poor sections of the population must be protected against rising costs, since they can least afford any additional burden, and they are the ones least to blame for the problem. On the international scale, the knowledge-intensity of new green technologies could provide high-income countries with first mover advantage as they have a well-educated workforce and capacity for innovation. Countries that do not satisfy those requirements may have less ability to partake in the

Table 2: Green industrial policy instruments and interaction with conventional industrial policy aims (source: Weinmann et al., 2016: 83)

Co-benefit or co-cost	Using the market		Cap and trade	Mandating	Voluntary, informational, and nudging instruments
	Taxes / charges	Subsidies			
Competitiveness	Global coordination or compensation of taxpayer needed if global competition is strong.	Compatibility with trade rules needs to be considered.	Trading instruments may fit into framework of international treaties.	Global coordination or compensation needed if global competition is strong, but may also open up new export markets, e.g. organic food.	Information can be used as a signal to environmentally conscious export markets when their standards are adhered to.
Employment	Effects depend on use of revenues; can be positive e.g. when ancillary wage costs are reduced ("double dividend").	Effects depend on success in building new industries versus negative price effects on incumbent industries.	Effects depend on likelihood of production relocation to other, less regulated countries ("carbon leakage").	Effects can be negative (e.g. if compliance costs lead to layoffs) or positive (e.g. if mandating leads to efficiency and competitiveness gains of regulated firms).	Unlikely to have negative effects.
Innovation	Send a stable price signal which, if high enough, can spur innovation.	Effects depend on the subsidy design. Innovation subsidies can be mission oriented.	Can have effects similar to taxes, but depend on stability and scale of the price signal.	Can have positive effects (Porter & van der Linde, 1995), but not automatically.	Unlikely to have negative effects. Information and nudging can lead to consumer demand shifts and thus spur innovation.
Distribution / poverty	**Regressive effects** of taxes can be mitigated by revenue use. Charges may be politically more palatable.	Distributive effects depend on who receives and who pays for the subsidies.	Tradable permits are popular with polluters if allocated freely ("**grandfathering**"), but can lead to price increases (e.g. energy prices) with subsequent negative distributive effects.	Can have direct effects on distribution when costs are passed on to the consumer.	Unlikely to have negative **distributive effects**.

Key term: Regressive tax effects
Taxes taking a proportionally greater amount from those on lower incomes. Adapted from https://en.oxforddictionaries.com/

Key term: Grandfathering
Allocation of permits based on past emission levels. In this scenario, bigger polluters are granted more permits and thus "rewarded" for their high emission levels.

Key term: Distributive effects
Distribution of income gains and/or losses across individuals in the economy. Adapted from https://2012books.lardbucket.org/

benefits of a green economy. Table 2 gives an overview of green industrial policy instruments and their potential positive or negative interaction with industrial policy aims.

2.2.1 Competitiveness

Impacts of green industrial policy instruments on competitiveness can occur at the individual enterprise the sectoral, or the national levels. Competitiveness of enterprises refers to their ability to sell their goods or services and stay in business (OECD, 2010). Aggregated over enterprises in a sector, these abilities make up competitiveness of the sector. At the national level, competitiveness is the aggregated ability of firms in a country to produce goods and services for international markets, and simultaneously maintain and expand real incomes in the long run (OECD, 1992). Competitiveness depends on the individual capabilities of firms, as well as the micro- and macroeconomic contexts, i.e. the conditions they find in their respective sectors and the national economy. The effect of policy instruments on competitiveness at different levels is not necessarily uniform – while a country's international trade balance improves, individual sectors may struggle. While a sector gains competitiveness, individual firms within that sector may not be able to keep up with technological change. Firms in the same sector often have similar input needs, production modes and customers, which increase the likelihood of a uniform impact. However, due to differences in their adaptive capacities firms may gain or lose competitiveness compared to their competitors in the same sector.

> **Key term: Cost structure**
> The proportion of a business' fixed costs to variable costs. Adapted from https://www.accountingtools.com/

When the impact on their **cost structure** is limited or positive, firms tend to be less affected or can even gain competitiveness from green industrial policies. This is the case when their modes of production are more environmentally friendly than those of their competitors, when alternatives to harmful processes or inputs are easily available and affordable (or when they become so through innovation), when their competitors have to comply with similar regulation or when they can pass on cost increases to input suppliers or customers. Conversely, firms which have benefitted from externalizing environmental costs or for which the adaptation to cleaner production modes is costly or impossible, can lose competitiveness. This is also the case if they cannot pass the additional cost on to preceding or subsequent stages of the value chain, and, crucially, if their national or international competitors are better positioned.

In addition, to the direct effects on firms' cost structures, firms can experience indirect effects when adopting cleaner production modes. On the one hand, these effects can be positive, for example when the new modes are more efficient, allow for product differentiation with opportunities for higher revenues, provide access to new markets, improve stakeholder relations, or open new business opportunities (Ambec & Lanoie, 2008; OECD, 2010). On the other hand, they can also be negative, where switching to the new modes lowers the quality of the goods produced or requires investment in new machinery without equivalent productivity gains. This can happen when the switch to cleaner production processes leads to disruptions, or when new machinery is not as productive as previous models. Despite that, the pressure to adapt can also incentivize firms to become more innovative and efficient, and in the long term, lead to a competitive edge vis-à-vis its competitors (Porter & van der Linde, 1995).

Shifts in the competitiveness from polluting to clean sectors are, in principle, a desired outcome of green industrial policy. However, when firms stand to lose from a government policy, they seem to be more likely to organise towards influencing policy in their favour than those firms that are potential winners. As Baldwin and Robert-Nicoud (2007) put it, "losers lobby harder" (p.5). In consequence, actors who stand to lose from a change in policy usually receive more governmental attention (OECD, 2007).

A frequent concern (and argument in the discourse on stricter environmental regulation) is the relocation of firms to other countries once regulation makes their activities less profitable. When firms choose to relocate and establish similarly polluting activities in other countries, there is a negative economic impact on the regulating country and no positive effect on the environment in general. For carbon dioxide emissions, Rutherford (1992) termed this issue 'carbon leakage'. Firms that experience negative impacts on their competitiveness, and that can relocate their productive activities relatively easily, are particularly prone to carbon leakage (Meunier & Ponssard, 2014). However, there is little empirical evidence that environmental policies actually cause firms to relocate internationally

Box 9.5: From export-processing zones to low-carbon zones: New approaches towards dedicated spaces

There is a long history of using various types of dedicated spaces with a view to attracting foreign direct investment into developing economies. From the early days of **export-processing zones** (particularly in East Asia from the 1960s onwards) to the concept of special economic zones during China's economic opening in the 1980s, such zones were provided as experimental areas for offering special conditions and incentives to foreign investors which governments were not ready to apply nation-wide. Typically, this would involve low levels of regulation, **duty drawback** schemes for imported goods, cost-free or low-cost infrastructure, and restrictions on trade union activities, among other factors. A controversial debate has ensued on the trade-off involved between promoting competitive industries and technological spill over effects on the one hand, and sacrificing goals related to social and regional inclusion on the other. Today, this approach is advocated by some economists specifically for African countries with poor infrastructure and general business environments that are not conducive to attracting foreign investment (Lin, 2012, p.174).

> **Key term: Export processing zones**
> Defined by the ILO as "industrial zones with special incentives set up to attract foreign investors, in which imported materials undergo some degree of processing before being exported again". Available at: http://www.ilo.org

> **Key term: Duty drawback**
> Refund of feeds collected at importation. Adapted from https://www.cbp.gov

At the same time, a new breed of zones is emerging that are explicitly linked to environmental goals. These range from simple pollution control zones aimed at environmental compliance to eco-industrial parks and, more recently, low-carbon zones. For instance, both China and India have already formulated policy guidelines for such zones, which are often aimed at attracting energy-efficiency or renewable energy investments within the framework of the **Clean Development Mechanism** (Yeo & Akinci, 2011).

> **Key term: Clean Development Mechanism**
> reduction targets under the Kyoto Protocol by undertaking emission reductions in low-income countries. Adapted from https://cdm.unfccc.int

(UK Green Fiscal Commission, 2009). The decision for production (re)location hinges on a multitude of factors, including wage levels, availability of high quality inputs, infrastructure, rule of law, corporate taxes, and the general macroeconomic investment climate of countries. In this broader context, the concept of green and/or low-carbon industrial zones has recently gained momentum (see Box 9.5, overleaf).

Nonetheless, many green industrial policy instruments make concessions to protect the competitiveness of affected industries. Carbon tax schemes, for example, entail exemptions for large polluters, and carbon trading schemes rely on grandfathering emission permits – that is, allocating polluters permits for free. Exemptions can severely reduce the potential to drive structural change and protect the environment. Both exemptions and grandfathering come at the cost of revenue raising, thereby reducing the room for manoeuvre by governments to soften negative distributive effects or foster upcoming, clean sectors. However, they may be temporarily necessary to avoid abrupt structural change and give industries time to adapt, but should be phased out as soon as possible.

An alternative to exemptions is the stepwise introduction of green industrial policy instruments to give firms sufficient time to adapt. When firms have no possibility to adapt to cleaner production modes and are subject to intense international competition, protection may be necessary as long as there is no international coordination on pollution regulation. The EU, for example, regularly determines sectors at risk from emissions trading, such as coal mining or metal production, which receive higher shares of free emissions allowances (European Commission, 2014). In some cases, it can be a challenge to determine whether such free allocation is economically necessary and justified or an outcome of political capture (see Section 2.3.2 on the management of policy rents).

2.2.2 *Employment*

The effects of structural change towards sustainability on competitiveness, as discussed above, are closely related to effects on employment. When green industrial policy measures increase production costs, firms may have to decrease other cost factors, such as those for personnel. However, structural change towards low carbon activities is unlikely to bring large employment losses in OECD countries. In 2004, a mere 8 per cent of the total workforce worked for the sectors responsible for 82 per cent of the OECD's CO2 emissions (OECD, 2011).

In contrast, green industrial policies can also have the potential of increasing employment. Germany, for instance, used the revenue of energy taxes to reduce pension insurance contributions (Forum ökologischsoziale Marktwirtschaft, 2015). This leads to a relative cost shift from the productive input factor labour to the factor energy – labour becomes cheaper, while energy becomes more expensive. The result is a double dividend of increased employment and increased energy efficiency, leading to less environmental impact. The potential double dividend makes reductions in labour related costs one of the most commonly used revenue recycling options in high-income countries. In most low-income countries employment often takes place in the informal sector, and social security systems are underdeveloped or lacking. The positive effect of reduced labour related costs is therefore uncertain. Other options for revenue use may be more beneficial, such as targeted support of people living in poverty. Peer learning among developing and emerging countries may therefore be more suitable than the transfer of best practices from high-income countries.

2.2.3 Innovation and R&D

The impact of environmental regulation on innovation has been discussed since the 1990s, when Porter (1990) put forward the hypothesis that strict environmental regulation improves competitiveness because it forces firms to upgrade technology and innovate. Taxation of pollutants by governments, therefore, has an advantage over setting technology standards. When firms are regulated to adhere to a standard, their incentive to innovate abates once they have reached the standard. With taxation, the price incentive continues to reward further innovation. First mover advantages in new green technologies can mean that countries secure substantive shares in fast-growing markets, for example in renewable energy technologies. For example, Pegels (2017) shows that Germany achieved a first mover advantage in wind converters, and is now competing with Denmark for world market leadership.

Gaining a first mover advantage in knowledge-intensive new green technologies may not be realistic for most low-income countries. Second mover advantages, on the contrary, are within reach: after Germany created a lead market for solar photovoltaics, Chinese firms started mass-manufacturing of solar panels and exported them to the German market, putting pressure on German manufacturers (Pegels & Lütkenhorst, 2014). Similarly, low-income countries may be well placed to develop resource-efficient low-tech solutions.

2.2.4 Inequality and poverty

The effect of green industrial policies on inequality is a highly relevant question in high and low-income countries alike, and reducing poverty is a particularly pressing issue in low-income countries. As suggested by Pegels (2015), governments may use a checklist for a rough assessment of potential impacts of green industrial policies on poverty, followed by a more thorough assessment, should critical areas be identified. The questions to be asked can be grouped in two areas. First, the ability of people living in poverty to be economically active should not be hampered. Policy makers may therefore ask whether the planned policy affects:

(a) Sectors with an above-average share of people living in poverty (for example, agriculture or the informal sector);

(b) Production factors which people living in poverty require for their livelihoods (for example, financial, physical, social and **natural capital**, and human capital, that is, their health and education [Hallegatte et al., 2014, p.6]); and

> **Key term: Natural capital**
> Specific natural resources, such as forests, agricultural land, fisheries, and more generally, the stock of ecosystems that supply economically useful services (for an in-depth discussion of the different kinds of capital, see Chapter 2).

(c) Employment opportunities that people living in poverty depend upon (for example, low-skilled or informal labour). This aspect needs to consider net employment effects, that is, it needs to factor in both the green employment opportunities created, and the brown employment opportunities lost (Bowen, 2014).

Second, the consumption dimension needs to be considered and can be assessed by asking whether the planned policy affects:

(d) Access to key goods or services by people living in poverty (such as shelter, food, energy, or water, but also to political processes and education); and

(e) Affordability of key goods and services (such as those stated above).

Should any negative effects be found, mitigating measures can be oriented along the affected dimension. This can, for example, include the creation of alternative employment opportunities, re-training and capacity

Table 3: Green industrial policy instruments and capabilities required for implementation (source: Weinmann et al. 2016, p.83)

Implemenation issues	Using the market		Cap and trade	Voluntary approaches / mandating	informational, and nudging instruments
	Taxes / charges	Subsidies			
Technical capabilities	Taxes can be easier to establish, administer and monitor than, for example, cap and trade systems. Most governments already have tax systems in place in which they can use for environmental purposes. Regular tax discussion and revision in **budget cycles** enhances transparency and eases **policy-learning**.	Information on appropriate subsidy level can be obtained by competitive processes, e.g. public tendering of renewable energy feed-in tariffs. However, tendering requires relatively high technical capacity.	Possible if number of polluters is sufficient and pollutions sources can be monitored, but requires relatively high technical capacity. Trading schemes often need to be set up from scratch, including institutions to monitor emissions, register allowances, and keep track of allowance trade. Taxing or mandating may be preferable if technical capacity to manage the market is lacking.	Voluntary instruments usually require relatively little administrative capacity, but can be less effective than mandating. They can, in a sequenced approach, be made mandatory after companies have time to adapt. Mandating is useful if compliance is observable, the number of regulated agents is small and enforcement can be safeguarded. Requires less technical capacity than many market-based instruments.	Information disclosure requirements can be powerful instruments to provide consumers with the basis for informed choices, and to increase societal pressure on polluters. Nudging instruments can also have strong influence on consumer decisions, at low cost and with little technical management requirements. However, they should be tested before implementation to optimise intervention design.
Political / rent management capabilities	Political aspects of monitoring and enforcement need attention, corruption complicates market-based policies. Smaller numbers of actors can coordinate more easily and thus exert pressure to achieve a favourable design of market-based instruments.		Trading schemes may be used as an entry barrier, polluters will lobby for free allocation of permits. Risk of price manipulation when the number of market participants is too small.	Individual negotiation entails risks. Risk of non-compliance of powerful entities.	Low risk of **rent-seeking** since rents involved are typically low to non-existent.
	Taxes typically engender opposition.	Subsidies may be subject to lobbying, trigger rent-seeking and wasteful activities. **Sunset clauses** should be introduced and communicated from the beginning.			

Key term:
Budget cycles
The major events stages in making decisions about the budget, and implementing and assessing them. It usually consists of four stages: formulation, approval, execution and audit. Adapted from https://www.oecd.org

Key term:
Policy learning
How policy systems generate and use knowledge about policies, their rationales, design and impact. Adapted from https://www.innovationpolicyplatform.org

Key term:
Sunset clauses
Measure in a law or regulation that provides that the law will lose effect after a specific date, unless it is extended. Adapted from https://en.wikipedia.org

Key term:
Rent seeking
The manipulation of economic conditions to increase prof-its. Adapted from https://en.oxforddictionaries.com

building, or price subsidies such as through electricity lifeline tariffs.

2.3. Practical challenges in instrument implementation

In Section 1.2 above, we elaborated on strategic challenges to green industrial policy. Some of these challenges translate into very practical implementation challenges of varying relevance, depending on the selected green industrial policy instruments. Table 3 gives an overview.

As the synopsis in Table 3 shows, both technical and political capabilities are required to ensure effective implementation of green industrial policy. Even at the seemingly straightforward technical level, the challenges are immense. Specifically, in low-income countries, instruments like cap and trade are often without precedent and need to be designed from scratch. Ideally, this presupposes a sophisticated institutional infrastructure capable of formulating policies, steering implementation, ensuring transparency and consistency, codifying legal enforcement, and putting in place business development services that are efficient and regularly monitored and evaluated. Even for a country like China, moving from **pilot schemes** towards a national emissions trading scheme is considered a daunting challenge (Zhang, 2015, p.27).

> **Key term: Pilot schemes**
> Testing a scheme in a limited context before introducing it on a larger scale. Adapted from https://www.collinsdictionary.com

> **Key term: Policy coherence**
> The systematic promotion of mutually reinforcing policies for synergies towards achieving set objectives and to minimize negative spillovers. Adapted from http://www.liaise-kit.eu

Given the strong case for active green industrial policies in an environment of failing markets, there are demanding requirements in terms of **policy coherence** between a broad range of responsible agencies. They typically involve thorny issues of aligning energy, environment, competitiveness, trade and social policies, and thus should be consistently coordinated by a high-level authority. For well-designed strategies to succeed, the creation of competently staffed and well-resourced supporting institutions is key to success.

Now enter the political economy dimension.

The major structural shift of private investment required for the green transformation can only be achieved with the help of change coalitions across government and the private sector (Schmitz et al., 2013). The identification of co-benefits with the traditional industrial policy aims discussed above may give the transition to sustainability a considerable boost, since it will create a broader base of supporters than just environmentalists, such as trade unions representing workers in new green industries. Similarly, the identification of the level and distribution of co-costs, and of measures to mitigate negative effects is crucial, since it may avoid the formation of veto groups. Both elements can be key to forging change coalitions.

Change coalitions with industry will depend on profit opportunities (and loss risks) resulting from green structural change. Given the manifold market failures discussed in Section 1.2, policy needs to play a major role in inducing the aforementioned investment shifts. This task is two-fold. On the one hand, policy rents need to be created to make sustainable investments artificially attractive. Overly generous incentives are an obvious risk, leading to wasteful allocation of scarce resources and turning rent-seeking into the very objective of investment, thus stifling the entrepreneurial drive for innovation. On the other hand, profit sources of unsustainable business practices need to be reduced, because they either have negative economic impacts, or can result in a gradual dilution and diversion of policy measures away from their intended goals, thereby reducing their effectiveness and impact.

Creating and withdrawing rents to direct private investment towards sustainability is thus the most fundamental challenge, or indeed the “heart of green industrial policy”, as Schmitz et al., (2013) put it. A powerful tool are policy rents, which have the potential to become a strategic resource for driving structural change (Altenburg & Engelmeier, 2013). This presupposes, however, that political capture by lobby groups can be kept in check. For green incentive systems, the risk of rent-seeking political capture is particularly high (Altenburg & Pegels, 2012). By their very nature, these incentives are (a) provided under technological uncertainty, meaning they are aimed at taking incipient technologies towards the threshold of commercial viability; (b) devised in an open-ended manner to last for long-term transition periods; and (c) effective economy-wide, rather than just in a confined number of specific sectors. This makes it almost impossible to establish unambiguous causality chains and to hold policymakers accountable.

This particular nature of green incentives makes them an attractive target for lobbyists and puts the responsible government agencies under high pressure to stay their policy course. Resisting such pressure is especially difficult in many low-income countries with poorly developed government capabilities, weak monitoring systems and insufficient transparency. However, even mature industrial economies can be prone to political capture. This raises the question of which institutional conditions and economic incentives can be created to facilitate implementation and at the same time ensure efficiency and effectiveness. We will turn to this issue in the following section.

2.4 Good practice principles of green industrial policy

From the preceding sections, it is clear that preventing political capture of green policy measures is essential for their effectiveness. This in turn calls for the design and implementation of long-term, consistent policy scenarios that are credible in their goals and intentions as well as a general readiness for policy monitoring and learning. These fundamental requirements are elaborated below and illustrated with examples. For more specific good practice elements of industrial policy in general see Altenburg and Lütkenhorst (2015, Sections 5.4 and 9.2), and for green industrial policy in particular Pegels (2014b).

(1) Agreeing on long-term policy paths

If green industrial policy is to effectively support broader transformative goals, societal acceptance is key. In charting a long-term policy path, or to put it differently, designing a national transformation project, the inclusiveness of stakeholder consultations is thus an indispensable element. It is only by achieving a high degree of consensus on policy goals (and on future technology corridors to be prioritized [4]) that resistance to policy implementation can be kept in check. This presumes that stakeholder engagement has an actual influence on policy design and implementation, and is not just a mock process, with influence taken effectively by interest groups in back rooms. A key aspect to the acceptance of any policy reform is trust in the capability and willingness of governments to consider a broad range of interests, and to use revenues and distribute costs in a way which is fair and benefits society (Pegels, 2016).

It is thus the crucial role of the state to ensure that the views of all relevant stakeholders – public and private, business and academia, domestic and foreign, local and regional – are brought to bear on defining a national green transformation agenda. A better understanding of the issue at hand, its causes, impacts, and possible measures, can be achieved if relevant stakeholders are involved and instruments are designed in cooperation with those affected. For carbon taxes, for example, the OECD (2007) recommends creating green tax commissions, with relevant ministries, industrial organizations, trade unions and environmental organizations. Studies by independent research organizations can provide a sound empirical basis for the discussions in such commissions.

Key term: Embedded autonomy
An autonomous state needs to be connected to society by a concrete set of social ties ("embeddedness") in order to avoid corruption and rent-seeking.Adapted from http://chtzeng.blogspot.com

At the same time, through organising an inclusive and structured process of stakeholder dialogue, government action becomes embedded (see Evans, 1995 on the concept of '**embedded autonomy**') in the broad spectrum of societal interests and can more easily "elicit information about objectives, distribute responsibilities for solutions, and evaluate outcomes as they appear" (Rodrik 2007, p.112). In turn, this can provide an effective platform both for building transformative alliances on the basis of identified co-benefits (see Sections 1.2 (7) and 2.2 above), for anticipating attempts of political capture by lobby groups (see Section 2.3.2 above), and for institutionalising policy learning (see below).

(2) Ensuring long-term policy credibility, while continuously improving policy by systematic monitoring and learning

Transformative policies must be designed with continuity and consistency in mind with a view of ensuring policy credibility. They must be geared towards creating a path that locks in the desired policy goals and the

4 "The history of technological change teaches us that choosing particular sectors in this process is absolutely critical ... the green revolution will not take off until it is firmly picked and backed by the state" (Mazzucato, 2014, p.27).

Box 9.6: The German energy transition as a long-term national 'project'

The German energy transition ('Energiewende') is a project that aims at radically changing the country's existing energy system in the direction of renewables and climate sustainability. Similar policy-relevant endeavours are seen across different regions and in countries with different economic endowments and capabilities (Pegels & Lütkenhorst, 2014; Buchan, 2012; Matschoss, 2013; Quitzow et al., 2016). Notwithstanding debates on various implementation challenges and shortcomings, to date the German energy transition has consistently enjoyed exceedingly high levels of popular support. It can legitimately be considered as a national transformation project that is in line with the country's generally high public backing of climate change and environmental policy objectives (Uekötter, 2014).

The rapidly rising contribution of renewables in Germany's energy mix is among the cornerstones of the energy transition. From around five per cent 15 years ago, the share of renewables in total electricity consumption has surged to over 30 per cent in 2016.

From the outset, the German energy transition has been policy-driven and constitutes a clear-cut case of deliberately changing the main parameters as well as the long-term price signals for energy markets. Apart from a whole range of conventional promotional instruments (e.g. preferential financing and targeted R&D support), the introduction of feed-in tariffs constituted the major and decisive policy innovation, which is characterized by:

- Guaranteed feed-in tariff levels for 20 years, with initially fixed amounts (for 5-12 years) subject to a **degressive** scale later on;

Key term: Degressive tariffs
Tariffs which gradually decrease over time below a certain rate. Adapted from https://www.thefreedictionary.com

- Source-specific application in accordance with different technologies and deployment conditions;
- Purchase guarantees for unlimited volumes of energy produced;
- Grid priority in terms of connection ("feed-in") and transmission; and
- Burden sharing of additional costs by all electricity consumers.

Providing long-term security to both investors and financing institutions, and remaining open-ended in terms of technology choice, the feed-in tariffs have triggered the roll out and up-scaling of a whole range of renewable technologies. However, over the course of time the original feed-in tariff approach has become the victim of its own success by causing an excessive expansion of heavily subsidized solar PV deployment – a development that in recent years has led to a series of policy reforms. The recent reforms have resulted in significantly reduced tariff rates in response to unexpectedly steep technological learning curves and decreasing unit costs for renewable energy; the introduction of an expansion corridor linking future feed-in tariff reductions to actual capacity expansion ('flexible ceiling'); and the gradual introduction of competitive mechanisms, such as competitive bidding procedures. The latter had been applied before in some emerging economies, such as China, India and South Africa (for the latter case see Pegels, 2014a), which points to an interesting example of reciprocal inter-country policy learning.

Currently, the debate in Germany is moving towards the design of a credible long-term strategy for "moving out of coal", based on a legally binding roadmap agreed by all societal stakeholders. A proposal by AGORA Energiewende (2016) includes 11 actionable principles, encompassing:

- Convening a roundtable with all relevant stakeholders tasked with reaching a national coal consensus with broad societal support, which would be complemented with a legally binding roadmap for phasing out coal by 2040;
- Imposing a ban on new coal power plants and designing a concrete decommissioning plan for all existing coal power plants;
- Committing to accompanying policy measures to mitigate the economic and social costs of structural adjustment. Specifically, this would include a structural adjustment fund for affected lignite regions; a close monitoring of energy supply security during the transition phase; and special attention to maintaining the competitiveness of energy-intensive companies;
- Ensuring supranational policy alignment through a mechanism to be built into the EU ETS that would ensure the automatic withdrawal of certificates released through the coal phase-out (see also Box 4).

Obviously, this proposal is exceedingly ambitious both in its overall goal and its implementation modalities. Yet Germany does have a track record of reaching broad-based consensual policy decisions, as was the case, for example, in a 2007 agreement on the future phase-out of hard-coal mining. Furthermore, the policy-driven push of renewable energy sources into the market has now been pursued for 25 years, bearing in mind that the predecessor law to the **EEG** went into force back in 1991. Thus, the principal lesson seems to be that policy coherence over long periods of time is not necessarily elusive.

Key term: EEG
German Renewable Energy Sources Act – law to promote renewable electricity in Germany. Adapted from https://www.bmwi.de

Source: Authors, partially adapted from Deep Decarbonization Pathways Project (DDPP, 2015)

commensurate policy tools, be they tax or financial incentives, standards or regulations. This can be exemplified with the German energy transition and the specific instrument of feed-in tariffs – a case where strong support for renewable energies has created and scaled up markets beyond a point of no return, i.e. rendering this particular industrial policy direction endogenous to the economic system itself (see Box 9.6).

At the same time, long-term credibility and pathways locking in desired policy goals and tools, calls for greater attention to patterns of consumer behaviour that respond to new technological options.

While policy credibility and long-term reliability are key to providing investment certainty, there is a potential conflict between locking in a specific policy path and being open to policy learning and adjustments based on results derived from regular monitoring and evaluation (see Box 9.7). A compromise needs to be found between, on the one hand, keeping incentives robust and reliable, while, on the other hand, allowing for adjustments that must remain possible in the spirit of continuous improvement and technological cost

Box 9.7: The concept of policy learning

As argued throughout this chapter, the green transformation process is of a long-term nature, involves high levels of uncertainties and risks, and demands knowledge of both synergies and trade-offs between goals and outcomes. As such, it calls for a policy process that is able to respond to these challenges through systematic policy learning, which must have two main dimensions: learning from others as well as learning over time. Cycles of learning should be put in place, where reviews and revisions of goals and achievements are regularly carried out. The implications that such an approach has on policy actors is not trivial, as it requires a shift from policy-making based on linear thinking to one based on complex adaptive systems (Hallsworth, 2012).

