Chapter 2
Overuse, Scarcity, and the Debate About Sustainable Development

The last decades have shown that natural capital in basically all its dimensions is subject to substantial overuse. Rogall (2008, pp. 31–39) classifies overuse into five exemplary areas. They include but are not restricted to (1) climate change; (2) overuse of renewable resources; (3) use of nonrenewable resources; (4) destruction of ecosystems, species, and landscapes; and (5) threats to human health. Each of these will be briefly described[1]:

1. The consequences of a failure to prevent a global temperature increase of over 2 °C may result in a reduction of water reserves, drought, desertification, and more frequent extreme weather events. This in turn causes problems for human health, damage to ecosystems, and the extinction of species. The Intergovernmental Panel on Climate Change as well as the Stern Report estimate that mitigation costs of climate change will comprise up to 3.5 % of global GDP (IPCC 2007, p. 69; Stern 2007, p. 260).
2. Examples of renewable natural resources which are being overused beyond their regeneration rate include soil, fish, and freshwater. 66 % of cultivable land worldwide is damaged and around 11 % of all soil is degraded (BMU 2006). Similarly, around 70 % of all freshwater sources are either contaminated or degraded. Biodiversity loss due to human actions occurs 1,000 times faster than the long-run natural rate of extinction; 10–30 % of mammal, bird, and insect species are threatened by extinction (Millennium Ecosystem Assessment 2005, p. 39).[2] The Food and Agriculture Organization of the United Nations reports that in 2007 only 20 % of global fish stocks were moderately underexploited or moderately overexploited, with the remaining 80 % fully exploited, overexploited, depleted, or recovering from depletion (FAO Fisheries and Aquaculture Department 2009). The Millennium Ecosystem Assessment

[1] For more details, see also OECD (2001c).

[2] An overview on the arguments regarding the necessity to protect biodiversity can be found, for instance, in Bergstrom and Randall (2010, pp. 380, 400–401).

L. Talmon-Gros, *Development Patterns of Material Productivity*, Contributions to Economics, DOI 10.1007/978-3-319-02538-4_2,

(2005) considers approximately 60 % of ecosystem services to be degraded or used in an unsustainable manner.

3. The use of nonrenewable resources: Although the market exhibited major price increases and increased volatility for raw materials like minerals and ores in the last decade, Tietenberg and Lewis (2009) argue that "for most resources we shall never run out" (ibid, p. 604). They consider the rising cost of extraction and use (including environmental cost) as the limiting factors, rather than the exhaustion of nonrenewables, and argue that "the limits of our uses of the resources are not determined by their scarcity in the crust of the earth, but rather by what we would have to sacrifice to extract and process them" (ibid). This is in accord with the reasoning that current reserves can be expanded with the help of technological progress, which can facilitate finding new sources for conventional material, uncover new uses for conventional materials, and reduce the amount of resources needed to produce the products (Tietenberg and Lewis 2009). For example, the extraction of ores and fossil fuels lowers the average quality of the deposit, as initially higher quality ores and fuels are extracted but as prices rise it also becomes profitable to mine lower grade ores. The mining of inferior deposits leads to higher pressures on the environment, as more mining waste is accumulated in these cases (see also UNEP 2011a).
4. The destruction of ecosystems, species, and landscapes relates closely to the overuse of renewable resources but focuses more on species and ecosystems that are not or cannot (yet) be used as factors of production. Important aspects include aesthetic and ethical questions with regard to the extinction of species and the destruction of ecosystems and landscapes (Rogall 2008).
5. Production and consumption processes lead to organic and inorganic pollutants being emitted into the environment which can cause a slow toxification of the biosphere due to their longevity. Ultimately they can pose threats to human health. Examples are heavy metals and environmental toxins, emissions of pollutants, noise, summer smog, or the thinning of the ozone layer (Rogall 2008).

In conclusion, there is significant evidence for the overuse of natural capital, including its sink function. In an attempt to quantify overuse beyond safe limits, Rockström et al. (2009) provide an overview of planetary boundaries for a number of earth-system processes as well as their threshold levels. They argue that these boundaries have been crossed regarding climate change, biodiversity, and the nitrogen cycle.

Reasons for the overuse and consequently possible scarcities of natural resources are diverse. The next section provides an overview of economic explanations for overuse of natural resources.

2.1 Reasons for Overuse

The market system sets a number of incentives for consumers and producers to act in the face of scarcity, as long as property rights are well defined (Tietenberg and Lewis 2009, p. 606). However, especially in the case of natural resources, property rights are often not well designed which in turn leads to the appearance of externalities [see, e.g., Bergstrom and Randall (2010), Faucheux and Noël (2001), Endres (2007), or Tietenberg and Lewis (2009)]. Additionally, many natural resources exhibit public good characteristics, which are another important factor for overuse. Whenever "many costs of using unsustainable resources are born by someone other than those making the resource choices, private and social cost will not align" (Tietenberg and Lewis 2009, p. 607) and thus the market process will not be able to function correctly.

