KYUSHU UNIVERSITY

Measuring sustainability and well-being

INCLUSIVE WEALTH REPORT 2018

UN environment

United Nations Environment Programme

2018 | Measuring Sustainability and Well-Being

CHAPTER 3: MORE ON NATURAL WEALTH OF NATIONS AND REGIONS

Shunsuke Managi

3.1. Introduction

An economy may satisfy current sustainable development criteria or may have satisfied the criteria in the recent past but might not continue to do so in the near future. Whether an economy can continue sustainable development depends on the scale of the economy (e.g. GDP). If it becomes too large relative to the natural capital base, the economy will be unable to maintain its IW. Therefore, maintaining the natural capital base is critical for sustainable development.

This chapter focuses on the role and importance of natural capital in measuring the IW of nations. The analysis is based on the same data set used in Chapter 1: a 140-country analysis of IW over 25 years (1990–2014). Following Arrow et al. (2012) and previous editions of the IWR, this report expands the scope of national capital in accounts of national wealth to allow for a broader understanding. In this report, national capital is classified into two major categories: (1) renewable resources and (2) non-renewable resources.

As shown in Fig 3.1, renewable resources are further broken down into (a) forest resources, which consist of timber and non-timber forest benefits; (b) fisheries, which are represented by the catch; and (c) agricultural land, which consists of cropland and pasture land. Non-renewable resources can be broken down into (d) fossil fuels (oil, natural gas and coal) and; (e) minerals (bauxite, copper, gold, iron, lead, nickel, phosphate, silver, tin and zinc). A relatively common accounting method is used to value these resources: total natural wealth is estimated by calculating the physical amount available and the corresponding shadow prices (rent) of the resources.

As we have illustrated elsewhere in the current report, the IWI is a linear index of produced, human and natural capital. In theory, however, shadow prices are defined as the additional contribution to social well-being. This contribution is expected to change as natural capital becomes relatively scarce, so shadow prices will also change in the long term. This is also true of produced and human capital but is especially relevant to natural capital, for which the assumption of absolute substitutability is not a realistic one (IWR 2012).

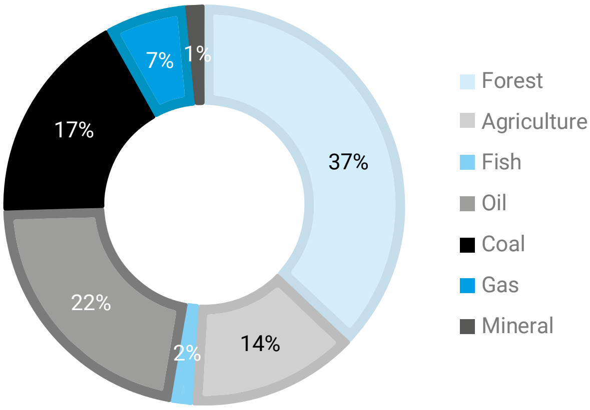
Natural capital also deserves special attention because it can collapse in a non-linear manner, with no advanced warning. This relates to the idea of thresholds and tipping points. Climate change is a prime example of this, which is why negotiations to set the 2-degree target in the Paris Agreement have reached a consensus. The non-linearity of natural capital is also observed in local contexts as well (e.g. Walker et al. 2009). This is explored in section 3 of this chapter, in which we examine the regional disaggregation of natural capital change for the studied period. It is misleading to talk about natural capital trends without differentiating regional disparities and types of natural capital (non-renewable versus renewable, etc.).

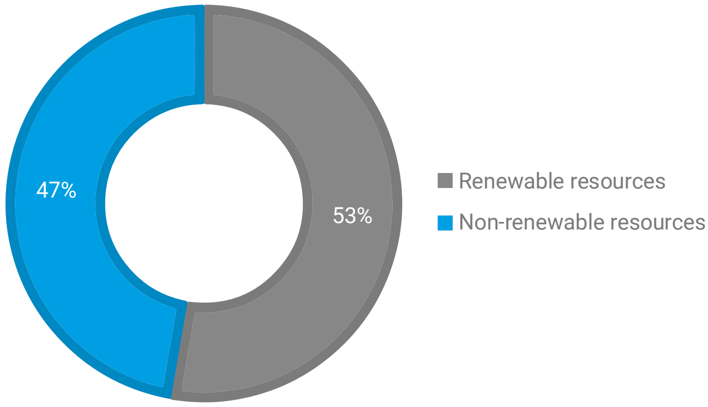
In section 4, we explore the interaction between natural capital and natural disasters. Some natural capital helps vulnerable regions cope with natural disasters. Mangrove trees act as a defence against flooding, for example (Barbier 2009; IWR 2012). So, while nature can, at times, threaten human beings, it also provides multiple benefits. We discuss this interconnectedness, citing recent examples of natural disasters.

In section 5, we report the fishery capital stock of nations in more detail. We begin with the concept of renewable resource dynamics, on which our methodology for counting stocks is based. Stock trends are contrasted with capture production. Overall, we show that global fishery capital is declining at an alarming rate, whereas capture production continues to rise, especially in Asia. This may be attenuated by investing in aquaculture, and sustainable and responsible management of the industry.

Section 6 is devoted to, as far as we are concerned, the first estimate of renewable energy as capital stocks. Although there has been growing interest and investment in renewable energy in both developed and emerging economies, there has, as yet, been no discussion of the issue in debates on inclusive wealth accounting and sustainability assessments. Section 7 provides a summary and concluding remarks.

Fig 3.1: Average share of resources, renewables and non-renewables in natural capital from 1990 to 2014





3.2. The Natural Capital of Nations

Natural capital is extremely important and, in many ways, unique. It is different from human and manufactured capital stock in that it operates according to its own complex laws and systems. It has been scientifically proven that important aspects of natural capital are irreplaceable (the assumption of strong sustainability). The concept of environmental sustainability largely addresses the issue of critical natural capital (Ekins et al. 2003). It is important to distinguish between weak and strong sustainability. The maintenance of human well-being is the main purpose of economic activity, as our inclusive wealth framework stresses, but at the same time, there is little doubt of the necessity of natural capital in itself. This section, therefore examines trends in the growth (or decline) in natural capital, independent of other forms of capital.

Overall, 17 of 140 countries have experienced a positive growth in natural capital. Natural capital indicators, for instance, show that forest resources increased in 55 of 140 countries between 1990 and 2014. In addition, 39 of 140 countries meaningfully increased their renewable resources – an important contributor of natural capital. However, the overall trend is a decline in natural capital. If this trend continues, it could take its toll on the future development of developed and developing nations, both of which rely on natural capital as an important source of resources.

The average annual growth rate of wealth and natural capital per capita can be classified into four quadrants in Fig 3.2:

- **Quadrant 1:** Growth in wealth and natural capital
- **Quadrant 2:** Decline in wealth and growth in natural capital
- **Quadrant 3:** Decline in wealth and natural capital
- **Quadrant 4:** Growth in wealth and decline in natural capital
-

Our empirical findings show that most countries (123 of 140) experienced a decline in natural capital while achieving an increase in wealth over 1990-2014. A group of seven countries (Albania, Armenia, Estonia, Guyana, Lithuania, Russia and Slovenia) experienced the most desirable situation: growth in wealth and natural capital (Quadrant 1, Fig 3.2). These countries could be considered to be on a sustainable development path both from a strong and weak sustainability perspective. Additionally, five countries in our sample show a decline in wealth while increasing their natural capital (Quadrant 2, Fig 3.2).

Fig 3.2: Per capita changes in natural capital and IW: average annual growth rate from 1990 to 2014

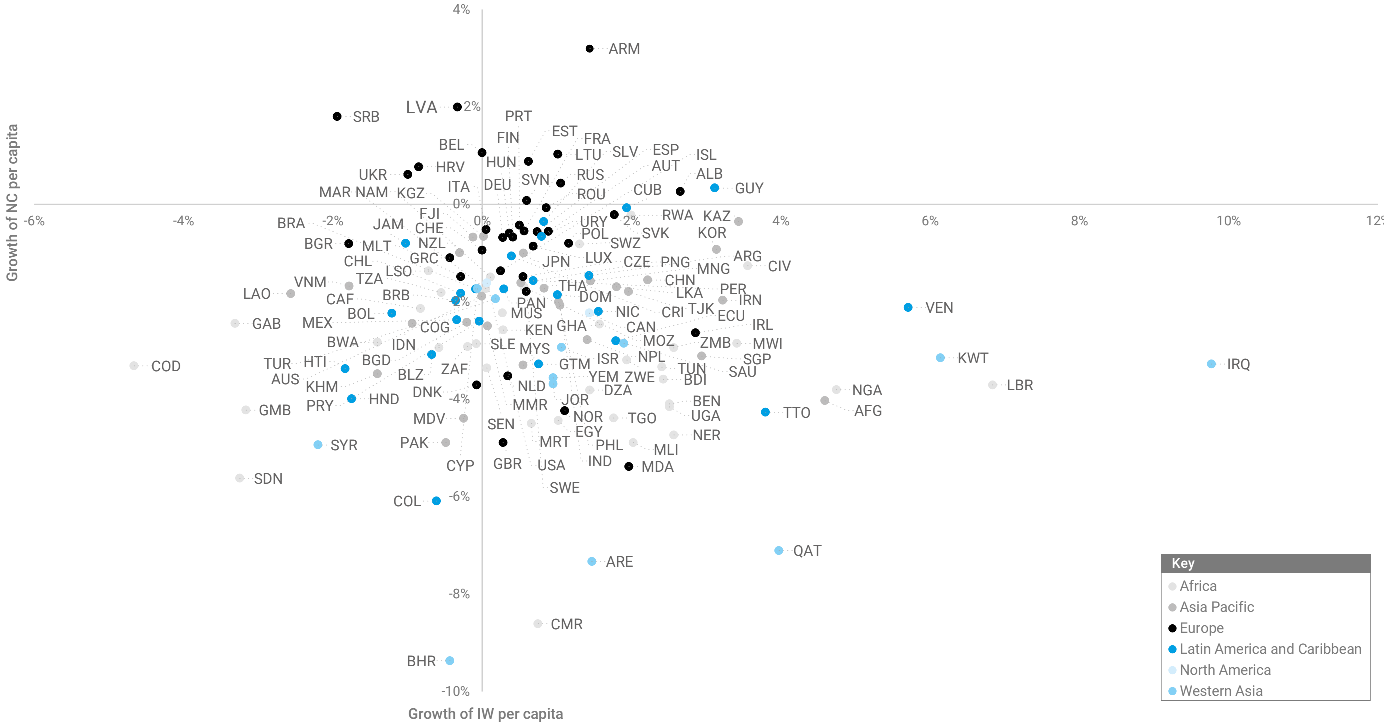
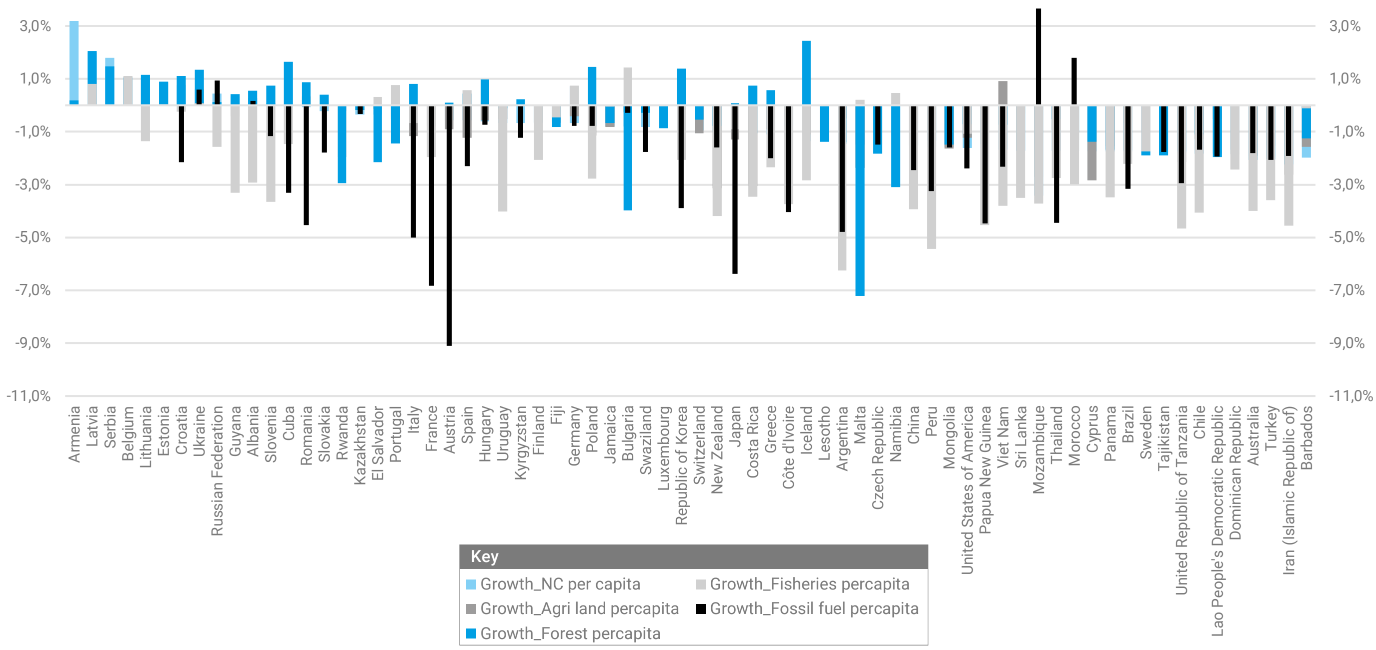
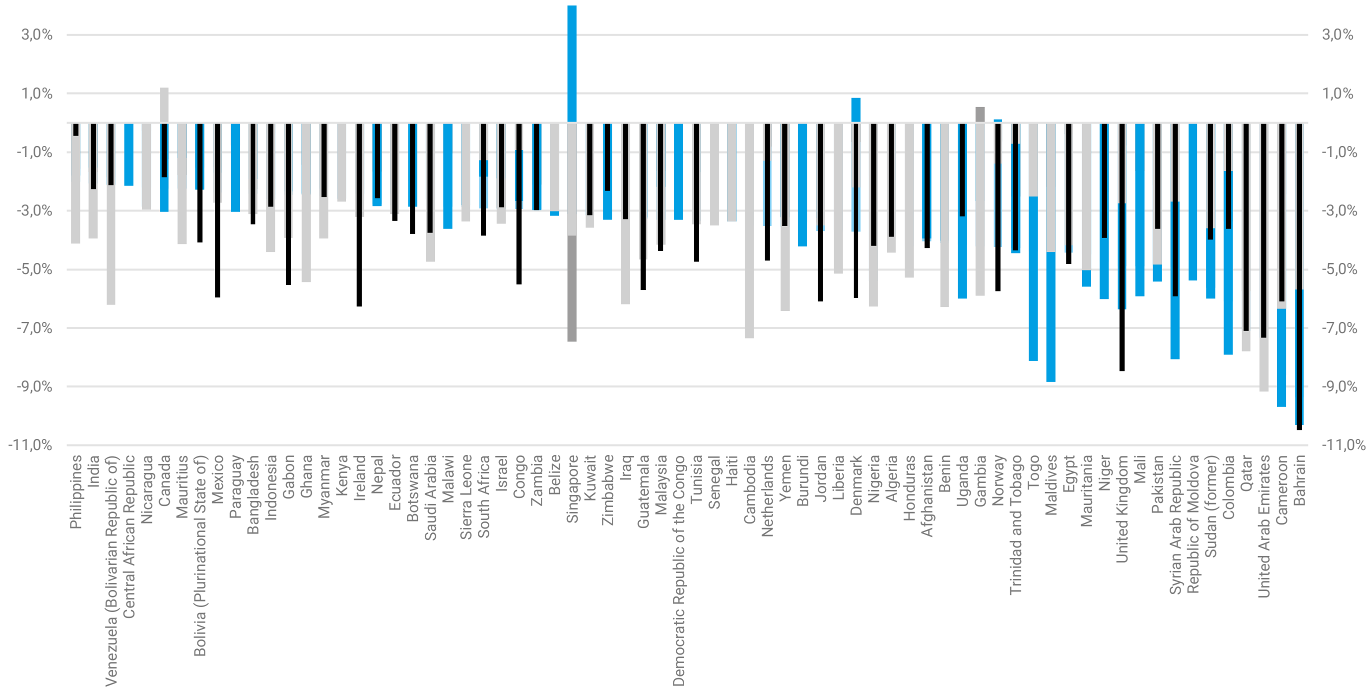