Several studies have recently explored how to achieve an effective policy process when dealing with complex problems (Jones, 2011). One of the most compelling approaches to integrate learning in policy-making is the 'learning spiral' developed by the World Bank based on several theoretical and practical concepts (Blindenbacher, 2010). At its core is an iterative process based on feedback loops that allows the integration of new knowledge in the decision-making process and adds flexibility to revise earlier goals and objectives to ensure adaptability to a continuously changing reality.

Within a scenario of disruptive change, as is the case in the current green transformation, it becomes imperative to challenge not just specific policy goals and measures but also the prevailing framework conditions, for example, not just to reduce resource consumption and waste but to aim for building up a truly circular economy. In the parlance of organisational learning theory, this would imply a move from 'single loop' learning, i.e. revision of actions, to 'double loop' learning, i.e. revision of frame conditions (Argyris & Schön, 1978), which are based on methodologies such as technology foresight or **horizon scanning**.

Key term: Horizon scanning
Technique for identifying early signs of potentially promising developments by systematically examining threats and opportunities, especially for new technology. Adapted from https://www.oecd.org

Sources: Adapted from Lütkenhorst et al., 2014 and Altenburg et al., 2016 (where further methodological details are provided).

degression.This is a fine balance to be struck and no general recommendations can be given.

Two different dimensions of policy learning need to be distinguished. Before deciding on the policy path to be chosen, there is a need for a radical challenging of existing pathways and an open-minded look at possible alternative scenarios. Subsequently, when implementing the chosen policy, the emphasis needs to shift to regular checks of achievements against expectations. This presupposes the existence of independent and transparent monitoring and evaluation institutions, which are autonomous from those parts of government in charge of setting targets and regulating economic activity.

3. Conclusions and open issues

From the broader perspective of green transformation goals, this chapter has taken a fresh look at the industrial policy discourse in general, and the characteristics and modalities of green industrial policy in particular. The genuine rationale and role of industrial policy as a tool, not just to optimize economic processes, but rather to support societies in reaching shared goals was emphasized. It was argued that the raison d'être of (green) industrial policy interventions cannot primarily be derived from the correction of market failures but lies in the provision of guidance and direction for economic agents, above all private sector investors, along a socially desired development path. In this, markets evidently have a major role to play - yet within boundaries that must be drawn by policy decisions and with outcomes that must be subjected to political assessments.

In this final section, we turn to a number of areas that are still subject to on-going, somewhat controversial debates and that in our view would call for additional research efforts.

3.1 Implications of a finite global carbon budget

Notwithstanding scientific debates on its precise volume, there is consensus that the available global carbon budget is limited and that it will be used up fast under any realistic decarbonization scenario. For green industrial policy this has several implications. First, the transition towards sustainability and decarbonization must be radical (with negative emission levels to be achieved within a few decades) and has to take place under extreme time pressure. Second, high and low-income countries alike need to define valid, effective, and socially agreeable approaches towards their stranded carbon assets - again very much a distributional question and as such a make-or-break issue for the societal acceptance of any meaningful green industrial policy. This is what the OECD refers to as the political challenge of reducing 'carbon entanglement' (OECD, 2015). Third, the action remit of green industrial policy needs to transcend the national level and move towards global negotiations about the distribution of the remaining carbon budget.

Research carried out in the context of the United Nations' Deep Decarbonization Pathways Project (DDPP, 2015) demonstrates the magnitude of the global challenge: The project's ambitious modelling scenarios assume an average emission level as low as 2.1 tons CO_2 per capita by 2050 across the 16 countries covered. This must be seen against a 2016 world average of approximately 4.8 tons per capita and, in terms of illustrative country examples, 17 tons for the USA, 7.2 tons for China and 8.3 tons for South Africa (Global Carbon Project, 2017). This is a stark reminder of the massive adjustments needed towards reducing the carbon intensity of future growth in high-income countries, while ensuring that the new productive and infrastructural capacities in low-income countries are of a low-carbon nature.

3.2 Global collective action

Thus, in fighting climate change and accelerating a green transformation, the case for collective action at the global level is compelling. Many examples in this chapter point to the significance of supranational and ultimately global policy alignment. Although issues related to public goods and collective action requirements are well known to the industrial policy discourse (e.g. in terms of harmful incentives in the competition to attract foreign investment), they assume significance in the green industrial policy discourse where boundaries are truly global. By its very nature, this applies primarily to effective mitigation action, which presupposes global coordination and negotiation, thus opening significant space for free-riding behaviour on the part of individual nation states. In contrast, the benefits to be gained from adaptation action occur at the local or regional level and can thus be appropriated more directly. A good example would be the case of a country that is building dams along its coast against rising sea levels.

At the same time, there are worrying trends towards a gradual marginalisation and exclusion of low-income countries. On the one hand, these countries are not normally members of the new decentralised networks, which tend to concentrate on major emitters of carbon. On the other hand, growing amounts of climate finance are predominantly spent on mitigation programmes in emerging, middle-income countries rather than on adaptation requirements in poorer countries (Boyle, 2013).

This puts the commitment to global carbon justice into great doubt. Low-income countries are expected to invest in low-carbon technology patterns at low levels of per capita income, i.e. to get green before they get rich (for the case of sub-Saharan African countries, see Hogarth et al., 2015). In more technical terms, they are supposed to 'tunnel' the environmental Kuznets curve (Munasinghe, 1999, and Chapter 2 in this volume). While this may be technologically feasible, it would clearly require an enhanced political and financial commitment on the part of the international community.

3.3 New metrics

An important conceptual foundation, and one that underpins a consensus on long-term green industrial policy goals, could be established through defining new ways of measuring social welfare. Gross domestic product (GDP) alone, which is the most widely used proxy, is incompatible with a green growth paradigm. Clearly, there is a need to design, and agree upon, new welfare indicators (see Chapter 10 in this volume for a more detailed discussion). At the same time, "in most countries there is an almost paradoxical disconnect between green transformative goals on the one hand and their continued measurement by conventional economic indicators on the other hand" (Lütkenhorst et al., 2014, p.44).

However, various conceptual innovations of measuring welfare have been introduced in recent years and are in the process of being refined (for a comprehensive discussion on the issue of metrics, see Chapter 10). In addition to such innovative macro-level approaches, there is also a need to revisit prevailing statistical classification systems at the micro-level with a view to allowing a sharper identification of environmental goods and services. This holds true for both disaggregated sectoral statistics (such as the International Standard Industrial Classification [**ISIC**] approach) and various patent databases that are important for measuring the innovation capacity of economies.

Key term: ISIC
International standard industrial classification of all economic activities (ISIC): Standard classification of economic activities by the United Nations Statistics Division to promote international comparability of data. Adapted from http://ec.europa.eu

3.4 Disruptive structural change

In recent decades, the fundamental dynamics of competitive integration of world markets (i.e. globalization) have barely changed. Currently however, strong indications of more radical, path-disrupting changes going forward have surfaced.

In addition to the environmental imperatives discussed in this chapter, fundamental implications are likely to arise from the digital revolution in its various manifestations. There is ongoing, contentious debates regarding the impact and potential pervasiveness of various technological innovations (such as robotics, additive manufacturing and the internet of things), yet there is no doubt that they will affect the current patterns of international specialization: “If you take most of the costs of labour out of the equation by installing robots and other types of automation, then the competitive advantage of low wages largely disappears” (Brynjolfsson & McAfee 2014, p.184). This resulting trend of production ‘**reshoring**‘ could be further exacerbated by the impact of environmental footprinting in global value chains. The combined effect of digitalization trends and new environmental trade standards may lead to a significant regionalization and shortening of value chains, and would deserve heightened attention in future research.

> **Key term: Reshoring**
> Bringing production back to the domestic country. Reverse process of offshoring production to cheaper countries. Adapted from https://www.inc.com

Generally, in scenarios of fast and radical transformation within certain framework conditions, anticipating the future is rewarded, while extrapolating from the past is penalized. If the current emphasis on disruptive structural change is justified – and there is growing evidence that we are facing long-term fundamental transformation forces at work – then the methods of how we identify future competitive advantages have to be revisited (for some methodological implications, see Altenburg et al., 2016).

The most fundamental question is whether modern high-income economies can maintain and even enhance their levels of productivity, innovation and welfare without relying on economic growth. The need to decouple economic growth from resource consumption and emissions has become accepted in large parts of society, international policy circles, and important parts of the business community: “Action to decouple business and economic growth from resource intensity and environmental impact has never been more critical to the long-term success of business” (WEF 2012, p.5). However, the more radical proposition that there are “limits to growth” (Meadows et al., 1972), and that hence economic growth itself can no longer be regarded as a sustainable foundation for welfare (Jackson, 2009), has remained highly controversial. Obviously, this all depends on how economic growth processes are shaped and measured. Circular economy concepts (WEF, 2014b), cradle-to-cradle approaches (Braungart & McDonnough, 2009) and other forms of new growth models could go a long way in making our future sustainable (see appendix of Chapter 1 for an overview of concepts). They deserve priority attention in multi-disciplinary research efforts going forward.

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CHAPTER 10: THE GREEN ECONOMY PROGRESS MEASUREMENT FRAMEWORK: A DIDACTIC INTRODUCTION

CHAPTER 10: THE GREEN ECONOMY PROGRESS MEASUREMENT FRAMEWORK: A DIDACTIC INTRODUCTION

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline the main challenges facing humanity and analyse their drivers;
- Articulate how the inclusive green economy model seeks to address these challenges; and
- Understand the major characteristics that underpin national strategies on inclusive green economy, the related analytical tools, key actors and initiatives as well as the critical role of public policy in turning the inclusive seen economy model into practice.

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CHAPTER CONTENTS

1. Introduction

When we speak of green economy measurements and indicators our main interest is in evaluating the extent to which an economy is *inclusive* and *green*. Put simply, an inclusive green economy (IGE) is one that successfully provides a response to three sets of challenges currently facing humanity:

(1) persistent poverty

(2) overstepped planetary boundaries

(3) inequitable sharing of growing prosperity

The goals of this chapter are to: 1) identify some *basic desiderata*, or overarching principles, that we would want any IGE measurement framework to satisfy; 2) survey the existing initiatives aimed at tracking whether an economy is green, inclusive, and sustainable; and 3) to provide an example of what a green economy measurement framework that satisfies the *basic desiderata* looks like in practice.

Measurements and indicators on how inclusive and green an economy is, are meant to serve a purpose. As Section 6 in Chapter 2 has stressed, the goal should be to have a measurement framework that is truly useful for guiding countries in their formulation and evaluation of their social, economic and environmental policies. At the country level, indicators and measurement should support policymakers along all main stages of the policy process, from the setting of policy objectives; to planning, design, to policy implementation; and, finally, monitoring and evaluation (UN Environment, 2014). (See UN Environment (2015) for an application of the methodology to the cases of Ghana, Mauritius, and Uruguay.)

Key note: Green economy measures

The list of green economy measures discussed in this chapter varies significantly in terms of their methodologies and the indicators used. One example of such diversity of indicators is that some measurement frameworks use indicators for social inclusion while others do not. This could be explained, at least in part, by the evolution of the concept of green economy, as already discussed in Chapter 1, since inclusiveness was not initially given much attention in the conceptualization of green economy, but it has recently received more attention as the concept has evolved subsequently.

The remainder of this chapter is structured as follows: In Section 2, we briefly discuss the limitations of the GDP to measure progress and establish the *basic desiderata* for an IGE measurement framework. In Section 3, we review the main kinds of differences that exist among current composite indices and dashboard of indicators and consider the role of indicators in supporting green economy policy-making. Section 4 presents an empirical application of a Green Economy Progress measurement methodology that satisfies the *basic desiderata* to a sample of 105 countries and compares it to other methods. Section 5 provides the conclusion.

2. Moving 'beyond GDP'

Measuring human progress and its sustainability is a challenging task, fraught with a myriad of statistical and real-world complexities, as we will outline below.

The most prevalent way, even to this day, in which most individuals evaluate the extent to which a society is making economic progress is the Gross Domestic Product (GDP). As Section 6 of Chapter 2 explains, it is well known that the GDP paints an incomplete picture of well-being, and it will be reviewed here so as to better understand why we need to complement GDP with other measures. First, GDP tracks aggregate economic activity and it is insensitive to the distribution of the gains and losses of that economic activity across the individuals in society. Second, it is not adjusted (or does not account) for the depletion of existing natural and physical assets, including geology, soil, air water, and many others. Third, it does not track those factors that matter for well-being, which lie outside of the sphere of market transactions.

Another way to say this is the following: some of what GDP tracks does not matter for well-being and some of what matters for well-being is not tracked by GDP. Think about the pollution of a river, from the production of a clothing factory – whereas the economic outputs of the factory would be taken into account, the pollution it generates (thereby creating environmental and health-related costs, contributing to the depletion of natural capital), would not. Moreover, even those parts that matter are evaluated 'on average,' and without regards to their distributional characteristics, or their sustainability. Thus, one quickly lands at the conclusion that, rather than to 'repair' GDP one needs entirely different measures altogether if one wishes to evaluate societal well-being.

The first global Human Development Report in 1990 introduced the Human Development Index (HDI) as an alternative to GDP in which people are put at the center. The HDI has since become a widely used measure of human progress, which is more related to the lives of people than GDP alone.

The search for alternatives to GDP in measuring progress have significantly expanded through the availability of new data and methodologies, including subjective measures of human well-being. The Better Life Initiative, developed by the Organization for Economic Cooperation and Development (OECD), is among the efforts to better capture what is important to people's lives. They have been significantly influenced by the Stiglitz-Sen-Fitoussi Commission (2010), which concluded in 2009 that a broader range of indicators about well-being and social progress should be used alongside GDP. The Report of the United Nations Secretary-General's High-level Panel on Global Sustainability also highlights that the international community should measure development beyond GDP, and it recommends the creation of a new index or set of indices that incorporate sustainability considerations.

The task of developing and testing such measures belongs to the field of Welfare Economics, the subfield of economic theory that encompasses social choice theory, the theory of fair allocation and cost-benefit analysis. Of course, the exercises carried out in these measures are heavily value laden, by necessity. As Section 2 of Chapter 2 explains, reasonable people will differ regarding how to carry out those measurements, depending on their philosophical postures about what matters most for well-being.

In principle, it is relatively simple and uncontroversial to identify principles that a well-being measure should satisfy. The desired measure, denoted as $W(t)$, is the well-being of the present generation (t). Here, well-being depends on consumption, so think of $W(t)$ as a function $W(y(t))$ that depends on the consumption flows $y(t)$, for all individuals belonging to the present generation (t). A second measure, denoted as dV^*, is necessary to track sustainability of well-being.

Intergenerational well-being, denoted as $V(y)$, is a sum of the well-being of all generations, starting from the current generation t to infinity.

Key note:
Mathmatical notation

Current generation: t
Future generations: τ
Consumption by individuals of the current generation: $y(t)$
Consumption by individuals of a future generation τ: $y(\tau)$
Well-being of the current generation: $W(t)$
Intergenerational well-being: $V(y)$
Sustainability of well-being, assessed by the change in intergenerational well-being: dV^*
Discount factor: μ
Different physical, natural and other capital stocks are referred to by $K(t)$, $K(\tau)$
Projected joint trajectory for consumption flows: $y^* (K(t))$

(1) $$V(y) = \int_t^{\infty} W(y(\tau))\, e^{-\mu(\tau-t)} d\tau$$

Let us look at the second part $(e^{-\mu(\tau-t)})$ of this function in greater detail: this part discounts the well-being of **future generations** vis-à-vis the current generation t at the rate of a certain discount factor μ over continuous time (expressed by the exponential function e). Discounting over time with $\mu > 0$ means that future well-being is valued less than present well-being.

Key note:
Discount on current generation

For the future generation: $\tau = t$, so that $(t\text{-}t)=0$, and e^$0=1$, so there is no discounting for the current generation.

This formula certainly is not the only way to aggregate intergenerational well-being, but entering this debate is not crucial for what we are trying to do here. (See Chapter 2 for a simple explanation of discounting.)

The evolution of the consumption flows $y(\tau)$ for the members of each generation τ, starting with generation t, depends on what happens to key physical, natural and other stocks $K(\tau)$. The consumption function can thus be written as $y(K(t))$. Given that there is an initial condition $K(t)$ for those stocks, a projected joint trajectory for these consumption flows and stocks can be denoted as $y^* (K(t))$.

To evaluate intergenerational well-being along such trajectory we include this in expression (1) and obtain: $V(y^* (K(t)))$, which for simplicity we can call $V^* (t)$. Let's now compute the change, $dV^* (t)$, in such intergenerational evaluation by calculating the total differential of $V^* (t)$, as follows:

(2) $$dV^*(t) = \sum_j \frac{\partial V^*}{\partial K_j(t)} \cdot dK_j(t)$$

Where $\frac{\partial V^*}{\partial K_j(t)}$ tracks how a change in a stock j affects intergenerational well-being and $dK_j(t)$ tracks the change in stock j for generation t. Expression (2) is adding up the changes in the set of relevant stocks, where stocks that are more important for intergenerational well-being count more by being given stronger weights.

Present well-being $W(t)$ can be said to be sustainable if future generations experience a well-being which is as large as the well-being enjoyed by the current generation. This means that $W(\tau)$ should be at least as large as $W(t)$ for the members of each generation τ following generation t. We show in Appendix 1 that if present well-being $W(t)$ is sustainable, then $dV^*(t)$ has to be positive.

In other words, we have established that if $dV^*(t)$ is negative then present well-being $W(t)$ is not sustainable, because there will be a future generation with a level of well-being below that of the present generation, $W(t)$.

Thus, the ideal set of indicators for a comprehensive evaluation of a country's current economic situation and its sustainability is perhaps the profile:

$$\langle GDP, W(t), dV^* \rangle$$

To see how this profile could be used in practice, let's look at their expected behavior in the case of an unexpected negative shock to physical capital. Imagine that a storm destroys buildings, factories and workshops. The repair of broken machinery along with the execution of other reconstruction efforts needed to restore the lost physical capital would be registered as an increase in GDP. If these efforts were to be purely based on GDP would mean that the catastrophic event of a storm is actually beneficial for the economy. However, looking at the above set of indications, the W index will drop due to the higher work intensity necessary to undertake reconstruction, sending the correct message that the initial catastrophe was definitely not a blessing. In this case, the dV^* index tells us that sustainability is not threatened: by increasing work intensity the current generation is offsetting the damages inflicted by the catastrophe and does not pass the costs on to future generations.

If, on the other hand, the economy does not try to reinstate its lost capital and aims instead to maintain its pre-catastrophe standard of living, as measured by W, then the message can be a decrease in economic activity as measured by GDP, because less capital is available for production. Whether the level of well-being W is sustainable depends on whether or not the economy was, before the shock, on a more than sustainable path. If, for example, the economy was just sustainable enough before and the shock is large, then this could tip the scales towards unsustainability. In that case, the dV^* index would tell us that the level W is no longer sustainable.

In practice, however, we face serious difficulties in the computation of the panel $\langle GDP, W(t), dV^* \rangle$. Even if we were to include on the GDP measure all that we ought to include, and if we were to agree on a methodology for the calculation of the well-being index W, we face multiple layers of uncertainty that make it very difficult to accurately calculate dV^*. We cannot escape the fact that informing about sustainability is informing about the future. In other words, as Section 7 of Chapter 2 has already identified, we do not merely face a measurement problem, we also face a forecasting problem.

We learn, however, from the theoretical exercise that at the very least we should:

(D1) Identify as many factors important for present well-being as possible, in order to estimate the progress countries are making in their levels of well-being;

(D2) Identify as many assets that matter for future well-being as possible, their current stocks, and how they evolve over time;

(D3) Complete where possible with relevant information about potential critical thresholds for the stocks of those assets;

(D4) Understand that it is near impossible to combine all of these into a synthetic indicator of sustainability, or sustainable development, in a manner that will be fully satisfactory.

These four ingredients, D1 to D4, which we call the *basic desiderata* in what follows, become the starting point of what we would want any Green Economy measurement framework to have.

To summarize, the logic behind the desiderata is the following: D1 is about identifying the profile of consumptions flows, $y(t)$, that matter in the evaluation of present well-being. D2 is about the identification of the changes in the relevant stocks, $dK_j(t)$, critical for the computation of any indicator of sustainability dV^*. Ideally, we would have, for each stock that would enter into the computation of dV^*, a measure of how the stock affects intergenerational well-being. Since this is bound to be difficult, a minimum requirement would be to know the thresholds below which the marginal intergenerational value of those stocks, in other words, the intergenerational value from using one more unit of these stocks, would be very high or very low. This is the rationale behind D3. D4 expresses that, as we have seen above, the technological, ethical, and environmental uncertainties we face make a precise calculation of dV^* very difficult. "Doubts about our ability to build an all-purpose scalar index of sustainability are too strong (…) This suggests concentrating efforts on a well-defined set of warning indicators covering separately the various dimensions of sustainability" (Fleurbaey and Blanchet, 2013, p. 249).

3. An overview of measurement frameworks

In this section, based on the understanding we just gained about what we would ideally want to have as a measure of sustainable well-being, and what we are likely to be able to achieve in practice, we now review the most important initiatives that are aimed at monitoring well-being and sustainability of well-being that have been developed in recent years.

There are four types of measurement frameworks represented in this literature:

(1) adjusted economic measures

(2) dashboard of indicators

(3) composite indices

(4) index-dashboard combos

Below we summarize 18 of the numerous initiatives aimed at measuring development 'beyond GDP' and that formally incorporate sustainability considerations as an important part of their methodological approach.

3.1 Adjusted economic measures

The System of Environmental-Economic Accounting (SEEA)

The SEEA 2012 Central Framework is a statistical framework, consisting of a comprehensive set of tables and accounts, which guides the compilation of consistent and comparable statistics and indicators for policymaking, analysis and research. It is a conceptual framework for understanding the interactions between the economy and the environment, and for describing stocks and the trend of environmental assets. The main purpose of the SEEA Central Framework is to place statistics concerning the environment and its relationship to the economy at the core of official statistics. This framework has been produced as part of a joint effort between the United Nations, the European Commission, the Food and Agriculture Organization of the United Nations, the Organisation for Economic Co-operation and Development, the International Monetary Fund and the World Bank Group.

The **SEEA Central Framework** is based on agreed concepts, definitions, classifications, and accounting rules. As an accounting system, it enables the organization of information into tables and accounts in an integrated and conceptually coherent manner to inform decision-making. The SEEA Central Framework allows for its implementation in parts or as a whole, adjusting to the different needs, priorities and resources of its users.

Key note: SEEA Central Framework

The SEEA Central Framework (2012) was adopted as an international standard by the United Nations Statistical Commission at its forty-third session in March 20121. It is the first international statistical standard for environmental-economic accounting. See United Nations (2014).

The SEEA Central Framework allows for the measurement of physical flows and stocks while providing guidance on the valuation of renewable and non-renewable natural resources and land within the System of National Accounts (SNA) asset boundary. While not having an inclusivity emphasis per se, this framework is the base of indicators, such as Inclusive Wealth Index (IWI), or Adjusted Net Savings (ANS), which will be discussed below. However, some of the critics of such measures have highlighted important limitations in their weighting systems. This is because within the SEEA Central Framework, a full valuation of assets and flows, that relate to natural resources and land beyond the valuation and that are included in the SNA, is still an outstanding challenge (see also Section 3.1.1 below).

The Genuine Progress Indicator (GPI)

The GPI is designed by the U.S.-based Centre of Sustainable Economy and the Institute for Policy studies This adjusted measure is applied in some U.S. states and it is one of the several attempts made to substitute GDP and provide a better measure of the economic welfare. The GPI is related to an earlier measurement initiative that led to the creation of the Index of Sustainable Economic Welfare (ISEW). This index measures the economic welfare of a country by using personal consumption and making deductions to account for the costs of crime, environmental degradation, and loss of leisure, as well as additions to account for the flow of services from consumer durables, public infrastructure, and the benefits of volunteering and housework. Inclusivity enters the calculation by also allowing for deductions to account for income inequality.

Inclusive Wealth Index (IWI)

The IWI is designed by the United Nations University International Human Dimensions Programme on Global Environmental Change (UNU-IHDP) and UNEP, in collaboration with the UN-Water Decade Programme on Capacity Development (UNW-DPC) and the Natural Capital Project. The IWI measures the wealth of nations by carrying out a comprehensive analysis of a country's productive base. This measure covers 140 countries over the span of 20 years from 1990 to 2010. The report is produced every two years and each edition is focused on a specific topic: the 2012 report was focused on natural capital, while the 2014 report focused on Human Capital. The index tracks the amount of capital in a nation by adding the 'social worth' of three forms of capital: Manufactured, Human and Natural Capital. Produced capital and human capital are directly calculated by use of formulas derived from the theory behind the measurement exercise, whereas natural capital is an aggregate of natural stocks.

Adjusted Net Savings (ANS)

Pearce and Atkinson (1993) first introduced the concept of ANS and the World Bank reports the data. ANS aims to assess an economy's sustainability based on the concepts of extended national accounts. This adjusted measure comprehends 213 Countries and it is calculated by adding fixed capital, human capital and environmental capital to the standard savings. There is no explicit accounting for inclusivity in this methodology.

Comments about the adjusted measures

The purpose of any dashboard of sustainability indicators is to track the evolution of key stocks of built, human, intellectual, natural, cultural and institutional capital at the country and at the planetary level, that are priorities to sustain life on the planet. We explained in Section 2 that in the ideal world such dashboard could contain only a single number: the indicator $dV^*(t)$ since, as we saw in that Section, if $dV^*(t)$ is negative, then present well-being is not sustainable. It is this theoretical ideal, $dV^*(t)$, what the adjusted measures are trying to proxy. The serious difficulties of computing $dV^{\wedge *}(t)$ with any degree of accuracy was also discussed in that section. If the economy was perfectly competitive and had complete contingent claims markets, the weights $\frac{\partial V^*}{\partial K_j(t)}$ could be recovered from the behavior of the market prices of the different stocks. Yet it is a fiction that all the relevant information about future trends is adequately reflected in current observed prices. It is thus difficult to take the currently computed adjusted measures as good estimates of what we would ideally like to measure to assess sustainability, namely, indicator $dV^*(t)$, and for that reason these measures are in a conflict of sorts with desideratum D4.

Key reference:

Fleurbaey and Blanchet, 2013, p. 63. See also Chapter 2, Section 4 in this textbook.

3.2 Dashboard of indicators

Green Growth Indicators

The OECD Green Growth Indicators are developed by the Organization for Economic Cooperation and Development. This dashboard is composed of more than 50 indicators and is intended as a guideline for Countries that want to assess themselves in terms of green growth. The OECD collects data for the 34 OECD countries, as well as Brazil, China, India, Indonesia, the Russian Federation, and South Africa and the indicators are available on the OECD website. Actually, OECD extends the set to countries in Latin America and the Caribbean, Central and East Asia, and the Caucasus. Green growth indicators are also being integrated into OECD work, including country reviews and policy analysis.

The indicators are grouped into four main categories: 1) environmental and resource productivity; 2) natural asset base, environmental quality of life; 3) economic opportunities; and $) policy responses. Indicators describing the socio-economic context and the characteristics of growth complete the picture. There is no explicit accounting for inclusivity in this methodology. Together with these indicators a small set of six representative indicators were chosen to facilitate the communication with policy makers, media and citizens.

Sustainable Development Indicators (SDIs)

Eurostat produced the SDIs, where the dashboard of indicators covers 28 EU countries. It was first published in 1997, and the most recent changes to the indicator set were related to the adoption of the Europe 2020 Strategy. Eurostat publishes a report every two years with key trends in each sector for the EU as a whole. The SDI dashboard is composed of more than 100 indices, where twelve of them have been selected as headline indicators. The indicators are divided into 10 categories:

1. Socioeconomic development
2. Sustainable consumption and production
3. Social inclusion
4. Demographic changes
5. Public health
6. Climate change and energy
7. Sustainable transport
8. Natural resources
9. Global partnership
10. Good governance

The set of EU SDIs is divided in three levels of indicators, complemented by contextual indicators, which provide useful information about the countries, but do not directly monitor progress.

Comments about the dashboard of indicators

While all these dashboards contain information on variables that affect current well- being, as well as variables that affect the sustainability of such well-being, it is difficult sometimes to get a clear sense of whether or not a country is making progress overall, especially when the dashboards contain a large number of variables. This task of overall country evaluation could be easier if we knew how close the country was to meeting its goals or targets, and whether or not it was perilously close to reaching sustainability thresholds it wishes to avoid in key capital stocks. None of those initiatives, however, identify in a systematic manner critical thresholds or targets for the stocks of the assets they monitor for each country, as would be required by desideratum D3 (see section 2).

