UN environment programme

INCLUSIVE WEALTH REPORT 2023

MEASURING SUSTAINABILITY AND EQUITY

What is Inclusive Wealth?

The Inclusive Wealth Report (IWR) is a biennial effort led by the United Nations Environment Programme (UNEP) to evaluate national capacities and performance in terms of measuring economic sustainability and well-being. Existing national statistical systems use Systems of Environmental and Economic Accounts, which are geared towards measuring the flow of income. These flows critically depend upon the health and resilience of capital assets like manufactured capital, human capital and natural capital.

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Acknowledgements

Report Directors
Shunsuke Managi is Distinguished Professor at Urban Institute, Kyushu University.
Pushpam Kumar is Chief Environmental Economist, United Nations Environment Programme.

Authors
Edward B. Barbier, Professor at the Department of Economics, Colorado State University, USA
Shuning Chen, research fellow, Urban Institute, Kyushu University.
Barbara M. Fraumeni, Research Associate at National Bureau of Economic Research, USA and Professor at Central University for Finance and Economics, China.
Moinul Islam, research fellow, Urban Institute, Kyushu University.
Pushpam Kumar, Chief Environmental Economist, United Nations Environment Programme.
Robi Kurniawan, research fellow, Urban Institute, Kyushu University.
Gang Liu, research fellow at Statistics Norway, Norway.
Shunsuke Managi, Distinguished Professor at Urban Institute, Kyushu University.
Xiangdan Piao, research fellow, Urban Institute, Kyushu University.
Yogi Sugiawan, research fellow, Urban Institute, Kyushu University.

Advisory Board
John Agard, Executive Director, Global Institute for Climate-Smart and Resilient Development, University of West Indies, Saint Augustine, Trinidad and Tobago.
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Carlos Manuel Rodríguez, Chief Executive Officer and Chairperson, Global Environment Facility, Washington D.C.
Kevin Urama, Acting Chief Economist, vice-president for Economic Governance, African Development Bank.
Jianto Xu, Boya Distinguished Professor of Economics, Peking University.

In consultation with or reviewed by:
UNEP: Ligia Noronha, Susan Garden, Bruno Maggi G Pozzi, Doreen Robinson, Andrea Hinwood, Steven Stone, Jamil Ahmad, Nicolas Bertrand, Jian Liu, Deborah Kirby.

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Abbreviations

GDP	Gross Domestic Product
UNEP	United Nations Environment Programme
IMF	International Monetary Fund
IWR	Inclusive Wealth Report
IWI	Inclusive Wealth Index
HDR	Human Development Report
UNDP	United Nations Development Programme
SNA	System of National Accounts
SEEA	System of Environment Economy Accounting
IPBES	Intergovernmental Science-Policy Platform on Global Biodiversity and Ecosystem Services
OECD	Organisations of Economic Cooperation and Development
FAO	Food and Agriculture Organization
SDGs	Sustainable Development Goals
UNDESA	United Nations Department of Economic and Social Affairs
UNICEF	United Nations Children's Fund
WHO	World Health Organisation
USD	US Dollars
G20	Group of Twenty (G20)
EAP	East Asia and Pacific
ECA	Europe and Central Asia
LAC	Latin America and Caribbean
MENA	Middle East and North Africa
SA	South Asia
SSA	Sub-Saharan Africa
ANNI	Adjusted Net National Income
WB	World Bank
GNI	Gross National Income
PPP	Purchasing Power Parity
HDI	Human Development Index
ASEAN	Association of South East Asian Nations
IPCC	Intergovernmental Panel on Climate Change
TFP	Total Factor Productivity
COVID-19	Coronavirus Disease 2019

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Overview

World leaders increasingly believe the time has come to move beyond Gross Domestic Product (GDP). At their 2018 meeting in Canada, G7 Heads of State recognized that GDP alone is "insufficient for measuring success" (Government of Canada 2019). The United Nations Secretary-General clearly states in 'Our Common Agenda' (United Nations [UN] 2021) the need to improve national measures of progress beyond GDP: "I urge Member States and others to already begin implementation of the recent System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting and the system for population and social conditions, and to consider existing complements or alternatives to GDP, such as the Human Development Index and the Inclusive Wealth Index." 'Our Common Agenda' provides compelling reasons to supplement the use of GDP with measures that include natural and human capital stocks in measuring progress. This has further been elaborated in the brief of the UNSG on Valuing What Counts (UN 2023). The Stockholm+50 meeting convened by the United Nations General Assembly in 2022 also presented a strong mandate for measuring societal progress and sustainability more holistically.

> ***"I urge Member States and others to already begin implementation of the recent System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting and the system for population and social conditions, and to consider existing complements or alternatives to GDP, such as the Human Development Index and the Inclusive Wealth Index."***

The Inclusive Wealth Index (IWI) is a metric of the United Nations Environment Programme (UNEP) in response to the Beyond GDP movement. Inclusive wealth measures the assets that underpin a nation's income flows and human well-being: natural, human and produced capital. Measuring inclusive wealth is key to driving sustainable investments across all policy areas. As The Economics of Biodiversity (Dasgupta 2021) noted, judging "whether the path of economic development…is sustainable" requires nations to adopt "inclusive measure[s] of their wealth". The United States White House Office of Science and Technology Policy has clearly compelling articulated need for natural capital assets accounts (White House 2022). The World Bank (2021), the Organisation for Economic Co-operation and Development (OECD) (n.d.) and the World Economic Forum (2019) agree that decision-makers must focus on increasing wealth if they want to ensure well-being in the 21st century.

The Inclusive Wealth Report (IWR) 2023 is the fourth in UNEPs Inclusive Wealth Report series. This latest iteration of the report further confirms that the wealth economy approach, applied through the IWI, provides policymakers with essential knowledge for making informed decisions towards sustainable economic development.

The IWR 2023 undertakes a comprehensive global assessment of the inclusive wealth of 163 countries for 1990–2019[1]. Following previous iterations (United Nations University International Human Dimensions Programme on Global Environmental Change [UNU-IHDP] and UNEP 2012; UNU-IHDP and UNEP 2014; Managi and Kumar 2018), the IWR 2023 adds an explicit focus on the nexus between inequalities and natural assets, highlighting that the loss of nature negatively impacts rural and poor communities in developing countries most directly and most acutely.