Besides the two main reasons for the overuse of natural resources—externalities and public good characteristics—the next paragraphs also describe factors from outside the economic sphere such as social and political factors.

There exists an extensive literature on externalities and they may be the most discussed source of market failure (Bergstrom and Randall 2010, p. 192). "An externality exists whenever the welfare of some agent, either a firm or a household, depends not only on his or her activities, but also on activities under the control of some other agent" (Tietenberg and Lewis 2009, p. 71). In a regime of private property rights, the exclusivity of the benefits and costs using the resource should accrue to the owner of the resource. However, in the case of natural resources, the costs of using the resource are often borne not only by the owner but also by other agents or the public. In this case the marginal costs of production are greater for society as a whole rather than for the individual producer. This can in consequence lead to a suboptimal allocation of resources and therefore their overuse.[3]

Open-access resources on the other hand have no defined property rights; therefore, no one can legally restrict access to them. As a consequence, they can be exploited on a first-come-first-serve basis. Their main features are nonexclusivity, which means that anyone can exploit the resource, and divisibility, meaning that any withdrawal from the stock lessens the amount available for the use of others. These features also lead to inefficient allocations, as with sufficient demand open access will cause overuse and as scarcity rents cannot be appropriated by anyone, there is therefore no incentive to conserve. Well-known examples of an open-access resource are global fisheries (Tietenberg and Lewis 2009).

Another main reason for the overuse of natural resources lies in the public good characteristics that some of them display. A public good is characterized by non-excludability and indivisibility. Non-excludability refers to the fact that once a good is provided, everyone can enjoy the benefits of it, regardless of whether he or she has paid for it. One person's consumption does not lessen the consumption possibilities of other people when a good is indivisible. Examples of public goods

[3] See, e.g., Tietenberg and Lewis (2009, p. 71) for the well-known river example.

are clean air, clean water, biological diversity, or a beautiful landscape. The special characteristics of these goods can lead to a supply that is smaller than efficient or an overuse, as existing scarcities are not reflected in the prices (Tietenberg and Lewis 2009; Bergstrom and Randall 2010; Rogall 2008).

Additionally, there are three major socioeconomic factors that facilitate the overuse of natural resources, especially in the light of open-access resources and public goods. These are the so-called *Tragedy of the Commons, the Prisoners' Dilemma, and Freeriding*. The "tragedy of the commons" refers to a situation in which it is rational for an agent to use open-access resources less carefully than he or she would have done in a regime of private ownership (Hardin 1968). The "prisoners' dilemma," a game-theory concept, refers to a situation when the rational behavior of the participants leads to a result that is explicitly bad for them. In the context of natural resources, this means that a change could only be achieved if *all* individuals altered their behavior, but as the individual cannot be sure of this, it is rational for the individual not to forego the additional utility (Rogall 2008, p. 64). "Freeriding" is a problem often found in the context of public goods and occurs because once the good is provided each person can enjoy the benefits of the good without having had to contribute to it. This in turn diminishes the incentives to supply this good which accordingly leads to an undersupply (Tietenberg and Lewis 2009; Rogall 2008).

The debate about further factors affecting overuse of natural resources includes imperfect market structures, divergence of social and private discount rates, discounting of future damages in general, government failure (rent seeking as well as the failure to ensure sustainability), population growth, economic growth, consumption patterns, psychological barriers to change, as well as poverty which leads to increased environmental pressures [see, e.g., Bergstrom and Randall (2010), Tietenberg and Lewis (2009), and Rogall (2008, pp. 64–67)].[4]

The combination of the above factors leads to a suboptimal allocation of resources and therefore substantial overuse. The European Environmental Agency considers past as well as future trends to be the result of a range of interdependent social and economic factors (European Environment Agency 2005, pp. 11–17). Notably these include demographic development, economic growth, and development patterns such as technology, economic structure, as well as production and consumption patterns. The link between demographic development and resource use is intuitive: more people in general use more resources. The United Nations World Population Prospects (2009) predicts that global population will increase by about 30 % until 2050 (assuming a medium fertility scenario). For the greatest part, this increase will take place in developing countries and emerging economies, in parts of the world where basic material needs are greatest. Therefore, material use can be expected to rise accordingly. Additionally, changing consumption patterns in emerging economies towards the "western" mode, for instance, in terms of diet,

[4] Especially the aspects discounting of future damages and the role of economic growth play in environmental degradation are discussed extensively. See, e.g., Bergstrom and Randall (2010, Chap. 7) and Neumayer (2010) for the debate on discounting.