3.3 Composite indices

Yale Environmental Performance Index (EPI)

Key reference:

The first three sub-sections of this Section are based on Pineda, J. and Galotto, L. (2015). The fourth sub-section is based on PAGE (2017a).

Yale (Center for Environmental Law & Policy) and Columbia University (Center for International Earth Science Information Network) designed the EPI and it is calculated for 178 countries. The first report published was the pilot in 2006, and then EPI was calculated every two years until the last edition of 2014. EPI is divided into two main environmental protection objectives: environmental health and ecosystem vitality. These two areas are further divided into nine core policies categories:

1. Health impact
2. Air quality
3. Water and sanitation
4. Climate and energy
5. Biodiversity and habitat
6. Fisheries
7. Forests
8. Agriculture
9. Wastewater management

Those are further divided into 20 indicators. EPI provides an overall as well as a category score to all the 178 countries considered. The indicators were chosen according to a generic guideline that considers relevance, performance orientation and data quality. Moreover, the indicators should be available over time for a large number of countries. Normalization was done by converting the transformed and logged data into one indicator through the proximity-to-target method. This methodology measures each entity's performance on any given indicator based on its position within a range established by the lowest performing entity (equivalent to 0 on a 0-100 scale) and the target (equivalent to 100). The indices are aggregated through the arithmetic mean. There is no explicit accounting for inclusivity in this methodology.

Low Carbon Competitiveness Index (LCCI)

The Climate Institute with the support of Vivid Economics projects the Low Carbon Competitiveness Index. This composite index, first released in 2009 and last published in 2013, is currently used in the G20 countries. Its objective is to measure the current capacity of each country to be competitive and generate material prosperity to its residents in a low carbon world, based upon each country's current policy settings and indicators. LCCI derives from the aggregation of 19 variables, divided into three categories: 1) *Sectoral composition*: how well, or otherwise, the composition of the economy is currently structured towards less emissions intensive activities; 2) *Early preparation:* the steps that countries have already taken to move towards a low carbon economy; 3) *Future prosperity:* the impact on the level of production of goods and services. The variables were selected according to their relationship with the carbon competitiveness (GDP per tonne of emissions). Among the 36 variables likely to be linked to a country's low carbon competitiveness, only the 19 with the strongest statistical correlation were chosen. The normalization of the variables is made through a min-max transformation, while aggregation of indices in the categories is made by arithmetic mean. There is no explicit accounting for inclusivity in this methodology.

Global Sustainable Competitiveness Index (GSCI)

The World Economic Forum (WEF) developed The GSCI and it has been published since 2014 and the last report (2016) covers 180 countries. The GSCI is based on 109 quantitative performance indicators grouped into the 5 pillars of sustainable competitiveness. Data sets have been scored both for the current levels as well as the recent development of the indicator, not only reflect current standing, but also development potential. The GSCI aims to evaluate the ability of countries to create and sustain wealth that does not negatively affect the underlying fundament of wealth creation, based on the definition of Sustainable Development. The data, taken from international organizations and an internal survey, was aggregated in countries through a sector-weighted country average procedure. The variables are normalized and aggregated. There is no explicit accounting for inclusivity in this methodology.

Global Green Economy index (GGEI)

The GGEI is projected by Dual Citizen LLC. It measures both the green economic performance of 80 countries and how experts assess that performance. This aggregate index of 32 indicators studies 60 countries and their largest metropolitan areas. It was first published in 2010 and together with the Performance Indicator, Dual Citizen publishes a Perception Index. The performance index of the 2014 GGEI is defined by 32 underlying indicators and datasets, each contained within one of the four main dimensions of leadership & climate change, efficiency sectors, markets & investment and environment & natural capital. Data are selected according to a 'top down' method. First, the dimensions and sub-categories to include in the GGEI were defined. Then those third-party datasets able to provide a value measure or generate a system for calculating a qualitative scoring for each category were identified. There is no explicit accounting for inclusivity in this methodology. The normalization approach uses GDP accounts for differences in the size of a country's economy, while aggregation is made by calculating a z-score and the associated percentile of the standardized distribution. Then, these percentile values are aggregated in a uniform manner, generating a country score that is expressed on the spectrum of 0-100.

Comments about the composite indices

While they can communicate complex ideas more quickly, composite indicators can be difficult to interpret. Ravallion (2012) presents several criticisms of composite indices, including the the fact that this approach inherently implies substitutability between different indicators, as well as the sensitivity of their resulting ranks to factors set by their producers (such as indicator weights and aggregation methods). A perhaps more problematic aspect of the single composite index approach in this arena is that it attempts to combine the variables behind desiderata D1 and D2 into a single measure. A composite index that rewards the growth in variables important for present well-being but that penalizes the growth in variables threatening the sustainability of that well-being may end up classifying countries in an unintuitive way. For example, countries having low life expectancy and low greenhouse gas emissions may have similar index values as those with high life expectancy and high emissions, while their positions clearly need to be differentiated. This follows as long as we adopt the principle that we consider it our moral duty not to impose on future generations any form of sacrifice that we do not accept for ourselves .

3.4 Index-dashboard combos

The Green Economy Progress Measurement Framework (GEP)

The Green Economy Progress measurement framework is composed of a GEP index, a companion dashboard of sustainability indicators, and a country ranking that is based on the index and the dashboard. It was designed with the specific aim of meeting the *basic desiderata* identified at the end of Section 2, and for this reason we explain this methodology in more detail.

The Index

As in expression (4) above the GEP index is a weighted sum of how much progress a country makes in each of the variables, y_i, that matter for present wellbeing $(i=1,\dots,I)$. We measure progress in each variable by the extent to which a country is meeting its targets. If dy_i^* denotes the desired level of change in the variable and:

$$dy_i := y_i^1 - y_i^0$$

denotes the actual change in the variable we then measure progress in the variable by the computation of the ratio:

$$Progress(i) := \frac{dy_i}{dy_i^*}$$

This ratio has a straightforward interpretation: when $Progress(i)$ for variable i equals one this means the country met its target for that variable, when it is greater than one this means the country exceeded its target, when it is positive but less than one it means that the country made progress but did not meet its target, whereas when it is negative it means the country regressed, or got worse, in that variable.

The GEP for a country is calculated as

$$GEP := \kappa \cdot \sum_{i=1}^{I} Importance(i) \cdot Progress(i)$$

for some (normatively determined) country-specific importance levels, $Importance(i)$ for each $i=1,\dots,I$ and some country-specific proportionality constant κ.

Figure 1 below illustrates the level curves for the GEP of two countries for the case where there are only two variables of interest. Variable 1 is one that we want more of, so progress is positive when the level of variable 1 grows over time. Variable 2 is one that we want less of, so progress is positive when the level of variable 1 shrinks over time. Notice that the slopes of these level curves differ across the two countries in the example. This illustrates the general principle that different countries may value certain kinds of progress more than others, depending on their initial conditions and the characteristics of other countries.

As a way to put this general principle into practice we introduce the idea of **thresholds**: levels for the variables that the countries should critically try to avoid. If it is desirable that a country's level for a variable should **exceed** a certain threshold, then we can assign a greater importance to progress in that variable when the current level is **below** the threshold (and lower importance when the variable already exceeds the threshold). Similarly, if it is desirable that a country's level for a variable should be **below** a certain threshold, we assign a greater importance to progress in that variable if the current level is **above** the threshold.

Appendix B1 contains more details about the determination of the importance levels, which determine the slopes of the level curves in Figure 1 below, as well as the proportionality constant, which determines the units in which GEP is measured.

The Dashboard

The GEP measurement framework keeps track of the changes in relevant capital stocks (dK_j) and presents those changes in a dashboard of progress for each country. Progress for each capital stock is calculated for each indicator K_j in the dashboard in the same way it is done for the variables in the index, that is:

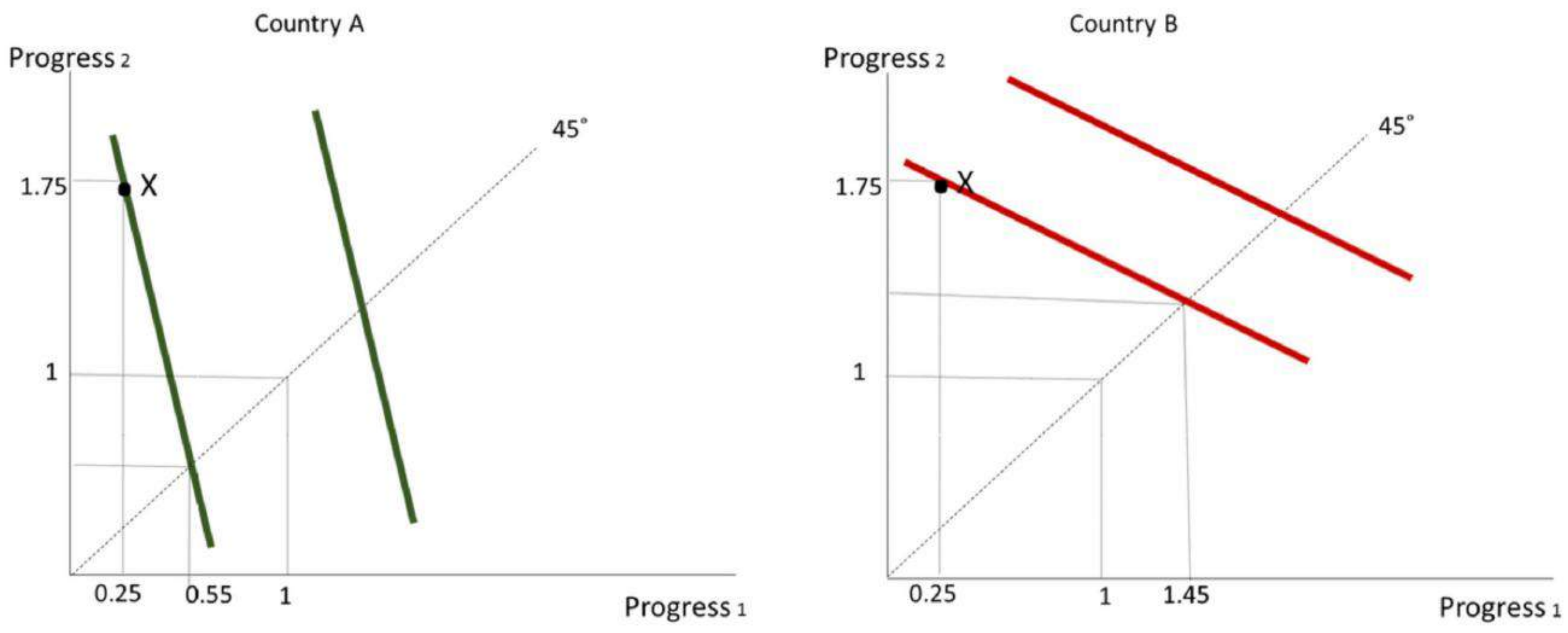

Figure 1: Level curves for the GEP for two countries

$$Progress(j) := \frac{dK_j}{dK_j^*}$$ for all relevant indicators in the dashboard $j=1,\ldots,J$.

The thresholds for these stocks are calculated with respect to planetary boundaries. This approach of not combining all of the progress measures in the dashboard into a single measure intended to approximate $dV^*(t)$, is compatible with: (a) an outright acceptance of the intrinsically limited substitutability between the different forms of capital under consideration or, even if it wasn't limited; (b) the extraordinary difficulty, both ethical and technical, in identifying the proper "trade-offs" between forms of capital.

Despite the fact that the GEP measurement framework does not combine the variables in the dashboard into a single scalar measure, determining the importance levels associated with each variable in the dashboard is, of course, relevant. We explain how the GEP measurement framework determines those importance levels in Appendix B2.

The Ranking

Even though the GEP index is not combined with the dashboard indicators into a composite measure of sustainable development, the information from both instruments can nevertheless inform which countries are in a comparably more favorable position than others.

To do this the GEP measurement framework defines the *achievement profile for each country* as follows:

(i) The country's achievement for each stock *j* in the dashboard is given by the expression $Progress(j) \cdot Importance(j)$.

(ii) The country's GEP achievement is given by the expression $GEP \cdot \overline{Importance}$, where $\overline{Importance}$ is the average across all importance levels $Importance(i)$ for each $i=1,\ldots,I$. The *achievement profile* for each country is then the $(J+1)$-*vector* given by the GEP achievement and the achievement for each of the stocks in the dashboard, as calculated above.

To determine how to use the information in the achievement profile of two countries in order to see which country is in a comparably more favorable position than another, the GEP measurement framework appeals to three normative principles: the *Pareto principle*, the principle of *Priority to the Worst Achievement*, and the principle of Independence of Identical Achievements. We explain why it makes sense to employ these principles in this setting in Appendix B3.

These principles allow us to order countries in terms of their worst achievement but only considering the dimensions on which they differ. This order is known as the *protective criterion*. This methodology allows us to rank all index-dashboard achievement profiles but not to combine the index and dashboard information into a synthetic index.

To summarize, when comparing progress based on the GEP index and the dashboard, countries will be ranked according to their comparatively least-performing type of achievements. This approach sends the policy message that a country that is only making substantive achievements or on a few issues (indicators) of an IGE, at the cost of others, will not necessarily be doing better than one that is making small achievements in all areas. Ranking countries based on the issues in which they are making comparatively the least progress provides maximal incentives for countries to not dismiss any specific issue, and to develop a more balanced and integrated policy approach aimed at making progress in a large number of the dimensions that characterize an IGE.

Comments about the Index-Dashboard Combo

This comment is about the GEP measurement framework since it is the only index dashboard combo under consideration. Because the GEP measurement framework was structured, by design, to satisfy the basic desiderata identified in Section 2, the framework has a disciplined methodology for the identification of the kinds of variables that go in the index and the dashboard; it uses country level targets and thresholds as key inputs for the determination of the importance that each variable of interest has; and is able to use the information from both the index and the dashboard to give guidance to a country as to its multidimensional performance without the need to combine all the relevant information into a single scalar measure. On the other hand, it achieves all this at the cost of added conceptual complexity, and this was perhaps unavoidable. Below we illustrate the payoff behind this conceptual effort by way of showing the kinds of insights one can derive about both country and planetary performance from its implementation.

4. Measuring progress in practice

From the multitude of approaches that have been surveyed, there is no unanimous agreement on what analytical framework ought to be used to measure green economy. However, an important step towards developing such unifying framework has been done in a joint effort by the OECD, UN Environment, the World Bank, and GGGI as part of their collaboration on the Green Growth Knowledge Platform (GGKP, 2013). One potential useful framework that came out of this initiative is the use of the concept of production function, viewed in the context of government policies, economic opportunities and the underlying socio-economic background.

The framework proposes considering the environment as natural capital, which together with other forms of capital, are essential inputs to many production processes. This is illustrated in Figure 2, which presents the transformation process from inputs into outputs passing through a production function, as in OECD, 2011. The main ingredients in this formalism are the following:

Inputs: the natural asset base. Natural capital provides services as well as natural resources *per se*, which provide crucial inputs into production or direct consumption. Indicators capturing the state of the natural asset base are crucial for identifying risks of overuse and/or depletion that may threaten future green growth.

Production: intensity/productivity. These indicators focus on environment-related "productivity," or its inverse, "intensity." Progress can also be captured by measures of product-life environmental footprints or various proxy measures of innovation— which are important drivers of a green economy.

Outputs: material and non-material well-being. Outputs refer to broad notions of well-being that capture aspects that are not reported by conventional macroeconomic measures. This type of indicator attempts to capture the environment-related aspects of the quality of life and their impact economic processes (for example, the effect of good air quality on health that affects labor productivity).

Measuring green economy can support policymakers along the main stages of the policymaking process: objective setting; planning, design, and implementation; and monitoring and evaluation (UN Environment, 2014), as shown in Figure 3.

Key reference:

See UN Environment (2015) for an application of the methodology to the cases of Ghana, Mauritius and Uruguay.

Regarding the objective setting, it is necessary to conduct diagnostics based on approaches and indicators that measure the present state, changes over time and future trends. Outcomes, such as expected climate change or health consequences of air pollution, and their drivers, such as emissions, are the only elements taken into account in these diagnostics. These diagnostics identify challenges and opportunities that can lead to the formulation of respective policy priorities and goals. For example, it may involve establishing a long-term vision for green economy policy, developing baselines against which to compare developments over time, and defining long-term targets aligned with domestic priorities (Mediavilla-Sahagun and Segafredo, 2014).

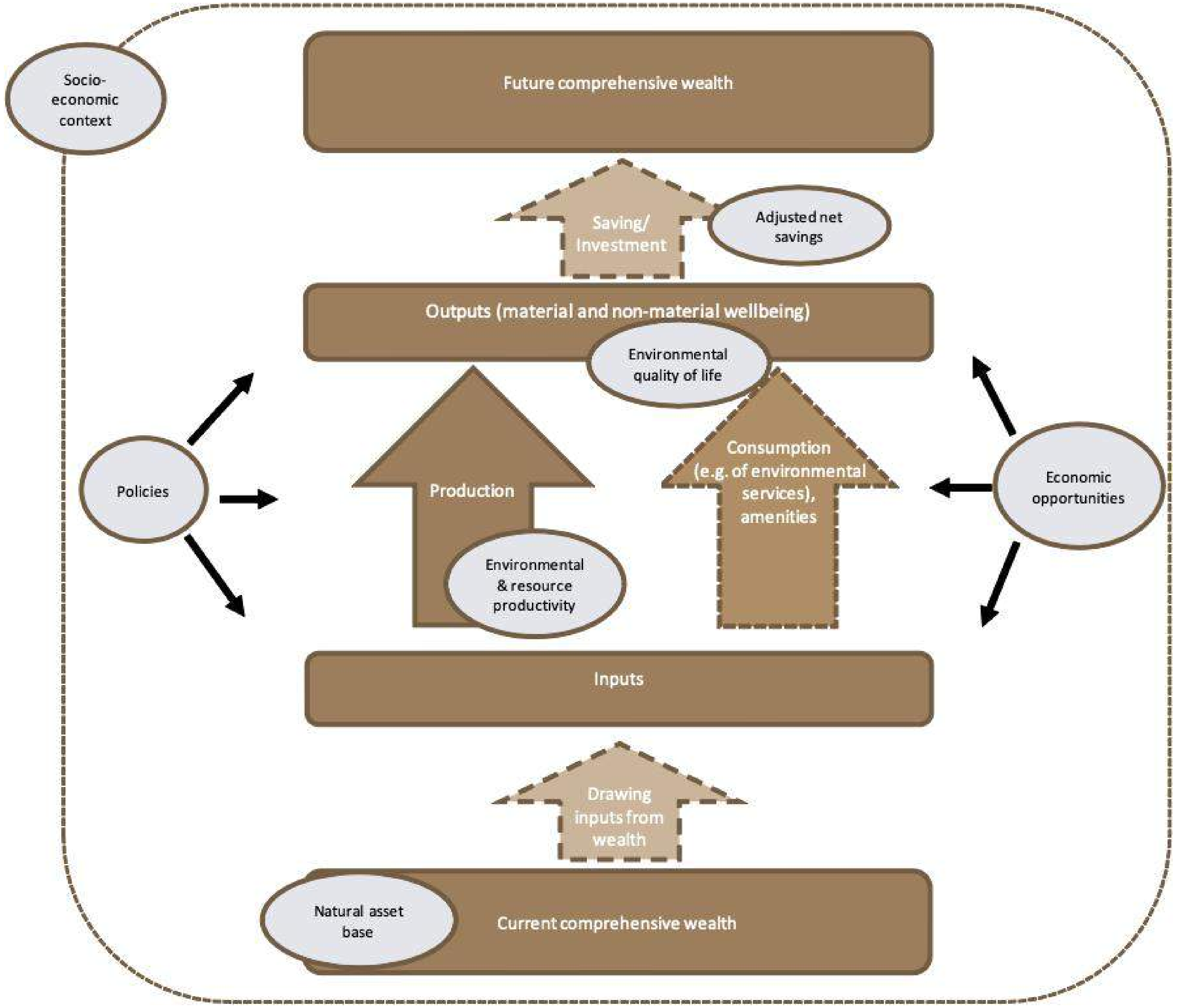

Figure 2: The production framework for green economy indicators and wealth accounting (GGKP, 2013). Note: Grey ovals represent indicator categories.

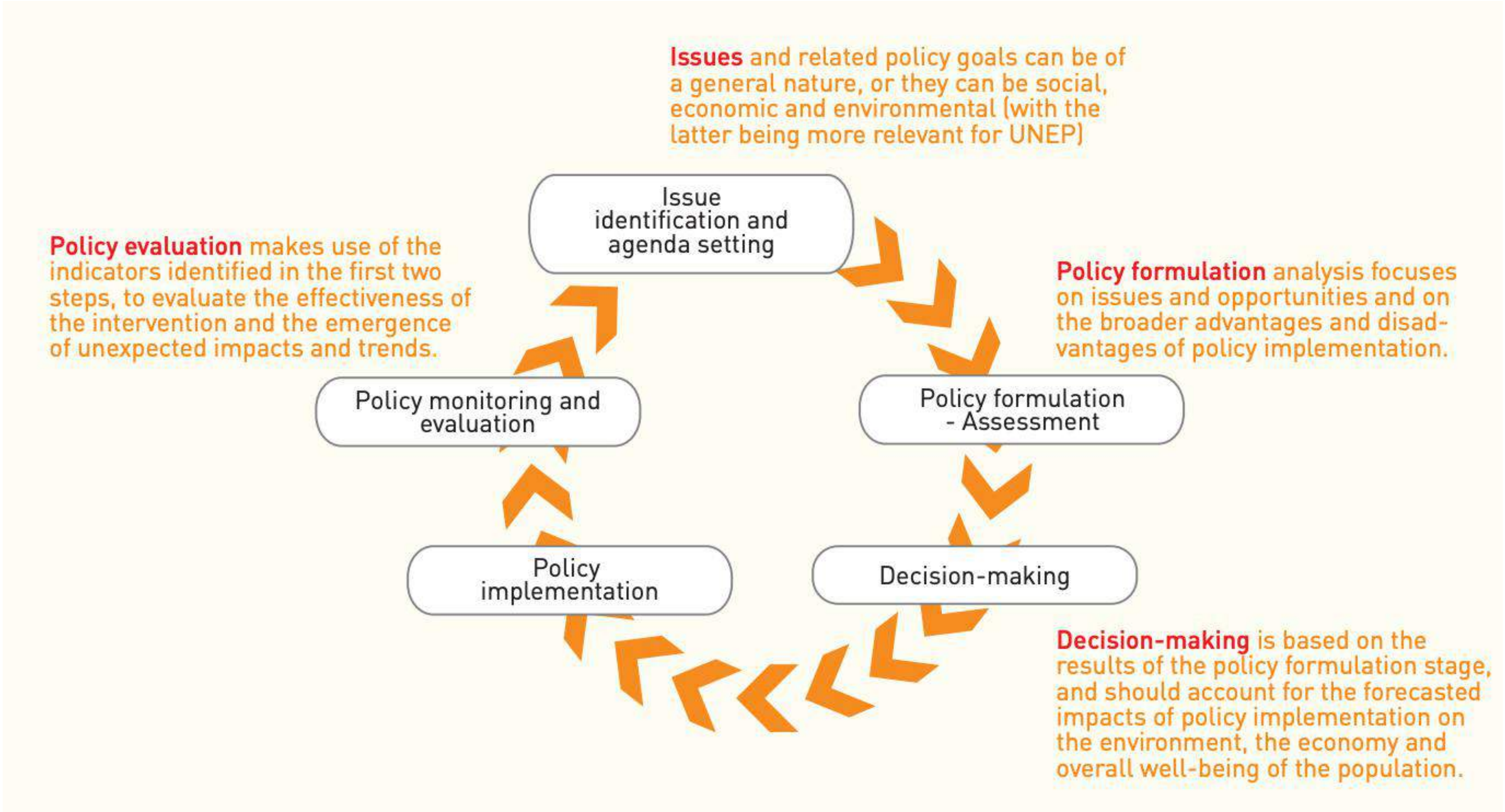

Figure 3: Overview of the Integrated Policymaking Process and the role of indicators (UNEP, 2015).

Finally, when desirable policies have been identified and measurable actions are implemented, indicators can be employed to monitor progress and assess the impact of policy actions (such as electricity production from renewables or the improvement in energy efficiency over time). The need to implement other policy interventions or mitigating actions can be determined through these indicators, thus supporting the achievement of the desired policy objectives.

Despite the significant efforts that have been done in order to have a common frame-work (e.g. GGKP (2013)), the reality is that there are a variety of different approaches that work with indicators on green economy, as we already saw on Section 3. In this Section, we will present a practical application of the GEP measurement framework and how it compares with alternative methods for measuring green economy progress. In many cases, the indicators being used in the evaluations convey the same message, but in other cases this will not be so. This is, in essence, a reflection of the methodological differences behind these indicators.

4.1 Indicators in the GEP measurement framework

The GEP measurement framework is composed of a GEP index, a companion dashboard of sustainability indicators, and a country ranking that is based both on the index and on the dashboard (this country ranking is called the 'GEP+' (more on this below). The GEP index is used to track the changes in GE indicators, relative to desired changes, which directly or indirectly impact current human well-being. It captures particular characteristics of the concept of an IGE by including a set of multidimensional indicators (e.g. indicators that capture the link between health and the environment). The dashboard of sustainability indicators aims to monitor the sustainability of well-being (i.e. the well-being of future generations). It tracks some of the main forms of natural capital (e.g. freshwater and land), as well as other key stocks of capital (e.g. human, health), as reflected in the Inclusive Wealth Index (UNU-IHDP/UNEP, 2014) and which affect long-term sustainability. Figure 4 gives an overview of the indicators included in the GEP measurement framework.

In terms of the production function analogy, discussed in Section 3, indicators included in the GEP index tend to be more related to production and outputs, while indicators of natural capital appear primarily in the dashboard of sustainability indicators.

4.2 Practical examples: Comparing the cases of China, Colombia and Ireland

To illustrate some of the main properties of the GEP measurement methodology, Tables 1a-c presents the weights, the slope of relative weights, and the value of progress for the 13 indicators used in the GEP index for the case of China, Colombia and Ireland. The best way to understand how the weights are useful to set national priorities, is the construction of the slope (ratio) of weights across indicators.