1 Inclusive Wealth assessment in the IWR 2023 covers 166 countries, with variation in the number of countries analysed for each individual capital asset, i.e. natural, human, produced.

The report highlights how inclusive wealth—incorporating natural, human and produced capital—is a sophisticated yet streamlined measure for assessing national and global development and economic progress. By mapping the inclusive wealth levels (in absolute and per capita terms) of 98 per cent of the global population, this report presents unequivocal findings that:

- global inclusive wealth has increased by almost 50 per cent in the 30 years since reporting began;
- however this increase has cost us more than one quarter of our natural capital during this same period;
- per capita inclusive wealth has actually dropped, unable to keep pace with soaring population growth[2];
- rising income inequality is correlated with the exploitation of marine fishery resources for some emerging economies countries.

Inclusive wealth in the sustainable development agenda

Economic development since the industrial revolution has ushered in an era of improvements in the human condition. Life expectancy, literacy rates, the empowerment of women and marginalized peoples and the spread of ideas, people and cultures have all been made possible by the accrual and use of wealth. However, despite these remarkable improvements, concerning trends in environmental, social and economic indicators are emerging and require urgent action. For instance, recent years have seen unprecedented loss of biodiversity (Intergovernmental Science-Policy Platform on Global Biodiversity and Ecosystem Services [IPBES] 2019), increased levels of air pollution (World Bank 2022) and extreme weather events (Food and Agriculture Organization of the United Nations (FAO) 2021), a resurgence of populism and social unrest, spiralling inequalities in health, skills and opportunities (International Monetary Fund [IMF] and World Bank 2020) and a growing sense of dissatisfaction with democracy. Combined, these pressures threaten to undermine more than a century's worth of progress.

The Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda for Sustainable Development were developed in response to such crises, but the COVID-19 pandemic has, in part, undermined progress towards them by exacerbating many of the existing challenges and inequalities faced by society. However, the COVID-19 pandemic has also highlighted our capacity to mobilize assets and work cooperatively to address global challenges. If allocated properly, public investment can help to support a sustainable, inclusive, resilient and prosperous recovery in all parts of the world.

Building capacity and resilience after the COVID-19 pandemic requires investment in vital assets that can underpin a sustainable 21st century and calls to 'build back better' are now widespread. But in practice, this requires building back differently. The core ingredients of economic prosperity are known as capital assets—human, natural and produced—and these comprise an economy's inclusive wealth. Inclusive wealth focuses on the stocks of underlying assets that generate income flows. Although short-term income can be temporarily boosted by overconsuming capital, this reduces productive capacity in the longer term. It is this change in productive capital stocks that can be monitored by inclusive wealth measures. This is pertinent not only to the sustainable development of national economies but also to ensure the delivery of the SDGs.

The IWR 2023 outlines in no uncertain terms how the absolute wealth of countries is changing, and how the composition of that wealth, in terms of capital stocks, is also changing – and not necessarily on a sustainable pathway. This information is useful to policymakers to ensure the welfare of current and future generations.

2 When considering levels of inclusive wealth per capita.

Data developments

The Inclusive Wealth Framework does not require all types of capital to increase in order for wealth to increase in the context of sustainability. In this framework, capital is regarded as substitutable – a decrease in one type of capital can be compensated for by an increase in another. This implies, for example, that a certain level of depletion of natural capital, such as mineral stocks to derive economic growth, may be compensated for by an equivalent improvement in human capital, like the quality of education and health care[3].

However, natural capital has historically been under-priced (Barbier 2015). One consequence of this is the economic gains from depleting natural capital have been insufficient for commensurate investments to be made in human and physical capital. This under-pricing has further resulted in massive exploitation of natural resources in an unsustainable manner. There is little empirical evidence to notice this unsustainable progress for many regions in the world. To address this, the IWR 2023 focuses on the composition and distribution of natural capital at regional levels. The report uses the World Bank classification of countries[4] to compare regional differences, and makes a separate analysis of the Group of 20 (G20) economies. For a full list of the countries/economies included in these seven regions see Appendix 2.

This report also investigates whether the inclusion of natural capital in the wealth accounts of nations can explain wealth inequality estimates. Multiple databases measure natural capital and its link to wealth inequality among the G20 countries. Inequality measures utilize data from the Inequality-adjusted Human Development Index (HDI), inequality in income statistics, data on the loss in HDI due to inequality and the Gini Index.

The IWR 2023 analyses the capital assets of 163 countries, an increase from 140 in the previous editions of the report, with all countries in Africa now covered. Consequently, it now incorporates all major economies on all continents, accounting for 98 per cent of the world's population.

In this assessment, natural capital is categorized by renewable and non-renewable resources. Renewable capital stock includes fisheries, forests and agricultural land. Non-renewable natural capital includes three energy sources and 11 mineral resources. Moreover, the report captures both the market values (those that have a defined economic value) and the non-market values (those for which an estimate needs to be made as to their value as they are not traditionally sold in the marketplace) for ecosystems. For the first time, this report also considers blue carbon emissions, i.e. carbon stored in, or released from, marine and coastal ecosystems.

The estimation of human capital has also been further developed from previous Inclusive Wealth Reports. Human capital calculations are now gender-differentiated, and both education and health are now incorporated. Estimations of education levels are made on expected years of schooling rather than, as previously, mean years of schooling. This enables explanation of the length of time a population is in school, which better confirms the size of the working population.

A key benefit of conducting inclusive wealth assessments is that they provide an ongoing analysis of changes in countries' wealth over time. This report, the fourth in the series, now includes 30 years of data and analysis on changes in countries' natural, human and produced capital stock, and provides a global analysis of how these have changed in tandem with population growth.

3 It should be noted that the full range of benefits provided by nature often cannot be obtained by human-made replacements, and the extent of substitutability of natural assets remains highly debated, both philosophically and empirically (IPBES 2019).

4 Africa, East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, and South Asia.

What the data shows

Since 1990, (the baseline of all IWRs), growth in absolute inclusive wealth has been positive for most countries. This is reflected by a 49 per cent increase in total global inclusive wealth within the study period. However, this seemingly positive result is tempered when world population growth is considered. The global population has increased by 2.4 billion people (from 5.3 billion to 7.7 billion) in the same period, and taking this into account, global inclusive wealth per capita has dropped by 5 per cent.