Fig 3.3 shows the trends for individual countries, providing a better understanding of the contribution of natural capital to sustainability. We disaggregated the annual average per capita growth rate of natural capitals, to identify the contribution of agricultural land, forests, fisheries and fossil fuels for each nation.

Countries are ordered according to their growth rate in natural capital per capita from 1990-2014. The figure shows major discrepancies between countries. The decrease in natural capital is also clearly visible across the board.

Fig 3.3: Annual average growth rate of natural capital per capita disaggregated by agricultural land, forests, fisheries and fossil fuels

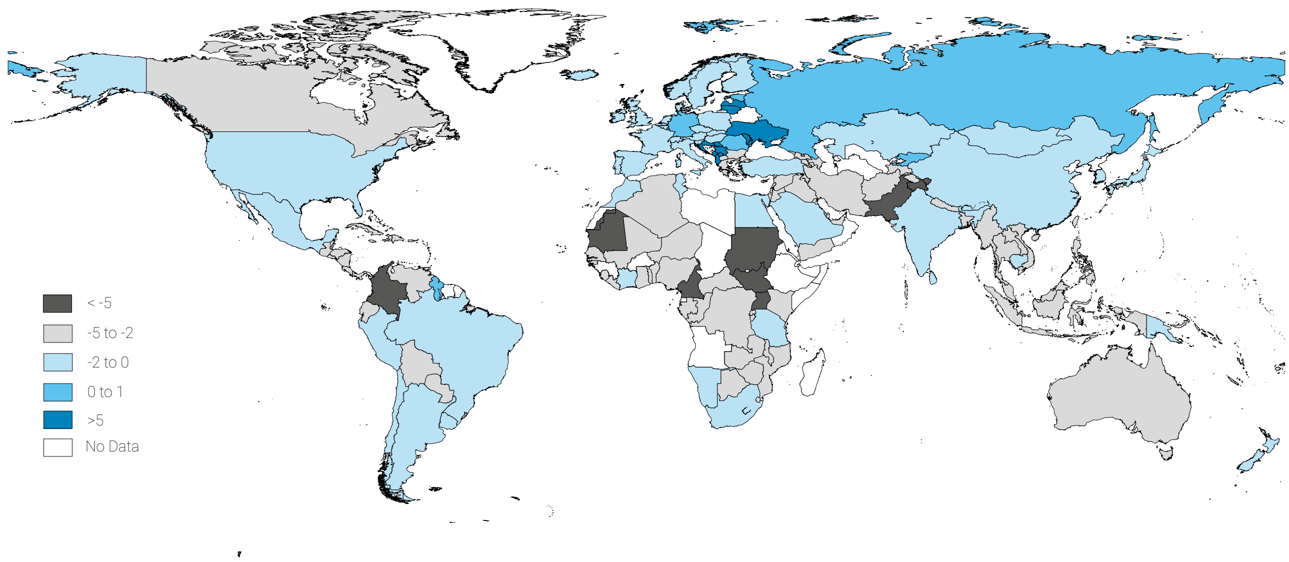




3.2.1. Renewable resources

In this section, we present an overview of renewable resources of natural capital, which includes agricultural land, fisheries and forest resources. Natural capital and renewable resource growth was positive for 25 of the 140 countries. Belgium, Côte d'Ivoire and Tanzania have experienced positive growth of over 1 percent in natural capital and renewable resources from 1990 to 2014. In addition, 15 countries experienced 1 percent growth or more in forests over this period, while only six countries achieved 1 percent growth or more in fisheries. Overall, only seven countries have reported a positive renewable natural capital growth rate of over 1 percent from 1990 to 2014. Fig 3.4 represents the growth rate of renewable resources from 1990 to 2014 per capita, which is a gloomier picture than that of growth in IW.

Fig 3.4: Average annual growth rate of renewables per capita from 1990 to 2014



3.2.1.1. Agricultural land

As defined by the FAO, agricultural land is comprised of cropland and pastureland. Overall, 49 countries have experienced a positive growth in cropland, while only 15 countries have a positive growth rate per capita (Fig 3.5). For pastureland, 36 countries reported positive growth and 7 countries show positive growth per capita (Fig 3.6). However, the way in which these changes affect the natural capital depends on how important these changes are with respect to the total share of the natural capital.

Globally, food security is tremendously important, and available land is in high demand. However, the increasing population in developing countries, where millions are undernourished due to food shortages, maintains continuous pressure on agricultural land. Together with dietary preferences (IWR 2014), population growth has been a major obstacle to the achievement of sustainable economic development.

The impact on natural capital of converting natural ecosystems to agriculturally productive land is an important consideration when measuring food availability and security. For instance, the increased demand for pastureland and for biofuel in Brazil is a significant threat to the Amazon rainforest, which is being destroyed to accommodate this growing demand for land. There has been a notable growth of cropland in Latin American countries over last 25 years, which continuously substitutes other important land uses.

Fig 3.5: Average annual growth rate of cropland per capita from 1990 to 2014

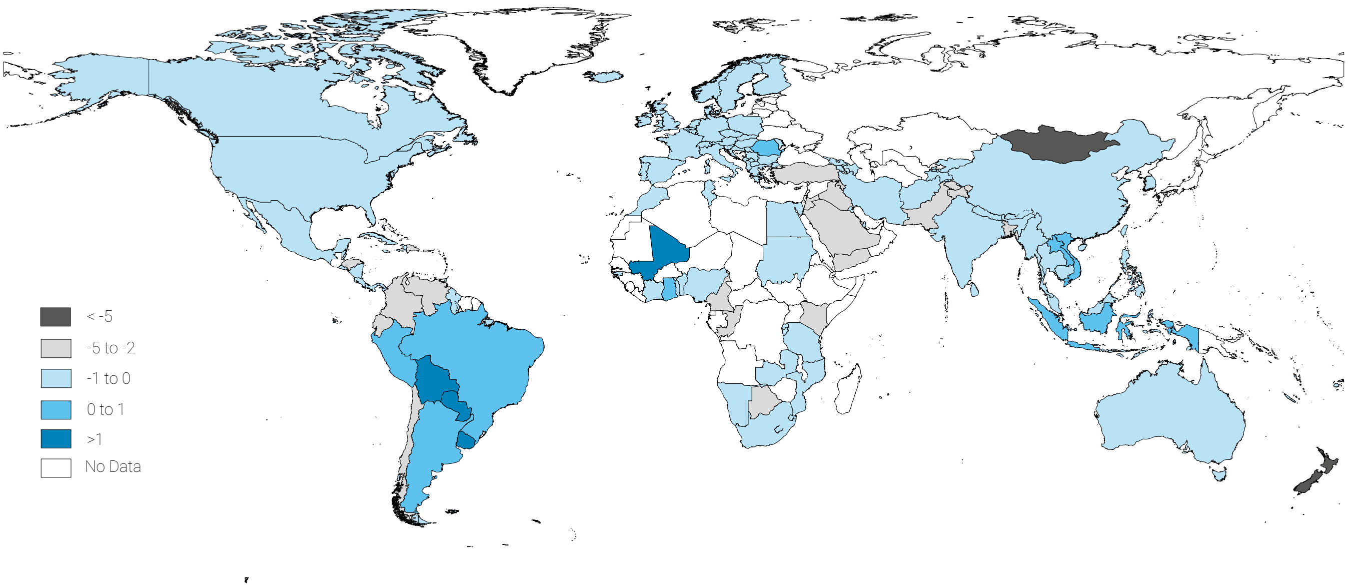
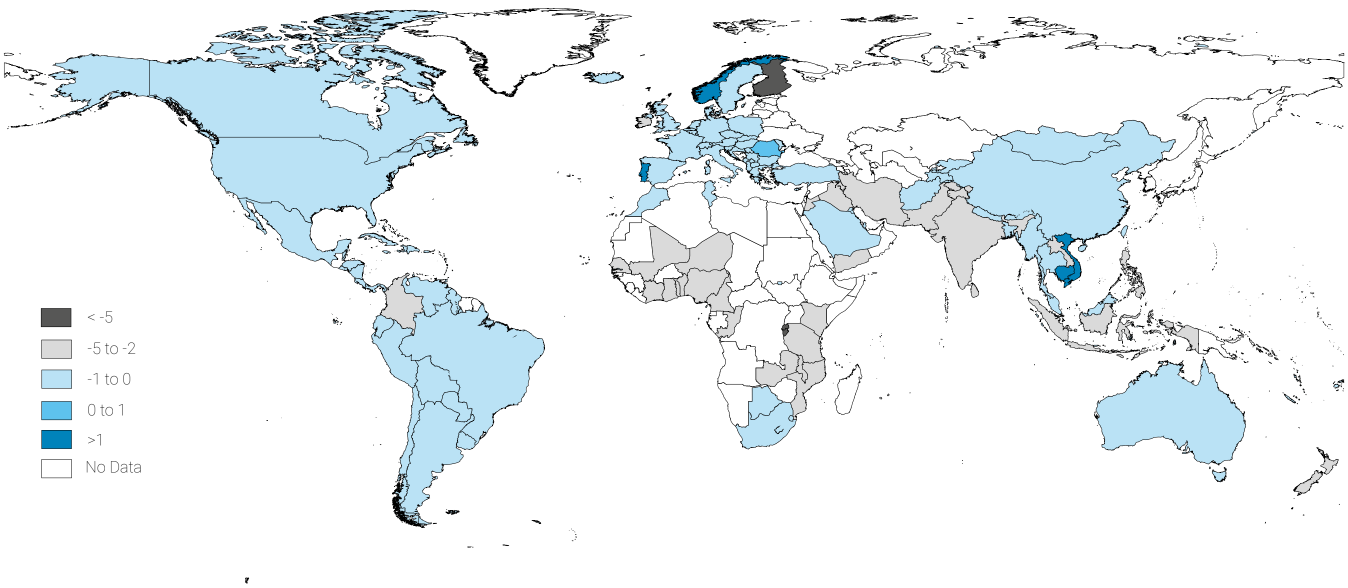


Fig 3.6: Average annual growth rate of pastureland per capita from 1990 to 2014



3.2.1.2. Forest and fishery resources

Forest resources consist of accessible timber and non-timber forest resources. Trends in forest sources of timber and non-timber resources generally follow the same pattern because they are both directly connected to the total forested area of a county. The growth of forest resources is positive for EU countries, Japan and Russia. On the other hand, the decline of forests in Africa, Latin America, China, India, Brazil, the US and Canada is threatening their sustainable development.