The weighting system of the GEP methodology allows us to understand the complexity

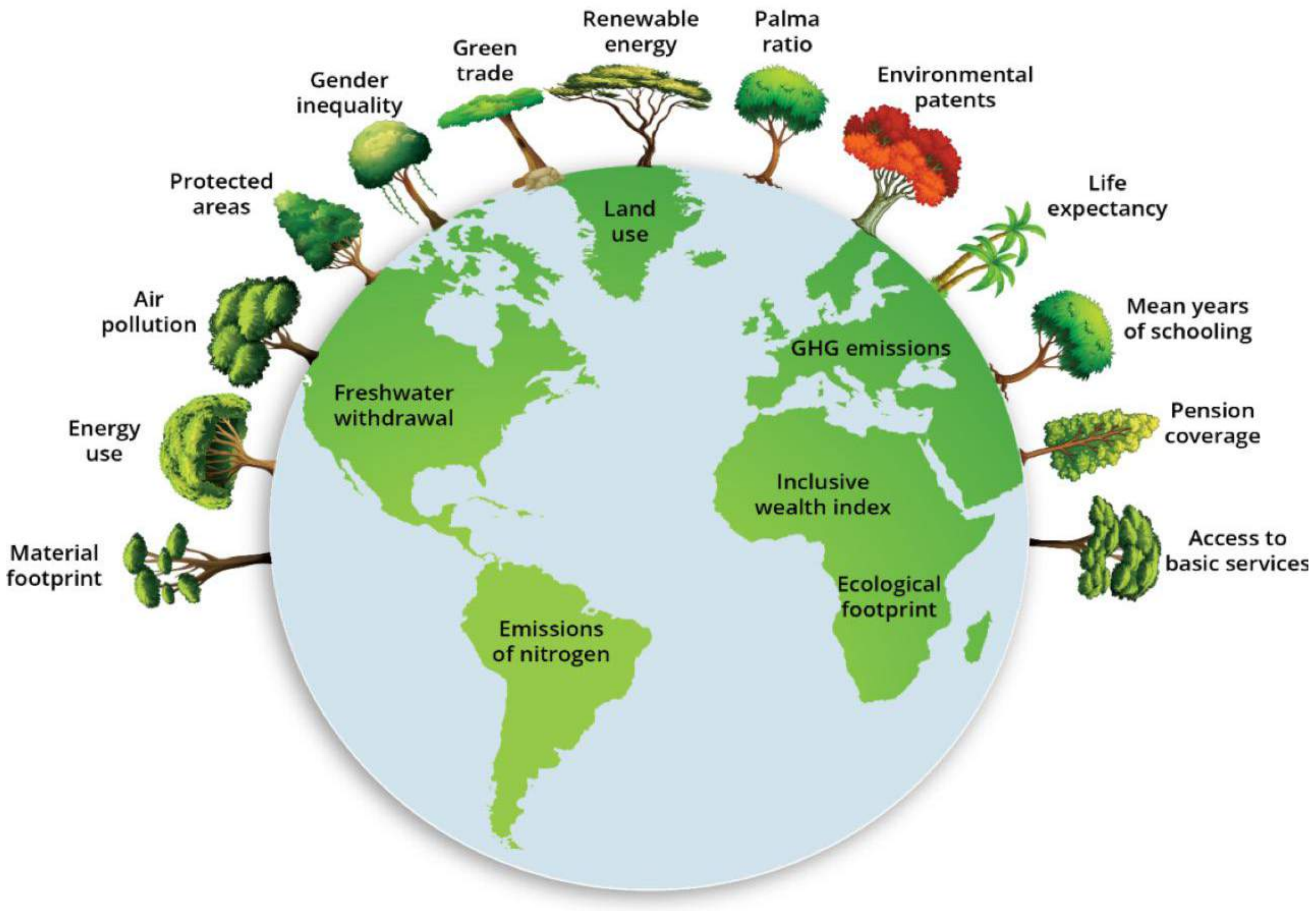

Figure 4: Indicators used in the GEP Measurement Framework (PAGE, 2017b).
Note: The 13 GEP Index Indicators are represented as trees while the elements of the dashboard of sustainability indicators are represented as the continents

of the multidimensionality of an IGE in a way that is useful for setting priorities both at the national and global level, and to understand the interplay between these two. For example, the three countries in Table 1 are exceeding the global threshold for material footprint per capita. For this indicator, the initial situation was worse for Ireland, followed by China and then Colombia. However, China experiences other significant challenges, for example in air pollution, so the slopes of weighting relative to material footprint

Tables 1a, 1b, and 1c (right): Progress, slopes and weights by indicators for China, Colombia, and Ireland (Authors' own caculations, based on PAGE, 2017b)

The weights in the table are defined as $\pi_i=\kappa \cdot Importance(i)$ and the slope of indicator i with respect to mfp is $Importance(i)/Importance(mfp)$. See Appendix B1 for details.

China	Material footprint	Air pollution	Protected areas	Energy use	Green trade	Environmental patents	Renewable energy	Palma ratio	Gender inequality	Access to basic services	Mean years of schooling	Pension coverage	Life expectancy
Weights π	0.0728	0.3303	0.2639	0.0704	0.0085	0.0355	0.0154	0.0360	0.0348	0.0400	0.0365	0.0116	0.0442
Slope with respect to mfp	1.0000	4.5350	3.6214	0.9660	0.1170	0.4881	0.2116	0.4942	0.4779	0.5487	0.5015	0.1597	0.6074
Progress	-3.8662	-0.1587	0.0387	0.5196	0.2306	0.4183	-0.5050	-0.1856	1.4626	0.6365	0.3624	0.6614	0.4121

Colombia	Material footprint	Air pollution	Protected areas	Energy use	Green trade	Environmental patents	Renewable energy	Palma ratio	Gender inequality	Access to basic services	Mean years of schooling	Pension coverage	Life expectancy
Weights π	0.1222	0.0527	0.1334	0.0406	0.0520	0.0820	0.0218	0.1416	0.0878	0.0675	0.0709	0.0399	0.0874
Slope with respect to mfp	1.000	0.4317	1.0921	0.3325	0.4256	0.6710	0.1784	1.1592	0.7188	0.5524	0.5805	0.3269	0.7156
Progress	-1.6227	-0.1889	0.1015	0.4568	-0.1547	0.4070	-0.1194	0.2291	0.3021	0.1972	0.2914	0.1621	0.3635

Ireland	Material footprint	Air pollution	Protected areas	Energy use	Green trade	Environmental patents	Renewable energy	Palma ratio	Gender inequality	Access to basic services	Mean years of schooling	Pension coverage	Life expectancy
Weights π	0.3896	0.0414	0.1619	0.0269	0.0198	0.0397	0.1814	0.0470	0.0200	-	0.0250	-	0.0473
Slope with respect to mfp	1.0000	0.1063	0.4156	0.0690	0.0509	0.1020	0.4657	0.1205	0.0513	-	0.0642	-	0.1214
Progress	0.2588	-1.3650	0.2872	0.5965	0.0965	0.5188	1.1076	0.4897	0.6252	-	0.4115	-	0.5137

indicate that progress on material footprint will be important but not as important as progress on air pollution (relative slope of 4.535). So, even though the first weight indicates that it will be more important that China makes progress on material footprint than Colombia, the analysis of the slopes incorporates information on the other indicators for each country, making it clear that progress on material footprint is of higher relative priority for Colombia and progress on air pollution is of higher relative priority to China (relative slope of 4.535 vs 0.4317 for China and Colombia, respectively). In the case of protected areas, another indicator for which all three countries are exceeding the global threshold, the comparison of the relative slopes indicates that, in the case of China and Colombia, protected areas are higher priorities than material footprint while for the case of Ireland material footprint is the highest priority. In this way, the flexibility of the weighting system allows for better articulation and action on national and global priorities based on when the global and national priorities coincide and when they differ.

Another important advantage of the GEP weighting system is that it helps to know if progress is happening where it is most needed. One way to

> **Key reference:**
>
> Notice that this comparison is meant to be illustrative and by no means exhaustive. However, we consider that comparing these indicators could illustrate not only the complementarities across approaches but also their methodological differences and how they may explain differences in their results.

> **Key reference:**
>
> For the EPI weights were selected according to the quality of the underlying dataset, as well as the relevance or fit of the indicator to assess the policy issue. The weightings given to Environmental health and Ecosystem vitality were chosen to balance the contribution of these indicators to the overall EPI; these explicit 60-40 weights provide an implicit 50-50 weighting because of the differences in variability of the two policy objectives (less variability across countries is observed for Ecosystem Vitality). Moreover, lower weights are used to lessen the impact of an indicator with a lower quality of data or for proxy indicators. For the GGEI the weightings for the four dimensions and sub-categories are applied equally, with the exception of the Leadership & Climate Change dimension, where the weighting for the head of state and media coverage sub-categories was lessened. See Appendix C for a more detailed description of the indicators used and their weights.

understand this is by comparing the differences between the simple average of progress across indicators (which assumes equal weights across indicators), with the value of the GEP index, which is the weighted average of progress across indicators by using as weights. The values of the simple average of progress across indicators are 0.002044, 0.032693, and 0.325819 for China, Colombia and Ireland respectively. Now, the values of GEP index are -0.169356, -0.022191, and 0.400391 for China, Colombia and Ireland respectively. Notice that in the case of Ireland, the GEP index is greater than the simple average, reflecting that progress was important where it was of higher priority; it also reflects the fact that Ireland only had regress on one indicator (air pollution). Ireland made progress on the three indicators that were of the highest global and national priority. In addition, notice that the GEP index is negative for Colombia and China as opposed to the positive simple average of progress values. This reflects the fact that these countries experienced regress on more indicators (four indicators each), but, more importantly, that regress was made in areas of high priority (material footprint for Colombia and material footprint and air pollution for China). These examples illustrate the richness of change that can be captured by the weighting system used in the construction of the GEP index.

Let's now compare the relative performance of these countries with two well-known measures, the EPI and the GGEI, which were discussed earlier. Do they paint the same picture? Table 2 presents, for these three countries, the values of each of these indices. We can see that the relative order between these three countries is similar for the GEP index and the EPI, while there is a change in relative order between Colom-

Table 2: Rank and index value for a selected group of countries (Source: Authors' own caiculations, based on PAGE, (2017b), GGEI (2016), and Hsu, A., et el. (2016)).

	Rank GEP index	GEP index	Rank EPI	EPI	Rank EPI
Ireland	5	0.4004	17	86.60	29
Colombia	81	-0.0222	49	75.93	16
China	93	-0.1694	77	65.10	52

Table 3: Rank correlations for GEP index, Progress, EPI, and GGEI (Source: Authors' own caiculations, based on PAGE, (2017b), GGEI (2016), and Hsu, A., et el. (2016))

Note: Progress is the simple average of the progress made in all indicators of the GEP index (Progress is a version of the GEP index with equal weighting).

	Rank GEP index	Rank progress	Rank EPI	Rank GGEI
Rank GEP index	1			
	100			
Rank progress	0.5405	1		
	100	100		
Rank EPI	0.0368	0.382	1	
	100	100	100	
Rank GGEI	0.1689	0.2574	0.4255	1
	62	62	62	65

bia and Ireland, but China is still the worst performing country among the three. So, it seems to be the case, at least for these countries, that the different indices may provide some similar information.

However, when we extend the analysis to all countries in the sample, it seems to be the case that the EPI and the GGEI have more in common among themselves than with the GEP index, as shown in Table 3. This lack of correlation of the ranking produced by these different measures could be a reflection of the differences in their methodologies and indicators covered. To illustrate this point, we have added as a measure the simple average of progress across indicators (a simplified version GEP index without its weighting system). As the rank correlation table shows, both EPI and GGEI have positive and statistically significant rank correlations with the simple average of progress but not with the GEP index, which could be partially explained by the differences in weighting across indices.

4.3 Can composite indicators be combined with a dashboard of indicators to better capture progress in all aspects of green economy and sustainability?

Table 4 shows the results of the combination of the GEP index and the progress on the dashboard of sustainability indicators to make a final assessment of green economy progress for a selected group of countries.

Imagine that we base the progress on an IGE of a country only using the GEP index, as we can see from Table 4, Bulgaria has a higher GEP index value than Ireland. However, Ireland is a country with progress in all indicators (the GEP index as well as all of the dashboard indicators).

Table 4: GEP+ (Rank among selected countries) (Source: Authors' calculations based on PAGE (2017b)).

Note: Observations in bold indicate the minimum value among all categories. The ranking presented in this table is based on the following four categories: (a) the GEP Index; (b) greenhouse gas emissions; (c) nitrogen emissions; and (d) the share of land used as permanent crops.

Country	Progress GHG (CO_2-e/cap)	Progress nitrogen emissions	Progress land use	GEP index	GEP+
Bulgaria	-0.5471	**-1.7996**	0.1097	0.5328	5
Ireland	2.3998	7.8447	**0.0012**	0.6197	3
Germany	0.5734	0.2181	**0.0039**	0.1664	2
Jamaica	1.1022	0.4906	0.1682	**0.1256**	1
Singapore	0.6208	0.4228	0.0211	**-0.1218**	4

So, if progress is assessed just based on the GEP index, the fact that the progress achieved by Ireland seems to be more sustainable than the progress by Bulgaria, where there is regress on GHG and nitrogen emissions, could be missed. Similarly, Germany has a higher GEP index value than Jamaica, and although both countries experienced progress in all indicators, the progress experienced by Germany on land use progressed the lowest. However, if we compare Germany and Singapore, we can see that Singapore exhibits more progress in all of the dashboard indicators. In addition, Germany has also a positive GEP index and therefore Germany will have a higher overall progress than Singapore.

What these examples illustrate is that the assessments of progress across countries could be misleading if only a portion of the information is used. Some countries may have similar GEP indices but different performances on the dashboard of indicators, or they may have a high GEP index but low progress on its dashboard, compared to another country that may have progress on the dashboard of indicators but a negative GEP index. Given that we aim for a comprehensive assessment of progress, we want to be able to combine the information in all indicators, not just the GEP index.

The GEP+ combines the information from the GEP index and the dashboard of sustainability indicators into a measure of progress that can give us an overall assessment that is conceptually sound (as it was explained in Section 3). It also produces very intuitive results, as illustrated in the examples discussed below.

In Table 3, we showed that part of the lack of rank correlation between the GEP index, the EPI, and the GGEI was due to the weighting system. In addition, the fact that both EPI and GGEI have indicators related to sustainability like CO2 emissions could also explain such differences.

In fact, Table 5 shows that there is a positive and statistically significant correlation of the ranking from the GEP+ (which also takes into account the sustainability indicators from the dashboard) and those produced by the EPI and the GGEI. (See Appendix B, for a more detailed description of the indicators used in the EPI and GGEI.)

Table 5 shows that there is a positive and statistically significant rank correlation

Table 5: Rank correlations for GEP+, Progress, EPI and GGEI (Source: authors' calculations based on PAGE (2017b), GGEI (2016) and Hsu, A. et al. (2016))

	Rank GEP+	Rank GEP index	Rank EPI	Rank GGEI
Rank GEP +	1			
	100			
Rank GEP index	0.2338	1		
	100	100		
Rank EPI	0.3122	0.0368	1	
	100	100	100	
Rank GGEI	0.4003	0.1689	0.4255	1
	62	62	62	65

between the GEP+ and both EPI and GGEI. The correlations in Tables 4 and 5 illustrate that, although many indicators may be aiming to capture progress on green economy, their differences in terms of what indicators they include and how they're calculated could matter a great deal in terms of the assessment done. Knowing such differences is key in the interpretation and comparison of results among different methodologies.

4.4 Are measures like the GEP+, EPI or GGEI adding information relative to what we can learn from per capita GDP growth?

Arguing the need to go beyond the GDP, which is particularly important for promoting a transition towards an IGE, started the conceptual discussion. In this section, the results from the GEP+ are checked to see if they add relevant information relative to what can be learned from analyzing per capita GDP growth.

Figure 5 (overleaf) presents the rank differences of GEP+ versus per capita GDP growth rank. Notice that an observation in red (green) means that the rank of GEP+ is higher (lower) that the rank of per capita GDP growth. As we can see from the figure, the information presented in the GEP+ is very different from the ranking information from per capita GDP growth. The rank correlation is -0.6051 and statistically significant at 1 percent.

The countries highlighted in the figure represent the top and bottom 5 percent of the sample in terms of improvements in position relative to other countries, or when comparing rankings from the GEP+ with those from the per capita GDP growth. For example, if we only use per capita GDP growth, countries like China and Belarus will appear in the top positions of the ranking, but when we focus on progress towards an IGE (measured by the GEP+), these countries appear at the bottom of the distribution.

The opposite is true for countries like Italy, Japan and United Kingdom. These countries are among the top 20 in the GEP+, but perform among the bottom 20 countries (out of 100) in terms of per capita GDP growth.

Table 6 shows the rank correlation between GEP+, EPI, GGEI and GDP growth. There is a statistically significant negative correlation between the ranking from GDP growth

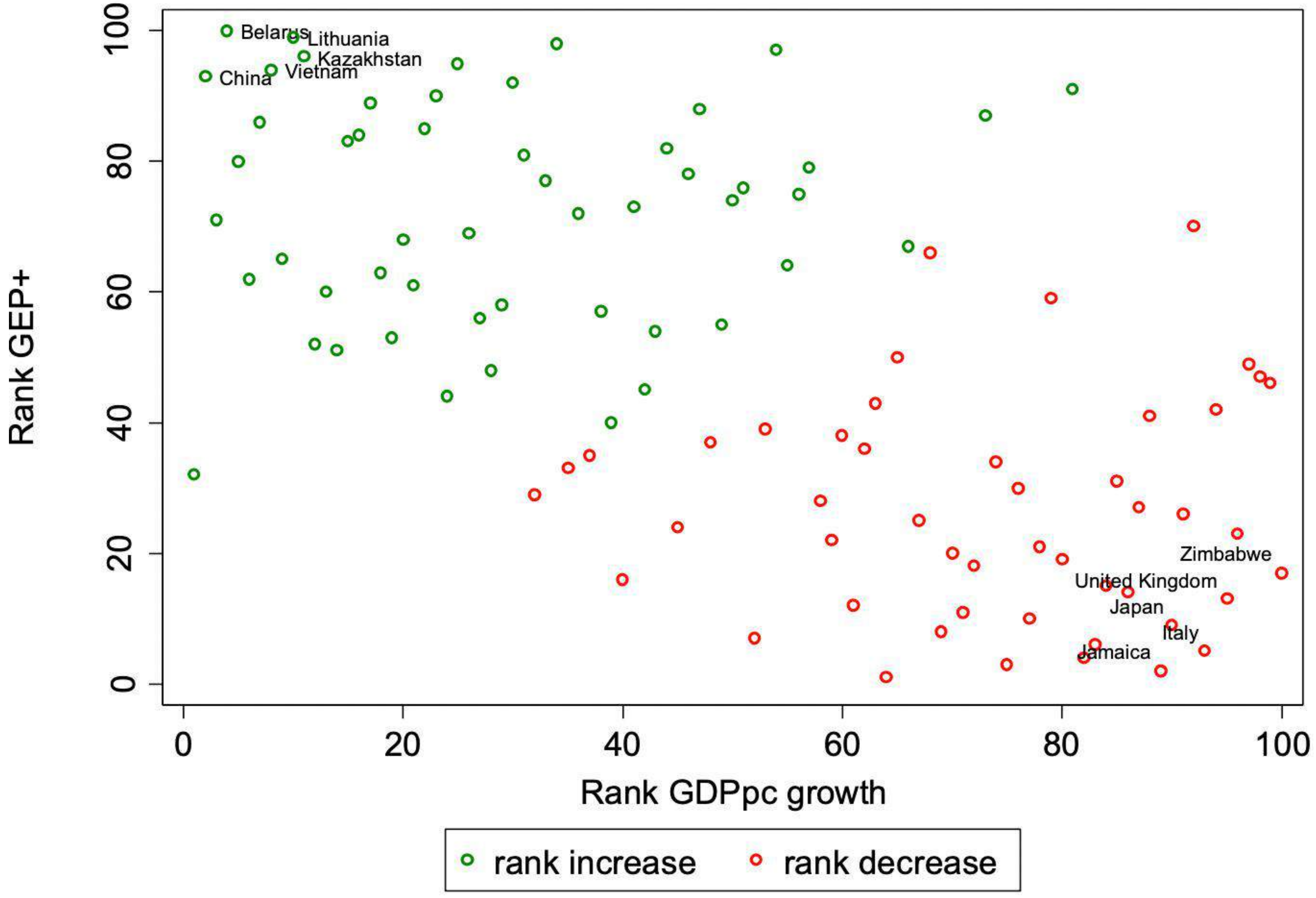

Figure 5: Rank differential of GEP+ vs GDP growth. (Source: Authors' calculations based on PAGE (2017b)

Key note:

Notice that in terms of the three countries discussed on table 2, the relative ranking in terms of GDP growth will be the opposite, with China being at the top with Colombia and Ireland many positions behind, which is not the case when we focus on indicators measuring green economy progress.

and the ranking from the GEP+ and GGEI, while the correlation is not statistically significant for EPI. This result illustrates that green economy indicators present a very different assessment of progress than GDP growth, which reinforce the need for **pushing forward the work on green economy indicators** as part of the broader beyond GDP agenda.

5. Concluding remarks

In this Chapter, some of the main methodological and practical aspects to consider when working with green economy indicators were presented. The discussion in Sections 6 and 7 from Chapter 2 was built on and an extensive list of the main approaches for the measurement of green economy was presented, and some of the challenges we face to achieve a unified framework was discussed. Particular focus was on the green economy measurement framework, recently developed by PAGE, since it is an example of a comprehensive methodology for the monitoring of progress towards key social, economic and environmental goals, integrating key theoretical aspects to its methodology and application. The GEP measurement framework follows an extraordinarily pragmatic approach, guided by theory.

An effort to focus on measurement instruments that will be a practical guide to policy at the country level was made. This allows for tracking their performance in key stocks such as material footprint, rising emissions and increased freshwater withdrawal, while at the same time ensuring that further development is not put at risk, economic opportunities are created, ecosystem services are preserved, and social inclusiveness is promoted. Towards the end of the chapter, the results from the GEP framework was compared with other well-known indices measuring green economy, the EPI and the GGEI, to illustrate the implications of using different indicators, discussing their main results and highlighting some of their important differences (in terms of methodology and indicators used). In some cases, specific countries examples were used in order to illustrate the main points and why these methodologies may be providing different, and many times complementary pictures, of countries' progress on green economy. This kind of analysis is critical for assessing the policy implications of using any measurement framework to help select among competing frameworks, and to keep advancing the frontiers on this line of research.

The GEP measurement framework, in its current state, satisfies the *basic desiderata*, synthetizes the ideas of monitoring changes in key variables, taking into account: (a) global thresholds that should not be surpassed; and (b) ambitious but achievable targets that may help the countries move in the right direction through policy interventions. These are critical to obtaining a useful measure of progress, which will be recognized as a valid instrument by practitioners, as well as by the wider community of researchers and academics working in the field.

The flexibility of the GEP measurement framework has allowed its application for policymaking at the country level. The methods used in the framework are flexible when it comes to selecting indicators, thereby making inter-country comparison possible as long as the underlying data is available, allowing for adjustments in the choice of indicators to specific country needs and priorities. A particular application of this framework was done by the Partnership for Action on Green Economy (PAGE) for China's Jiangsu Province in 2017. At the same time, the United Nations Industrial Development Organization (UNIDO) launched a project to construct a Green Industry Progress (GIP) index as a sectorial focused index, which would complement the ongoing PAGE development of a GEP index. The latest application of the methodology ranks the progress of 18 Chinese provinces based on seven indicators. Similar efforts are ongoing in other countries as South Africa, taking advantage of the methodology's ability to do benchmarking at the national and international level to inform policymaking.

Finally, a variety of green economy indicators were shown which can portray a very different assessment of progress than just focusing on GDP growth. Although the challenges on green economy measurement are many, results like this illustrate the importance of going beyond GDP, in particular for the measurement framework to support the transformative policy agenda suggested by the green economy.

Appendix A: The sustainability of present well-being

Claim:

If present well-being $W(t)$ is sustainable, then $DV^*(t) \geq 0$.

Proof:

Let W(t) be sustainable. Then,

$$W(\tau) \geq W(t), \text{ for all } \tau \geq t. \quad \text{(A.1)}$$

Therefore, along the trajectory $Y^*(K(t))$ we obtain, integrating both sides of (A.1),

$$V^*(t) = \int_t^{\infty} W(y^*(\tau))e^{-\mu(\tau-t)} \geq \int_t^{\infty} W(y^*(t))e^{-\mu(\tau-t)} = \frac{W(y^*(t))}{\mu},$$

that is,

$$V^*(t) \geq \frac{W(y^*(t))}{\mu} \quad \text{(A.2)}$$

Now applt Leibnitz rule to $V^*(t) = (V(y^*(K(t)))$ to obtain

$$dV^*(t) = -W(y(t)) + \mu V^*(t). \quad \text{(A.3)}$$

It follows from (A.2) that $\mu V^*(t) \geq W(y^*(t))$, and from (A.3) we obtain that $\mu V^*(t) - W(y^*(t)) = dV^*(t) \geq 0$.

Appendix B: The Green Economy Progress Measurement Framework

B.1 The determination of the importance levels of the components of GEP and its units

In Section 3.4 a general principle was introduced to satisfy green economy measurement framework: that different countries can value certain kinds of progress more than others, depending on their initial conditions and other country characteristics. The GEP measurement framework uses the idea of thresholds to make this general principle operational. If it is desirable that a country's level for variable y_i be above a certain threshold t_i greater importance is assigned to progress in that variable if the country's current level is below the threshold.

On the other hand, if it is desirable that a country's level for another variable y_i to be below a certain threshold t_i a greater importance is assigned to progress in that variable if the country's current level is above the threshold. The interpretation is that progress in a variable is more important the worse the country is, in relationship to the relevant threshold for that variable.

Specifically, the importance of progress in variable y_i is defined as $Importance(i)$ to be equal to if $\frac{t_i}{y_i^0}$ the outcome is for variable y_i to grow (like with education, protected areas and other 'goods'), and to be equal to $\frac{y_i^0}{t_i}$ if the outcome is for variable y_i to shrink (like with air pollution, inequality and other 'bads').

The implementation just described establishes the relevant tradeoffs between the different dimensions of progress (as represented the slopes of the level curves illustrated in Figure 2). It allows for comparisons between different types of progress for each country and to make an overall determination of whether or not a country is making progress. Thus far, however, the implementation is silent about the units in which GEP is measured. This determination is important, for example, in order to know how to compare the GEP to its component parts (the progress measures for each variable of interest), and how to compare the GEP of different countries.

To make this determination, the GEP measurement framework adopts the 'equivalence approach' from microeconomics. For a given progress profile *[Progress(1),Progress(2),..., Progress(I)]* of the indicators that matter for present well-being the GEP of this country is identified with the level L such that, if the country were to progress in each of its dimensions by a magnitude equal to L, it would achieve the same level of green economy progress as when the country's progress profile is actually *[Progress(1),Progress(2),... ,Progress(I)]*. It follows, in particular, that if $Progress(i)=1$ for all $i=1,\dots, I$, then $GEP=1$, which implies that:

$$\kappa \cdot \sum_{i=1}^{I} Importance(i) = 1.$$

As a consequence, the magnitude and sign of the GEP can be interpreted in the same way as was each individual measure of dimensional progress: when GEP is equal to one this means the country is equivalent to a position in which it met all its targets, when it is greater than one this means the country is equivalent to a position where it exceeded its targets, so on and so forth.

Figure B1 again illustrates how this works. In the Figure, countries A and B exhibit the same magnitude of progress in both variables in point x: they exceeded their target in variable 2 by 75 percent while they fell short of their target in variable 1 also by 75 percent. A simple average would put country A and B in the same level of progress overall, but that is not what the GEP does. In this example, country A is below its threshold –a bad thing– in variable 1 and above its threshold –a good thing– in variable 2. It is, therefore, far more important for country A to improve in variable 1 than in variable 2, and the GEP consequently puts greater weight on variable 1 relative to variable 2. This is what makes the level curves for country A's GEP comparatively steep. The GEP for country A in situation x can be found by identifying where the level curve that passes through x crosses the 45-degree line. Because this level curve is steep, this intersection happens below the 'perfect progress' point (1,1), which means that the country gets a GEP less than one. In the same example, country B is above its threshold –a good thing– in variable 1 and below its threshold –a bad thing– in variable 2. It is therefore far more important for country B to improve in variable 2 than in variable 1, and the GEP consequently puts greater weight on variable 2 relative to variable 1. This is what makes the level curves for country B's GEP comparatively flat. The GEP for country B in situation x can be found by identifying where the level curve that passes through x crosses the 45-degree line. Because this level curve is flat, this intersection happens above the 'perfect progress' point (1,1), which means that the country gets a GEP greater than one. Put simply, country B's GEP is greater than country A's GEP because country B made comparatively more progress in the dimension where it needed it the most.