Moreover, the growth in absolute inclusive wealth has been accompanied by a severe loss of natural capital. This report shows that from 1990 to 2019, the world's natural capital declined by more than 28 per cent – over 1 per cent per annum. Reduced natural capital with more people to share and utilize it has resulted in a smaller share of natural capital per person. Consequently, natural capital has dropped by over 50 per cent per capita during the same period. This decline is a key factor in the five per cent decrease in per capita inclusive wealth globally: a decline in natural capital negatively affected the growth of inclusive wealth per capita in 151 of the 163 countries analysed[5].

The main driver in the growth of inclusive wealth was produced capital. Per capita produced capital increased by over 90 per cent globally in the last three decades. However, in terms of absolute contribution to inclusive wealth, it was human capital—rather than produced capital—that was the most important factor. Human capital contributed to well over half of the total global inclusive wealth in 2019. In comparison, natural capital only accounted for around 18 per cent.

The Middle East and North Africa showed the greatest growth in human capital, nearly tripling between 1990 and 2019. South Asia, sub-Saharan Africa, Latin America and the Caribbean all at least doubled their human capital in this time. In high-income advanced economies, with a high level of human capital per capita, education was the main factor behind increased human capital. In low-income countries, population growth was the main driver.

The cost of ongoing climate change—captured as the cost of global carbon dioxide (CO_2) emissions—is also estimated in the present analysis. Carbon emissions from fossil fuel energy and deforestation are both considered. Carbon damage losses occurred in 115 of the 163 countries, with the most significant impact on wealth in Bangladesh, Djibouti, Ethiopia, India, Ireland, Lesotho, Mali, Rwanda, Sri Lanka and Uganda.

On a global scale, Latin America and the Caribbean have lost more natural capital than any other region. Five countries—Barbados, Chile, Ecuador, Peru and Trinidad and Tobago—have lost more than half of their natural capital since 1990. Accordingly, Latin America and the Caribbean's share of natural capital has fallen to less than 15 per cent of the global total. It is clear that the excellent economic performance of the G20 countries has been made at the expense of depleting their natural resources, with most countries showing a decrease in natural capital. The biggest loss in natural capital occurred in Japan, which had a natural capital loss of 70 per cent through overexploitation of fisheries and forests.

This report also analyses progress towards the 17 SDGs. It achieves this by applying three different measures of environmental impact as follows:

- net environmental impacts associated with SDGs 11–15 (the environmental SDGs)
- natural resource depletion as a share of national income
- per capita natural capital change

5 Except for Albania, Armenia, Bulgaria, Croatia, Estonia, Georgia, Latvia, Lithuania, Malta, Moldova, Serbia and Ukraine.

The analysis finds that gains from 2000 to 2019 associated with meeting the 17 SDGs are often accompanied by adverse environmental impacts and natural capital depletion. The net welfare impacts from achieving the 17 SDGs are especially correlated with the net environmental impacts (SDGs 11–15). Countries with higher SDG welfare gains over this period tended to have lower environmental losses and vice versa. This suggests that long-term progress towards the SDGs will hinge on improved management of natural capital and the environment in emerging market and developing economies.

The report additionally analyses the relationship between inclusive wealth and inequality. By applying an analysis framework across multiple databases of natural capital assessments, the report measures natural capital and its link to the wealth inequality of the G20 countries (Barbier 2017). The G20 countries were selected for this study due to their commitment to promoting inclusive and sustainable economic growth, good availability of data and the alarming fact that over half of the world's impoverished populations reside in these countries.

Key findings

Key findings in the IWR 2023 include:

- The global inequality of inclusive wealth is identified through the Gini Index, which accounts for wealth and income distribution among nations (United Nations Department of Economic and Social Affairs [UN DESA] 2015).

- Per capita inclusive wealth inequality among countries rose between 1990 and 2010, but declined after 2010. Overall, in 2019 global inclusive wealth inequality was lower than the inclusive wealth inequality in 1990. This result is attributed to a rapid reduction in produced capital inequality, due to the accumulation of produced capital, particularly in developing countries such as China and India. Human capital inequality rose in the 1990s, but stabilized after 2000. However in 2019, human capital inequality was the highest of all wealth inequalities.

- Global inequality in per capita natural capital has been increasing since 1998 (from Gini Index 0.67 in 1998 to 0.72 in 2019) showing deepening inequality in per capita natural capital across countries (Figure 5.13).

- This trend in inequality of per capita natural capital across countries since 1998 and the decline in per capita natural capita (Figure 5.9) are likely to continue because of shrinking nature and ever-growing population.

- Since natural capital is hard to be substituted by any form of capital, for long, inequality in per capita natural capital across countries and global decline in per capita natural capital might lead countries of the world to unhealthy competition in the future for access to critical natural resources like land, water forest, fish and extractives that may trigger conflicts.

- The global community needs to reverse the declining trend in natural capital which would in turn require investments in augmenting the renewable natural capitals through restoration and clean energy technologies via innovation, diffusion and deployment.

The report recommends policy solutions that prioritise sustainable natural capital management to achieve the SDGs. Analysis of the G20 countries' natural capital and inequality conditions strongly suggest that it will only be possible to achieve the SDGs by focusing on the environmental risks that result from different economic development pathways.

Conclusions

The IWR 2023 highlights changes in the absolute levels, and more importantly, relative proportions of different capital types over time. Although some countries have managed rapid accumulation of human capital and productive capital with relatively minor depletion of natural capital, most have significantly depleted their natural capital in achieving growth.

This indicates that countries need to consider their development pathway individually, as substitutability between types of capital may not be equitable between countries. It also further highlights the utility of the Inclusive Wealth Index (IWI) for government policymakers. Application of the IWI enables individual governments to understand at a fine-grain level how they are utilizing their country's wealth, and the long-term consequences and opportunities of any growth strategy. This will enable nations to engage in nuanced and effective policymaking to ultimately build socially just and environmentally sustainable development pathways.

Preface to IWR 2023

That economic policies should be evidence-based is (and should be) an incontrovertible requirement, but it is of no use if the evidence is obtained from a misleading conception of the human condition as faulty models produce spurious evidence. Systems of thought that do not acknowledge humanity's embeddedness in nature when used to project present and future possibilities open us to be misled. The findings of ecologists and Earth scientists have increasingly demonstrated that such systems of thought mislead so hugely that policies based on them not only endanger future generations but also damage the lives of the world's contemporary poor. The present volume is of great importance because it constructs ways to include nature in economic measurement. In this note, I try to place the heroic efforts of the authors in perspective and extend their analysis by presenting a grammar for discussing the idea of sustainable development[6].