Forests account for 37 percent of the natural capital of nations, although with major differences between countries. Only 31 of 140 countries experienced positive growth in forest resources per capita, whereas 54 countries reported an overall positive growth in forestry. There are major discrepancies even among high-income countries: Singapore experienced an 8 percent growth in forest resources from 1990 to 2014 and a 5 percent growth in forest resources per capita; while, in contrast, the United Kingdom saw a 6 percent reduction in forest resources over this 25-year period.

Fisheries are one of the most important renewable resources and directly relate to the food security of nations. Within each country, there is an enormous variation in fish stocks and species. Fisheries are a small but essential part of natural capital, but most nations are experiencing a decline in their fishery stocks. Fish stocks can be managed as a renewable resource by limiting the harvest of endangered species and harvesting abundant species.

Overall, we find that 15 countries have successfully increased their fishery wealth. However, 92 countries reported a negative growth in fishery wealth, while 33 countries reported no fishery wealth at all. Fig 3.8 shows the growth rate for global fishery wealth – only Canada and some European countries have seen their fish stocks increase in the past 25 years. This can be explained by high population growth in Asian and African countries and recent pressure for more sustainable fishing in western countries.

Fig 3.7: Average annual growth rate of forests per capita from 1990 to 2014

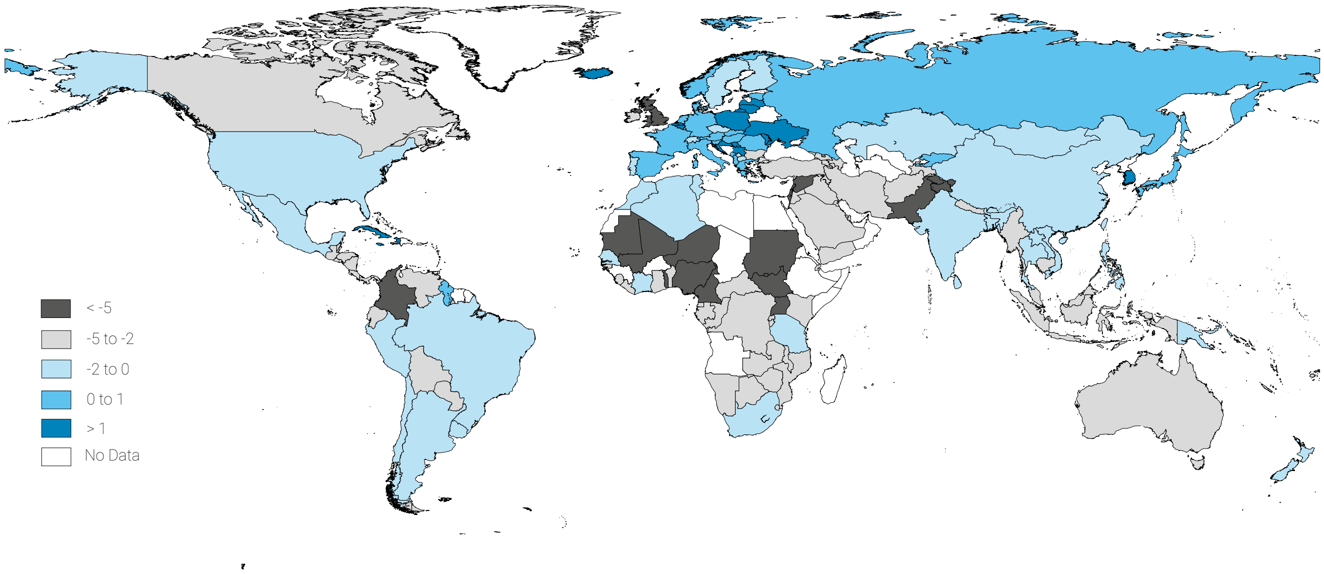
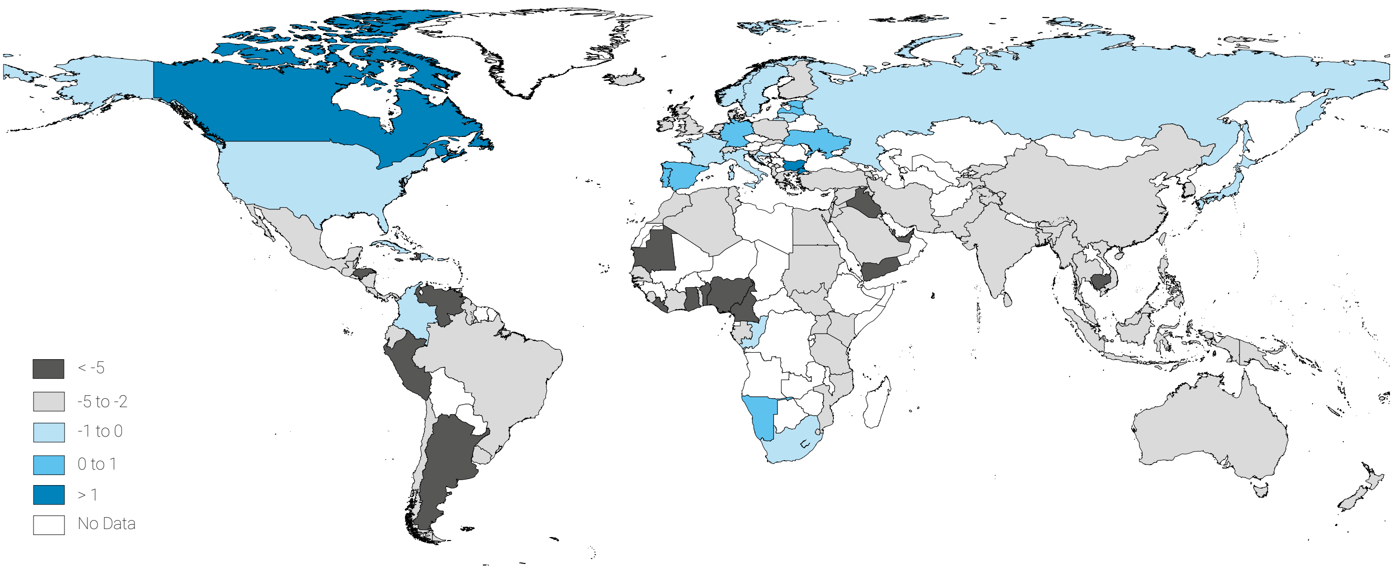


Fig 3.8: Average annual growth rate of fisheries per capita from 1990 to 2014



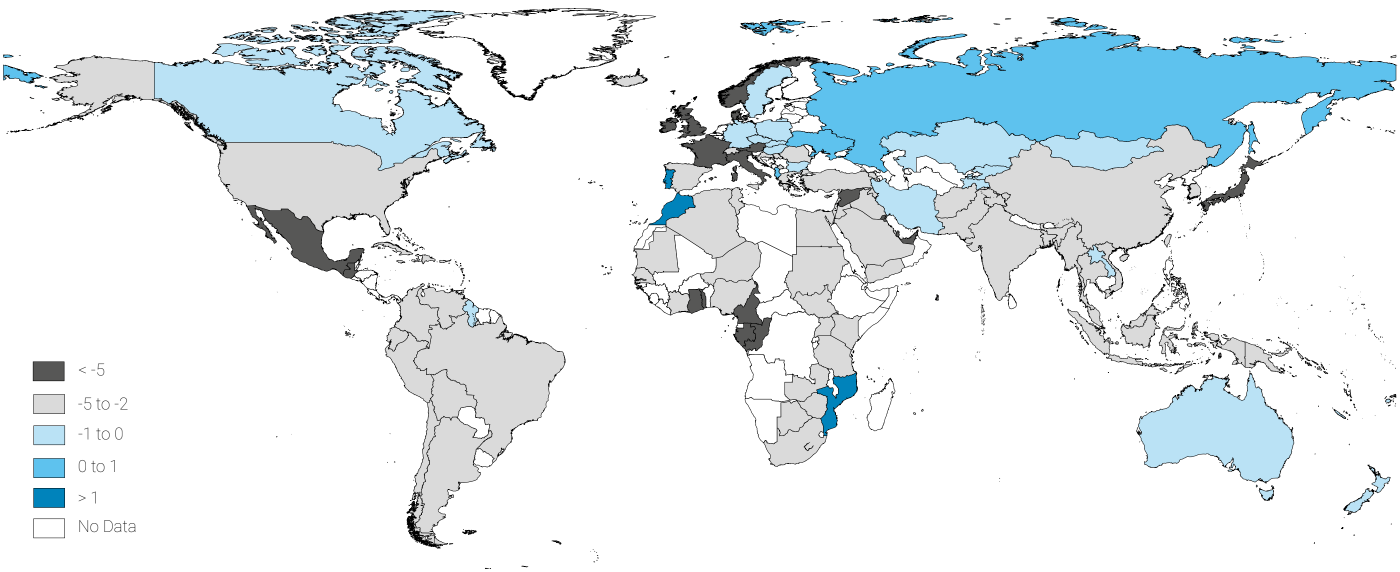
3.2.2. Non-renewable resources

3.2.2.1. Fossil Fuels

Non-renewable sources of energy are the main inputs for the energy system in most countries. Countries with abundant fossil fuel resources are greatly reducing their stock value over time. In Fig 3.10 and Fig 3.11, the per capita growth of oil and gas was negative for all countries from 1990 to 2014.

The reduced availability and production of fossil fuels is clearly visible, which is a good sign for sustainable development. As expounded in section 5, alternative sources of renewable energy are garnering more attention and contributing to sustainable development by substituting fossil fuels.

Fig 3.9: Average annual growth rate of non-renewables per capita from 1990 to 2014



Oil is considered the most widely used fossil fuel and contributes to 22 percent of global natural capital. It is widely considered a carbon-intensive source of energy, and its non-renewable characteristics mean a gradual decline of this resource. Fig 3.10 shows the average annual growth rate of oil per capita from 1990 to 2014.

Natural gas is another important source of energy, and accounts for 7 percent of global natural capital. Natural gas has a lower carbon content than oil, which improves our carbon damage adjustment for the IWI. Its use is also increasing due to its widespread availability. According to Fig 3.12, with the exception of Ukraine, all countries have seen a reduced growth in coal resources over the last 25 years.

The rules of the game have changed for non-renewable resources recently. In particular, following the steep rise in oil prices in the late 2000s, the United States has been aggressive in developing unconventional resources such as shale oil and gas, making North America an important fossil fuel exporter. This could change the future of oil and gas, as well as important adjustments to well-being such as oil capital gains and carbon damage.