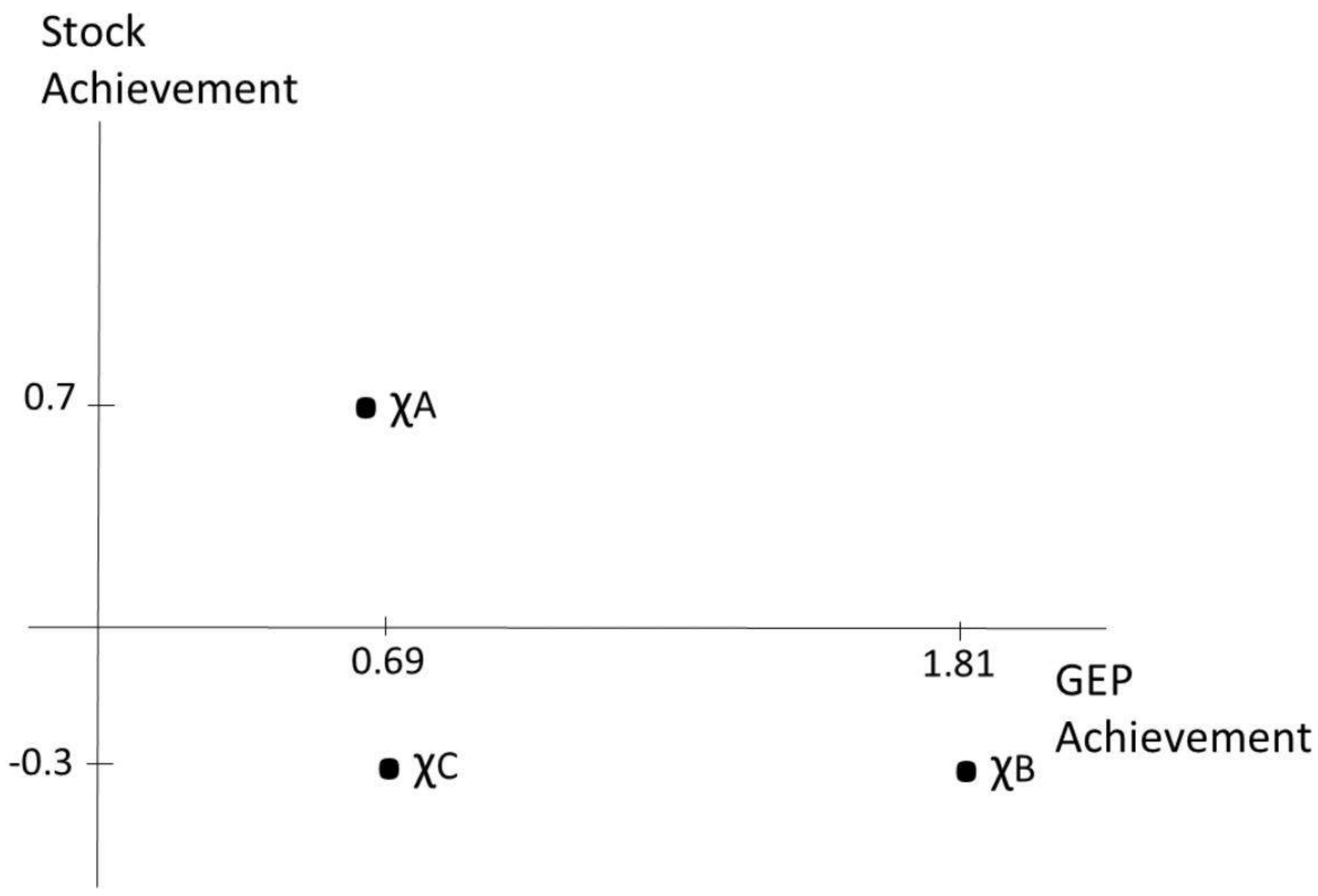

Figure B1. The GEP Index-Dashboard space

Box 10.1: The details from the example illustrated in Figure B1.

The parameters behind the example in Figure 2 are the following: Variable 1 is a good, variable 2 is a bad. *Progress(1)= 0.25, Progress(2) = 1.75*.

These are the progress levels for these variables for both countries, which means that both countries improved their levels of variable 1 and reduced their levels of variable 2. The thresholds for all variables equal 1 for both countries. The rest of the variables are as follows: For country A we have $y_1 = y_2 = 0.5$, whereas for country B we have $y_1 = y_2 = 2$. It follows that the slope of the level curves of the countries' GEP are: -4 for country A and -.25 for country B, and that *Importance(1) = 2, Importance(2) = 0.5* for country A, whereas *Importance(1).5, Importance(2) = 2* for country B.

The weights on progress for country A are then $\kappa_A \cdot Importance_A(1) = 0.8$ and $\kappa_A \cdot Importance_A(2) = 0.2$, while these same weights are $\kappa_B \cdot Importance_B(1) = 0.2$ and $\kappa_B \cdot Importance_B(2) = 0.8$ for country B.

Finally, the GEP for country A is then 0.55 and the GEP for country B is 1.45.

B.2 The determination of the importance levels of the components of the dashboard

To determine the importance levels of the components of the dashboard, the GEP measurement framework proceeds just as with the determination of the importance levels of the variables in the GEP index. In other words, *Importance(j)* is determined to be equal to $\frac{t_j}{K_j^0}$

in order for stock K_j to grow, and to $\frac{K_j^0}{t_j}$

in order for stock K_j to shrink.

B.3 The Protective Criterion and its Properties

To understand how one could use the information in the achievement profile of two countries to see which country is in a comparably more favorable position than another, we consider first the case is one in which a country's achievement levels are larger than the same respective achievement indicators for some other country. It is then perhaps suitable to assert that the first country is in a more favorable position than the second country. This is, after all, what the Pareto principle, when applied to this setting, would prescribe.

While less obvious, there are two additional cases in which one could argue that a comparison between countries is suitable.

Consider the case where x and z are the achievement profiles of two countries. Then it can be argued that if x is in a more favorable position than z, it must be that the worst achievement in x is greater than the worst achievement in z. This is the principle of *Priority to the Worst Achievement*.

To illustrate the principle, go back to the example illustrated in Figure 3 and add a dashboard to each country consisting of a single capital stock, with a measured level of achievement equal to 0.7 for country A and -0.3 for country B.

These index-dashboard achievement combos are illustrated in Figure A1 as points x_A and x_B. [1] The worst achievement for country A is therefore 0.69, whereas for country B is -0.3. The principle says that country B cannot rank over country A, since 0.69 > -0.3. While in this example Country B obtains a high GEP achievement, equal to 1.81, it achieves it at the cost of depleting its capital stock, as represented by the -0.3, and it cannot obtain a high rank as a consequence. Even if country B's GEP achievement level was much higher, the conclusion would be the same.

Consider now a case where x and z are the achievement profiles of two countries, such that they share the same achievement in some dimension. Then it is reasonable to assert that whether x is in a more favorable position than z is independent of how the countries do in the dimension in which they fare equally well. This is the principle of *Independence of Identical Achievements*.

To illustrate the principle, go back to the example illustrated in Figure B1 and consider country C, with a GEP achievement of 0.69 (just like for country A) and a measured level of achievement for the capital stock of -0.3 (just like for country B). Because achievement in the capital stock level is the same for B and C the principle says that the countries ought to rank according to the GEP achievement information alone, and country B would rank over country C, since 1.81 > 0.69. Similarly, the GEP achievements are the same for A and C and the principle says that the countries ought to be ranked according to the achievements on the capital stock alone.

Thus A would be ranked over C, since 0.7 > -0.3. Notice that this is a refinement over what the principle of Priority to the Worst Achievement would prescribe in this case, as that principle would allow countries B and C to be ranked equally, since the worst consequence in both cases is the same and equal to - 0.3.

These principles, therefore, countries are ordered in terms of their worst achievement, but only considering the dimensions on which they differ. This order is known as the protective criterion [2]. This methodology would allow all index-dashboard achievement profiles to be ranked but not to combine the index and dashboard information into a synthetic index [3].

1 Because the average importance of the progress indicators is 1.25 in that example (see Box 1 above), the GEP achievements for the countries are, respectively, 0.55 * 125 = 0.69 for country A and 1.45 * 1.25 = 1.81 for country B.

2 Barberà and Jackson (1988).

3 This is so because the Protective Criterion (see Annex I.C in UNEP (2016)), like the leximin, does not admit a real-valued representation due to the lack of continuity of the preference ordering. For proof see the example of Moulin (1998, page 34).

Appendix C: Details on indicators and weights on selected composite indices

Table C1: Yale Environmental Performance Index (EPI).
Environmental health (40%)
Source: Hsu, A. et al. (2016). 2016 Environmental Performance Index. New Haven, CT: Yale University. Available: www.epi.yale.edu.

Policy category	Indicator	Indicator description
Health impact (33%)	Child mortality (100%)	Probability of dying between a child's first and fifth birthdays (between age 1 and 5)
Air quality (33%)	Household air quality (33%)	Percentage of the population using solid fuels as primary cooking fuel
	Air Pollution avg. Exp to PM2.5 (33%)	Population weighted exposure to PM2.5 (three- year average)
	Air Pollution avg. Exp to PM2.5 exceedance (33%)	Proportion of the population whose exposure is above WHO thresholds (10, 15, 25, 35 micrograms/m3)
Water and sanitation (33%)	Access to drinking water (50%)	Percentage of population with access to improved drinking water source
	Access to sanitation (50%)	Percentage of population with access to improved sanitation

Table C1 (cont).
Ecosystem vitality (60%)

Policy category	Indicator	Indicator description
Climate and energy (25%)	Trends in CO2 emissions per KwH (33%)	Change in CO2 emissions from electricity and heat production
	Change of trend in carbon intensity (33%)	Change in Trend of CO2 emissions per unit GDP from 1990 to 2000; 2000 to 2010
	Trend in Carbon Intensity (33%)	Change in CO2 emissions per unit GDP from 1990 to 2010
	Access to electricity (N/A)	Per cent of population with access to electricity
Biodiversity and habitat (25%)	Terrestrial Protected Areas (National Biome Weights) (25%)	Percentage of terrestrial biome area that is protected, weighted by domestic biome area
	Terrestrial Protected Areas (Global Biome Weights) (25%)	Percentage of terrestrial biome area that is protected, weighted by global biome area
	Marine Protected Areas (25%)	Marine protected areas as a per cent of EEZ
	Critical Habitat Protection (25%)	Per cent of critical habitat sites as designed by the Alliance for Zero Extinction protected
Fisheries (10%)	Coastal shelf fishing pressure (50%)	Catch in metric tons from trawling and dredging gears (mostly bottom trawls) divided by EEZ area
	Fish Stocks (50%)	Percentage of fishing stocks overexploited and collapsed from EEZ
Forest (10%)	Change in forest cover (100%)	Forest loss - Forest gain in > 50% tree cover, as compared to 2000 levels

Table C1 (cont).
Ecosystem vitality (60%)

Policy category	Indicator	Indicator description
Agriculture (5%)	Agricultural subsidies (50%)	Subsidies are expressed in price of their product in the domestic market (plus any direct output subsidy) less its price at the border, expressed as a percentage of the border price (adjusting for transport costs and quality differences)
	Pesticide regulation (50%)	Scoring of whether countries have signed on to the Stockholm Convention and allow, restrict, or ban the "dirty dozen" POPs that are common agricultural pesticides
Water resources (25%)	Wastewater management (100%)	Wastewater treatment level weighted by connection to wastewater treatment rate

Table C.2 Global Green Economy index (GGEI). Source: Dual Citizen (2016). "The Global Green Economy Index GGEI 2016 Measuring National Performance in the Green Economy". 5th Edition - September 2016.

Sector	Sub-category	Source
Leadership & Climate Change (25%)	Climate Change Performance (50%)	International Energy Agency (IEA), Climate Change Performance Index (CCPI)
	International Climate Forums (20%)	Climate Action Network (ECO) reporting scored by Dual Citizen LLC on scale of 0-10
	Head of State (20%)	Google Analysis scored by Dual Citizen LLC on scale of 0-10
	Media Coverage (10%)	Google Analysis scored by Dual Citizen LLC on scale of 0-10
Efficiency Sectors (25%)	Buildings (25%)	LEED certification as reported by the U.S. Green Building Council (USGBC)
	Transport (25%)	International Energy Agency (IEA)
	Tourism (25%)	Scored by Dual Citizen LLC on scale of 0-10
	Energy (25%)	International Energy Agency (IEA)
Markets & Investment (25%)	Renewable Energy Investment (25%)	Renewable Energy Country Attractiveness Index (RECAI, Ernst & Young)
	Cleantech Innovation (30%)	Global Innovation Index (INSEAD), Cleantech Group, Heslin, Rothenberg, Farley & Mesiti p.c.
	Cleantech Commercialization (20%)	WWF Cleantech Group Global Cleantech Innovation Index 2014
	Green Investment Promotion & Facilitation (25%)	Scored by Dual Citizen LLC on scale of 0-10
Environment & Natural Capital (25%)	Agriculture (17%)	Environmental Performance Index 2014 (Yale University)
	Air quality (17%)	
	Water (17%)	
	Biodiversity & habitat (17%)	
	Fisheries (17%)	
	Forests (17%)	

Appendix D: An overview of measurement frameworks

Table D.1 An overview of measurement frameworks

Initiative	Framework type	Organisation	Details	Limitations
System of Environmental-Economic Accounting (SEEA)	Adjusted economic measures	United Nations, the European Commission, the FAO, the OECD, the International Monetary Fund and the World Bank Group	• International standard for environmental accounting (Ecorys, 2012); • Organizes information in an integrated and conceptually coherent manner to inform decision-making; • Can be applied fully or partially, depending on the needs, priorities and resources of its users; • Base of Inclusive Wealth Index and Adjusted Net Savings (see below).	• Missing full valuation of assets and flows related to natural resources and land; • Estimates of $dV^*(t)$ not satisfactory; • Accounts for depletion of natural resources, but not for overconsumption or underinvestment (Ecorys, 2012); • No consideration of quality of resource accounts, e.g. water, soil (Ecorys, 2012).
Genuine Progress Indicator	Adjusted economic measures	Centre of Sustainable Economy, Institute for Policy Studies	• Includes welfare losses from environmental and social factors in the calculation of a revised GDP (Hamilton 2002); • Income equality as a measurement of inclusivity.	Estimates of $dV^*(t)$ not satisfactory.
Inclusive Wealth Index (IWI)	Adjusted economic measures	United Nations University International Human Dimensions Programme on Global Environmental Change, UN Environment, UN-Water Decade Programme on Capacity Development, Natural Capital Project	• Tracks a country's amount of capital by analyzing its productive base; • Covers 140 countries over 20 years; • Produced every two years focusing on a specific topic.	Estimates of $dV^*(t)$ not satisfactory.
Adjusted Net Savings	Adjusted economic measures	Pearce and Atkinson (1993), World Bank data	• Extension of GDP; • Covers 213 countries; • Calculated by adding education expenditure to net national savings and subtracting energy depletion, mineral depletion, net forest depletion, carbon dioxide and particulate emissions damage. (World Bank 2018).	• No explicit accounting for inclusivity; • Estimates of $dV^*(t)$ not satisfactory; • Key estimates, such as the value of fossil water, net depletion of fish stocks, degradation of soils, important pollutants are missing from the calculation (World Bank, 2018); • Education expenditure is seen as an investment in human capital, without accounting for its effectiveness (Hamilton, 2002); • Sustainable growth rate of consumption set at 2.5% in the model is subject to debate (see Chapter 1) (Ecorys, 2012)

Table D.1 (cont.)

Initiative	Framework type	Organisation	Details	Limitations
Green Growth Indicators	Dashboard of indicators	OECD	• Comprises more than 50 indicators in four groups: environmental and resource productivity, natural asset base, environmental quality of life, economic opportunities and policy responses; • Collected for 34 countries; • Subset of six representative indicators to simplify communication.	• No explicit accounting for inclusivity; • Little coverage of indicators related to adaptation or resilience (Ecorys, 2012); • No threshold or target stock.
Sustainable Development Indicators (SDIs)	Dashboard of indicators	Eurostat	• Covers 28 EU countries; • Includes more than 100 indices grouped into ten categories: Socioeconomic development, Sustainable consumption and production, Social inclusion, Demographic changes, Public health, Climate change and energy, Sustainable transport, Natural resources, Global partnership, and Good governance; • 12 representative indicators to simplify communication.	• Difficult to monitor progress; • No threshold or target stock.
Yale Environmental Performance Index (EPI)	Composite index	Yale (Center for Environmental Law & Policy) and Columbia University (Center for International Earth Science Information Network)	• Covers 178 countries; • Calculated every two years; • Two main categories: environmental health and ecosystem vitality, with 9 subsections and 20 indicators.	• No explicit accounting for inclusivity; • Difficult to interpret; • Targets for some indicators are debatable, such as for marine protected areas (Ecorys, 2012).
Low Carbon Competitiveness Index (LCCI)	Composite index	The Climate Institute, Vivid Economics	• G20 countries; • Determines capacity of each country to be competitive and generate material prosperity to its residents in a low carbon world.	• No explicit accounting for inclusivity; • Difficult to interpret.
Global Sustainable Competitiveness Index (GSCI)	Composite index	World Economic Forum (WEF)	• Covers 180 countries; • 109 quantitative performance indicators in five groups of sustainable competitiveness.	• No explicit accounting for inclusivity; • Difficult to interpret.

Table D.1 (cont.)

Initiative	Framework type	Organisation	Details	Limitations
Global Green Economy Index (GGEI)	Composite index	Dual Citizen LLC	• Covers 60 countries; • 32 underlying indicators and datasets in four main dimensions of leadership & climate change, efficiency sectors, markets & investment and environment & natural capital.	• Difficult to interpret.
Green Economy Progress Measurement Framework (GEP)	Index-dashboard combination	EPartnership for Action on Green Economy (PAGE)	• Composed of a GEP index, a companion dashboard of sustainability indicators, and a country ranking.	• Complex.

Additional sources:

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CHAPTER 11: GREENING THE FINANCIAL SYSTEM

CHAPTER 11: GREENING THE FINANCIAL SYSTEM

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline the main challenges facing humanity and analyse their drivers;
- Articulate how the inclusive green economy model seeks to address these challenges; and
- Understand the major characteristics that underpin national strategies on inclusive green economy, the related analytical tools, key actors and initiatives as well as the critical role of public policy in turning the inclusive seen economy model into practice.

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CHAPTER CONTENTS

1. Introduction

Finance is the lifeblood of the economy and its keystone is the global financial system. It deploys US$300 trillion of mostly private finance assets through a financial system made up largely of banks, investors and insurance companies and a vast network of intermediaries. The pathways of economies – from the world's major nations to the most local community markets - are shaped by the financial system's evolving design and practice and is governed by a complex array of national and international policy makers, regulators, standards bodies and norms. Beyond this formal system lies the financing aspect of the informal economy, though these are rarely included in discussion and analyses of the financial system.

This chapter explores the relationship between the financial system and sustainable development, focusing on how financial and capital markets enable or impede the timely development of an inclusive green economy (IGE). The chapter provides background and the definitional and methodological building blocks needed to enable more systematic analysis. Underlying this, however, and described in the third section of the chapter, is a 'ground-up' view of on-going policy and market innovations seeking to improve the alignment of the financial system with sustainable development (see Exhibit 1), drawing on key reports and articles published by and through UN Environment (Robins & Zadek, 2015, 2016; Zadek, 2016). Building on these sections, the chapter concludes with considerations for the future.

> ***"Imagine a financial system that serves the long-term needs of a healthy real economy, an economy that provides decent, productive and rewarding livelihoods for all, and ensures that the natural environment remains intact and so able to support the needs of this and future generations. Imagine, furthermore, a financial system that is resilient and so able to serve its core purpose in the face of growing environmental and other sources of volatility."***
>
> Source: Zadek, 2016

1.1 Green Finance

Financing sustainable development will require the large-scale mobilization and redirection of investable funds. In the most comprehensive assessment to date, the United Nations Conference on Trade and Development (UNCTAD) World Investment Report 2014 has estimated that US$5-7 trillion a year are needed to finance the Sustainable Development Goals (SDG). Of the US$3.9 trillion per year that developing countries will need, only US$1.4 trillion is currently being supplied, resulting in a gap of US$2.5 trillion, which needs to be filled by private and public sources (UNCTAD, 2014). Much of this investment is for the development of IGE, notably access to energy, biodiversity, climate change, food security, water, and sanitation (ICESDF, 2014).

Public finance will only provide a small fraction of total financing needs for sustainable development?? (Greenhill et al., 2015). In China, for example, total green finance is estimated to require about US$600 billion annually, of which no more than 15 per cent can be expected to come from public sources, according to the People's Bank of China and the Development Research Centre of the State Council (PBoC & UN Environment, 2015; DRC & IISD, 2015). The bulk of the financing, in short, will need to come from financial and capital markets.

Modern economies depend on an increasingly sophisticated financial system to supply everything from payment services to investment, lending and insurance. Billions of transactions every day by hundreds of millions of people and institutions determine the creation and deployment of hundreds of trillions of dollars in financial assets. Every one of these transactions has some combination of social, economic and environmental impacts, whether positive, negative or both. Green finance, therefore, is not limited to a designated product or service, but concerns the manner in which decisions across the financial system take environmental considerations into account.

On a conceptual level, 'green finance' has been broadly defined by the G20 as "financing of investments that provide environmental benefits in the broader context of environmentally sustainable development" (G20 Green Finance Study Group, 2016). Environmental benefits might include, for example, reduction in air, water and land pollution, reductions in GHG emissions, and improved energy efficiency while utilizing natural resources. Such crucial benefits are associated with green economy developments in underpinning new green industrial sectors, products and technologies. Green finance, through the lens of financial decision-making, boosts environmentally friendly investments and reduces environmentally harmful ones by internalizing environmental externalities and adjusting risk perceptions. Table 1 provides an overview of categories of green finance by sector.

Green finance is a subset of sustainable finance, which embraces the full range of outcomes that need to be addressed in pursuit of sustainable development. For example, the UN-hosted 'Financing for Development' process, builds on the Addis Ababa Action Plan, which concerns financing for the SDGs, or the 2030 Agenda. Green finance includes many aspects of financing that addresses climate challenges. However, as climate

Table 1: Green finance taxonomies (illustrative only)

Concept	**Core** Categories broadly included across taxonomies	**Additional** Categories included in some taxonomies
Clean energy	Wind, geothermal, solar, small-scale hydro, biomass.	Other renewables, waste-to-energy, co-generation, nuclear large hydro, bioenergy feedstocks, clean coal, Improvements in fossil fuels, Cleaner fuel production
Electricity transmission	Transmission systems for renewables, storage systems, smart-grid, mini-gird.	Improving efficiency of transmission systems.
Efficiency	Waste heat recovery, industrial energy efficiency, co-generation, energy efficient products.	Efficient products, energy efficiency in fossil fuel use.
Green buildings	Building retrofits, new green buildings, energy audits, energy services, equipment (e.g. lights, HVAC).	Advance materials.
Transport	Urban mass transit, non-diesel railways.	Electric vehicles, hybrids, alternative fuel vehicles, Bicycle, pedestrian, waterways, logistics improvement, diesel railways, rail for transport of fossil fuels.
Non-energy greenhouse gases	Coal mine methane capture, fugitive emissions from gas and oil, carbon capture and storage, reduction in greenhouse gas emissions from cement and chemicals production.	
Pollution control and waste	Air and water pollution control, soil remediation, mine rehabilitation, waste to energy, waste gasification, composting, emissions scrubbers and filters, recycling.	Waste: landfill and incineration without energy/gas capture.
Agricultutre and land	Energy and water saving, afforestation, plantation, reforestation, managing forests for carbon, soil carbon management, no-till farming.	Conservation agriculture, sustainable fisheries, Identification of protected ecosystems, ecotourism.
Water	Water savings.	Municipal, industrial and agricultural water supply, improved drainage, treatment of wastewater to meet compliance obligations.
Disaster and resilience		Climate resilient infrastructure, Early warning systems, insurance against natural disasters.
Other		Broadband, Data centres using renewable energy, low carbon energy powered mobile base stations, Virtual conferencing/ tech substitution.

change also has an impact on social and economic outcomes, there are additional finance needs, which are not necessarily related directly to reductions in emissions or energy use. Furthermore, green finance covers aspects of financing not related to the climate, such as land remediation and waste management. In practice, green finance will always be loosely defined because of the connections to other parts of the sustainable development agenda. For example, financing clean energy can reduce the number of premature deaths, currently US$6.5 million every year, from air pollution linked to the energy system (OECD, 2016). Similarly, financing that reduces the impact of natural catastrophes on people could reduce the numbers displaced from their homes, currently an average of 26.4 million people every year. Thus, green finance in this context can also be seen as a financing for overall sustainable development more generally.

1.2 Why intervene in the financial system?

Conventional wisdom among economists suggests that the 'first best' solution to real economy externalities would be to intervene in the real economy. Pricing the negative effects of greenhouse gas emissions into markets for products and services is without a doubt key to addressing climate change (see also Ch.8 on fiscal policy). In some instances, this is a matter of correcting policy failures. The IMF, for example, calls for an end to energy subsidies that it estimates at US$5.3 trillion annually, or about 6.5 per cent of global GDP (Coady et al., 2015). Such subsidies, the IMF highlights, are made up of a combination of policy and market failures – policy failures including continued direct fossil fuel subsidies, and market failures including the externalised societal costs of negative health effects of carbon intensive energy production. Equally, tapping into private capital to provide finance for investments that have positive externalities as well as private benefits can legitimately require the subsidizing of the incremental costs to deliver the public benefits. Bringing forward the deployment of renewables is a case in point, where extensive use has been made of public subsidies or imposed surcharges on electricity consumer prices.

Interventions in the financial system may also be warranted. Here, the focus is on four specific circumstances (Robins & Zadek, 2015; Zadek, 2016; see also Exhibit 2):

(i) *Valuing externalities*: Action may be justified where financial markets systematically misprice the impact of externalities on financial returns, and thereby create negative spill-over impacts on third parties or society in general.

(ii) *Promoting innovation*: Action may be justified to stimulate "missing markets", generating positive spillovers, for example, through common standards for financial instruments that improve liquidity in embryonic areas.

(iii) *Managing systemic risks*: Action may be justified where the stability of parts of the financial system may be affected by environmental impacts, or by associated policy, technological and social responses.

Box 11.1: Barriers to transformational financing

Multiple barriers exist to mobilizing transformative levels of financing. These include weaknesses in project pipelines, significant incremental costs to "greening" infrastructure, poor commercial opportunities in financing the realization of some goals, scarcity or poor use of available public resources, and inadequate enabling environment for private investment.

The G20's innovative work on green finance highlights barriers within the financial system itself. A fundamental barrier is the continued failure in financial decision-making to account for environmental and related financial impacts. Information asymmetries explain this shortfall in part, as financial decision-makers do not have the data to understand social and environmental factors. Short-termism can deter financing from sustainable investments that tend to be more capital intensive with associated lower operating costs. Mispricing environmental risk can deter green financing and encourage investment in pollution-intensive assets.

Sources: G20 Green Finance Study Group, 2016; UN Environment & Smith School, 2014; Zadek & Robins, 2016

(iv) *Ensuring policy coherence*: Action may be justified to ensure that the rules governing the financial system are consistent with wider government policies.

These four reasons are, in the main, first-best solutions to providing public goods. The first three, in particular, which focus on ensuring markets effectively handle risk pricing, innovation and financial stability, are central to the role of financial policy makers and regulators, as well as standard-setters. From this perspective, these reasons for intervening need not concern any direct policy or principled interest in advancing an inclusive green economy.

The fourth intervention concerning policy coherence does relate to the broader policy landscape. Conventional wisdom rightly seeks to ensure the independence of regulators from shorter-term, political interests that could do longer term damage to the financial system and in turn underlying prospects and performance. Regulatory coherence with longer-term monetary and financial policy objectives is, however, important and often critically so (Group of 30, 2015). The Bank of England's prudential review of the impact of climate change on the UK's insurance sector was, for example, in direct response to the UK's Climate Change Act (Bank of England, 2015).

Together, the instrumental or ultimate aim of these four interventions is to improve the working of the financial system, which can be best understood along three axes (Robins & Zadek, 2016):

- *Effectiveness*: degree to which markets price sustainability factors into asset values.
- *Efficiency*: costs of running a system that delivers financial flows against requirements.
- *Resilience:* susceptibility of the system to disruptions related to unsustainable development.

There are, however, also times where 'second best' is justified. In some countries, notably many developing countries, environmental regulatory enforcement remains weak, resulting in pollution and broader environmental degradation. Improving regulatory enforcement is almost always the first best solution but might not be available in the short to medium term for political or economic reasons. In such circumstances, second-best solutions enacted through financial system interventions may be the only option. Enhanced environmental lender liability is an example, which effectively engages banks under threat of legal action to act as environmental stewards where conventional enforcement is ineffective (Sampaio et al., 2016).

Alongside the core first and second-best reasons for intervening in the financial system to advance an IGE is the need to consider potential negative impacts and unintended impacts of action on the financial system or real economy outcomes. Such negative outcomes can arise for a number of reasons, each leading to the implementation of a flawed measures, either because of system complexities, conflicting objectives, or political interference. One case of conflicting objectives concerns moves to integrate climate risks into sovereign credit ratings. Positively, such integration would ensure that bond default risks were sensitive to climate-related factors, and that countries were incentivised to mitigate such risks through adaptation measures. What is problematic, however, is that the countries that will be most immediately impacted by such developments would be the world's poorest and most vulnerable, including the 40 members of the **V20** (V20, 2016).