Nature's goods and services

The global standard of living has improved enormously since the end of World War II. Per capita global income has increased nearly five-fold to some US Dollars (USD) 16,000 purchasing power parity (PPP) annually, life expectancy at birth has increased from 46 years to 72 years and the proportion of people in extreme poverty has declined from approximately 60 per cent to 10 per cent. But these statistics should be tempered by the thought that prominent Earth scientists see 1950 as the year we entered the Anthropocene (Voosen 2016). Since then, expansion in our demands for nature's provisioning goods (food, water, timber, fibres, pharmaceuticals and non-living materials – that is the ingredients that, with human effort, go to shape the final products reflected in gross domestic product [GDP]) has eaten into nature's ability to supply maintenance and regulating services, such as carbon sequestration, nutrient recycling, decomposition of waste, pollination, nitrogen fixing, soil regeneration, purification of water and maintenance of the biosphere's gaseous composition[7]. For there is a tension between the global demand for the biosphere's provisioning goods and our need for maintenance and regulating services. When we engage in mining, quarrying, and more broadly in the land-use changes accompanying expansions of crop agriculture, animal farming, plantations and construction, tension is felt.

The processes that furnish us with maintenance and regulating services are for the most part silent and invisible (think of the things that are happening deep in the soils or the ocean depths). Which is why the significance of these services continues to be underestimated by decision makers[8]. But maintenance and regulating services are the foundation on which we exist. They are primary, akin to 'basic industries' in the standard classification of industrial production sectors.

6 I am deeply grateful to Shunsuke Managi and Pushpam Kumar for discussions over many years on the idea of sustainable development.

7 Here I am adopting the Common International Classification of Ecosystem Services, which was built on the pioneering work of the Millennium Ecosystem Assessment (MEA 2005).

8 Ecologists and Earth scientists trace the efficacy with which those processes are functioning and have functioned in the past from their visible signatures (Waters *et al. 2016)*.

UNEP's Inclusive Wealth Index

The Inclusive Wealth Index measures changes in nations' wealth, not just their levels of wealth. This enables policymakers to assess their countries' wealth stocks and the direction of their flow at any given moment, enabling them to manage their economies more sustainably.

The Inclusive Wealth Index incorporates natural, human and physical capital into a measure of wealth. This includes the following:

- Natural resources and ecosystem services (including air quality, biodiversity and climate systems);
- Human health, skills and education levels; and
- Physical infrastructure (e.g. transport, housing, utilities and information and communications technologies).

There is a further sobering fact. Although technological advancements have repeatedly shown ways to substitute provisioning goods among one another (fossil fuels replacing timber, solar panels substituting for fossil fuels in energy production and so on), nature's maintenance and regulating services are complementary to one another: disrupting one sufficiently disrupts the others. The mutual influence of climate change and destruction of the world's tropical rainforests is an example. Thus, the long-standing question whether natural resources can be substituted for in production by labour and produced capital pertains to provisioning goods (Dasgupta and Heal 1979), not to maintenance and regulating services. Complementarities among the latter tell us that we are embedded in nature, we are not external creatures. The biosphere is not exactly a house of cards, but we humans are now so ingenuous that we would be able to reduce it to one if we put our mind to it. As we confirm below, economic activity in the Anthropocene has been accompanied by a continual degradation of the biosphere. The post War period has enjoyed unprecedented improvements in the standard of living, but we have done so while practicing an ecological overshoot.

GDP is impervious to nature

The need to reconstruct growth and development economics and the economics of poverty in a way that sees we humans as being embedded in nature is not generally appreciated. It is not appreciated even in the received economics climate change (Nordhaus1994; Nordhaus and Boyer 2000; Stern 2006). Their models graft an isolated climate system into contemporary models of growth and distribution. And the latter see the human economy as being external to the biosphere. The received wisdom built on this conception sees indefinite growth in global GDP as viable so long as we invest sufficiently in clean energy (a broad consensus being at the rate of two per cent of global GDP) to bring about net-zero emissions, say, by 2050.

This is a misplaced reading of the biosphere's workings. That net-zero can be, and needs to be, attained should not be questioned; the false expectation is rather that net-zero is the only ecological goal. Indefinite increases in global GDP even under net-zero can be guaranteed to disrupt nature's other maintenance and regulating services, which in turn would disrupt the climate system, making net-zero even harder to maintain. Complementarities among nature's services are a reason our economic system is bounded. New ideas and new ways of doing things can make the bound larger than it is today, but the bound cannot be enlarged indefinitely. Over the past 70 years or so, the bound has in fact been shrinking. That's the Anthropocene[9].

9 That's the subject of The Economics of Biodiversity: The Dasgupta Review (Dasgupta 2021).

As a measure of economic well-being, GDP has been routinely criticized for being overly aggregative, for example it does not speak to income distribution or extreme poverty. But that's a criticism that can be levelled against any aggregate measure; it is why national income offices in response today collate statistics to cover those missing features[10]. Conceptually it's an easy move to add those features of an aggregate measure that are missing. The problematic bit in GDP is not its aggregative character, but that it is the wrong aggregate. The rogue word for which GDP is an acronym is 'gross' because the measure does not record the depreciation of capital assets that accompanies economic activities.

We are concerned here with depreciation of the biosphere. If contemporary economics is to be reconstructed, we would have to study our embeddedness in nature at all levels: from the individual person, through households, communities, nations and regions, to the global economy. The latter is the scene where growth and development economics of the long run is fashioned, so the needed reconstruction would also refashion macroeconomic models of the long run. It would read contemporary economic growth as being countered by depreciation of the finite, self-regenerative entity that is the biosphere[11]. That recognition is the source of the idea underlying inclusive wealth, the subject of this report.

The novelty of the report and its predecessors (UNU-IHDP and UNEP 2012; UNU-IHDP and UNEP 2014; Managi and Kumar 2018) is the presence of natural assets (sub-soil resources and ecosystems) in national accounts. It is customary to use the term 'natural capital' to denote environmental natural resources. Natural capital is the source of the maintenance and regulating services we enjoy. Accounting prices of natural capital reflect the social worth of those services. So, it pays to expand on why we should pay special attention to them.