Fig 3.10: Average annual growth rate of oil per capita from 1990 to 2014

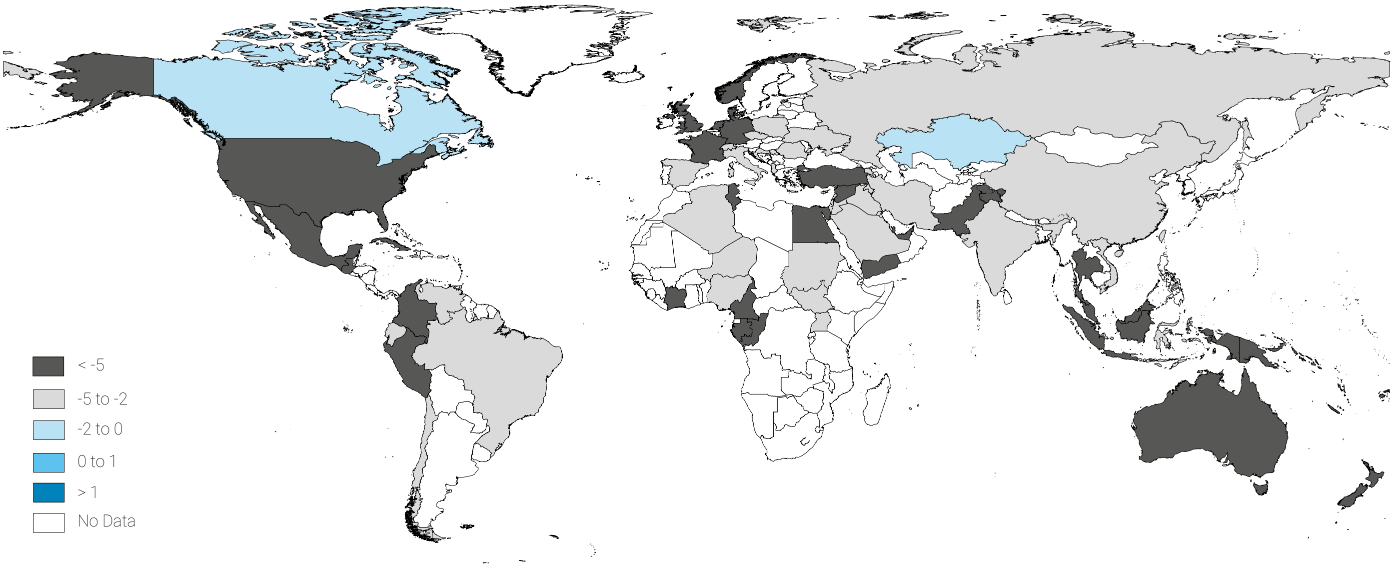


Fig 3.11: Average annual growth rate of natural gas per capita from 1990 to 2014

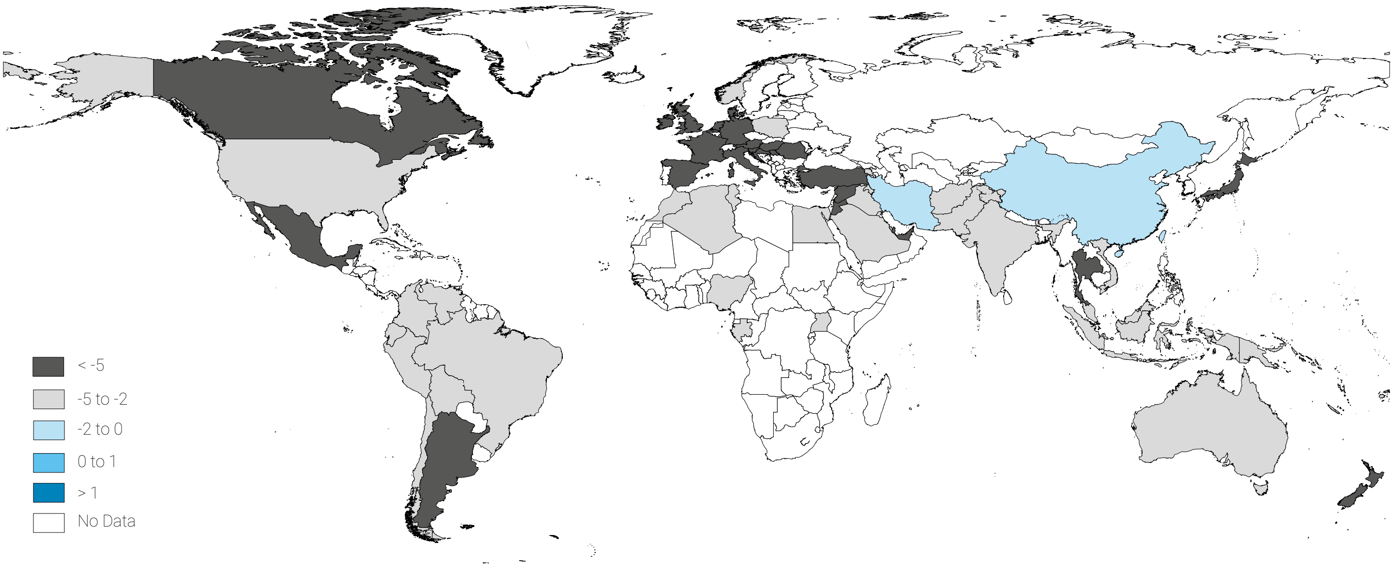
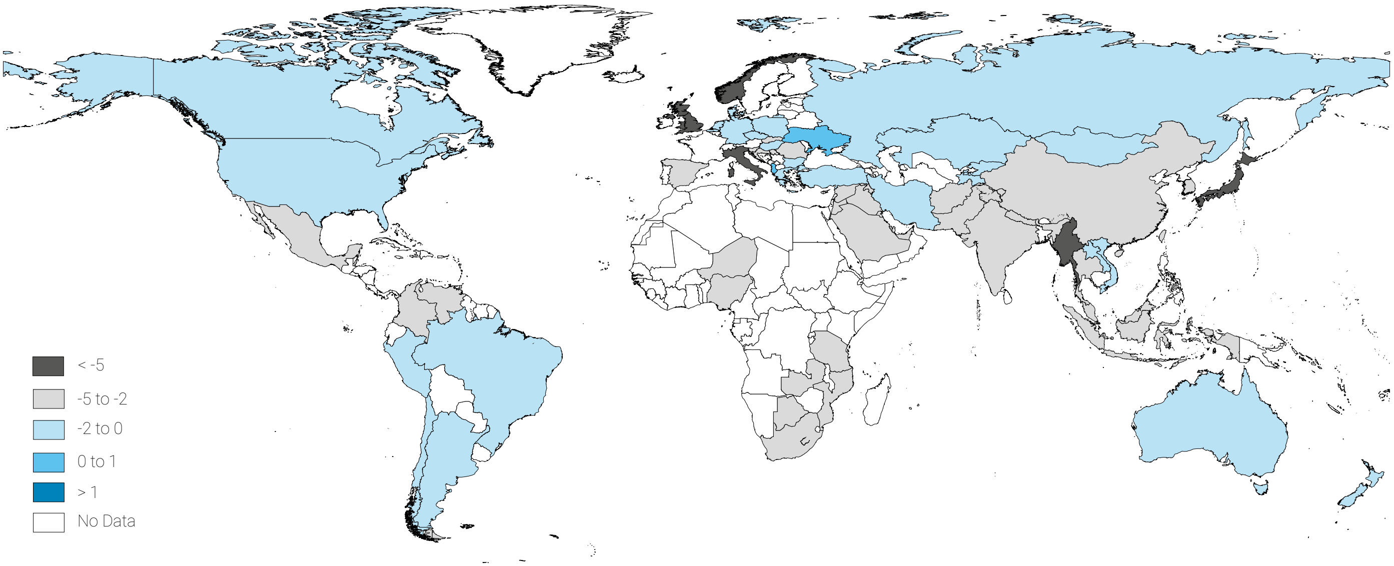


Fig 3.12: Average annual growth rate of coal per capita from 1990 to 2014

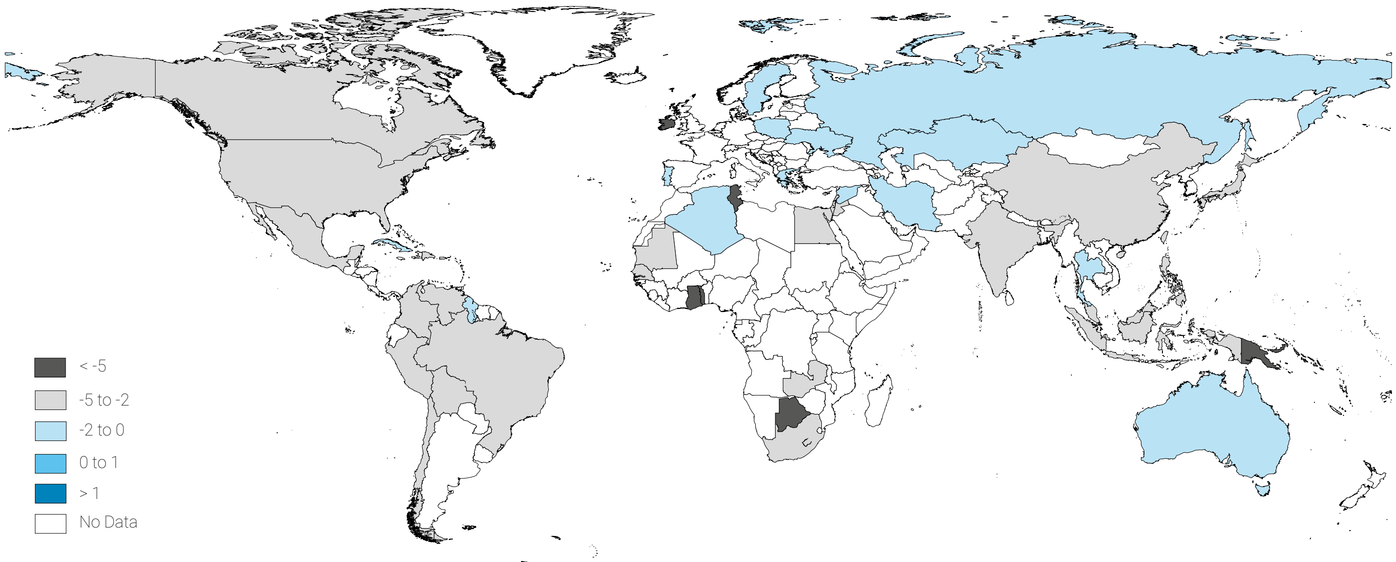


3.2.2.2. Minerals

Non-renewable mineral resources contribute the least to the natural capital of nations (1 percent of natural capital) in terms of capital stocks. According to Fig 3.13, minerals declined across all countries from 1990 to 2014, primarily due to the depletion of mineral stocks.

In our analysis, 44 countries reported negative growth in mineral wealth from 1990-2014 and, notably, several countries reported mineral depletion in excess of 5 percent.

Fig 3.13: Average annual growth rate of minerals per capita from 1990 to 2014



3.3. Regional Natural Capital Growth and Sustainability

This section describes natural capital growth at six regional levels; an examination of disaggregated resources provides a more in-depth assessment. The analysis examines natural capital and wealth from 1992 to 2014 in the following regions: Asia Pacific, Africa, Europe, Latin America and the Caribbean, West Asia, and North America. Our regional categories are based upon the UNEP Global Environment Outlook (GEO-6) Assessment (2016). The analysis can be used to assess the development and sustainability of each region.

3.3.1. Asia and the Pacific

Economic growth in Asia and the Pacific has had a notable impact on increased welfare but has also placed significant pressure on natural capital. The effects of climate change and the increasing number of natural disasters is causing major damage in the region. As a result, environmental awareness is gradually increasing, and Asia Pacific countries are implementing initiatives for low-carbon green growth and are investing in green technology.

This region is experiencing the fastest rate of urbanization and population growth, which creates significant environmental challenges (UNEP 2016). Stronger institutions, good governance and strict monitoring is important for sustainable development in the Asia Pacific region. Greater emphasis on regional and local climate change adaptation for increased resilience is also critical.

Asia Pacific countries have decreased their natural capital base as well as population growth. However, this drawdown of natural capital has not necessarily reduced the levels of wealth in the region. None of the countries in this sample show a decline in wealth while decreasing natural capital per capita, as is clear from Table 3.1. Fig 3.14 clearly shows a continuous decline in agricultural land, fossil fuels and fishery resources. In contrast, forestry is the only resource to show signs of recovery, after a decline from 1992 to 2010. New Zealand and Japan, in particular, have successfully recovered their forest resources, indicating greater sustainability.

Fig 3.14: Percentage change in natural capital in Asia Pacific countries from 1992 to 2014

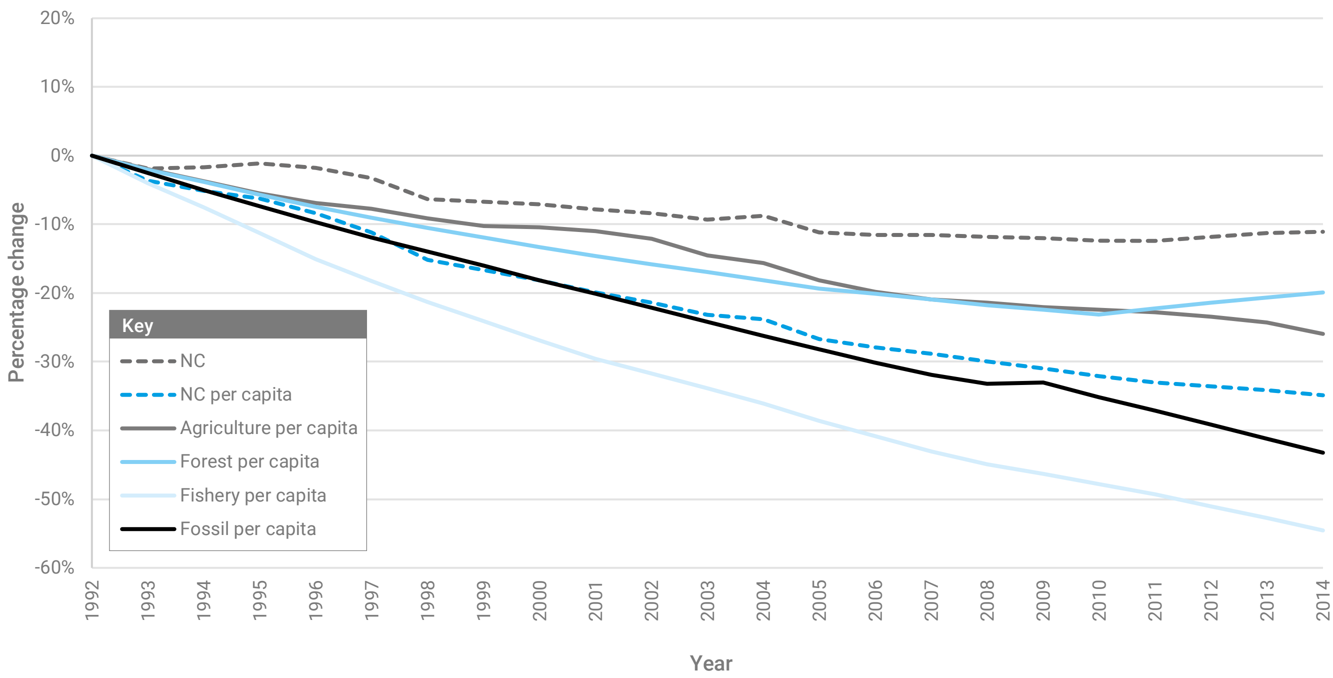


Table 3.1: Changes in natural capital in Asia Pacific countries: average annual growth rates from 1990–2014

Countries	Natural capital growth (%)	Population growth capita (%)	Natural capital per capita (%)	IWI per capita (%)
Australia	-0.6	1.3	-1.9	0.0
Afghanistan	-0.1	4.1	-4.0	4.6
Australia	-0.6	1.3	-1.9	0.0
Bangladesh	-0.8	1.7	-2.4	-0.2
China	-0.8	0.8	-1.6	2.2
Fiji	0.1	0.8	-0.7	-0.1
Indonesia	-1.1	1.4	-2.4	-0.9
India	-0.4	1.7	-2.1	1.0
Iran	-0.6	1.4	-2.0	3.2
Japan	-0.9	0.1	-1.0	0.6

Cambodia	-1.3	2.2	-3.5	-1.4
Republic of Korea	-0.3	0.7	-0.9	3.1
Laos	0.0	1.9	-1.8	-2.6
Sri Lanka	-0.9	0.8	-1.7	1.8
Maldives	-1.9	2.6	-4.4	-0.2
Myanmar	-1.5	1.0	-2.5	0.1
Mongolia	-0.4	1.2	-1.6	1.5
Malaysia	-1.3	2.1	-3.3	0.5
Nepal	-1.1	1.7	-2.8	1.4
New Zealand	0.3	1.3	-1.0	-0.3
Pakistan	-2.7	2.3	-4.9	-0.5
Philippines	-0.1	2.0	-2.0	1.0
Papua New Guinea	0.8	2.5	-1.6	0.5
Singapore	-0.7	2.5	-3.1	2.9
Thailand	-1.0	0.8	-1.7	0.8
Viet Nam	-0.4	1.3	-1.7	-1.8

3.3.2. Africa

Africa faces severe environmental challenges due to weak environmental governance, climate change, loss of biodiversity and dependence on fossil fuels. Although Africa has a large variety of natural resources, the sustainable management of natural capital is critical, since natural capital accounts for a relatively large portion of the region's wealth. Cropland and pastureland degradation are an ongoing problem due to soil erosion, salinization, etc. In addition, urbanization creates a continuous demand for land, which results in reduced agricultural productivity.