Key definition: V20

Group of countries especially vulnerable to climate change. Member countries are Afghanistan, Bangladesh, Barbados, Bhutan, Burkina Faso, Cambodia, Colombia, Comoros, Costa Rica, Democratic Republic of the Congo, Dominican Republic, Ethiopia, Fiji, The Gambia, Ghana, Grenada, Guatemala, Haïti, Honduras, Kenya, Kiribati, Lebanon, Madagascar, Malawi, Maldives, Marshall Islands, Mongolia, Morocco, Nepal, Niger, Palau, Palestine, Papua New Guinea, Philippines, Rwanda, Saint Lucia, Samoa, Senegal, South Sudan, Sri Lanka, Sudan, Tanzania, Timor-Leste, Tunisia, Tuvalu, Vanuatu, Viet Nam, and Yemen.
Information adapted from: https://www.v-20.org/about/

In conclusion, aligning the financial system with the financing needs of IGE requires a three-fold approach: 1) policy measures and market innovation across the real economy, 2) public financing where private capital should not be expected to pay for the delivery of public goods and services, and 3) interventions in the financial system itself to correct policy and market failures and ensure policy coherence.

2. Momentum in Greening the Financial System

Interventions across the financial system to better align it with diverse aspects of sustainable development have increased rapidly in recent years. Broadly, these interventions can be placed in one or more of three categories:

- *Business-as-Usual Developments*: financial system reform and developments intended to improve performances that unintentionally impact the handling of one or more aspects of sustainable development. Building out local capital markets, especially in developing countries, generally leads to increased domestic, long-term financing, which can, in-turn, lead to more environmental and broader sustainable development-related risks and opportunities. Conversely, post-financial crisis measures to reduce the risk of bank failures, such as the **Basel 3 regulations**, tend to make longer term lending less profitable and unintentionally reduces financing for low carbon, climate

Key definition: Basel 3 regulations
Set of measures to strengthen the regulation, supervision and risk management of banks developed after the 2007 financial crisis. Adapted from: https://www.bis.org/bcbs/basel3.htm

resilient infrastructure such as renewable energy (Alexander, 2014).

- *Market and Blended Action*: market leadership from financial institutions has enhanced environmental and societal considerations in financial market decision-making, at times together with public actors through enabling frameworks and public finance. An example of market action are green bonds (UN Environment, 2015), new stock market indices, risk modelling, advances in credit ratings (PRI, 2016) and remuneration and voluntary disclosure arrangements. An example of blended action is development banks, which have taken a lead in blending public finance to leverage more private capital, and, in some instances, tax credits are used domestically with the same aim in mind, notably in the US (Usher et al., 2016).

- *Targeted Rule-Making*: specific non-market measures have been taken by financial institutions, policy makers, regulators, standard setters and other non-market actors, or market makers such as stock exchanges, to embed aspects of sustainable development in financial system decision making. UN Environment has identified over 200 of these 'green/social' targeted financial system reform and development innovations, highlighting the leadership taken by developing countries in banking regulatory innovations and the developed country leadership in the area of institutional investor (Robins & Zadek, 2016).

At the time of writing this chapter, as part of the work of the G20 Green Finance Study Group, UN Environment prepared a progress report covering policy and partnership action on green finance across the G20 membership, and internationally (UN Environment, 2017). As Table 2 (overleaf) illustrates, progress has been made across all members, albeit still in a patchy manner

Considerable progress has been made in advancing green finance at the national level. As early as 2007, for example, the China Banking Regulatory Commission established the Green Credit Guidelines, which over the subsequent period have evolved into an annual assessment of each bank's progress in greening its balance sheet. Building on this development, the People's Bank of China and UN Environment established a Green Finance Task Force in mid-2014. This task force produced recommendations that informed the decisions made by the State Council in August 2016, to advance the greening of China's financial system.

As Box 11.2 suggests, Kenya's advance of green finance began with its digital efforts to increase financial inclusion (UN Environment & IFC, 2015). Indeed, by 2014, Kenya had the world's highest use of mobile payments. Building on the dominant mobile payments platform, M-PESA, a number of additional financial services have been added. Notable has been M-KOPA, which uses the platform to enable poorer people to pay for renewable energy supplied by distributed solar technology. Other examples include the Swedish start-up, Trine, that has added crowd-sourcing in Sweden to this technological eco-system to pay for the initial capital costs.

Box 11.2: Momentum in greening the financial system

- *California* has introduced requirements for insurance companies to report on holdings in high-risk carbon assets (California Department of Insurance, 2016).
- *China* has introduced a comprehensive set of guidelines to establish a green financial system, including for banking, capital markets, insurance, local finance and international cooperation (PBoC, 2016).
- *France's* implementation of new reporting requirements for corporate, as well as more specific reporting from institutional investors, and ongoing work on the assessment of climate-related risks in the banking sector are a key part of its low carbon transition strategy (Institute for Climate Economics, 2015).
- India's securities regulator has introduced green bond requirements to boost financing, particularly for renewable energy (UN Environment & FICCI, 2016).
- *Kenya* is building on its global leadership in promoting financial inclusion by developing a plan to mobilize green finance and position itself as a regional hub (UN Environment & IFC, 2015).
- *The Netherlands* central bank has assessed the implications of climate change for its financial system (Sustainable Finance Lab, 2015; De Nederlandsche Bank, 2016).
- The Philippines has developed a public-private disaster insurance pool that will make disaster insurance compulsory for homeowners and SMEs (Halle, Forstater & Zadek, 2015).
- *Switzerland* has undertaken a comprehensive roadmap of the opportunities for the Swiss financial community in developing a green finance expertise and reputation (Swiss Federal Office of the Environment & UN Environment, 2015).
- The *UK* has launched a green finance initiative focused on advancing the City of London as a global green finance hub (McDaniels & Robins, 2016).

SolarCoin from the US is experimenting with blockchain and crypto-currencies to further enhance its offering.

Enhanced disclosure has been a favoured route into promoting green and sustainable finance. Brazil and South Africa house the first stock exchanges that introduced sustainability-related disclosure as part of their listing requirements. Today, the UNCTD-hosted Sustainable Stock Exchange initiative has a membership of over 60 stock exchanges across the world advancing enhanced disclosure. Most recently, the Financial Stability Board's Task Force on Climate-Related Financial Disclosure has made recommendations on how listed companies and financial institutions themselves might advance a more systematic approach to climate related disclosure (TCFD, 2017).

Green bonds have been a favoured approach to promoting capital-raising for green investments. Originally advanced by development finance institutions such as the World Bank and a small number of banks, notably Swedish SEB, green bonds are now a growing asset class across the world. These bonds are supported by an increasing number of standards, certification models and institutions, and active promotion by governments and regulators. Most recently, the Monetary Authority of Singapore has introduced the world's first subsidy for issuers of green bonds that will cover additional costs such as certification.

The global financial system is dominated by a small number of regional and international centres, which in turn have considerable influence over the development of international norms and standards. Over recent years, a number of these centres have moved to develop more integrated strategies for taking advantage of new green finance opportunities as a means of mitigating

Table 2: Green finance progress in G20 countries

Country	1. Provide strategic policy signals and framework	2. Promote voluntary principles for green finance	3. Expand learning networks for capacity building	4. Support the development of local green bond markets	5. Promote international collaboration to facilitate cross-border investment in green bonds	6. Encourage and facilitate knowledge sharing on environmental and financial risk	7. Improve the measurement of green finance activities and their impacts
Argentina	✓			✓			
Australia	✓			✓			
Brazil				✓	✓	✓	
Canada	✓			✓	✓		
China	✓	✓	✓	✓	✓	✓	✓
France	✓	✓		✓	✓	✓	
Germany	✓		✓	✓		✓	
India	✓			✓	✓		
Indonesia	✓		✓	✓		✓	
Italy	✓			✓			
Japan				✓			
Mexico	✓			✓	✓		✓
Russian Fed.				✓		✓	
Saudi Arabia			✓				
South Africa	✓			✓	✓		
South Korea		✓		✓			
Turkey				✓			✓
UK	✓		✓	✓	✓	✓	✓
US				✓		✓	
EU	✓			NA	✓		
International	✓	✓	✓	✓		✓	✓

green-related risks. For example, the City of London has launched a Green Finance Initiative led by the private sector, and comparable initiatives have been set up in France, Hong Kong, Singapore, and Switzerland. A coalition of financial centres engaged in advancing green finance was established as part of the G7 under Italy's presidency in 2017.

3. Measuring Progress

Explicit efforts to 'green the financial system' are relatively recent. Partly as a consequence, most documentation of these efforts is made up largely of descriptions of their measures and activities, rather than providing an analysis of effectiveness. Some of the descriptions suggest impacts based on assumptions about what types of measures are beneficial. For example, it is generally assumed that providing more environmental impact information to the market can enhance the consideration of environmental aspects by lenders and investors.

As a result, the commitment of over 40 stock exchanges, through their membership of the Sustainable Stock Exchange initiative, to include sustainable development impacts in reporting requirements of listed companies is assumed to be a good thing. Other examples include the work of, and directions proposed by the Task Force on Climate-Related Financial Risk Disclosure established by the Financial Stability Board in 2016. Yet a study undertaken in 2015 of the effects on investment decisions of strict sustainable development reporting requirements at the Johannesburg Stock Exchange, suggested that if taken alone such measures had marginal if any

Table 3: Comparative potential for the five principle approaches (Robins & Zadek, 2015)

Approach	Current practice	Potential impact	
Enhancing market practice	Widely adopted as relatively straightforward and relevant to all countries' financial systems.	Aims to increase financial returns through better assessment of risk:return opportunities.	Likely to have slow, modest impact, unless undertaken with additional measures.
Harnessing balance sheets	Widely adopted, but limited by cost.	Aims to increase financial returns in return for provision of public goods.	Can be very effective where deployed, but is likely to be limited in impact because of scarcity of public finance.
Directing finance through policy	A long history of use, now being adpated for sustainability goals.	Varied effects on financial returns in requiring the delivery of public goods.	Can be successful, but with greater potential for unintended consequences.
Encourging cultural transformation	Not widely practiced, but potential for wide application and postive signs emerging post-crisis.	Can have varied effects on financial returns.	Can be effective, especially when linked to policy direction and incentives and aligned to broader societal expectations.
Upgrading governance architecture	Least practiced.	Is an essential enabler of the measures above.	

impacts on investors'decisions (Goldstuck & Naidoo, 2016).

China's Green Credit Guidelines, to take another case, have been highlighted as best practice in soft intervention by a banking regulator in seeking to promote green bank lending. Indeed, evidence indicates that today over 15 per cent of total bank lending in China is consistent with these Guidelines, a significant growth since they were launched in 2007 (Green Finance Task Force, 2015). Yet, there is no analytic evidence as to what extent the increase in green credit in China can be attributed to the Guidelines specifically, given that over the period other developments, such as enhanced environmental regulatory enforcement, might well have had a significant impact.

Despite the lack of data, an overview of available research, points to comparative performance across five approaches for improving the alignment of the financial system with sustainable development outcomes (see Table 3, above).

Furthermore, it is likely that there is a trade-off between speed and scale of impact with the risks of negative unintended consequences. For example, even if mea-

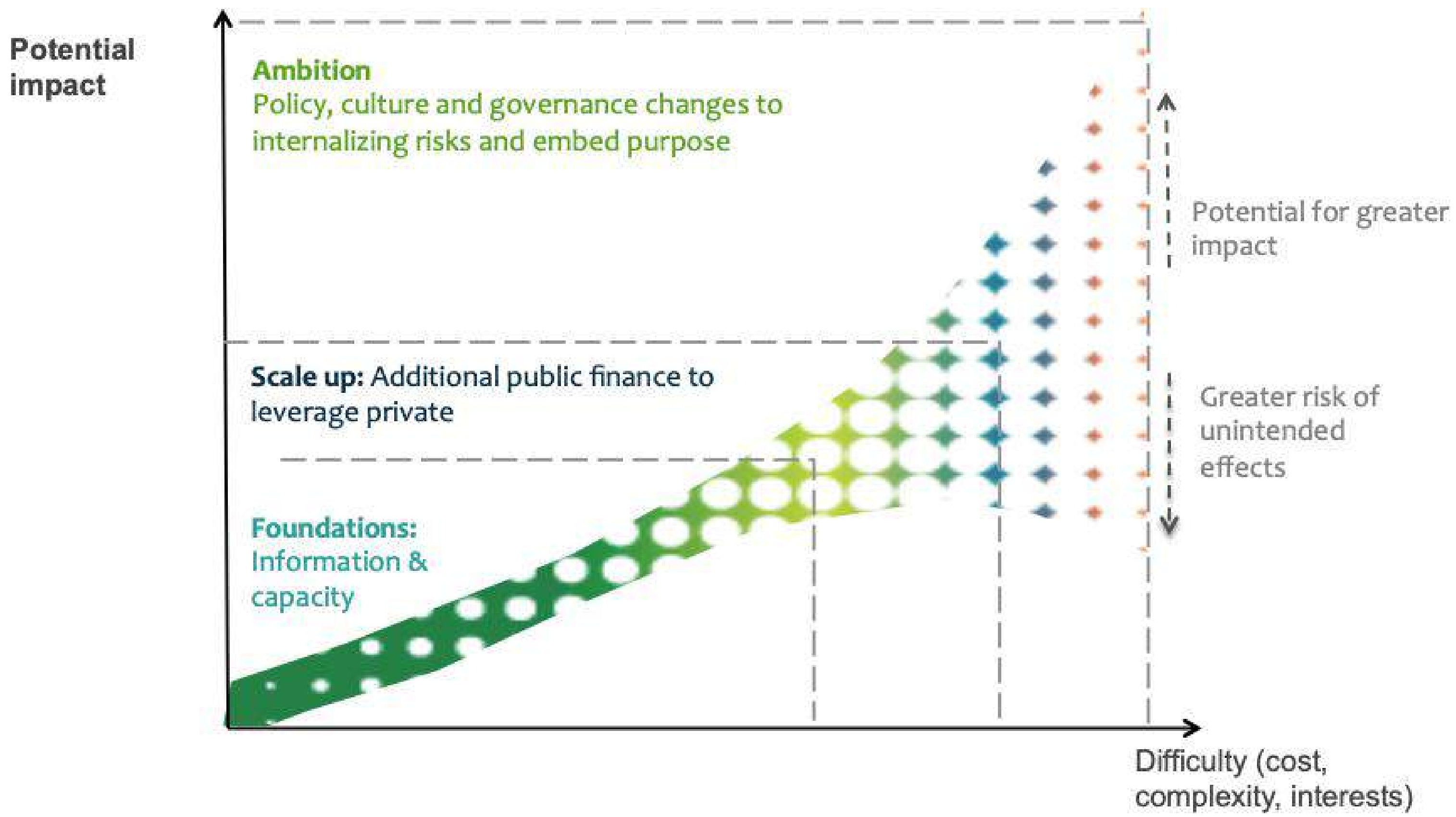

Figure 1: Potential impact and practicality of implementation (Inquiry, 2015)the five principle approaches (Robins & Zadek, 2015)

sures to improve market practice such as enhanced disclosure may not alone deliver the quantum changes required, the risk of something going wrong as a result are small. Measures such as priority lending and strengthened environmental liability, on the other hand, may over time drive greater change in moving towards a sustainable finance system, but need careful design and market preparation to avoid unintended consequences. For example, such a consequence could have occurred when Brazil's Supreme Court found in favour of a constitutional interpretation that banks had unlimited environmental liability: there was a real risk that this would lead to a collapse of lending for any environmentally sensitive projects, however well designed they were (Sampaio, 2016).

In conclusion, there is clearly a great deal of work needed to move from description of initiatives to analysis and assessment of their impact. Currently, the evidence available is largely qualitative, and fragmented across different approaches and quality levels.

Alongside the need to measure impact is the need to measure progress in aligning the financial system with the needs of IGE (see Table 4, overleaf). An obvious first step in this direction is to determine the requirements and flows - the extent of green finance needs, say of a country, and the actual level of green finance flows and, where relevant, stocks (e.g. of green bonds). Currently available information, however, suggests that very few countries have undertaken any systematic measurement of green finance. Several have, however, undertaken one-off studies of green finance flows.

Several Chinese institutions have undertaken one-off green finance studies, including annual green lending estimates by the China Banking Regulatory Commission, and the National Development and Reform Commission (Zheng, 2015). The study concludes that green investment rose between 2008 and 2012 from 2.2 per cent to 3.1 per cent of GDP, reaching US$260 billion in 2012. Furthermore, it concluded that market-based financing provided the greatest proportion of investment in each sector; ranging from 78 per cent in renewable power projects to 61 per cent in environment protection.

Looking forward, the study projects that China's green investment demand (based on a larger set of categories including energy efficiency) of 2,867 billion RMB (US$450 billion) in 2015, will grow to 2,908 billion RMB (US$465 billion) by 2020. Although the annual growth rate is not large, the average size of the annual investment is high, exceeding 3 per cent of GDP.

With respect to estimating flows, the Brazilian Bankers Federation FEBREBAN commissioned the Getulio Vargas Foundation to undertake a mapping study of green finance flows in Brazil (FGV, 2014). They used a methodology that looked at four levels across banking/credit, investment and insurance, and **non-reimbursable** funds (e.g. such as the Amazon Fund):

Key definition: Non-reimbursable funds
Funds that are granted as direct financial aid from public budgets for specific purposes in the public interest. Adapted from: http://www.omega-consulting.ro

- General policies and voluntary commitments;
- Integration of environmental, social and governance (ESG) considerations in processes and risk analysis (e.g. Equator Principles);
- Thematic investments (e.g. sustainable transport, renewable energy); and
- Thematic products (e.g. direct loans for energy efficiency).

Table 4: Key features of a performance framework for a sustainable financial system (Robins & Zadek, 2015)

Feature	Description	Comment
Requirements	Capital required to finance sustainable development.	Covering: (a) deployment of capital to fund incremental assets or activities; (b) elimination of “unsustainable” assets and activities previously funded by capital; and, (c) reserving capital against conditions that could challenge sustainability.
Flows	Flows of finance against such requirements.	Providing a common approach for measuring actual flows, building on existing methodologies, accepting that flow analysis does not clarify the effectiveness or efficiency of securing such flows.
Effectiveness	Degree to which markets price sustainability factors into asset values.	Core to assessing existence of market failures, although need to distinguish failures associated with real or financial economy market and/or policy weaknesses.
Efficiency	Costs of running the financial system that delivers financial flows against requirements.	Includes both transaction-specific and comprehensive financial system costs.
Resilience	Susceptibility of the system to disruptions related to unsustainable development.	Covering the direct impact of environmental stress as well as impacts of transitional effects. This is inherently future-oriented and requires (a) analysis over extended time periods and (b) distinguishing higher levels of resilience through externalization and internationalization of sustainability factors.

The analysis suggested that some US$2 trillion of bank balance sheets and investment assets under management are covered by general commitments and principles, and around US$67 billion by thematic investment criteria. In Indonesia, the financial regulator, Otoritas Jasa Keuangan, has estimated total green lending undertaken by banks, covering renewables, sustainable agriculture, green industry and ecotourism (OJK, 2014). This exercise found that the share of lending identified as green between 2011 and 2013 was very small, with only 1.2 per cent of total lending described as green in 2011. The share of green lending increased slightly to 1.3 per cent in 2012 and 1.4 per cent in 2013, amounting to 10.2 trillion IDR (Indonesian Rupiah, about US$1 billion).

Estimates of financial requirements, flows and stocks, however, do not provide a full picture of the efficiency, effectiveness or resilience of the financial system, given the challenges of sustainable development. The connection between efficiency – the cost of running the financial system relative to its output – remains largely unexplored, and its links to sustainable finance are entirely unexplored. Interestingly, research has suggested that the financial system’s efficiency has not improved despite going through a period of massive volume growth and the extensive application of enabling, cost-reducing technology, suggesting that actual cost savings have been captured by rent-taking intermediaries (Philippon, 2015).

Equally, there is little data or analysis that provides direct evidence of the effectiveness of the financial system in pricing and managing sustainable development, or more narrowly environment-related risks. Many studies point to a divergence between financial risk pricing compared to the extent of negative environmental externalities, indicating a gap between market and socially efficient outcomes.

The G20’s Green Finance Study Group highlighted this in its initial report (G20 Green Finance Study Group, 2016), and the creation of the Financial Stability Board’s Task Force on Climate-Related Financial Disclosures is premised on an assumption that climate risks are not priced effectively into private financing decisions (TFCD, 2016). Whether this implies that private actors are mispricing risk given their pursuit of private benefits is, however, another matter. The Chinese bank, ICBC, has published a report on its environmental risk assessment, highlighting the importance of taking approach based on longer-term scenarios, but nevertheless not finding significant risk mispricing across its balance sheet (ICBC, 2016).

Similarly, when it comes to financial system resilience, the Bank of England has led the way in undertaking a prudential review of the impact of climate change on the stability of the UK-based insurance sector. Other central banks have followed suit, particularly in Europe, with comparable assessments undertaken by the Dutch, European, German, and Swedish central banks. These higher-level assessments have, likewise, concluded that whilst the risk of instability exists, the likelihood is modest at present, with larger effects happening over time horizons that they consider to be beyond the formal mandates of central banks. As Mark Carney, Bank of England Governor, puts it, "once climate change becomes a defining issue for financial stability, it may already be too late" (Elliott, 2015).

UN Environment has developed an initial version of a performance framework, which rests on three analytical pillars: the architecture of rules, behaviour in markets and the flows of finance (Robins & Zadek, 2016). The architecture includes all rules, regulations, policies, norms, and standards in the financial system that could directly or indirectly improve sustainable development outcomes. This helps to understand whether the 'rules of the game' are aligned with sustainable development needs. Under markets, the approach identifies key aspects of the behaviours of market actors, and how well these market players, market makers, and financial services suit the sustainable development needs. And under flows the allocation of capital to sustainable (and unsustainable activities) is measured in terms of annual flows and overall stock of assets.

4. Systemic and Incremental Change

4.1 Finance as a tool for sustainable development

Understanding the finance system in the context of the needs of IGE is ultimately a matter of purpose. Finance does not exist for its own sake but rather to serve other purposes. The core purpose of the financial system has always been to serve the real economy by providing a range of essential services for companies, households, and public authorities. The transition towards sustainable development is now reframing the historic relationship between the real economy and the financial system and setting in motion a powerful new dynamic, focused on delivering inclusive prosperity, poverty elimination, and respect for planetary boundaries.

Focusing on purpose leads to a re-evaluation of the system itself. Progressing to a clean energy future is not, for example, simply a matter of more wind turbines and solar panels, although further technological innovation and large-scale deployment will certainly be needed. A clean energy future will require new market actors, new types of market relationships matching supply and demand, different ownership configurations for key parts of the energy system, and a radical overhaul of energy governance at every level.

Similarly, for finance, Zhou Xiaochuan, Governor of the People's Bank of China, explains that, "in China, establishing a green finance system has become a national strategy," because of the need to finance profound changes in China's economy over the coming decades (UN Environment, 2016). Likewise, Mark Carney, Governor of the Bank of England, has argued that, "achieving the SDGs will require mainstream finance. We need to build a new system – one that delivers sustainable investment flows, based on both resilient market-based, and robust bank-based, finance" (Robins & Zadek, 2016). It can thus be noted that a systematic transformation of the economy towards an IGE requires, equally, a systematically new approach to finance and investment, a 'paradigm shift' within the financial system.

According to Thomas Kuhn (2012), a paradigm shift occurs when evidence can be effectively described and dealt with only by affirming the explanations and worldviews that are new or were previously controversial and unacceptable. Paradigm shifts bring with them new norms, orthodoxies, and worldviews. Drawing on Kuhn's work, Peter Hall distinguishes three orders of change (Hall, 1993; see Figure 2):

(1) First-order changes are "paradigm maintaining" and involve processes that adjust policy without challenging their existing, underlying assumptions about the way things are.

(2) Second-order changes are more significant, where the instrument of a policy is adjusted but not the overarching policy. Both first and second-order changes are characterized by incrementalism.

(3) Third-order changes reflect deeper changes to the underlying terms of the discourse and indicate that a paradigm shift is occurring. Third-order change is the

> paradigm shift described by Kuhn, involving reappraisal of what have previously been considered certainly true. (Mackintosh, 2016).

Significant changes to the financial system will be necessary for the transition to sustainable development. Achieving ambitious goals, such as the SDGs and associated targets, will not be possible without system change, which could often mean the 'creative destruction' of existing markets and institutions, and the emergence of new configurations, rules and conventions. Here, finance is without doubt a case in point. It is not a coincidence that some developing countries, as opposed to richer countries, who play a leading role in progressing alignment of their domestic financial systems with sustainable development. Such leadership can partly be explained by the higher visibility and impact of unsustainable development.

Beyond this, or perhaps in part because of this, developing country central banks and financial regulators understand their role as being to align finance with national development priorities, alongside the roles they share with their developed country counterparts of monetary and financial stability and market integrity (UN Environment & AXA, 2015). As Dr. Atiur Rahman, the previous Governor of the Bangladesh Bank, pointed out, "developing countries appreciate more readily the profound connections between central and development banking" (Rahman, 2014).

4.2 Change processes

Today's momentum already shows some of Hall's second-level characteristics. At least two different narratives question inherited conventions concerning change in the financial system and provide an idea of an emerging new set of conventions. Innovations such as green bonds reflect the extended application of existing market architecture – and in many ways that is their strength, enabling rapid market expansion. Although progress is still relatively modest to date, it proves the potential and the need to take the current level of innovation to a greater scale by addressing the role of sustainable development in broader market norms such as credit ratings. While responsible, sustainable or low-carbon financing was once undertaken only by impact investors and social banking pioneers, we now see mainstream investors, insurers and banks increasingly embracing new metrics and norms. Notable shifts in the interpretation of, and regulations governing, pension funds' fiduciary responsibilities are looking increasingly like more avant-garde innovations in corporate governance, such as the B Corporation legal forms allowing for financial and non-financial corporate objectives. Similarly, central bank innovators have started signalling the need for an alignment of their mandates with longer-term policy goals by highlighting the complex dynamic between climate change and financial stability.