Inclusive wealth and collective well-being

An economy's inclusive wealth reflects the social value of its stocks of produced capital (roads, ports, buildings and machines), human capital (health and education) and natural capital. As accounting prices reflect social values, an economy's inclusive wealth can be read as the accounting value of the stocks of all its assets. The idea is not to dismiss GDP from national accounts (GDP is useful for short run macroeconomics management), but to create a parallel system of capital accounts, akin to firms' balance sheets, for judging economic performance. Financial and social capital, including institutions and culture, can be thought of as intangible assets that lubricate an economy. They enter inclusive wealth via the accounting prices of produced capital, human capital and natural capital.

Ownership of assets should be distinguished from access to assets. There are forms of natural capital, such as the atmosphere and the open oceans, that are not owned by anyone; but if agents in an economy have access to them, their accounting values should be included in inclusive wealth. This is of relevance for the way global common property resources are regarded in national accounts. Currently, they are missing in the accounts.

Accounting prices have ethical values embedded in them. The accounting price of a global public good such as the atmosphere as a sink for our carbon emissions (e.g. minus USD 200 per ton of carbon emitted) is the sum of the accounting prices of the asset enjoyed by each nation. This is the standard rule for the accounting price of public goods. Arrow *et al.* (2012; 2013) constructed a practical way to attribute the global social cost of carbon among countries[12]. But to the best of my knowledge the open seas as a sink for pollutants, a means of transportation of goods and people, and as a fishery have not been included in any study.

10 The United Nations Development Programme goes one step further in their Human Development Index by combining GDP per capita with measures of human capital (life expectancy to birth and literacy).

11 Dasgupta (2021, Chapter 4 and 13) provides a prototype of the kind of global economic model we now need to describe future economic possibilities.

12 Sacred objects would have an unboundedly large accounting price. The Endangered Species Acts in the United States of America and the United Kingdom of Great Britain and Northern Ireland point, not so much to sacredness but to the intrinsic value of species: the Acts place an unbounded value on endangered species. Environmental economists have long recognised the intrinsic value of nature. Freeman (2003), for example, reports extensively on the subject when describing contingent valuation exercises on environmental amenities and endangered species.

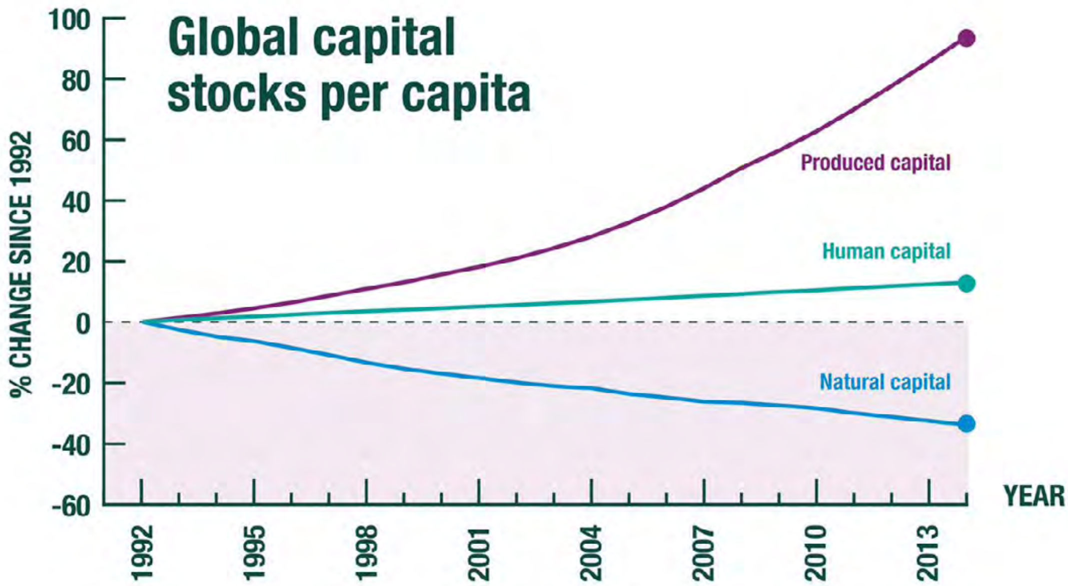


Figure P.1: Global capital stocks per capita, 1992-2014 *(Source: Managi and Kumar 2018)*

Inclusive wealth is not an *ad hoc* measure, plucked from air. It has firm normative foundations. It can be shown that inclusive wealth increases over time if and only if well-being across the generations increases over time. It can also be shown that the (net) present value (PV) of a policy (e.g. an investment project) is the contribution it makes to inclusive wealth. The pair of equivalence theorems tells us that inclusive wealth and well-being across the generations are two sides of the same coin. Inclusive wealth is therefore the measure with which to conduct both sustainability assessment and policy analysis. It remains a mystery to me that the United Nations SDGs (UN 2015) were put forward with no reference to how 'sustainability' should be measured[13].

A striking finding in Managi and Kumar (2018) is that over the period 1992–2014, per capita global produced capital doubled in size, per capita global human capital increased by some 15 per cent, but per capita global natural capital declined by 40 per cent (see Figure P.1). The authors also found that inclusive wealth per capita has declined in recent years in more than 40 countries, many in sub-Saharan Africa. The performance of countries has almost certainly been worse than what the publications report because many maintenance and regulating services were unaccounted for.

It is a simple matter to deduce from the equivalence theorem for sustainability assessment that a nation's inclusive wealth would increase over a period if aggregate consumption in the period was to be less than net domestic product (that is GDP less depreciation of capital assets). So, we have a criterion for sustainability based on flow accounts.

My understanding is that national statistical offices in an increasing number of countries are creating natural capital accounts, not as a substitute for national income accounts, but complementary to them. However, we should not expect national statistical offices to construct full blown inclusive wealth accounts. For one thing, accounting prices of natural

13 A project's PV, being the weighted sum of the flow of net benefits it generates, has the dimensions of a stock. The two equivalence theorems were proved in Dasgupta and Mäler (2000), and Arrow, Dasgupta and Mäler (2003a; 2003b). For a review of these results, see Dasgupta (2004; 2021). Arrow *et al.* (2004) offered a perspective on the idea of sustainable development and contrasted it with the idea of optimal development. Arrow *et al.* (2012; 2013) applied the theorem to study economic development in Brazil, China, India, United States of America and Venezuela over the period 1995–2004. The countries were chosen deliberately, to highlight specific features that colour the prospects for economic development.

capital are often deeply contentious; for another, the stocks are frequently hard to measure. The best that can be expected are natural capital accounts that offer qualitative descriptions of their state, for example, whether the health of an ecosystem has improved over the previous year or whether it has deteriorated. Even that would be valuable information.