It is important for Africa to improve land productivity as well as increase efforts to develop renewable energy. Policies to reduce marine and ecosystem degradation and enact inclusive natural capital management should be implemented. Simultaneous economic development and protection of ecosystems can help ensure the welfare of Africa.

Africa is rich in natural resources, but the potential gains are hindered by weak resource management. Most African countries experienced a decline in natural capital and high population growth during 1992-2014. Fig 3.15 shows a clear deterioration in agricultural land, forests and fisheries. Fossil fuels declined dramatically between 1992 and 2007 but started to increase from 2007 to 2009. However, they declined again from 2009 until 2014.

Fig 3.15: Percentage change in natural capital in African countries from 1992 to 2014

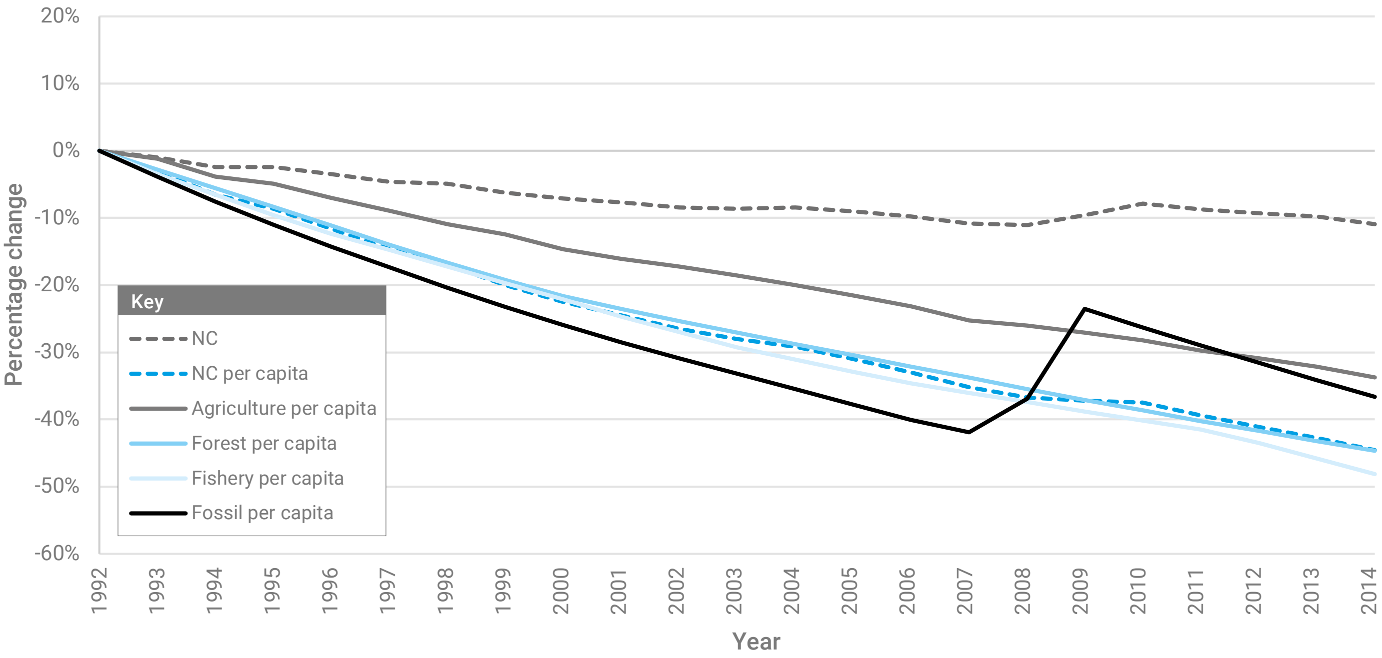


Table 3.2 shows a high population growth rate in the region, which has the potential to increase human capital. As a result, the impact on the growth of wealth from the decline in natural capital has not been as significant, and many African countries have experienced growth in IW.

By enhancing natural resource management, Africa is potentially able to enjoy higher levels of growth in IW.

Table 3.2: Changes in natural capital in African countries: average annual growth rates from 1990–2014

Countries	Natural capital growth (%)	Population growth capita (%)	Natural capital per capita (%)	IWI per capita (%)
Burundi	-0.9	2.8	-3.6	2.4
Benin	-1.0	3.2	-4.1	2.5
Central African Republic	-0.1	2.1	-2.1	-0.8
Côte d'Ivoire	1.2	2.5	-1.3	3.6
Cameroon	-6.2	2.7	-8.6	0.7
Congo D.R	-0.2	3.2	-3.3	-4.7
Congo	-0.3	2.7	-2.9	-0.6
Algeria	-2.2	1.7	-3.8	1.4

Egypt	-2.6	1.9	-4.4	1.0
Gabon	-0.1	2.4	-2.4	-3.3
Ghana	0.0	2.6	-2.5	1.6
Gambia	-1.2	3.1	-4.2	-3.2
Kenya	0.1	2.7	-2.6	0.3
Liberia	-0.7	3.1	-3.7	6.8
Morocco	-0.5	1.3	-1.7	0.0
Mali	-2.1	3.0	-4.9	2.0
Mozambique	1.2	3.0	-1.7	0.6
Mauritania	-1.8	2.8	-4.5	0.7
Mauritius	-1.5	0.7	-2.2	0.3
Malawi	-0.5	2.4	-2.9	3.4
Niger	-1.2	3.7	-4.7	2.6
Nigeria	-1.3	2.6	-3.8	4.7
Rwanda	1.6	1.9	-0.2	2.0
Sudan (former)	-2.9	2.9	-5.6	-3.2
Senegal	-0.6	2.8	-3.4	0.1
Sierra Leone	-0.9	2.0	-2.9	-0.1
Togo	-1.8	2.7	-4.4	1.8
Tunisia	-2.1	1.3	-3.3	2.4
Tanzania	1.1	3.0	-1.8	-0.5
Uganda	-1.0	3.3	-4.2	2.5
Zambia	-0.3	2.8	-2.9	2.6
Zimbabwe	-1.7	1.6	-3.2	1.9

3.3.3. Latin America and the Caribbean

Latin America and the Caribbean (LAC) includes some of the most unique eco-regions in the world and provides valuable ecosystem services. However, land degradation is creating major challenges for its ecological zones, resulting in unsustainable land management. Deforestation in the Amazon and other forest ecosystems is a major challenge for LAC resource management. The increase in cultivatable land to meet the demand for food is not sustainable.

The LAC region is responsible for approximately 25 percent of fishery catches, and overharvesting is affecting the local ecosystem. This continued marine biodiversity loss has far-reaching consequences and risks. For instance, some species will become extinct in the near future. However, the areas under protection increased over the 1990 to 2014 period.

LAC countries show a worrying and persistent degradation of natural capital. In Fig 3.16, there is a clear reduction in all forms of natural capital – agriculture, forests, fishery, fossil fuels, etc. The region is also experiencing biodiversity loss, climate change and unsustainable production and consumption patterns.

Fig 3.16: Percentage change in natural capital in Latin American and Caribbean countries from 1992 to 2014

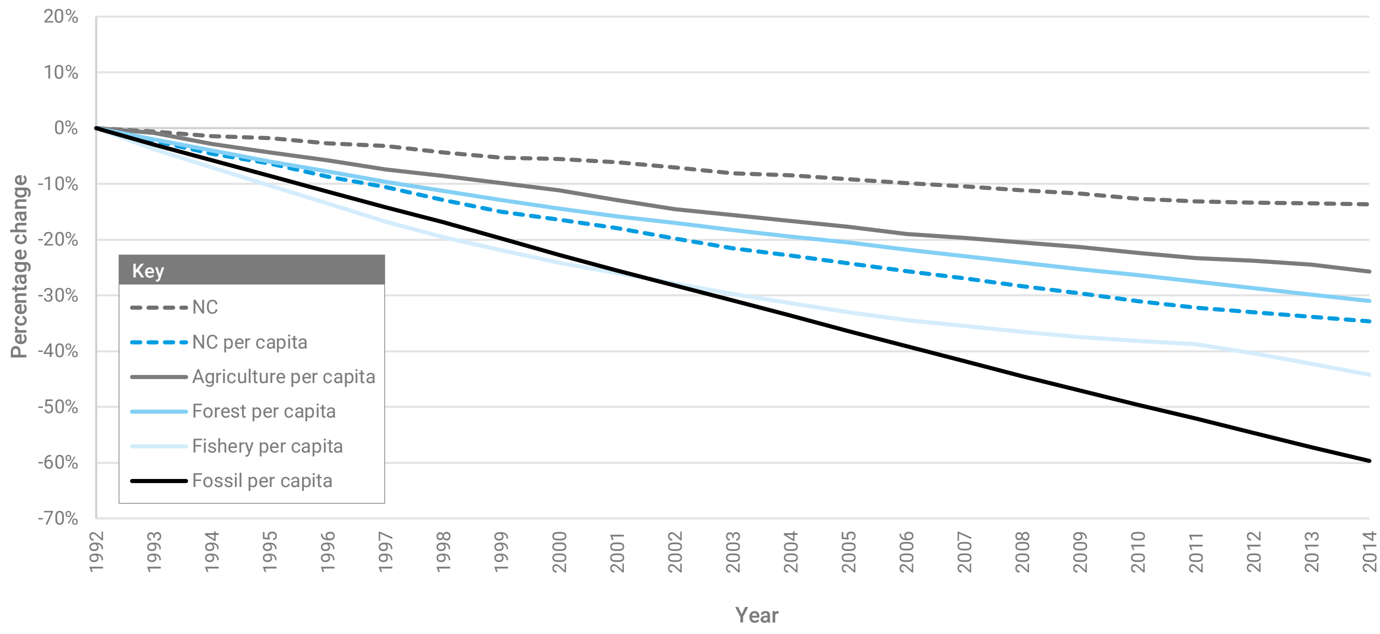


Table 3.3: Changes in natural capital in Latin America and the Caribbean countries: average annual growth rates from 1990 - 2014

Countries	Natural capital growth (%)	Population growth capita (%)	Natural capital per capita (%)	IWI per capita (%)
Argentina	-0.3	1.1	-1.5	1.4
Belize	-0.5	2.7	-3.1	-0.7
Bolivia	-0.5	1.8	-2.2	-1.2
Brazil	-0.4	1.3	-1.7	-0.1
Barbados	-1.6	0.4	-2.0	-0.4
Chile	-0.6	1.3	-1.8	-0.3
Colombia	-4.8	1.4	-6.1	-0.6
Costa Rica	0.7	1.8	-1.1	0.4
Cuba	0.2	0.3	-0.1	1.9
Dominican Republic	-0.3	1.6	-1.9	1.0
Ecuador	-1.0	1.9	-2.8	1.8
Guatemala	-1.0	2.4	-3.3	0.8
Guyana	0.6	0.2	0.3	3.1
Honduras	-2.0	2.0	-4.0	-1.7
Haiti	-1.8	1.7	-3.4	-1.8
Jamaica	-0.3	0.5	-0.8	-1.0
Mexico	-0.8	1.6	-2.4	-0.3
Nicaragua	-0.7	1.6	-2.2	1.6
Panama	0.1	1.9	-1.7	0.3
Peru	-0.1	1.5	-1.6	0.7
Paraguay	-0.6	1.9	-2.4	0.0
El Salvador	0.3	0.6	-0.4	0.8
Trinidad and Tobago	-3.9	0.4	-4.3	3.8

Uruguay	-0.3	0.4	-0.7	0.8
Venezuela	-0.3	1.8	-2.1	5.7

3.3.4. West Asia

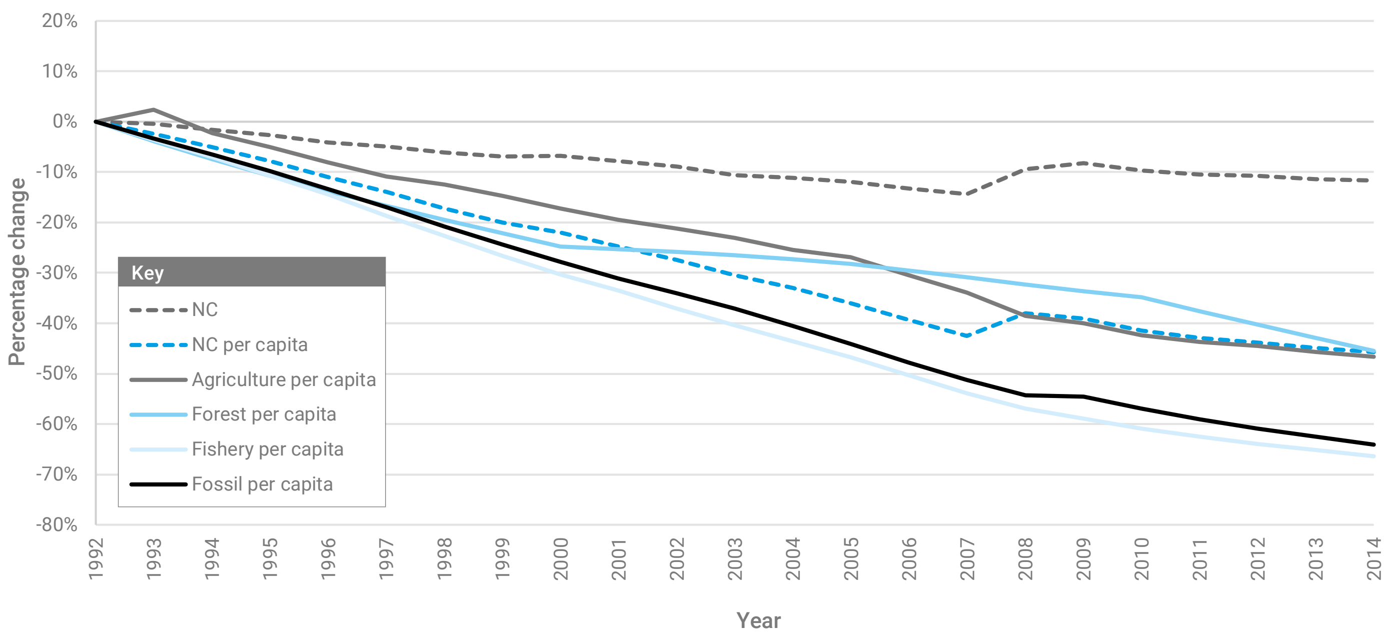
West Asia has experienced extensive deforestation and land degradation. High population growth is placing significant pressure on arable land, fresh water and food supplies. Urbanization, soil salinization, soil erosion and the conversion of wetland to dryland are some reasons for the degradation of agricultural land. As a result, food security in the region is at risk.