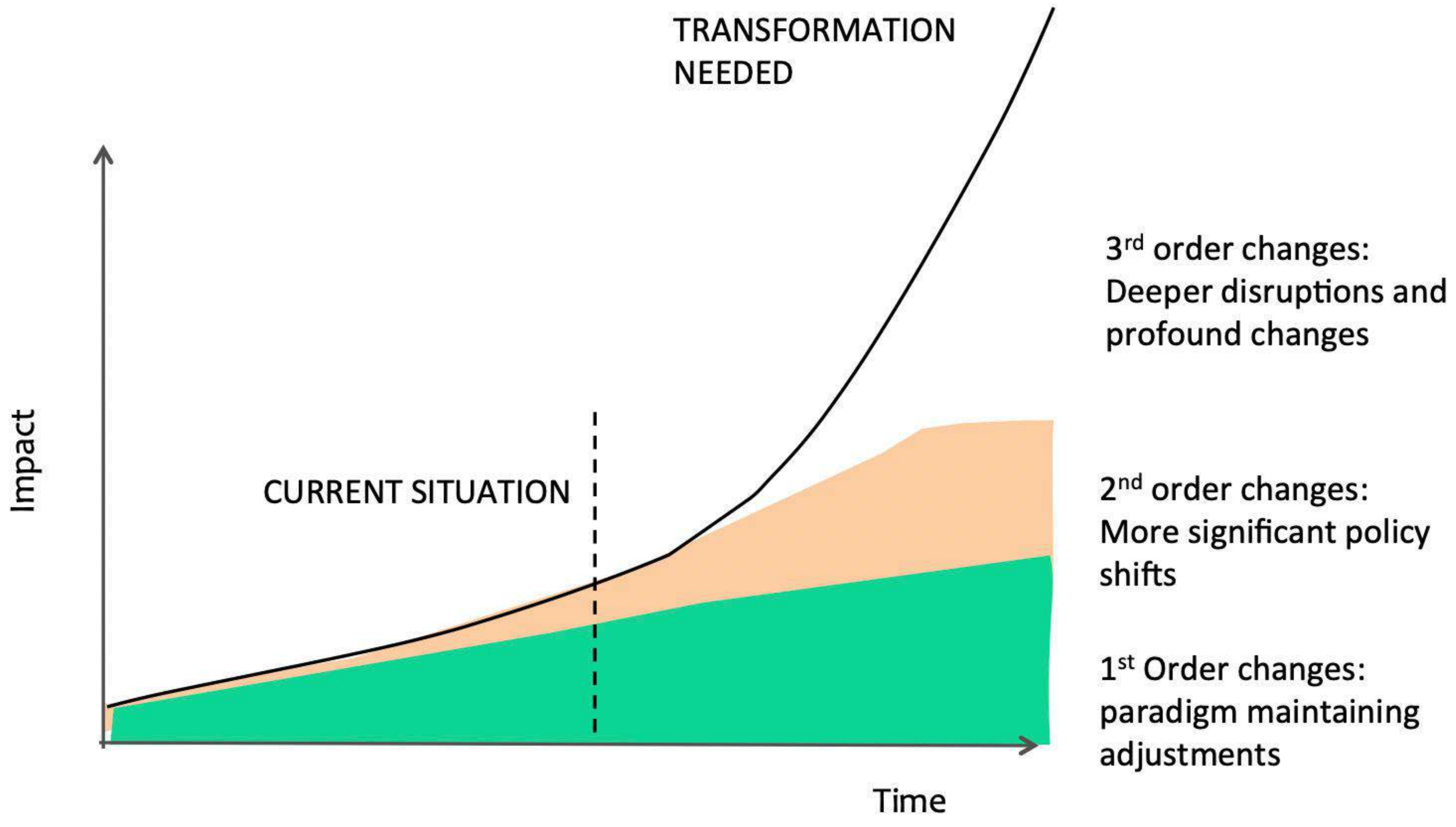

Figure 2: Three orders of changes needed for transformation

5. Concluding remarks

Greening the financial system is a work-in-progress. While there is no doubt as to the direction of travel, what remains unclear is how deeply rooted the changes need to, and will be, and how long it will take to undertake those changes. Early stage innovations demonstrate the potential for easing environmental considerations into decision-making across the financial system through what might be termed measures to improve the efficiency and effectiveness, and indeed resilience, of financial and capital markets. Improved information flows linked to capacity development are the symbols and practice of taking advantage of low hanging opportunities, as is the development of the green bond market. There is more of a challenge in addressing higher order changes that go beyond these basics and seek to overcome more endemic problems such as short-termism and an over-focus on highly leveraged, intra-sector trading, or an over-valuation of the benefits of liquidity. Changing such features of today's modern financial system requires significant, and often unpopular actions. Smart action along contingent pathways is needed to enable modest nudges to precipitate wider spread changes, and, as described above, there are examples of such actions being taken, with positive but as yet inconclusive results.

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CHAPTER 12: INTERNATIONAL DIMENSIONS OF GREEN ECONOMY

CHAPTER 12: INTERNATIONAL DIMENSIONS OF GREEN ECONOMY

LEARNING OBJECTIVES

This chapter aims to enable its readers to:

- Outline the main challenges facing humanity and analyse their drivers;
- Articulate how the inclusive green economy model seeks to address these challenges; and
- Understand the major characteristics that underpin national strategies on inclusive green economy, the related analytical tools, key actors and initiatives as well as the critical role of public policy in turning the inclusive seen economy model into practice.

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CHAPTER CONTENTS

1. Introduction

This chapter extends the green economy analysis from the national to international level with a primary focus on trade, but also covers foreign direct investment and technology transfer. By way of globalisation of economic activities in the past decades, trade has become an ever greater and more important part of economic activity. This makes it also increasingly relevant from an environmental and green economy perspective.

The chapter is organised as follows. Section 2 discusses the relationship between trade and environment, which has been extensively researched [1]. Section 3 explores the relationship between trade and green economy, which places greater emphasis on the structural impacts of transitioning to an Inclusive Green Economy (IGE). Section 4 zooms in on the negotiations on the liberalisation of the environmental goods and services sector, which lies at the core of the trade and green economy linkage. Sections 5 and 6 bring foreign direct investment and technology transfer into the discussions. Section 7 summarises the major points of this chapter.

1 See, for example, Copeland & Taylor (2004) for an overview of literature on the environmental consequences of economic growth and international trade.

2. Trade and Environment

The discussion of the relationship between trade and green economy invariably covers the complex links between trade and the environment. Complexities such as the environment-trade debate over the past decade that has often been marked by mutual distrust and a lack of mutual understanding: On the one hand, the environmentalist community has been critical towards free trade and wary about the effects of a more open trading system on the environment. On the other hand, the trade community has been concerned that environmental protection would be utilised as a disguised means of market protectionism. As Copeland and Taylor (2004) note in their review on Trade, growth and the environment, “The debate has often been unproductive because the parties differ greatly in their trust of market forces and typically value the environment differently”. Nagara (1994) elaborates this point by stating that….

> *“The debate over linkage between trade and the environment continues unabated. The entire complex of debates over this most enduring issue grows more complex even as it seems to become more finely tuned.*
>
> *(…)*
>
> *The relationship between the two is of growing significance, and in constant flux. Recent events such as the creation of the World Trade Organisation and renewed imperatives for the Non-Aligned Movement add to the kaleidoscope of movements, motivations, interests and objectives. Meanwhile, the distinct and perceptibly fixed interests of North and South remain, buttressing a framework that changes only piecemeal if at all.*
>
> *(…) The two polar extremes of (voracious) unbridled free trade and rampant (protecto-)environmentalism are still very much in play: growth at all costs, regardless of environmental decay or some irreparable consequence; and restrictive- punitive legislation ostensibly for environmental protection, but which is certain to restrict trade and punish foreign traders — while affording disguised protectionism to domestically-based transnational corporations. The two ends of this continuum have drifted further apart, and in doing so have created more grey areas in the widened spectrum between them.”*
>
> Nagara (1994)

Nevertheless, the research interest on the interlinkages between environment and trade since the 1990’s has contributed to a better understanding of the channels by which trade liberalisation and economic growth affect the environment. An example of this interlinkage can be seen, for example, by the so-called Environmental Kunet Curve proposed by the early economic literature, that have been relativised over time (see also Copeland and Taylor 2004). In the analysis on the effects of the North Atlantic Free Trade Agreement, Grossman and Krueger (1991) identified three separate mechanisms by which trade (and foreign investment policy) affects environmental factors: *scale*, *composition* and *technique*:

> *"A reduction in trade barriers generally will affect the environment by expanding the scale of economic activity, by altering the composition of economic activity, and by bringing about a change in the techniques of production."*
>
> Grossman and Krueger (1991)

First, by way of the *scale effect*, the expansion of economic activity through trade and investment (liberalisation) policy leads to an increase in the pollution generated among others by expansion of transportation services that are linked to trade. Second, by way of the *composition effect*, trade impacts upon the environment by affecting the nature of economic activities in which a country specialises. Depending on whether trade (liberalisation) will lead a country to adopt more or less polluting practises, this will decrease or increase environmental impacts (in the respecting country). The composition effect must also consider the potential export of environmental burden, where resource-intensive processes are shifted from the country of consumption to a country of production, with possibly lower income or less stringent environmental regulation. Third, the *technique effect* refers to the change of production methods due to a change in trade policy, such as trade liberalisation. As such, the technique effect may lead to emissions falling as a result of trade due to driving forces such as technology transfer and technology diffusion. The technique effect is linked to the Environment Kuznet Curve argument, which Grossman and Krueger (1991) explain as follows: "if trade liberalization generates an increase in income levels, then the body politic (voters) may demand a cleaner environment as an expression of their increased national wealth."

Over time, trade and environment have increasingly been understood in a synergetic, rather than solely opposing force. Some of it may relate back to the rise of the green economy and its contribution to trade flows (see below), as well as an recognition by the trade community that environmental problems, such as climate change, can seriously harm trade flows. From an environmental perspective, rather than solely framing trade as a driver of environmental pressures, trade and trade policy have increasingly been viewed also as a possible tool to advance environmental sustainability. This is also reflected in the 2030 Sustainable Development Agenda that view trade as a means of implementation for the Sustainable Development Goals (see also SDG 17.1). In their joint publication, UN Environment and the World Trade Organisation (2018) acknowledge that:

> *"The impact of trade on the environment hinges ultimately on the "structure" of economic growth – that is, the composition of inputs used (including environmental resources) and outputs produced (including pollution and waste). In turn, the structure of economic growth is a function of many factors, not least a country's institutions and policies, including those related to the environment."*

When it comes to fisheries, forests, wildlife and other ecosystem and biodiversity benefits research has indicated that trade is unlikely to be beneficial (see e.g. Bulte and Barbier 2005), and can sometimes have irreversible effects on the sustainability of natural capital (Copeland, 2012). unless issues like the lack of secure property rights and good governance are addressed, (Fischer, 2010) However, trade in environmental goods and services may support environmental protection by providing producers with a greater incentive to innovate. Innovations such as the possibility to sell to greater markets, as well as providing importing countries with access to goods and services, such as pollution control technology or renewable energy technology, thereby reducing environment impacts (see section 4). Supporters of trade as an instrument of the green economy maintain further that more efficient allocation of resources and higher levels of economic development, linked to trade, may free resources, which in turn be used for environmental protection and investment in the green economy. Moreover, trade can support the development of more environmentally-friendly pathways by connecting producers of more sustainable products with new markets (e.g. certified organic products exported from a country with low cost supplies to a region with high demand for organic products, such as the case for Europe or the US) (UN Environment, World Trade Organisation 2018). A robust trading system also provides a stable and predictable condition for innovation, which is crucial for tackling resource and environmental challenges. Rather than focusing on the 'if', the more important question to ask is probably how trade and trade policies could and should be shaped towards enhancing the potential of trade to positively contribute to human development and environmental quality, while minimizing damages and risk. Generally, scholars and practitioners agree, that environmental policies, such as emission standards and institutional frameworks as well as the effective enforcement of environmental rules and regulations, play a critical role in making trade more environmentally friendly (UN Environment, World Trade Organisation 2018). The role that trade-related policies can play in enhancing the contribution of trade to sustainable development will be outlined in some more detail in the remainder of this chapter.

3. Trade and the inclusive green economy

In connection to trade, the concept of a green economy goes beyond the traditional emphasis on minimising the negative impacts of trade on the environment and maximising the positive impacts such as efficient allocation of resources and the growth of environmental goods and services. Instead, it focuses on how investing in the environment and IGE as a whole can contribute to trade and, by extension, broader SDGs, and how trade can support the transition to green economies. Inversely, the discussion also includes consideration of how the global shift to IGE will affect the trading system, and what governance implications we might draw from that.

3.1 Trade as an instrument to support countries' transition towards the inclusive green economy

An important function of trade for economic development is its ability to enhance economic efficiency by capitalising on countries' respective competitive advantages and economies of scales, and allowing for the diffusion of goods, as well as related technologies and innovations. In many lower-income countries, domestic capacity for producing certain environmental goods (equipment and intermediate goods), services (technological and advisory services) and technologies does not exist, and local production and supply might currently not be efficient and economically viable (UN Environment WTO, 2018). Indeed, trade can enable countries to plug into value chains of production, and thus specialise on particular aspects of the manufacturing process, enhancing competitiveness and efficiency. Policies to remove barriers for the import of these products, services and technologies (often through licensing), can make these products (or the inputs for final products) available domestically at a low cost, as well as facilitating knowledge transfer and technology diffusion (Altenburg, T., & Assmann, C. (Eds.), (2017)). This can therefore support environmental protection in the country of consumption, as well as R&D contributing to efficiency improvements of these technologies.

However, it must be emphasised that this may only be viable if such policies are embedded in a sound overall policy framework (including a supportive investment environment, a robust IPR regime and sound domestic absorptive capacities). By way of opening new markets for producers, trade can provide impetus for greater investment in R&D and innovation in environmental technologies, thus strengthening the competitiveness of greener industries vis-à-vis more polluting ones. This, in turn, can help strengthen green industries in exporting countries, as well as support the emergence of these industries in consuming countries, in addition to the new job opportunities arising in the environmental services sectors. In countries that still feature a weak domestic production capacity for environmental goods and services, there may be trade-offs between facilitating green imports and developing domestic capacities for producing environmental goods, services, and technologies (see also Section 4). In this case, a country might choose to align its trade and green industrial policy strategies in a way as to advance its local production capacity for environmental goods, with the aim of unlocking a latent comparative advantage, while integrating into global value chains of production (see also PAGE, 2017). However, a country may also decide to facilitate green imports, and focus on the development of an environmental services economy. The debate on how much trade openness may be beneficial to the environment but also to the economic competitiveness of a particular country has also played an important role in the evolution of international negotiations, such as the Environmental Goods Agreement (EGA), as we will see in Section 4.

3.2 How investment in the inclusive green economy affects trade

As a result of the structural impacts that arise from the green economy transition, the global landscape and patterns of trade have been evolving and will continue to do so. This may be true in several distinct ways: First, with the green economy transition, the share of fossil fuels in global trade is expected to decline, thus reducing the 'carbon content' of trade in the long run. This impact is likely to be stronger for coal and oil, as international demand may remain high for natural gas, which is generally considered 'clean'. Second, the share of environmental goods and services in trade is expected to rise, reshaping the global landscape of production, consumption and trade. Thirdly, with the rise of major green products and the decline of polluting ones, international competitiveness is being redefined. The changes taking place in the global automobile industry are illustrative of transformative processes linked to the transition to green economies (See also Box 12.1).

How do these new patterns of trade, which will depend on the implementation of green economy policies, affect economic growth and development? Opinions on this vary greatly, depending on the basic assumptions of different academic schools of thought. For example, from a neo-classic economic perspective, the regulation of trade flows (the same as any type of regulation and interference with free market forces) may have a negative impact upon economic growth and thus lead to an overall welfare loss by hindering the efficient (or 'optimal) allocation of resources. This stems from the underlying assumption that the choice of rational actors in a free market will always lead to the best possible outcome, and that changes thereof, including by way of regulation, can therefore only be 'second best' outcome.

Box 12.1: Electric cars: international trade and market growth

Sales of electric cars hit a record of over 750 thousand worldwide in 2016. China was by far the largest market, accounting for more than 40 per cent of electric cars sold globally. In 2016, Tesla's vehicle exports (from the US) to China tripled to exceed a value of US$1 billion, accounting for 15 per cent of the company's global sales. Experiencing rapid sales growth in China while facing a tariff at 25 per cent, Tesla is now planning to invest billions of dollars (US) in a production facility in China.

In the meantime, the Chinese Government introduces an ambitious policy aiming to encourage the local production of electric vehicles, as well banning sales of fossil fuel-based cars. Similarly, France and Germany have policies in place to support the take-up of electric vehicles and many of the world's leading car brands home to those countries, including Renaud- Nissan, BMW or Mercedes, have started to invest in R&D of electric vehicle technology. However, with the departure from the fuel-based automotive sector, in which barriers of entry for new players were extremely high, this change of technology may reshuffle the cards of who will stay relevant in the clean automotive sector of the future.

However, it has since been widely acknowledged that the neoclassic economic approach has traditionally inadequately considered environmental and social factors. The basic assumption of neoclassic economic theory, such as a perfectly functioning market, never hold true as such in reality, due to the existence of market failures. Indeed, according to this school of thought, environmental problems itself can be seen as a market failure, as environmental costs and benefits are not being valued and assigned in a correct manner – they are either under-priced, not internalised and thus not accounted for by those responsible for them, or their essential functions entirely disregarded by market forces.

As the OECD (2019) also observes:

> *"The impact of trade liberalisation on a country's welfare depends on whether appropriate environmental policies are in place within the country in question (e.g. correctly pricing exhaustible environmental resources). Stringent environmental policies are compatible with an open trade regime as they create markets for environmental goods that can subsequently be exported to countries that follow suit on environmental standards – the so-called first-mover advantage. This is especially true for complex technologies such as renewable energies."*

From this perspective, environmental regulation can be seen as mechanisms to reduce market failures and increase economic efficiency, which contributes to economic development and supports global public goods like environmental quality. However, for environmental and trade regulation to work in sync it will require strong cooperation between decision-makers in the environment and trade domains: global economic governance and global environmental governance both affect the volume and dynamism of international trade and investment in green goods and services. Their co-evolution and interaction shape the dynamic institutional context of an international green economic transition.

This also applies to the impact of environmental policies on international competitiveness, again affecting international trade (Copeland, 2012). Generally, the discussion points to the importance of ensuring a level playing field between countries, thus making the case for the importance of international cooperation in the field of environmental governance and the alignment of trade policies with environmental objectives (UN Environment, World Trade Organisation 2018).

3.3 The world trading system and the inclusive green economy

The world trading system consists of organisations, agreements and rules at multilateral, regional and bilateral levels. At the heart of the multilateral trading system is the World Trade Organisation (WTO), which was established in 1995 as the successor of the GATT to "develop an integrated, more viable and durable multilateral trading system", which encompasses "the General Agreement on Tariffs and Trade, the results of past trade liberalisation efforts, and all of the results of the Uruguay Round of Multilateral Trade Negotiations" (WTO 2019, Marrakesh Agreement establishing the WTO). A wide range of multilateral agreements have been negotiated and signed by the 164 WTO members, which represent the bulk of the world's trading nations. Generally, States enter into trade agreements to advance trade openness, and assure equal treatment and non-discrimination between different trading partners, and domestic and foreign companies. Trade regimes also serve an important role in promoting predictability, transparency and thus competitiveness of international trade.

Whereas the establishment of the General Agreement on Tariffs and Trade (GATT) in 1948 preceded the rise of environmental governance at the international level, sustainable development had already established itself as a central principle of international affairs at the time of the negotiation of the Marrakesh Agreement in 1994, to establish the WTO. This is also reflected in the preamble to the Marrakesh Agreement (WTO 2019):

> *"Recognizing that their relations in the field of trade and economic endeavour should be conducted (....) while allowing for the optimal use of the world's resources in accordance with the objective of sustainable development, seeking both to protect and preserve the environment and to enhance the means for doing so in a manner consistent with their respective needs and concerns at different levels of economic development."*

The text of the WTO therefore enshrines environmental protection as one of the organisation's core objectives. However, the WTO mandate is generally restricted to the advancement of advance trade-related issues, similar to the environmental conventions, which cover solely environmental issues. This makes it challenging to address crosscutting topics at the interface of environment and trade.

Of course, policies in one area such as trade, can affect other policy areas, such as the environment. Hence, policies conducted by a country to advance national objectives and/or fulfil its obligations under one treaty of international law, might infringe a country's obligations in another. To navigate potential conflicts between trade and other areas of policymaking, GATT Article XX on General Exceptions lays out a number of instances in which WTO members may be exempted from GATT rules, including, for example, reasons linked to environmental policy. Similar exceptions can also be found in a number of other WTO agreements (see box 12.2). Legally, this can exempt Member States from their obligations under WTO law, in line with the criteria of Art XX, thus providing Countries with the necessary policy space to legislate on national level. Put bluntly, this shall enable WTO Members to put in place policies to protect the environment (among others), even though such a policy may violate a commitment under WTO law. However, rather than providing countries with a blank check for violating their commitments under WTO law, invoking Art. XX relies on a number of conditions, and has been used in a quite restrictive manner in the past. Despite this, its scope has changed over the years, as we will touch on below.

The text of the GATT and other WTO Agreements has not been modified since these agreements entered into force. However, through jurisprudence, the interpretation of provisions of the agreements, including Art XX (Art 20), have evolved over time. Overall, decisions by the WTO Dispute Mechanisms have provided succinctly more space to environmental-policy related matters over time. Nevertheless, critics maintain that the current framework still does not provide sufficient policy space and clarity for States to put in place necessary measures to protect the environment and advance the green economy. To explore how the negotiation of new rules

Box 12.2: WTO agreements & environmental protection

- General Agreement on Tariffs and Trade (GATT). Article XX of the GATT on General Exceptions specifies two exceptions that are relevant for the protection of the environment. WTO members may adopt policy measures that are inconsistent with GATT disciplines, but necessary to protect human, animal or plant life or health, or relating to the conservation of exhaustible natural resources.
- Agreement on Technical Barriers to Trade (TBT) (1995). The TBT Agreement deals with technical regulations and standards and aims to ensure that they do not create unnecessary obstacles to trade. At the same time, it recognises WTO members' right to implement measures to achieve legitimate policy objectives, such as the protection of human health and safety, or protection of the environment. The TBT Agreement strongly encourages members to base their measures on international standards as a means to facilitate trade.
- Agreement on Sanitary and Phytosanitary Measures (1995). This agreement entered into force with the establishment of the WTO on 1 January 1995. The agreement addresses the application of food safety and animal and plant health regulations.

at the trade and environment interface is unfolding at the WTO, the following section will introduce the WTO dispute settlement procedures and two central environment related negotiations at the WTO.

The WTO dispute settlement procedures and the environment

Since the establishment of the WTO, resolving trade disputes has become one of the core activities of the organisation, as over 500 disputes have been brought to the WTO and over 350 rulings have been issued (WTO 2019). WTO's dispute settlement mechanisms can help resolve disputes between countries effectively based on clearly-defined rules. Such a dispute arises when a WTO member State believes WTO another member State is violating an agreement or a commitment of the WTO. Among these disputes, there have been disputes between two WTO Member States that concerned environment-related measures, including a growing number of cases related to green products, such as solar panels. These cases also point to the increasing economic importance of the Environmental Goods industry. As a result, potential violations of WTO law through national policy measures such as support measures provided to the national industry, are more likely to be scrutinized by other WTO Member (PAGE, 2017).

What makes trade law relevant from an international law perspective, and different to most other areas international law, is that its decisions are binding and enforceable by way of dispute settlement procedures and credible enforcement mechanisms. This gives trade law 'teeth', that most other areas of international law cannot rely on. From an environmental perspective, using trade and trade law as a tool to advance environmental objectives can therefore be seen as an attractive option. This is possible whenever an issue lies within the competency of the WTO, which means that it is trade-related and advances one or several guiding principles of the WTO such as openness, non-discrimination, or transparency. In order to make this more tangible, the next section will zoom in on two negotiations of particular relevance from an environment and green economy perspective: the WTO negotiations to prohibit subsidies to fisheries that promote overfishing, overcapacity, and IUU (illegal, unregulated, and underreported) fishing, as well negotiations on the liberalisation of Environmental Goods and Services.

The regulation of fisheries subsidies, as a trade-related issue of environmental concern, has been on the WTO agenda for decades. A large portion of the subsidies provided by States to their fisheries, are problematic from an environmental point of view, because they lead to overcapacity (too many fishing boats fishing for the same fish), leading to overfishing. From a trade perspective, fisheries subsidies are considered trade-distorting, thus obstructing several WTO principles, such as trade openness and non-discrimination. Abolishing environmentally harmful fisheries subsidies is thus considered a true 'win-win-win' topic – as it counters trade distortions as well as overfishing and supports economic development and social equity. As a result, and at the initiative of several WTO Member States that founded the 'Friends of Fish' group, disciplining environmentally harmful fishery subsidies has been on the WTO agenda for decades, and is currently being negotiated with full intensity at the time of writing this chapter, with an agreement envisioned for the 12th WTO Ministerial Conference, in 2020.

The negotiations on the Environmental Goods Agreement (EGA) can be considered one of the central environmentally relevant trade negotiations at the WTO in the past decade. The goal of those negotiating the EGA, is to eliminate tariffs for a range of important environment related products, including those generating clean and renewable energy, improving energy and resource efficiency, controlling air pollution, managing waste, treating waste water, monitoring the quality of the environment and combatting noise pollution (see also section 4). Whereas the fisheries subsidies negotiations are still ongoing, EGA negotiations have stagnated and, at the time of writing this publication, were discontinued. The difficulties of reaching an agreement reflect the complexity of finding a consensus at the multilateral level when it comes to trade and environment related issues, a topic which will be analysed in further detail in Section 4.

Environmental provisions in Preferential Trade Agreements (PTAs)

Facing a stagnation of trade negotiations at the multilateral level, countries have increasingly turned to negotiations at the regional and bilateral level outside of the WTO. Regional Trade Agreements and Free Trade Agreements (RTAs and FTAs), Preferential Trade Agreements (PTAs), economic partnerships and other arrangements aiming at trade liberalisation have grown substantially in the past 10-20 years (see figure 1 below). More recently, RTAs have increasingly taken up environmental and sustainable development related considerations as part of the text of the agreement (Berger, et al., 2017). This may be seen as a reaction to concerns raised in the past over the environment impacts of RTA's but may also signal that trade policy is increasingly understood as a tool to advance environmental objectives (UN Environment & WTO 2018).

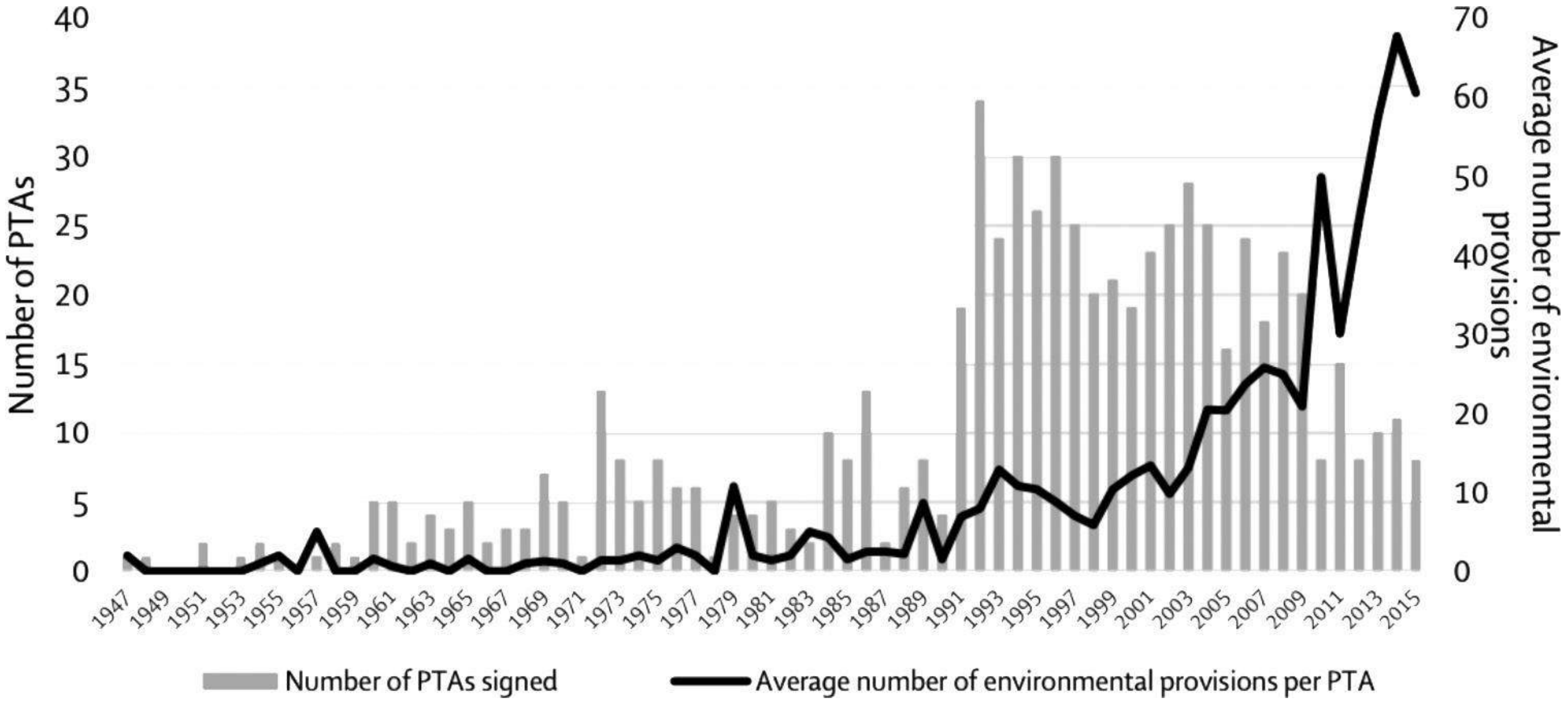

Figure 1: Environmental provisions in Preferential Trade Agreements (PTA's) (DIE and Universiy of Leuven 2017)

Environmental provisions in trade agreements can take many different forms, including: a reference to the environment in the Preamble of the Agreement; the use of exceptions based on GATT Article XX or GATS Article XIV; for the protection of human, animal and plant life; a commitment to uphold environmental law and not weaken it to attract trade or investment; more substantive environmental provisions; and associated *ex ante* impact assessments. A review of environmental provisions in regional trade agreements shows a steady increase in the number of agreements that include environmental provisions, and the incidence of more substantive provisions rose from around 30% in 2010 to 70% in 2012 (George, 2014).