That said, theory is a lot easier to digest than to put into practice. Today no one questions the equivalence between well-being across the generations and inclusive wealth—after all, a theorem is a theorem—but it will take a long while yet for economists to absorb the theorem and not equate 'economic growth' with 'GDP growth'. In a recent leader in the *Economist* (3 to 9 September, p. 9) the editors traced the United Kingdom of Great Britain and Northern Ireland's (UK) stalled GDP growth to the country's environmental laws. The leader began by insisting that "(all) public authorities should be given a mandate to boost growth," and then castigated the laws because under them, endangered species are protected against human encroachment. It complained that "a single wizened tree can scupper plans for 291 flats," and that "a colony of terns can stall the development of a nuclear-power station." No mention was made in the leader of the flip side that over the centuries populations of species have been obliterated by human encroachment. Millions of acres of forests have been decimated, bit-by-bit, on each round because by so doing it would provide employment for a few people. That bit-by-bit encroachment has taken gigantic proportions in the Anthropocene. Who in authority was speaking on behalf of populations of species that were decimated in consequence? The United Kingdom of Great Britain and Northern Ireland has been able to live well despite the decimation of its biodiversity because it has been able to clear the landscape of regions far away that were once rich in biodiversity. Today the Britain's ecological footprint is enormously larger than the global average (Wakernagel and Beyers 2019). It is the public recognition of that flip side that has led the British parliament to legislate environmental laws. The design of the nation's environmental laws, as with the design of any law, can be questioned, but the intention is clear and wholly admirable.

The impact inequality

We call the gap between the demand humanity makes of maintenance and regulating services and the biosphere's ability to meet that demand on a sustainable basis, the 'impact inequality'. To measure the global demand for those services, let global GDP serve as a measure of human activities. It is illuminating to decompose GDP by noting that it is, tautologically, the product of population size and per capita GDP. So, let N be global population and y be per capita global GDP. Global GDP is then Ny. But GDP is the market value of the final goods and services produced in a period (a year), expressed, say, in USD PPP. We need to relate that to the demand that our activities make on nature's maintenance and regulating services. Let α be numerical measure of the efficiency with which those services are transformed into marketed final products. It follows that Ny/α is the aggregate demand for nature's services. Today Ny/α would be called the global ecological footprint. Here I am adopting a global perspective; the global ecological footprint is an aggregate of individual footprints[14].

For expositional ease I assume that nature's maintenance and regulating services can be aggregated into a numerical measure, which we label by G. We should imagine that the flows of those services are valued at accounting prices, reflecting their social worth, and then summed to give us G. G is the biosphere's net regenerative rate.

The biosphere is a stock. We denote it by S. Again, we should imagine that S is the accounting value of the ecosystems that together comprise the biosphere. But G is a function of S. As with fisheries, G is a declining function of S when S is large (G is the net regeneration rate), but when S is small, G can be made to increase by allowing S to increase. Because S is bounded, G is bounded.

14 Ehrlich and Holdren (1971) decomposed the global ecological footprint (they called it 'impact') in terms of population, income, and technology. Barrett *et al.* (2020) formalised the latter as the efficiency with which nature's maintenance and regulating services are converted into final products. Both technology and institutions shape that efficiency.

Armed with this notation, the Impact Inequality (Barrett *et al.* 2020) can be expressed as:

$$Ny/\alpha > G(S) \quad (1)$$

The size of the inequality is a measure of humanity's ecological overshoot. By some estimates the ratio of our demand for maintenance and regulating services (the left-hand side of inequality (1)) to nature's ability to meet that demand on a sustainable basis (the right-hand side of inequality (1)) is today 1.7, hence the metaphor that we need 1.7 Earths to meet our demands (Wakernagel and Beyers 2019). The term 'sustainable' is an all-important qualifier here, for it says that we are enjoying the overshoot at the expense of the health of the biosphere; that is, by depleting S. The number 1.7 is almost certainly an underestimate, which makes it even more a reason that inequality (1) be converted to an equality sooner rather than later. We are in a fire-fighting situation[15].

All other things equal, increases in α would reduce the ecological footprint. The received economics of climate change has focused on technological change and pricing carbon emissions as the means for raising α (Nordhaus and Boyer 2000; Stern 2006). We should, for example, also be looking for ecological solutions. Raising S and therefore G by allowing nature to grow is investing in nature. Such investment does not so much involve machinery and hardware as it involves simply waiting; that is, waiting for nature to recover. The remaining factors in the Impact Inequality are N and y. Dasgupta (2021) studies policies that affect both N and y.

The Impact Inequality is a snapshot of the global socio-ecological system. It is an accounting statement on the state of Earth's ecosystems at a moment in time. The inequality contains no information on how the five factors N, y, α, G and S influence one another over time. To identify their mutual influence requires a dynamic model that sees the human economy embedded in nature[16].

Global payments for ecosystem services

Imagine a chain of supermarkets so inefficient at their check-out counters that customers take home most of what they pick without paying for them. Pilfering enables people to enjoy a high living standard, but it is bound to prove short lived, as the chain is guaranteed to go bankrupt. We don't pay for vast quantities of maintenance and regulating services, which means the high standard of living rich countries currently enjoy comes at the expense of future living standards. Here are three examples of why our use of the biosphere amounts to pilfering from nature:

(a) Environmental subsidies

The aggregate subsidy humanity pays itself to 'mine' nature (e.g. energy subsidies) is of the order of USD 4–6 trillion annually, or some 5–7 percent of global GDP. That amounts to a negative price for nature and creates an enormous pressure on the world's ecosystems. The subsidies provide us with a string incentive to plunder the biosphere, not preserve it.

(b) Global commons

We don't pay for such global public goods as the open seas and tropical rainforests. The former is an open-access resource (they lie beyond exclusive economic zones), suffering from the 'tragedy of the commons'. The latter are located within national jurisdictions, meaning that national incentives to conserve them are less than the global incentive.