can be expected to further increase material use. Large disparities in income can make international cooperation more difficult and poverty often leads to a deterioration of environmental quality besides the consequences with regard to disease, malnourishment, conflicts, and migration (OECD 2001d, pp. 22–27). Generally, economic growth is expected to lead to an intensified material throughput in the economy and therefore to an increased use of resources. However, economic growth caused by technological progress or capital accumulation may also lead to efficiency improvements and therefore reduced resource inputs.[5]

The third important set of drivers for resource use patterns includes technology, structure of an economy, as well as patterns of production and consumption. The use of natural resources and their influence on the environment are substantially influenced by the form and efficiency of the dominant technologies. The extent to which resource-intensive or resource-extensive industries play a role in the economy is relevant for its structure and therefore patterns of resource use. Additionally, the stage of economic development influences resource use. It is assumed that the more industrialized a country is, the lower its resource use per unit GDP. Given these factors and their interdependencies, it is very likely that resource use will continue to intensify in the future and make existing scarcities more acute (Millennium Ecosystem Assessment 2005, p. 17).

As a consequence of the overuse of natural resources, the differences between modern and preindustrial environmental damages become more evident. Environmental problems are not longer locally restricted but have become universal; they have also become so complex that a cause can no longer be easily identified. Scientific tools have become necessary to measure the effects of environmental degradation; they can no longer be experienced through sensual experience. And the damages occurring are often irreversible damages rather than short run [Sieferle (1988) cited in Förstner (2008)]. Additionally, there is evidence that nonlinear changes in ecosystems are becoming more likely. This means that once a threshold is crossed, the state of the system is fundamentally altered. These alterations can be abrupt, large in magnitude and difficult, expensive, or even impossible to reverse. They pose severe consequences for human well-being; however, their prediction is very difficult. Examples include disease emergence, such as in the case of cholera, eutrophication and hypoxia, collapse of fisheries, species loss, and regional climate change. Loss of biodiversity lowers the level of disturbance an ecosystem can withstand without crossing a threshold and fundamentally changing its structure and functioning (called resilience). Additionally, pressures from different directions push the ecosystem more strongly above their thresholds (Millennium Ecosystem Assessment 2005, pp. 11–12).

[5] The question whether economic growth automatically improves environmental quality is at the center in the debate about the environmental Kuznets curve. The environmental Kuznets curve postulates an inverted-U relationship between pollution and economic development. Neumayer (2010) presents an overview on economic growth and the environment as well as the environmental Kuznets curve, and Tietenberg and Lewis (2009) also discuss the Kuznets curve.

Another, though different consequence of the overuse of natural resources, is the emergence of debates concerning sustainability, sustainable development, and subsequent policies.

2.2 Sustainability, Green Growth, and Environmental Policies

Environmental problems due to the overuse of natural resource have increasingly gained public attention over the last 3–4 decades. A growing concern is whether economic development in today's form can be sustainable in the long run leading to a greater concern for the environment. As a result of this global phenomenon, the United Nations held a conference on environment and development in 1992 and agreed on the idea of sustainable development (Rogall 2008). The United Nations adopted the definition of the Brundtland Report which defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p. 8). Part of the appeal and yet at the same time the problem of the concept is that it is very vague and therefore allows a whole range of definitions. For instance, Pezzey (1992) mentions several dozen different definitions found in the literature.

Discussion since then has focused on three aspects: the definition of sustainable development or sustainability, the determination of conditions for sustainable development, and the question of whether a national or the global economy is on a sustainable development path (Pearce and Atkinson 1996).

Considering only the economic definition of sustainable development, sustainability can be defined as "non-declining per-capita human well-being over time" (Pearce and Atkinson 1996, p. 166) or as "non-decreasing capacity to provide non-declining per capita utility for infinity" seem most accepted (Neumayer 2010, p. 7). This translates into the condition that the underlying capital stock is kept constant [see, e.g., Neumayer (2010), Pearce and Atkinson (1996)].

The composition of this capital stock and the substitution possibilities between the different components gives rise to the distinction between weak sustainability and strong sustainability. Weak sustainability demands that the overall stock of capital remains the same, whereas the different forms of capital such as natural capital, human capital, and man-made capital can compensate for each other, i.e., under this rule, it is permissible to diminish natural capital if man-made capital is increased in return. Strong sustainability demands that the natural capital stock is held constant while at the same time total capital remains constant or is increasing (OECD 2001d; Pearce and Atkinson 1996).