3.4 Enhancing synergies and addressing potential conflicts

As we can observe from the cases above, the world trading system may support countries' transition to green economies in various forms, including through their function to support transparency, by facilitating and regulating trade. However, critics note that areas of conflict remain and that trade institutions, notably the WTO, are still too slow to incorporate environmental considerations, and to adapt their rules and frameworks accordingly.

As explained earlier in this chapter, the WTO framework allows members to impose trade restrictions to achieve legitimate policy objectives, which also include environmental objectives. However, diverging opinions exist on whether these ‘exceptions’ granted to the application of WTO law are indeed broad enough to cover policy measures necessary to achieve the transition to truly sustainable IGE. Many policy measures relevant to the green economy transition are, by definition, aimed at both transforming economic structures, and thus in many instances affect trade and competitiveness in ways not covered by the exception clause Art. XXX. Green industrial policies (see also Chapter 4) are a case in point for this: this policy approach shall serve to advance environmental as well as a country’s economic objectives (and with that a country’s competitiveness in international trade). An example can be the provision of subsidies to a country’s renewable energy. Such policies are usually not permissible under the WTO framework and not covered by Art. XX. From a trade perspective, this is important in order to avoid environmental policies being used as covert protectionism. In practice, however, green economy relevant policies are working on the interface of the economy and the environment, and a clear differentiation of policy objectives is problematic. In recent years, the clean energy sector has been an important case in point for this, often in the context of import restrictions imposed by States, also to react to perceived unfair support provided by the importing countries to their industry (See also Box 12.3).

As the interaction between environment and trade has not been addressed in a systematic manner, gaps between the two areas remain. This is resulting in legal and political uncertainty on various topics, such as the legality of border tax adjustments under WTO law (see also Holzer 2014, or Pauwelyn 2013), or the possibility of differentiating products based on their process and production methods (PPM) under WTO law (see also Eisen 2019, Sifonio 2018, or Ziegler 2017).

Box 12.3: Restrictive trade practices

Some commentators have pointed to the trade restrictive effects resulting from the application of excessively high and punitive duties in the clean energy sector in recent years (UNCTAD, 2014). This has also triggered momentum for retaliatory patterns of use of these measures in the clean energy technology space.

This occurred, for example, in the case of the US countervailing duties targeting China between 2007 and 2012. China challenged several such duties and took the case to the WTO. In 2014, the WTO Appellate Body found US duties inconsistent with WTO law. China then, in 2016, went back to the CTO to request consultations concerning the failure of the US to implement recommendations and rulings. The dispute is still ongoing.

(Source: PAGE, 2017)

A stronger cooperation among the environment and trade community would help to clarify many issues at the interface of environment and trade, enhance synergies and avoid possible conflicts. A closer working relationship between trade, environment policy makers, and global institutions would also help to establish a vision on the role of trade for sustainable development, and how it may best be employed as an instrument to advance countries’ transition to IGE. The enhanced cooperation between UN Environment and the WTO, proclaimed in 2018, can be considered an important step in this direction. However, many more steps will be necessary going forward (see also UN Environment & WTO 2018). The following section zooms in on the Environmental Goods and Services (EGS) negotiations at the WTO, demonstrating some of the complexities encountered in this process.

4. Liberalising trade in environmental goods and services

The liberalisation of trade in EGS has been one of the main topics linking green economy and trade at the global level. The EGS industry has been rapidly growing, driven by its rising economic importance, which has been supported by increasingly stringent environmental policies and enhanced environmental awareness. Liberalising and facilitating trade in EGS is expected to further boost the growth of this important industry.

This means that tariff and non-tariff barriers to trading EGS are reduced, which is expected to enhance their overall trade volume, thereby making them more widely and cheaply available. Major negotiations have been taking place both at the multilateral level, in the context of Environmental Goods Agreement (EGA) of the WTO, and at the regional level within trading blocks, such as the Asia Pacific Economic Cooperation (APEC).

4.1. Trends and drivers of global EGS trade

Global trade in EGS, most notably Environmentally Sound Technologies (ESTs), has increased by over 60%, from US$0.9 trillion in 2006, to US$1.4 trillion in 2016 (UN Environment 2018). The most traded environmental goods include renewable energy technologies, wastewater management and water treatment, solid and hazardous waste management, and products related to air pollution control.

Also, the involvement of developing countries' in the world trade of environmental goods has been growing. Driven mostly by **BRIC countries**, the value of environmental goods exports from developing countries' has doubled between 2006-2016. Yet, the majority of less developed economies, especially least developed countries (LDCs), do not yet fully participate in the trade of these products (UN Environment 2018), which can be linked to various factors including effective domestic markets or sound productive capacity (see also Box 12.4).

> **Key term: BRIC countries**
> This term is used to describe the four nations of Brazil, Russia, India, and China. The acronym was first used in 2001 by Jim O'Neill. It was used to group together the four nations that were believed to be in the same stage of economic development. However, it wasn't until 2009 when the countries' leaders created a summit. Then, the following year it became a formal institution. Adapted from: http://worldpopulationreview.com

Studies suggest that environmental regulation is a major driver for the development of a domestic market for EGS, as well as domestic productive capacity. A study by the OECD (Sauvage, 2014) that addresses conceptual and empirical evidences point to a positive relationship

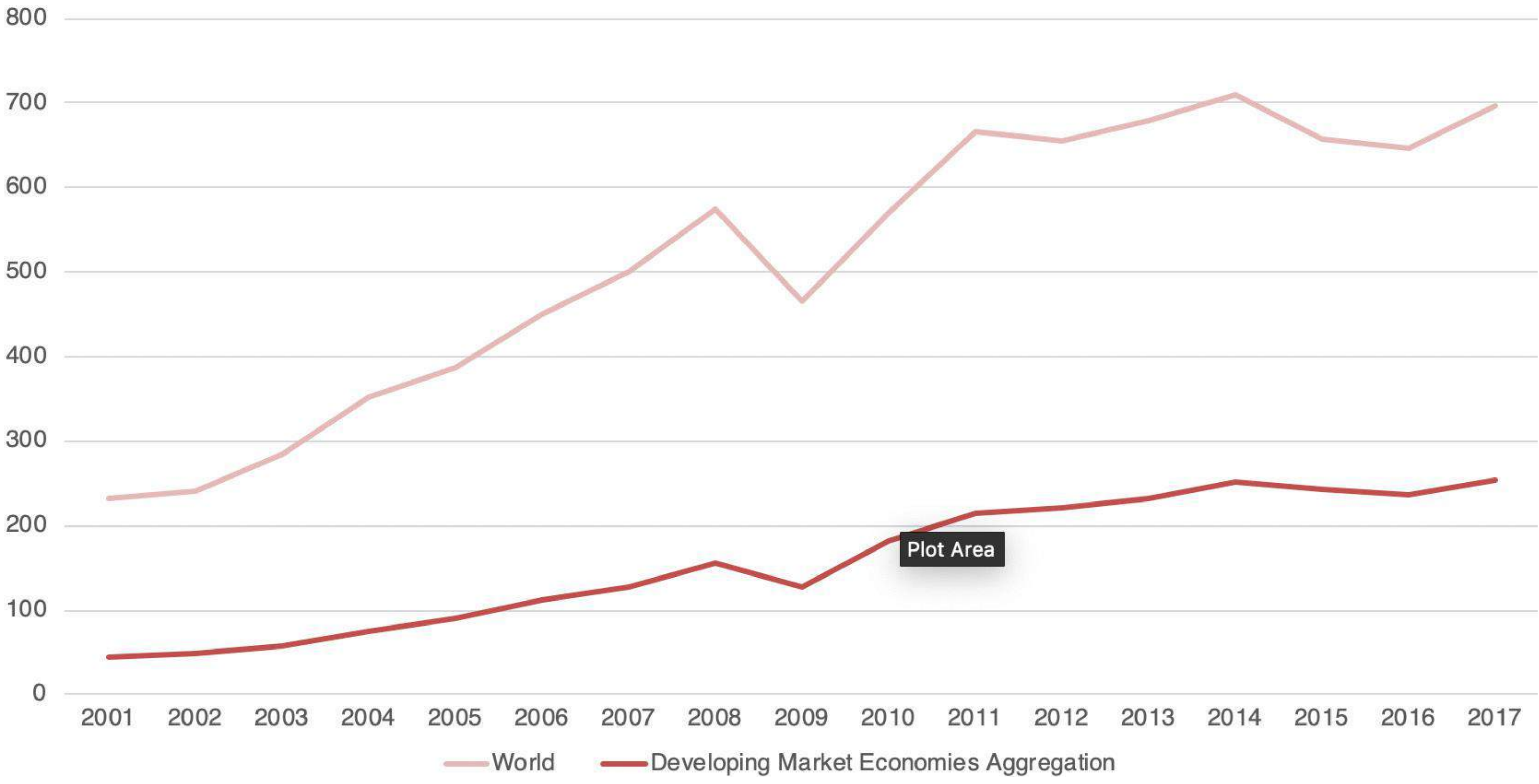

Figure 2: Exports of environmental gooda 2001-2007 (US$ billion) OECD list (source: UN Environment 2018.

between a country's regulatory stringency and its international trade in EGS. For example, South Korea has applied a selective and targeted policy approach that focuses on reducing greenhouse gas emissions of its industrial sector by providing incentives to industry for developing 1) green technologies and products, and 2) public policy tools to increase awareness and demand for these green products. The introduction of policy incentives has helped the country enter rapidly into high-end, low-carbon industries (Shim et al., 2009).

Many developing and emerging economies are at the early phase of market development, which requires significant government investment in environmental infrastructure for goods and services, such as waste and wastewater. A strategic political framework, which accounts for environmental, economic, industrial and trade policies can help put in place measures to advance a country from an early stage of market readiness in EGSs to a more mature phase, while, at the same time, improving environmental outcomes, competitiveness and economic development. Green Industrial Policies can play an important role in this respect (PAGE 2017, UN Environment 2018).

4.2 Liberalisation and facilitation of the EGS trade

Key negotiations for liberalising and facilitating trade in EGS have been taking place at the multilateral level. In the WTO's Doha Ministerial Declaration in 2001, members agreed to the reduction, or if deemed appropriate, the elimination of tariff and non-tariff barriers to EGS. However, due to the stall of the Doha round, negotiations were not finalised. Taking up this issue later, 14 WTO members released a joint statement in Davos on 24 January 2014 and pledged to launch negotiations to liberalise global trade in environmental goods. The Environmental Goods Agreement (EGA) negotiations were then formally launched on 8 July 2014 in Geneva

The EGA is a plurilateral agreement, which means that it is covering a group of WTO Members, rather than all members of the WTO. WTO Member States negotiation participants have grown to 18 by 2018, representing 46 WTO members and accounting for 86% of the global trade in environmental goods. Negotiations are in theory open to all WTO members and outcomes will extend to all WTO members on a 'most favoured nation' basis. This means that tariff reductions negotiated as part of the EGA will benefit all WTO members (WTO, 2014). Some negotiators also mentioned that a two-phase approach would be applied, which is to firstly negotiate on a wide range of products for tariff reduction purposes, then to tackle non-tariff barriers (WTO, 2014).

For those countries that have already built a significant EGS industry, facilitating the export of those products and services can bring important economic opportunities. An analysis conducted by the EU negotiation team demonstrates that the successful conclusion of the current full WTO EGA list can bring a EUR 21 billion increase for global trade (Monkelbaan, 2017). Various studies show that a more liberal trade in EGS may also benefit countries that currently do not have a sufficiently high level of production and services capacities (Bucher et al. 2014), if embedded in a holistic approach policy-making (see also box 12.4). However, some countries have expressed concerns that liberalising the trade of these goods and thus facilitating the import of EGS would make their own industry less competitive or might hinder them from developing such an industry in the future, which may partially explain their hesitance to engage in negotiations.

Besides concerns over competitiveness, the negotiations on the EGA have been slowed down due to technical difficulties. One such difficulty has been on what can and should be considered an 'environmental' good (or service). According to the definition proposed by Eurostat and OECD (1999), the environmental goods and services industry consist of "activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-system". This includes cleaner technologies, products, and services that reduce environmental risk and minimise pollution and resource use (OECD & Eurostat, 1999). However, some countries have adopted a definition based on their own scope and criteria. For example, Canada, Japan and the United States have adopted a broad definition, thus encompassing a wider range of goods; while Italy, Germany and Norway's definitions are rather narrow and focused on pollution

Box 12.4: A holistic approach to help developing countries further harness trade opportunities in Environmentally Sound Technologies.

- Many developing countries, especially LDCs, have not been able to develop effective domestic markets or sound productive capacity for ESTs. To address this, a holistic approach is needed including research and data capture, awareness raising, capacity building, and policy coherence at national, regional and global levels.
- A better data system would need to ensure environmental credibility of defined ESTs, address the issue of dual-use, improve classification of environmental services, capture the relationship between environmental goods and services, and promote standardisation and harmonisation of data collection.
- At the country level, policy measures could be taken to promote and encourage trade and investment in EST sectors, build productive capacity, improve the skills of the labour force, ensure coherence between environment and trade policies, and effectively assess impacts of EST trade based on comprehensive sustainability assessments.

Source: Entirely based on UN Environment (2018), Key findings prevention activities and related commercial services (Vikhlyaev, 2004).

Nevertheless, making this definition work in practise has proven more complex than it may appear at first sight. One such complexity is that many 'green' products have dual or multiple uses. For example, a 'green good' traded on preferential terms may equally be used for a 'brown' activity. Similarly, it is difficult to define what products may qualify as 'greener' than others, as environmental performance standards change frequently. Taking into account innovation and technological advances, at what level should a more efficient product be deemed an 'environmental' product and granted with lower tariff levels? For this reason, Lim (2017) and Cosbey (n.d.) suggested that a technical and scientific advisory body is needed to provide assessment and adjustment to what is considered an environmental good to ensure the environmental credibility of a list of goods and services that are categorised as EGS.

The second major technical difficulty lays in the way that major trade agreements classify goods: Major trade agreements are based on the *Harmonized Commodity Description and Coding System* (or the "HS" code) (UN Trade Statistics, 2017). These so-called subheadings, or HS codes, are used as a harmonised classification system for goods traded internationally, using a six-digit code. However, there are no HS codes on the international level that correspond to 'environmental goods'. The absence of a category for environmental goods that is harmonised internationally makes negotiations difficult. The APEC group of states that have successfully agreed on a voluntary reduction of tariffs on environmental goods can serve as an illustration on how to practically address this issue (Box 12.5).

However, as also a survey by Environmental Business International from 2013 demonstrated, tariffs are not one of the top concerns of companies active in environmental industries worldwide [2]. However, many studies indicate that non-tariff barriers such as countervailing duties and anti-dumping policies significantly influence trade in EGS. The APEC list, as well as the EGA, however, focus on the reduction and elimination of tariffs only; non-trade barriers have not been brought into the discussion and negotiation yet. In addition, environment services, such as renewable energy equipment maintenance, is another area that not yet explored.

Box 12.5: APEC: a leader in liberalizing trade in environmental goods and services

The APEC group of States has been a leader in the liberalisation of EGS trade. Through its Early Voluntary Sector Liberalisation (EVSL) initiative launched in 1997, APEC aimed to obtain more favourable tariff treatment among APEC member economies (Sugathan, 2013). In Sydney 2007, APEC leaders made a commitment to clean and sustainable development and launched an action agenda including promoting the development of EGS sector, and in 2009, endorsed the APEC EGS work programme. During its meeting in 2011, APEC leaders agreed to voluntarily reduce the tariff to no more than 5% on a list of environmental goods to be released in 2012 by the end of 2015 (APEC, 2011, 2012a

To specify the list of environmental goods that were found in 54 HS codes or product categories, the APEC further specified the environmental goods they targeted within the HS codes, naming this specification a so-called *ex-out*. To implement these international categories into tariff reduction on the national level, these ex-out categories must be translated to the level of tariff lines in national tariff schedules, which is the way traded goods and the respective tariff that applies to them, is organized on national level. As these are not harmonised internationally and look very different in each country, they do not form part of the negotiations. In the APEC example, APEC members chose different approaches towards implementation on the national level: Some countries, including Brunei Darussalam and Chile simply reduced tariffs for all tariff lines corresponding to the 54 HS product categories. Most countries however identified the corresponding tariff lines for all ex-outs within the 54 HS product categories. As this will result in a broader list of goods to be liberalised than specified in the ex-outs, Mexico chose to create new tariff-lines that are identical with the ex-out categories. Korea and China again implemented tariff reductions for parts of already existing national tariff lines.

The endorsement of the APEC list marks the first multilateral tariff-cutting for environmental goods. Although the APEC list of environmental goods is only for APEC members, they represent nearly 60% of world trade flow in those 54 sub-headings in 2011. According to APEC sources (APEC, 2012b and APEC, 2015), this could boost a US$500 billion global industry towards supporting job creation and economic growth in the region.

5. Foreign direct investments & inclusive green economy

Shifting to a green economy relies on substantial investment in green sectors, such as energy efficiency, renewable energy generation, green transport and low-carbon construction and production. In addition to domestic financing and investment, foreign investment can help to leverage additional financial resources from abroad. This may involve commercial but also non-

2 More information please refer to: ICTSD (2014), A conversation on green goods trade with Ronald Steenblik and Grant Ferrier. Biores, Volume 8-Numer 1. Available at: https://www.ictsd.org/bridges-news/biores/news/a-conversation-on-green-goods-trade-with-ronald-steenblik-and-grant-ferrier

Box 12.6: Multilateral funds and climate finance

Climate finance draws from public, private and alternative sources of financing at various levels. Article 9 of the Paris Agreement stipulates that developed country parties shall provide financial resources to assist developing country parties with respect to both mitigation and adaptation, while other parties are encouraged to provide or continue to provide such support voluntarily. At the multilateral level, several funds have been established for environmental issues in general and climate change mitigation and adaptation in particular:

- Global Environment Facility (GEF). The GEF was established to help tackle environmental problems on the eve of the 1992 Rio Summit. It serves as a financial mechanism for 5 major international environmental conventions: the UNFCCC, the UN Convention on Biological Diversity, the Stockholm Convention on Persistent Organic Pollutants, the UN Convention to Combat Desertification and the Minamata Convention on Mercury. For climate finance, the GEF has been entrusted to operate the Special Climate Change Fund established in 2001 to finance projects relating to adaptation; technology transfer and capacity building; energy, transport, industry, agriculture, forestry and waste management; and economic diversification.
- Adaptation Fund (AF). The AF was established in 2001 to finance climate change adaptation projects and programmes in developing country parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change. It is financed with a share of proceeds from the clean development mechanism project activities and other sources of funding. The fund is supervised and managed by the Adaptation Fund Board.
- Green Climate Fund (GCF). The GCF was established at UN Climate Change Conference held in Cancun in 2010 as an operating entity of the financial mechanism of the UNFCCC. Governed by the GCF Board, the fund seeks to promote a paradigm shift to low-emission and climate-resilient development. When the Paris Agreement was reached in 2015, the fund was given an important role in serving the agreement and supporting the goal of keeping climate change well below 2 degrees Celsius.

commercial sources, such as official development aid. Investment from several multilateral funds also plays an important catalytic role in areas such as climate finance (Box 12.6).

The need for additional sources of finance arises as emerging green products, sectors, and economic activities are often considered 'high risk' investments by traditional banks. In addition, financial sectors that specialise on high-risk investments, such as venture capital and private equity, are not fully developed in many countries. In such cases, foreign investment, including foreign direct investment (FDI) may fill this gap. FDI is an investment by an individual or multinational enterprise of one country that establishes a lasting interest in and control over an enterprise in another country (UNEP Inquiry, 2017).

Beyond its function of providing foreign capital, FDI can also support technology and knowledge transfer and facilitate foreign market access (UNCTAD, 1999). This promotes green industrial policy efforts of countries in multiple ways: strengthening local production or delivery of green goods and services; access to foreign capital and technology, which are crucial for the development of green industries (section 2.3); employment and human resource development; value creation; and various indirect effects via demonstration and **spillover effects**.

> **Key term: Spillover effects**
> The beneficial effects of new technological knowledge on the productivity and innovative ability of other firms and countries. Adapted from: https://www.igi-global.com

In this context, an appropriate degree of openness to foreign investment, therefore, is important for fostering the development of green service and manufacturing industries (see also PAGE 2017, Chapter 2 on 'border measures'). Depending on the sector, different contractual modalities and models of cooperation between the private and public, domestic and foreign players may be useful. This may include public-private partnerships (PPPs) in the forms of build-own-operate (BOO), build-own-transfer (BOT) or concession arrangements. In some cases, support measures from the host State may also be linked to the requirement to invest in the local economy (see also PAGE 2017). Making FDI work for the recipient country will only be successful however, if a coherent legal and regulatory framework, transparent public decisions and a commitment to green economy and sustainable development are in place. The appropriate use of International Investment Agreements (IIAs) can play an instrumental role in this respect (See also Box 12.7).

6. Green technology transfer and knowledge flows

Diffusion of green technology and knowledge transfer is vital to a global transition to the green economy. A challenge that many less industrialised countries encounter is a lack of sufficient innovative capacities and ability to invest in R&D in advanced green technologies.

Box 12.7: International investment agreements

International Investment Agreements (IIAs) are treaties between States to promote and protect foreign investment under international law. By concluding IIAs, capital-exporting countries (home States) aim to offer an additional layer of protection to their domestic companies investing abroad, while capital importing countries (host States) aim to attract additional foreign investment to their economy. Over 2,500 IIAs are currently in force.

However, promoting foreign investment through techniques such as investment contracts, domestic investment laws and, above all, IIAs, has come under much criticism in recent years as a result of the surge in disputes brought by foreign investors against host countries. This has been the case as the way many IIAs are designed at present overlook the importance of environmental and social considerations. Moreover, in their present form and operation, IIAs may restrict the ability of States to implement enabling policies. In response, more recently concluded 'third-generation treaties' increasingly make reference to environmental provisions in the text of the agreement.

However, going a step further, institutions such as PAGE argue that IIAs should be designed in a way as to support countries' transition to IGE by promoting sustainable investments vis-à-vis investments in the so-called 'brown' economy. This would require IIAs to be drafted, designed, interpreted and applied in a way as to facilitate investments contributing towards the green economy, as well as regulating and potentially excluding unsustainable investments from investor protection under the terms of the treaty.

Based on: PAGE 2018

In that case, building up national production capacity for green technologies is challenging, as it would take more time and money to generate the same technologies already available in some other places. Here, technology transfer becomes central, in particular for many developing economies, as a way to access advanced green technologies. In reality, today, the production of sophisticated environmental technologies is organised in complex regional or global value chains of production, within which countries specialise on particular aspects of production. For highly industrialised countries currently leading on the production of green technologies, access to green tech, as well as the development of their green manufacturing sector only functions in a context of extensive trade relations. However, technology transfer is more than the import or export of goods.

One may identify three basic ways through which a firm can transfer its technology abroad: export products and services to a foreign market, license its technology to a foreign firm, and investing abroad. These represent major processes of cross-border transfer of technology. Various channels of green technology transfer function in different manners, as illustrated in Box 12.8.

These channels of green technology transfer do not happen automatically. To describe the necessary conditions that are required for technology transfer to take effect, the term 'absorptive capacity' has been coined (see also Zahra and George 2002, Griffith 2003). Absorptive capacity thus refers to the conditions that need to be present in order for a country to realize the potential of cross-border technology transfer for its own technological learning and industrial development (Assman and DIE, 2017). In addition to adequate absorptive capacities, an enabling environment for cross-border flows of technology at the macro level is essential. For example, for attracting low-carbon technologies some countries have established low-carbon special economic zones, others provide specific incentives (UNCTAD, 2010). The effectiveness and efficiency of the transfer of green technologies are also affected by the national system of innovation

Box 12.8: Green technology transfers

- **Imports of goods and services.** Advanced green technologies are 'embodied' in machinery, equipment and components that are transported from one country to the other. They may be subsequently 'disembodied' via demonstration or training. Together with imports of relevant services, such as technological and advisory services, important knowledge can be transferred and utilized.
- **Technology trade and licencing.** Technologies can be traded between countries through the exchange of intellectual property rights (IPRs), the outsourcing of technical services, international R&D, licensing and to some extent franchising. Among them, licensing stands out as a major mode of international technology transfer. From the perspective of the licensee, the decision to obtain a licence depends largely on the size and growth potential of the domestic market for the green products. For the licensor, market growth is also a major determinant for achieving a royalty that is sufficient to compensate the risks, such as technology leakage and reverse engineering of proprietary technologies.
- **FDI and technological spillovers.** FDI is a major means of international transfer of technologies, including for such soft ones as managerial expertise, marketing skills and knowledge of export markets. In addition, technologies can diffuse to a wide range of domestic firms from foreign affiliates, both vertically and horizontally. Technological and knowledge spillovers take place through demonstration effects, labour turnover and linkages to domestic firms, especially those in upstream activities (UNCTAD, 2001). In the growing market of green consumer products, for instance, domestic suppliers can enhance their technological capabilities by engaging in the supply chain of local affiliates of Multinational Companies.
- **Movement of people.** International movement of people, in particular the inward movement of green technology professionals and experts into the country, is another channel for international transfer of green technologies. This is related to the domestic delivery of environmental and/or green technological services. According to the definition of the WTO, a supplier of one Member in the territory can deliver services internationally to any other Member through the presence of natural persons. Domestic companies relate this to the employment of foreign professionals and experts, as well as returnees. For both, the international movement of people is crucial.

in general and the sectoral innovation system for specific green products in particular. For low-income developing countries where the innovation systems are often weak, a friendly business environment, an open trade and investment policy framework, and a sound education system have been highlighted as fundamental prerequisites in fostering technology transfer and knowledge diffusion.

Another challenge pertains to intellectual property rights (IPR) protection, particularly when it comes to incentivising economic activities which involve the use of advanced green technologies from abroad. Protection of IPR is important to foster innovation, in order to provide appropriate incentive for firms to innovate. Inversely, however, an IRP system, which is too rigid, may stifle technology transfer and technological learning. WTO's intellectual property rules regarding those from the environmental perspective have been subject to continuous debates. This has led the 2001 Doha Ministerial Declaration to mandate the Committee for Trade and Environment (CTE) to look at IPR-related issues. Since then, the committee's discussions have mainly centred around the relationship between the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and the Convention of Biological Diversity. However, conflicts and diverging opinions remain: some developing countries reiterate their proposal on amending the TRIPS Agreement to require patent applications to disclose the source of biological materials, others believe that such a proposal is neither necessary or appropriate, or support a more limited patent disclosure requirement at the international level.

How can innovation be boosted and new environmentally sustainable technologies be adopted? How can speedier diffusion of these technologies be enabled to developing countries where the need is greatest? From a policy-making perspective, the following points may be made: One central factor is the strengthening of policy efforts at both the national and international levels. From the viewpoint of recipient countries, the efficiency and effectiveness of green technology is affected by various institutional and policy factors, such as environment regulation, international economic policies, science, technology and innovation policies, and IPR regimes. These institutions and policies affect firms' incentives to acquire and absorb green technologies. For example, strong environmental regulation and enforcement are the main incentives for firms to acquire new technologies (Tébar Less and McMillan, 2005) and a major predictor for environmental technology export (Sauvage 2014). Given the positive externalities of green and low-carbon technologies, there is a need to strengthen international cooperation on R&D in specific technological areas relevant for the green economy, and to expand the space for these technologies in the public domain. In addition, accelerating the diffusion of those technologies to developing countries and stimulating the transfer of publicly funded technologies will prove essential.

7. Conclusion

By examining the two directional relationship between international trade and green economy, the chapter showed that green economy represents significant trading opportunities and that trade can provide an engine for the green transition. The role of international trade in this regard is closely related to other international economic activities, including foreign direct investment and cross-border technology transfer. The chapter demonstrated that the environmental impacts of trade liberalisation are contingent on a multitude of factors. Looking at international efforts to liberalize trade in the areas of green goods, services and technologies, the chapter zoomed in on the Environmental Goods Agreement negotiations at the WTO, and made visible some of the political but also technical complexities that arose in the negotiation process. Concluding, the chapter made visible that trade has a strong potential to act as a driver for a country's transition to a green economy, and that green economies, inversely may strongly affect trade flows. However, policy alignment and a high willingness of actors to cooperate and find common ground, overcoming technical as well as political difficulties, will be essential to move forward.

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