15 If accounting prices are not available, the Impact Inequality would be a string of inequalities, reflecting the overshoot of various maintenance and regulating services. The idea of planetary boundaries (Rockström *et al.* 2009; Steffen *et al.* 2015), nine in number, is cast in the latter language.

16 For this, see Dasgupta (2021, Chapters 4 and 13).

(c) Trade and wealth transfers

It is not an accident that the bulk of the world's biodiversity is in the tropics and that most of the world's poorest people live there. Principal exports from those regions are primary products, whose extraction (from mines, plantations, wetlands, coastal waters and forests) inflicts adverse externalities on local inhabitants. The externalities are not reflected in export prices, meaning that local ecosystems are overexploited. But that amounts to a transfer of wealth from the exporting country to the importing country, that is, from a poor country to a rich country. If the emphasis in recent decades on trade liberalization is anything to go by, such wealth transfers as above are probably not appreciated. Propositions on the benefits of free trade suppose that all goods and services have perfectly competitive markets. The economics of biodiversity is perforce built for a world where markets are missing for many of nature's services.

Policy implications arising from the three examples drawn from the contemporary economic world suggest themselves. The moral to be drawn from example (a) (environmental subsidies) is obvious. But perhaps it is because the directive is obvious that there have been few attempts at assessing quantitatively the effect on our consumption patterns if the subsidies were removed. On the one hand, an immediate effect would be an increase in commodity prices and therefore lower disposal incomes; while on the other hand, reduced taxation would mean an increase in our disposable incomes. Moreover, production structures would change over time and there would be distributional effects. The key point though is that removing the subsidies would lead to consumption moving away from nature intensive goods. Reduction in the Impact Inequality would trace it to a combination of changes in y, α and S.

The oceans have received far less attention among national and international decision makers than the atmosphere as a sink for our carbon emissions. But the seas are vital for our existence. Example (b) (global commons) points to the need for an institutional mechanism that provides incentives to reduce pressure on them, that is, to reduce the stress inflicted on the oceans by commodity transportation, cruises, fishing and pollutants emanating from land. The standard tools of public economics are regulations (e.g. quantity restrictions) and taxes. The former is enshrined in such policies as protected zones. They have weaknesses because the oceans are mobile. On the other hand, such policies can be reached by international agreements without the need for an international agency to implement them. That is their attraction. One problem with such schemes is that, even though the open seas are, to use a phrase popular in the 1970s, a 'common heritage of mankind', the rents from their use would be enjoyed by users, not by the public.

The latter tool, taxation, has the merit that the rents would in principle accrue to us all. But to implement it requires an international agency. Dasgupta (2021) suggested the establishment of an agency with the remit to monitor and charge for the use of the high seas (e.g. taxing ocean transportation, deep-sea fishing and the refuse that is deposited into them by nations). That could raise billions of dollars annually, for a trillion or more dollars of merchandise are shipped annually across the oceans.

The further reason behind such a taxation scheme is that the rents so collected could be used in part to pay nations to conserve the tropical rainforests in their jurisdiction. Currently, the rest of the world complains about the continual destruction of what remains of the world's rainforests, but little is done about it. Payment for ecosystem services is becoming familiar within nations. The idea would be to extend such a payment system to the international sphere[17].

The proposal has not found enthusiasm among national and international civil servants, on grounds that the world does not have an appetite for that grand an undertaking. Neither COP26 nor COP15, nor for that matter Stockholm 50+ raised the matter. At the same time, I would judge from the response global decision makers have made to the *Review* that they agree the world needs to undergo transformative changes if the impact inequality is to be

17 A government minister in Gabon was recently quoted as having made a demand for such a payment.

eliminated. At the end of World War II nations created the World Bank, the IMF and the United Nations and its subsidiaries. The Marshall Plan was designed to lift Europe from ashes, and it helped to do that. Those were transformative steps. Ashes and rubbles are visible. The silent and invisible processes that are a characteristic of nature escape our attention.

Example (c) (trade and wealth transfers) tells us that the global South should collectively impose export taxes on primary products[18]. That would ease pressure on their local ecosystems (e.g. rainforests and fisheries) and would also be a source of income for the exporting nations. The World Trade Promotion Organizations held their 2022 conference in Accra in May. The conference's brief was to find ways to raise GDP in African countries while encouraging companies to move toward sustainable policies. But the event fielded no quantitative models with which to ask whether GDP can be raised even while protecting the region's ecosystems, nor whether companies would adopt ecologically sustainable polices without export taxes. If climate negotiations are taken as illustrative, it would prove hard for African nations to reach collective agreements.

Although exports of primary products involve wealth transfers from exporting to importing countries, it is not an unalloyed benefit for importing countries. That's because the transfers carry with them risks for importing companies. Investment companies and financial institutions increasingly express concerns over the financial risks that investors experience because of our ecological overshoot. Appendix 1 constructs a formal model that traces the risks importing firms face to the risks of ecological collapse in the countries from which they import primary products. The risks are embedded in the accounting prices. Insuring against such risks in the marketplace is not a viable option. In addition to the moral hazard that is inevitably present along long supply chains, the risks are positively correlated (e.g. if a wetland is damaged, pollination suffers in neighbouring farms). What is needed are incentives for importing firms to protect ecosystems that are upstream in their supply chains, not to insure against their collapse. Investment in nature would be the needed form of insurance.

There are ethical investors who believe that maintaining the integrity of ecosystems in their supply chains is sound business practice for companies, if for no other reason than that firms would enhance their reputation among investors. There is of course the risk that a company that makes a unilateral move toward ecological stewardship faces additional risks should consumers not be ecologically minded; first movers don't necessarily have an advantage. There have however been examples where companies have enjoyed early move advantages by declaring their trade practices to be fair. It is hard to generalize from these experiences. How strongly investors and consumers feel about ethical practices matters.