Measures to monitor sustainability differ according to the chosen concept of sustainability. In Neumayer (2010), a discussion of several measures for weak and strong sustainability can be found.[6]

The issue of "Green Growth" (OECD 2011c) or a "Green Economy" (UNEP 2011b) has entered the international policy agenda alongside the debate about sustainable development in recent years. It is related to sustainability in such a way that over the years, the recognition has been growing that "achieving sustainability rests almost entirely on getting the economy right" (UNEP 2011b, p. 16). The United Nations Environment Programme considers the transition towards a green economy as a strategic economic policy agenda for achieving sustainable development (UNEP 2011b, p. 19). Similarly, the OECD explains that its Green Growth Strategy develops an "agenda for delivering a number of Rio's key aspirations" (OECD 2011c, p. 11). It is not to be considered as a replacement for sustainable development but as a subset of it. The concept of "Green Growth" is narrower than the concept of sustainable development, because the "Green Growth" approach focuses on economic and natural assets, whereas sustainability requires also the concern for human and social capital. Nevertheless, specific attention to social issues and equity concerns resulting in a greening of the economy is warranted and strategies concerning the broader social pillar of sustainable development should be implemented in parallel (OECD 2011c). The UNEP's concept of a green economy also caters for broader issues such as intergenerational equity and poverty eradication.

These recent approaches can thus be seen as a subset of the wider approach of sustainability. Next, the essentials of the OECD Green Growth Strategy will be briefly presented. Generally, the strategy seeks to "encourage greener behaviour by firms and consumers, facilitate smooth and just reallocation of jobs, capital and technology towards greener activities and provide adequate incentives and support to green innovations" (OECD 2011c, p. 11). Amongst others, it aims to close the gap between private and societal returns from economic activity and raising returns to "green" investment and innovation. Its implementation involves two sets of policies: the first policy set includes framework conditions which mutually enforce economic growth and the conservation of natural capital and which are supplemented by innovation policies. Possible instruments are core fiscal and regulatory measures like tax and competition policy, designed and executed to maximize the efficient allocation of resources. Innovation policies aim at rewarding the inventiveness necessary for using less natural capital in a more efficient manner. The second policy set explicitly targets efficient use of natural resources and increasing pollution costs. With regard to instruments, the OECD recommends

---

[6] Measures to examine weak sustainability include Genuine Savings and the Index of Sustainable Economic Welfare (ISEW) or Genuine Progress Indicators. The most important indicators for strong sustainability are physical indicators like ecological footprints and material flows as well as hybrid indicators combining physical indicators with monetary valuation, such as the Greened National Statistical and Modelling Procedures (GREENSTAMP), the so-called sustainability gaps, and the sustainable national income according to Hueting (SNI) (Neumayer 2010).

using prices where possible in combination with other complementary policy instruments (OECD 2011b, c, pp. 12, 35–83). Practically, the use of taxes or tradable permit systems is suggested as core strategies [see also von Weizsäcker (2009)]. These instruments can be supplemented by regulation, technology-support policies, and voluntary approaches as well as information-based measures. More details on environmental policy instruments can be found in OECD (2011c) Chap. 2. Particular attention is required for innovation and overcoming inertia; OECD (2011b) discusses this as well as challenges specific to green innovation.

Progress towards "Green Growth" should be monitored by groups of indicators describing and tracking changes in several fields: These comprise the productivity in the use of environmental assets and natural resources, the economic and environmental asset base, environmental dimensions of the quality of life, and policy responses and economic opportunities. This set comprises about 25 indicators which may be used to construct a composite indicator. Alternatively, a selection of these indicators will be chosen as headline indicators (OECD 2011c). The area of environmental and resource productivity comprises of carbon and energy productivity indicators, resource productivity indicators, as well as of multifactor productivity (including environmental services).

Similarly, within the Europe 2020 strategy and the appertaining Flagship Initiative for a Resource Efficient Europe, the European Union proposes a range of policies to make Europe more resource efficient. As part of that, resource productivity has been established as the provisional lead indicator for measuring progress (European Commission 2011b).[7] This indicator is the focus of this dissertation. However, instead of the term resource productivity, the term material productivity will be used, as this is conceptually more correct. Despite its relevance for economic and environmental policy making as well as for future development scenarios, very little is known about empirical regularities or development patterns of material productivity. Moreover, the requirement to cater for and avoid the so-called rebound effect is included in all three approaches mentioned above, even though actual measures remain vague. A rebound effect occurs when efficiency gains are translated into lower prices, which increases the real income of consumers and in turn makes increased consumption possible, for instance, if more efficient heating results in warmer homes instead of lower energy use (OECD 2011c).[8]

The prominent role played by innovation and technological progress for improving resource efficiency has been recognized in the context of policy recommendations. The next chapter will discuss the relation between technological progress and innovation and material consumption in depth.

[7] An overview over international as well as European environmental policy can be found in von Weizsäcker (2009).

[8] See, for example, Dujmovits (2010).

http://www.springer.com/978-3-319-02537-7

Development Patterns of Material Productivity
Convergence or Divergence?
Talmon-Gros, L.
2014, XIX, 210 p. 25 illus., Hardcover
ISBN: 978-3-319-02537-7