Biodiversity in West Asia is under threat due to the overconsumption of forestry, fossil fuel and other natural resources. Continued anthropogenic actions pose a serious risk to natural resources, exceeding biocapacity. The exploitation of marine resources has also increased dramatically in West Asia. In addition, extensive modification of the coast in Gulf Cooperation Council countries is responsible for marine biodiversity damage.

West Asian countries experienced a slow decline in natural resources but rapid population growth. The impact of population growth is clearly visible in Fig 3.17, where the natural capital per capita has sharply declined.

Natural resources in this region consist primarily of fossil fuels and are seen as dirty due to their emission of high levels of greenhouse gases. However, through environmental governance, coupled with prudent oil wealth management (Collier et al., 2010), West Asia can achieve sustainability.

Fig 3.17: Percentage change in natural capital in West Asian countries from 1992 to 2014



In Table 3.4, high population growth contributed to the growth of human capital in the region, and consequently IW has grown significantly.

The decline in natural capital is not driving wealth trajectories in these countries. However, multisectoral policy design can improve resilience in West Asia.

Table 3.4: Changes in natural capital in West Asia: average annual growth rates from 1990–2014

Countries	Natural capital growth (%)	Population growth capita (%)	Natural capital per capita (%)	IWI per capita (%)
United Arab Emirates	-0.9	7.0	-7.3	1.5
Armenia	2.5	-0.7	3.2	1.4
Bahrain	-5.5	4.3	-9.4	-0.4
Cyprus	0.0	1.7	-1.7	-0.1
Iraq	-0.4	3.0	-3.3	9.8
Israel	-0.6	2.4	-2.9	1.1
Jordan	-0.5	3.4	-3.7	1.0
Kuwait	-0.7	2.5	-3.2	6.1
Qatar	-1.0	6.5	-7.1	4.0
Saudi Arabia	-0.2	2.7	-2.9	1.9
Syrian Arab Republic	-3.3	1.7	-4.9	-2.2
Turkey	-0.5	1.5	-1.9	0.2
Yemen	-0.4	3.3	-3.6	1.0

3.3.5. North America

North America has rich biodiversity and diverse ecosystems. Agricultural land is well-managed and provides a sustainable food supply. Moreover, agricultural land has increased overall. Some Canadian forests have been converted to cropland. Despite the recent gains, the loss of forests to cropland poses risks and natural disasters such as wildfires also put pressure on forest resources.

Fisheries in North America and particularly in Canada have grown partly due to sustainable policies adopted by the government. The dependency on fossil fuel has also declined because of renewable energy technology development. Solar energy capacity in North America has increased and household use of solar power has become increasingly popular.

North America has performed relatively well on the natural capital front. In Fig 3.18, the decrease in non-renewable fossil resources and the increase in renewable fishery resources provides a snapshot of the improved environmental conditions. However, remaining and emerging environmental challenges could interfere with sustainable growth in the future.

Fig 3.18: Percentage change in natural capital in North American countries from 1992 to 2014

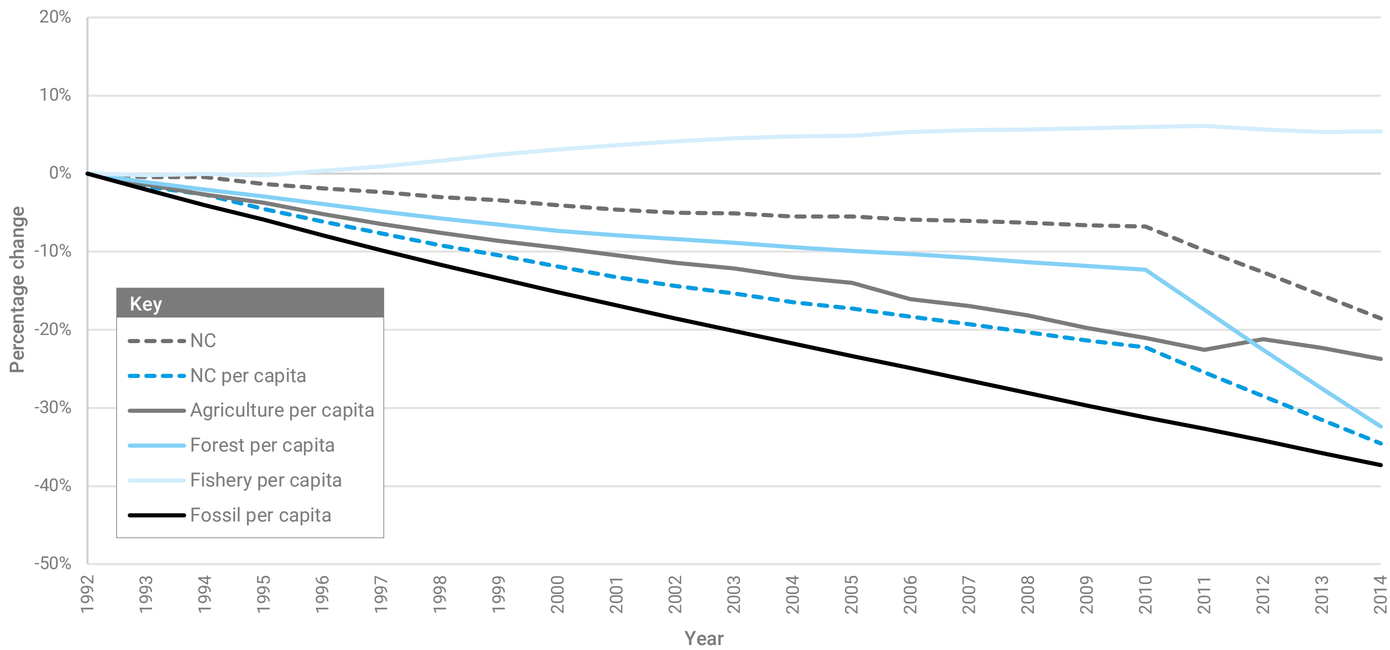


Table 3.5: Changes in natural capital in North America: average annual growth rates from 1990–2014

Countries	Natural capital growth (%)	Population growth capita (%)	Natural capital per capita (%)	IWI per capita (%)
Canada	-1.2	1.0	-2.2	1.4
United States of America	-0.6	1.0	-1.6	0.1

3.4. Incorporating Natural Disaster Resilience in the Assessment of Natural Capital

It is a common understanding that there is a positive relationship between the stage of economic development of a nation and its resilience to natural disasters (Toya and Skidmore, 2007). This is confirmed by the fact that the numbers of deaths, injuries and homeless people decline as national incomes rise (Kahn, 2005).

In this section, we discuss the importance of natural capital and the IW of nations in coping with natural disasters. Some forms of natural capital have been known to work as a form of protection against natural disasters. A prime example is the regulation ecosystem services that mangrove trees provide, particularly in terms of coastal protection (Barbier *et al*., 2008).

Of course, an abundance of natural capital may not translate into greater public awareness in vulnerable areas, and a stronger social response to disaster risk and management is essential. Governments may be less responsive and less efficient in handling disaster response initiatives in low-income countries.

However, a lower dependence on non-renewable resources is strongly correlated to increased awareness of climate change and a reduction in damage from natural disasters. We analyse the data from EM-DAT for every recorded natural disaster in the 140 countries over the 1990–2014 period, and identified that higher IW is correlated with an increase in the number of damage reduction policies.

Asia Pacific countries are the most disaster-prone in the world and most of the reported natural disasters in this region have occurred over the past 25 years. In the absence of adaptation, hundreds of millions of people will be affected by disasters. What is alarming is that this region continues to lose its natural forests, mangroves and croplands. Cumulative climate change and natural resource degradation are threating sustainability in this region.

Africa is also highly vulnerable to natural disasters. Drought, salinization and wildfires are destroying agricultural land, and wild fauna and flora. These natural disasters also result in a loss of biodiversity in the region. Climate change-induced challenges are clearly evident in Africa. For instance, 90 percent of the population in sub-Saharan Africa is exposed to air pollution and increased greenhouse gas emissions. The poor air quality in Africa is causing severe health problems for its inhabitants.

Climate change across Europe represents one of the most significant risks to the region and is responsible for extreme weather events.

Temperature increases and coastal sea level rises are affecting many areas. Flash and coastal floods have become more intense, and storms are becoming more frequent. However, ambitious EU mitigation policies helped to reduce carbon emissions between 1990 and 2014.

In the LAC region, the impacts of climate change are more visible in coastal areas and are causing disasters. Hurricanes, sea level rise, storm surges and coastal flooding have become more frequent and result in significant damage. However, integrated coastal zone management action may help improve the changing conditions in LAC.

Climate change-induced changes in weather are also taking place in West Asian countries. Rainfall, temperature and humidity are showing greater variations. This region also experienced an increase in carbon dioxide emissions due to fossil fuel consumption. Sea level rise will affect the economy, agriculture and tourism in the area.

The impact of climate change is more evident in the North America region. Recent devastating droughts and floods have damaged many parts of the US and Canada. Hurricane Sandy in 2012 and Hurricane Katrina in 2005 were directly responsible for large-scale human and economic losses. Canada and the US are taking steps to mitigate and adapt to unavoidable climate change across the regions and beyond.

Sustainability and resilience are important for understanding how the growth of the IW of a nation is performing. For instance, in addition to agricultural production, groundwater conservation is having a significant impact on regional welfare (Walker *et al*, 2010). Resilience is the capacity of a system to sustain itself after a shock and the ability to absorb the shock without it being transferred to an alternate system. According to Walker *et al.* (2004), the more resilient a system, the more shock it is able to absorb without shifting. Walker *et al.* (2010) attempted to include resilience as an addition to the list of capital stocks. While intriguing in itself as a regional case study of South-Eastern Australia, their approach faces many challenges when it comes to applying it to the national level.

3.5. Renewable Energy as Capital Stocks

Despite the fact that the shift from non-renewable to renewable energy sources is seen as a more sustainable move, what this means in terms of IW and sustainability assessment is not clear. In this subsection, therefore, we aim to clarify how this substitution can be incorporated into our framework for IW as an indicator of sustainable development, and to show the magnitude of this shift in the IW of nations.

Investment in renewable energy power plants is recorded as an increase in produced capital. This may feel awkward in a sense, especially when other renewable resources, such as forests, agricultural land and fisheries, are counted as part of natural capital in the IWI. Indeed, inputs into renewable energy facilities, such as solar, wind, water and geothermal energy plants, are actually renewable, and tend to substitute conventional natural capital such as oil and natural gas.

However, it is acceptable to count renewable energy plants as produced capital, not only because they are manufactured structures but also because they do not meet certain characteristics unique to natural capital. Natural capital differs from produced capital in many important ways. First, the transformation of natural capital to other types of capital is sometimes irreversible if the quantity of natural capital in, for example, an ecosystem has surpassed the (lower bound) threshold level – it would be difficult to restore the system to its original state. This has been found in ecosystems at varied scales, from non-convex shallow lakes with phosphorous deposits (Dasgupta and Mäler, 2003) to the global climate system (Lemoine and Traeger, 2016). Second, some natural capital can, to a limited extent, be substituted by produced capital, as the strong sustainability argument has stressed. Third, the response of and change in natural capital can be unexpected and, more often than not, non-linear. Renewable energy power plants do not have any of these characteristics.

There are at least two approaches to account for shadow prices of renewable energy (RE) capital. Given the current physical capital stock, shadow pricing can be performed based either on past unit cost data or on future income projection. In this illustrative analysis, we focus on the cost-based accounting of RE capital.[30]

Our data set of past investments in solar and wind power is based on BP (2017). We do not include hydroelectricity here as it is considered a conventional form of energy production, and the opportunity cost of using water is not necessarily nil, in contrast to solar and wind energy. We do not consider biofuels either due to the fact that they compete with food crops for land.

30 For a detailed discussion on cost- versus income-based or backward- versus forward-looking accounting of capital assets, and a further discussion and analysis of RE capital, see Yamaguchi (2017).

3.5.1. Solar energy

We estimate annual gross investment in solar energy based on the cumulative installed capacity of solar power (photovoltaics). We calculate net investment by applying a depreciation rate of 5 percent per annum. It could be the case that the cumulative installed capacity is already free of decommissioned power plants, in which case the depreciation would be double counted. However, this would only result in a conservative undervaluation of cumulative stock.

To value the actual expenditure involved in the construction and running of solar energy power units, one has to assume unit costs. The cost of RE, both in terms of instalment and operation, has sharply declined in recent years. The use of past average unit cost would inflate the value of the current capital stock, although it would be an accurate depiction of the actual expenditure. It is also the case that the unit cost of construction is lower for units with larger capacity due to economies of scale. Geographical factors matter as well: the unitary cost of installing solar power units in Japan, for example, is double that of Europe. Nevertheless, for brevity and clarity of analysis, we simply assume that the unit cost of installing a plant is $2,000 per kW across the board.[31] Note that this treatment tends to overestimate the value of the current stock in Europe and the US and underestimate it in Japan and some less developed countries.

The depreciation-adjusted solar energy capital in monetary units in 2014 was highest in Germany ($64b), followed by China ($54b), Japan ($43b), the United States ($34b) and Italy ($32b). It was only in 2016 that the Asia Pacific region surpassed Europe and Eurasia in unadjusted capacity, aided by the explosive growth in China.

In per capita terms, the picture changes. By far the largest is Germany ($785), followed by Italy ($540), Belgium ($480), Greece ($418) and Japan ($335). These top five countries have adopted some supporting mechanisms for RE, including for solar power: typically feed-in systems or quota obligations.

3.5.2. Wind energy

In much the same way as solar power capital, we can also estimate wind power capital. Past data on capacity instalment can be used to compute the current stock of wind power plants in terms of kW, which can then be converted to social value by using actual expenditures.

More specifically, to convert past investments into capital stock, requires certain assumptions about unit costs. The cost of wind turbines, which has been decreasing in recent years, makes up for most of the initial capital cost. The initial capital cost varies depending on the country, project, geographical conditions and technologies. For example, an offshore wind farm, which is still in its infant stage, is likely to cost more than conventional wind farms because of the required supporting infrastructure, such as a subsea distribution network. However, we bypass this heterogeneity as our information is limited and would create complexities in accounting. The DOE (2016) reports that in the US, the average turbine prices reached a low of $800/kW around the turn of the century, increased to $1,600/kW by the end of 2008, and then declined again to approximately $1,000. According to the same report, performance, in terms of capacity, has improved significantly: to 42.5 percent (for those built in 2014 or 2015), compared to an average of 25-32 percent for those built around the turn of the century.[32] Considering that our sample period ends in 2014 and that the US is one of the forerunners in wind energy technologies, we see no reason to adopt a lower figure. Thus, we assume that the unit cost of wind energy is simply $1,000 per kW for all periods and all countries – which happens to be half of our assumed unit cost for solar power. Again, this will make our estimates in some regions lower than the actual expenditure.

The cost-based capital stock of wind power is highest for China ($84b) followed by the United States ($51b), Germany ($26b), India ($17b) and Spain ($15b). In regional aggregates, the Asia Pacific region is leading ($109b), followed by Europe and Eurasia ($98b) and North America ($61b). Interestingly, in per capita terms, the top countries are in Europe: Sweden ($476), Denmark ($433), Ireland ($379), Spain ($328) and Portugal ($325).

3.6. Fish Wealth of Nations

3.6.1. Background

Fish and fisheries have sustained humans for many millenniums. Not only is fish a primary source of protein for humans, it also plays an important role in the food chain of marine ecosystems. Population growth around the world, along with changes in dietary habits and a growing awareness of healthy eating, has driven the increased demand for fish and related products. On the supply side, improving technology has given rise to greater availability for human consumption. Moreover, aquaculture surpassed conventional capture fishery for human consumption for the first time in 2014 (FAO, 2016).

The FAO assessment of fishery stocks, however, is sobering. Approximately one third of the total fishery stock was assessed as being "mined" at a biologically unsustainable level in 2013. In the context of the Inclusive Wealth Accounting Framework, fishery stock is a prime example of natural capital: it contributes to human well-being and displays characteristics such as thresholds and irreversibility, non-substitutability and non-linearity. Because of its poor substitutability for other forms of

31 This is slightly more expensive than the cost in Europe in 2014 and is two thirds of the cost in Japan (METI 2016).

32 Overall, "the capacity-weighted average installed project cost stood at nearly $1,690/kW, down $640/kW or 27 percent from the apparent peak in average reported costs in 2009 and 2010". This declined even further to $1,590/kW in 2016 (DOE 2016). In our cost-based accounting, we focus on actual investment expenditure, so the unweighted installed project cost should be used.

nutrition, it is imperative to preserve fisheries for the well-being of future generations. As is the case with other natural capital, the abundance of the stock and its careful management are important for sustainability. However, unlike other classes of natural capital, fishery resources are prone to yearly volatility. Thus, sustainability should be assessed from a longer-term perspective.

The current edition of the IWR is almost the first to estimate fish capital stock as part of renewable natural capital in the context of inclusive wealth accounting. The qualification "almost" refers to the accounting of fisheries in six selected countries in our pilot IWR (2012). IWR 2012 accounted for varying numbers of fish stocks from four countries between 1990 and 2008: 12 from Australia, 9 from Canada, 10 from South Africa and 40 from the United States. The fishery capital stock estimate was based on the available fisheries stock within these countries' fishing areas, taken from the newly developed RAM Legacy Stock Assessment Database (Ricard et al., 2012). To attach shadow prices, IWR 2012 derived prices per tonne from the total landing value and quantity of the Sea Around Us Project (SAUP 2011), which were averaged across species. This was finally converted to shadow prices using the fishery rental rate. Although IWR 2012 was commendable for partially including fisheries as part of natural capital, the scope and methodology was, admittedly, limited. In the following section, we illustrate how we attempted to extend our database to this important class of natural capital.

3.6.2. Methodology

Estimating fish stock is, for many reasons, a herculean task compared to other classes of natural capital. It cannot be estimated based on the size of the habitat, unlike forest or agricultural land, which is calculated by area. Moreover, the sheer mobility of the resource not only makes the exercise harder but also poses a fundamental question: to what area is a given fishery attributed to, given that marine fishery habitats do not usually fall within national borders? In the current exercise, we simplify the matter by assuming that a fish stock belongs to the country where harvest takes place and the resources are unloaded. Of course, this is a crude treatment in many ways: just because fishery biomass is unloaded in a particular country does not necessarily mean that the fishery stock belongs to that country. While we acknowledge this shortcoming, we have no alternative methodology for allocating harvests to countries. In what follows, our estimates of the fishery wealth of nations should be interpreted as capital stocks that exist in the fisheries operating in these countries.

In renewable resource economics, or bioeconomics, there is a long tradition of assuming resource dynamics (Clark 1976/1990). The stock is the population net growth of harvest:

$$\frac{dS_t}{dt} = G(S_t) - H_t,$$

where *St* denotes the renewable resource biomass stock; *G(St)* is the growth function; and *Ht* is the harvest. The population, whether it is a renewable resource or human beings, is often assumed to follow a logistic growth function:

$$G(S_t) = rS_t\left(1 - \frac{S_t}{k}\right),$$

where *r* and *k* are the parameters that represent the intrinsic (relative) growth rate and carrying capacity of the resource stock, respectively. The harvest, in turn, depends on the resource abundance. A simple but empirically supported harvest production function is to assume that it is proportional to the product of effort and stock, i.e.,

$$H_t = qE_tS_t,$$

where *q* is called the catchability coefficient. *Et* stands for the effort put into the production process, which is often proxied by the number of vessels or fishermen's working hours. Combining these two equations, we arrive at a well-known Gordon-Schaeffer model:

$$\frac{dS_t}{dt} = rS_t\left(1 - \frac{S_t}{k}\right) - qE_tS_t.$$

This means that, to estimate the fishery stock, *St* , we can resort either to the harvest function, (1), or total resource dynamics, (2). Global fish stocks are commonly assessed by examining the trends in catch or harvest data. Although this catch-based assessment method has attracted significant criticism (see, for instance, Daan *et al.* (2011)) either due to its technical or conceptual flaws, it is still considered the most reliable method for assessing fish stock (Froese *et al.*, 2012; Kleisner *et al.*, 2013). The main reason is simply that the only data available for most fisheries are the weight of fish caught each year (Pauly *et al.*, 2013). If effort and harvest are known data points as well as the catchability coefficient *q*, then *St* can be estimated solely from the Schaefer production function (Yamaguchi *et al.* 2016).

However, effort data are sparse worldwide, so we cannot employ this method for inclusive wealth accounting across the globe. Alternatively, we can appeal to resource dynamics. For the lack of reliable data on *r* and *k* for most fish stocks, we follow Martell and Froese (2013), who developed an algorithm to randomly generate feasible (*r, k*) pairs from a uniform distribution function. The likelihood of the generated (*r, k*) pairs is further evaluated using the Bernoulli distribution to ensure that the estimated stock meets the following assumptions: it never collapsed or exceeded the carrying capacity, and the final stock lies within the assumed range of depletion.

In cases where the values of (*r, k*) are not feasible, the stocks were simply estimated according to the following rules:

- if the year being studied follows the year of the maximum catch, then the biomass stock is estimated as twice the catch;
- otherwise, the biomass stock is estimated as twice the maximum catch, net of the catch (2 x Maximum Catch – Catch).

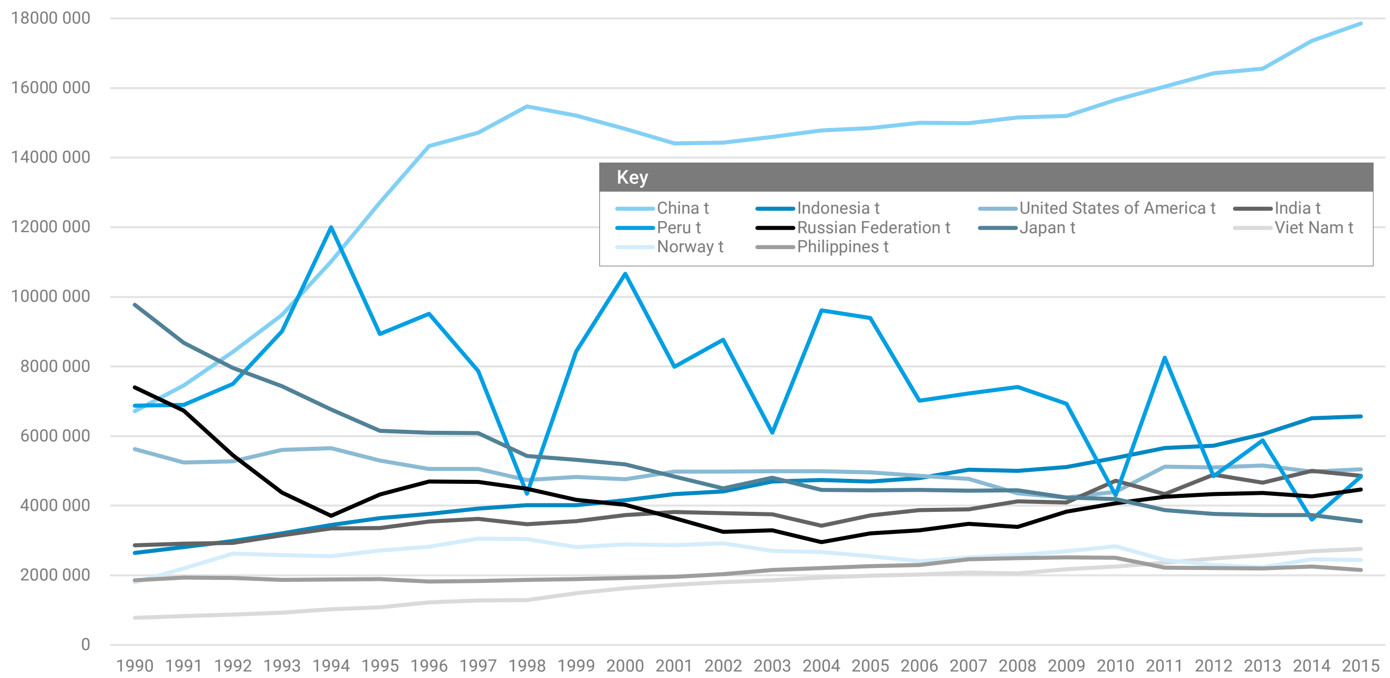
The time-series data of the catch (tonnage and value) of each country's economic exclusive zone (EEZ), either by domestic or foreign fleets, for the period 1950-2010, are obtained from the Sea Around Us Project (SAUP 2016). We only evaluate the stock with a catch record of at least 20 years and which has a total catch in a given area of at least 1,000 tonnes over the timespan.

The shadow prices of fisheries, like other classes of natural capital, ideally reflect their marginal contribution to social well-being. More specifically, they also represent not only their marginal abundance but the substitution possibilities with other capital forms (Dasgupta 2009). In a case study of predator-prey dynamics in a Baltic Sea commercial fishery, Yun et al. (2017) showed that the shadow prices of species are interdependent on relative abundance and scarcity in a multispecies ecosystem-based management context. Applying a similar methodology to our current natural capital estimate would need a much more detailed data set than ours. Moreover, there is an obvious trade-off between disaggregated, state-dependent shadow prices and clarity of accounting. For example, if we attach shadow prices that differ according to countries, species, cohorts, years, etc., it would be difficult to disaggregate the reason for the change in the value of capital stocks, although this may be resolved by advancing the way the figures are presented. Additionally, the period-average shadow prices, which are adopted elsewhere in the IWR, can be shown to be a good approximation, either in a short period of time or the shadow price change is linear in time. Thus, currently, we choose to use a simple unit market rent that reflects a period-average, species-average market price adjusted by the rental rate.

3.6.3. Results and discussion

In Fig 3.19, we show the past trends in catches from the top 10 countries. Asian demand has been on the rise, mostly driven by the increase in China, Indonesia and India. The US has been stable, and Russia and Japan have declined. Peru has been volatile, largely due to anchovy captures. Note that this figure only considers capture production for both marine and inland waters, which accounts for a portion of fishery production. Leading countries in aquaculture include China (59m tonnes) and India (14m tonnes). We also exclude aquaculture production, largely because this class of fishery production has more characteristics of produced capital. This is somewhat analogous to classifying cultivated forests as produced capital, not natural capital.

Fig 3.19: Top 10 countries in fishery capture production



Source: FAO – Fishery and Aquaculture Information and Statistics Branch

Fig 3.20 shows the capital stock levels in monetary value, comparing 1990 and 2014. Among countries with a large amount of fishery stock, it is only Canada and Spain that increased their level in the period from 1990 to 2014.

In other major fishery producing countries, including China, Indonesia, Japan, Malaysia, Peru and Viet Nam, capital stocks have decreased. In the US, capital stocks slightly decreased.

Fig 3.20: The value of fishery stocks of selected nations, 1990 and 2014

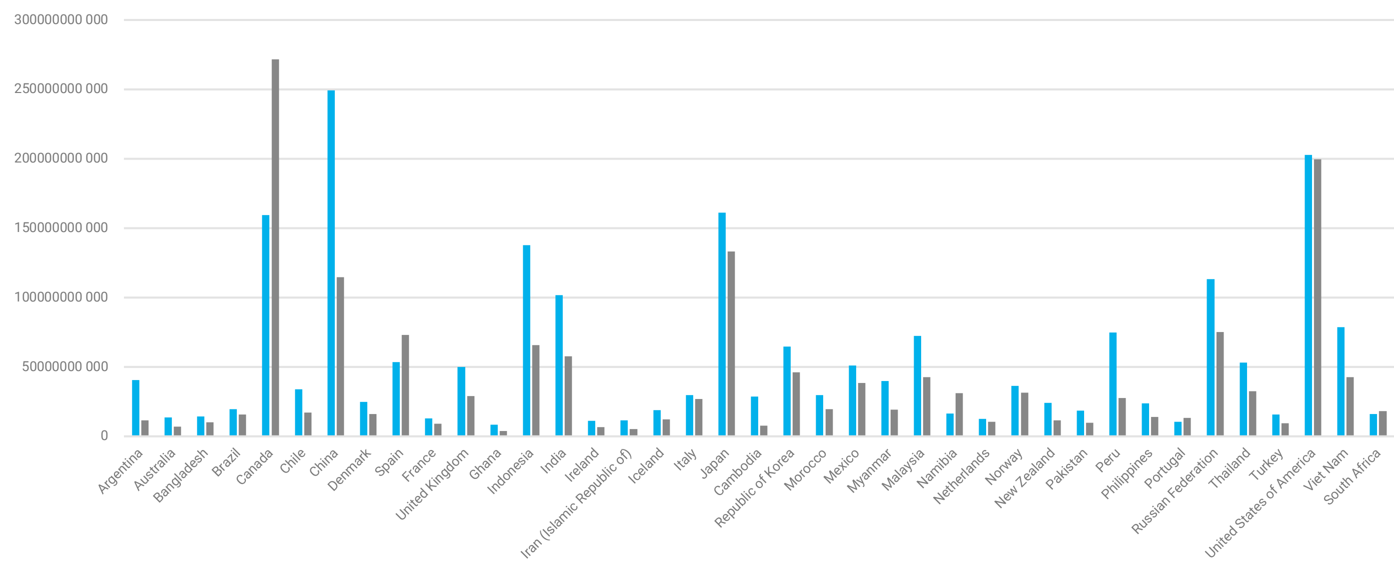
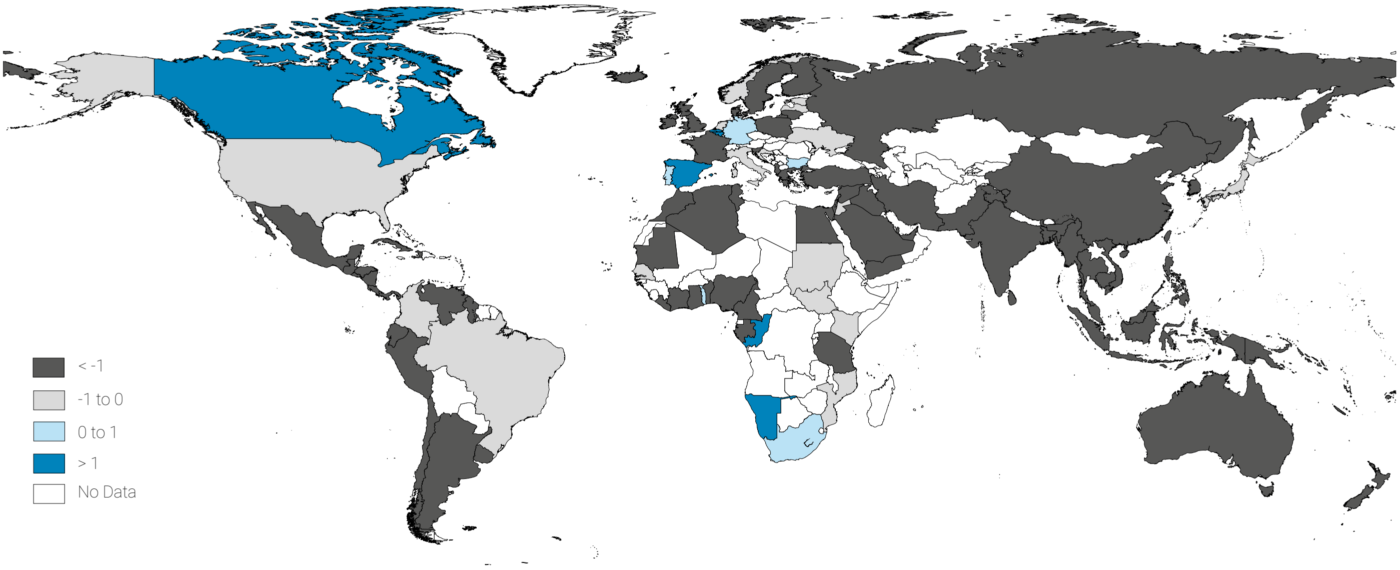


Fig 3.21: Average annual growth rate of fishery stocks from 1990 to 2014



Globally, the value of fishery stock has decreased from $2,325 billion to $1,713 billion. Although the methodology of shadow pricing can be improved, and the absolute figure has no welfare significance,[33] this declining trend is an alarming one per se. Given that capture production is on the increase, the pressure on stock appears to remain prevalent

Part of this problem may have been circumvented by the increase in aquaculture, as we have argued. In addition, there has been an effort to promote policy and management based on Maximum Sustainable Yield (MSY). MSY has its own limitations in that multispecies and ecosystem interactions tend to be absent; however, it is a step in the right direction to modify MSY-based fishery policy.

This has just begun, and its effect has yet to be seen, but we hope to have laid the foundations for monitoring policy intervention effects on the marine fish capital stock.

33 Note that the same price is applied to the whole stock for simplicity.

3.7. Conclusions

As we argued at the outset of this section, RE output can be considered a joint product of renewable energy-produced capital and natural capital. RE capital is produced capital from a physical perspective, but it can substitute for natural capital, especially non-renewable fossil fuels, such as coal, oil and gas. Thus, in Table 3.6, we show a comparison of our results with produced and natural capital (per capita) in selected countries. As Table 3.6 illustrates, China, Germany, the United States, Japan and Italy are the top five countries in terms of the value of total RE capital as of 2014. They are a mix of developed and emerging countries. Renewable energy capital per capita (REpc) has accumulated widely in Europe, particularly in Germany, Italy, Denmark, Belgium and Greece.

Table 3.6 also reports the share of RE in terms of produced capital, natural capital and IW. In the current Inclusive Wealth Framework, RE stocks have already been accounted for in the produced capital category. Apparently, RE only accounts for a tiny fraction of produced capital – Bulgaria and Romania have the highest shares: 1 to 2 percent of the total. This may be because RE has been aggressively introduced across Europe and produced capital has accumulated less in less developed parts of Europe.

More interesting is the ratio of RE to natural capital, which varies widely since natural capital endowment differs from country to country. In Belgium, for example, the combined RE capital of solar and wind has already surpassed the level of natural capital. Other European countries including the United Kingdom and Italy, and Israel already have RE capital equivalent to more than 10 percent of their natural capital. It could be the case that these countries have depleted their natural capital in exchange for investing in RE; or have invested in RE because they are poorly endowed with non-renewable resources in the first place. Another possibility is that they are replacing conventional power plants (produced capital) that use fossil fuels or nuclear power.

Table 3.6: Renewable energy capital of selected countries, and its ratio to other capitals

Countries	Solar	Wind	RE	REpc	RE/PC	RE/NC	RE/IW
Argentina	-	254	254	6	0.000	0.000	0.000
Australia	7,262	3,290	10,551	449	0.003	0.004	0.001
Austria	1,440	1,604	3,044	353	0.002	0.054	0.001
Belgium	5,389	1,636	7,025	626	0.004	1.084	0.001
Bulgaria	1,836	530	2,366	328	0.021	0.043	0.005
Brazil	-	5,503	5,503	27	0.002	0.001	0.000
Canada	3,507	8,162	11,669	328	0.003	0.003	0.001
Switzerland	1,945	-	1,945	236	0.001	0.023	0.000
Chile	434	716	1,150	65	0.002	0.004	0.001
China	53,869	84,342	138,211	99	0.008	0.018	0.003
Costa Rica	-	132	132	28	0.002	0.002	0.000

Czech Republic	3,376	-	3,376	318	0.005	0.059	0.002
Germany	63,930	26,182	90,112	1,106	0.008	0.064	0.002
Denmark	1,112	2,455	3,567	630	0.004	0.104	0.001
Egypt	-	427	427	5	0.001	0.004	0.000
Spain	8,242	15,253	23,496	505	0.005	0.076	0.001
Finland	18	528	546	100	0.001	0.004	0.000
France	10,103	7,461	17,564	274	0.002	0.064	0.000
United Kingdom	10,422	10,762	21,184	326	0.003	0.128	0.001
Greece	4,706	1,444	6,151	546	0.007	0.030	0.002
Honduras	8	-	8	1	0.000	0.000	0.000
Hungary	149	251	400	41	0.001	0.007	0.000
India	5,698	17,081	22,779	18	0.005	0.007	0.001
Ireland	-	1,777	1,777	379	0.002	0.060	0.001
Israel	1,265	-	1,265	159	0.002	0.101	0.001
Italy	32,202	6,560	38,761	651	0.005	0.116	0.001
Japan	42,903	1,945	44,848	350	0.002	0.098	0.001
Morocco	-	693	693	20	0.002	0.009	0.000
Mexico	191	2,216	2,407	19	0.001	0.003	0.000
Malaysia	386	-	386	13	0.001	0.001	0.000
Netherlands	2,091	1,810	3,901	231	0.001	0.052	0.000
Norway	12	666	678	132	0.001	0.003	0.000
New Zealand	-	502	502	110	0.001	0.000	0.000
Pakistan	233	248	481	3	0.001	0.001	0.000
Philippines	38	272	310	3	0.001	0.002	0.000
Poland	-	3,385	3,385	88	0.003	0.008	0.001

Portugal	737	3,407	4,144	396	0.005	0.071	0.001
Romania	2,506	2,667	5,173	259	0.010	0.028	0.003
Slovakia	918	-	918	169	0.004	0.065	0.001
Sweden	144	4,613	4,757	491	0.003	0.031	0.001
Thailand	2,440	208	2,648	39	0.003	0.010	0.001
Tunisia	-	203	203	18	0.001	0.012	0.000
Turkey	110	3,189	3,299	43	0.002	0.006	0.000
Ukraine	1,511	-	1,511	34	0.003	0.002	0.001
Uruguay	-	518	518	151	0.007	0.014	0.002
United States of America	33,947	51,095	85,042	268	0.002	0.009	0.000
South Africa	2,012	554	2,566	47	0.003	0.007	0.001

Source: Based on BP (2016), DOE (2015), UN (2017) and other sources.

Note: See Yamaguchi (2017) for detailed methodology. RE, REpc, PC, NC and IW stand for renewable energy capital, renewable energy capital per capita, produced capital, natural capital and inclusive wealth (in the conventional IWR 2014 approach), respectively. Solar, wind and RE are expressed in million USD, while REpc is in USD.

In this chapter, we took a deeper look at the natural capital of nations from regional perspectives. Data were also used to study the relationship between natural capital and natural disasters.

Some new insights were gained regarding regions and newer classes of natural capital – fishery and RE capital. Admittedly, some challenges remain: shadow prices of fishery and RE capital are still developing. In particular, they have to be estimated in a manner consistent with social well-being.

As IWR 2012 notes, "[w]e will never get shadow prices 'right', but we can attempt to narrow the range in which they are taken by reasonable people to lie". We believe that this chapter is a step in the right direction.

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