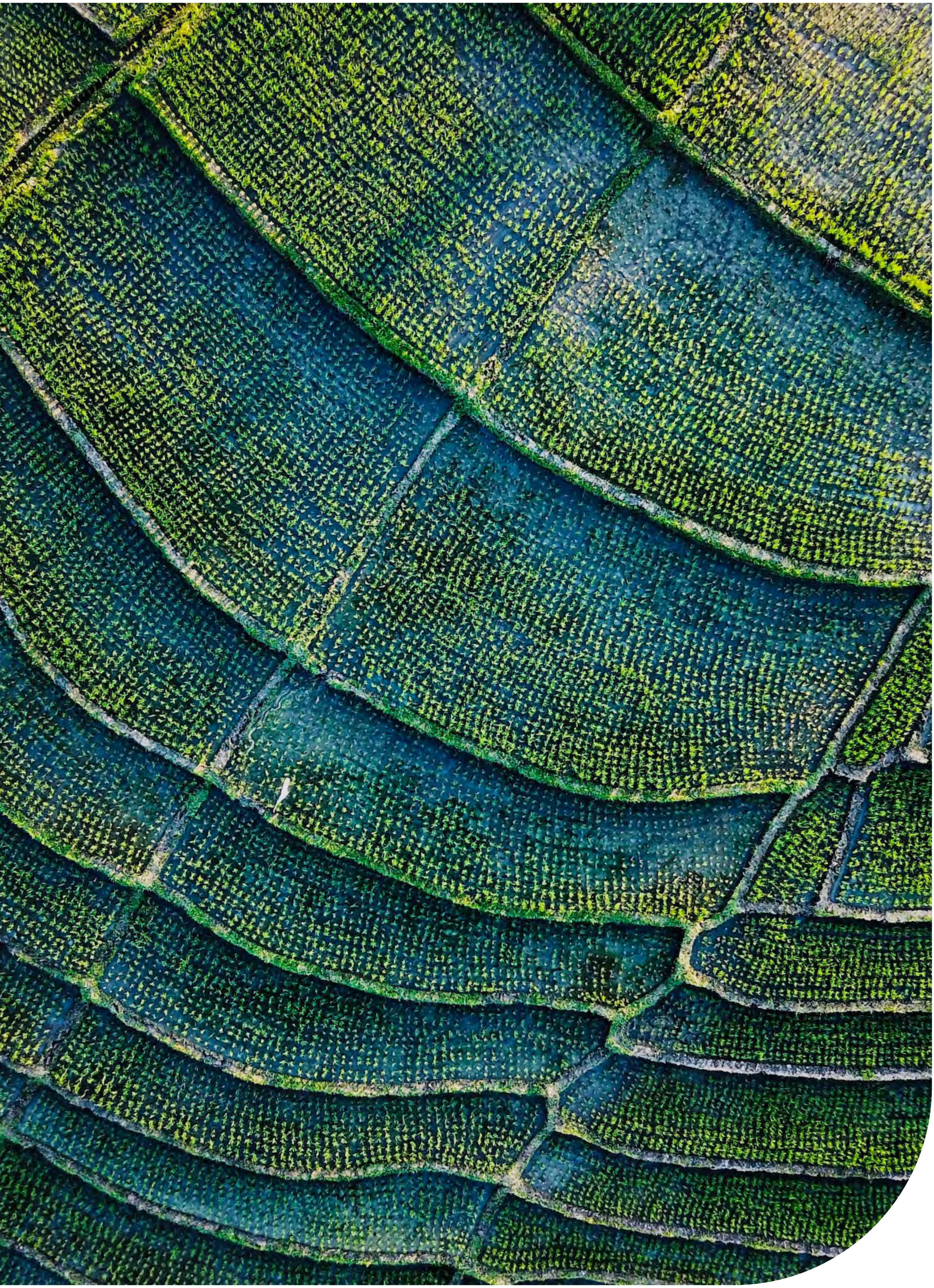
One way out of their dilemma would be for companies to disclose conditions in their supply chains collectively[19]. Disclosure would be a substitute for missing markets. A way to do that would be to lobby the government to make disclosure mandatory. Once again, problems besetting collective action rears its head. But firms need to translate ecological risks into business risks. The latter risks are embedded in the accounting prices of ecological services. In Appendix 1, an example is constructed for demonstrating how decision makers could estimate the accounting price of an asset that is expected to suffer collapse at an unknown date in the future.

I include Appendix 1 only to show how risks can be reflected in accounting prices and thus inclusive wealth.

Partha Dasgupta
University of Cambridge
September 2022

18 Individually, exporting nations would not do this for fear of losing markets. The global South faces the familiar prisoners' dilemma over the export of primary products.

19 That would be akin to disclosure over the content of food products. Consumers worry about their health, which is why governments in the West now require food manufacturers to disclose the content of their products. Disclosure here serves to reduce an adverse selection problem.



01 Beyond GDP: Inclusive wealth to measure progress in the post-pandemic world

Introduction

The inclusive wealth economy: A 21st century approach to measuring progress

Nature is our most important economic asset. More than half the world's gross domestic product (GDP), or USD 44 trillion, is moderately or highly dependent on nature and its services (World Economic Forum, 2021). Yet anthropogenic activities are placing an unprecedented pressure on the planet's capacity to support humankind, resulting in global biodiversity loss, pollution and climate change.

Economic development since the industrial revolution has ushered in an era of unprecedented improvements in the human condition, including in economic health and human health and well-being. However, worrying economic, social and environmental trends require urgent action. Over the previous century, CO_2 emissions have risen to levels where they now threaten the very foundation of society. Extreme global weather and natural events have become more frequent and catastrophic; plastic pollution is strangling the life out of our oceans; the world's major forests are becoming net emitters of CO_2; and air pollution causes an estimated seven million premature deaths per annum.

Although historically there has been a disconnect between our use of nature-based systems and our valuation of them, data are increasingly available. Global estimates suggest the world is currently losing USD 6.3–10.6 trillion per year in lost ecosystem services (Economics of Land Degradation 2021). Over-fishing alone is costing more than USD 80 billion a year in lost revenues as dwindling stocks require extra effort to find and catch (World Bank 2017). Failure to address this biodiversity loss will cause these economic costs to continue and potentially increase exponentially. It will also concomitantly compromise efforts to achieve other policy objectives, such as climate-change mitigation and food and water security.

The COVID-19 pandemic has brought to the fore the potential costs to society of mismanaging the natural environment. It has undermined progress towards the 17 SDGs of the United Nations 2030 Agenda for Sustainable Development, by exacerbating many of the existing challenges and inequalities faced by society. Calls to 'build back better' are now widespread, but in practice, this requires building back differently, in a manner that can be sustained into the future. Although growth in GDP is associated with improvements across many SDG targets and indicators, such as the elimination of poverty (SDG 1), addressing hunger (SDG 2) and the provision of decent work and economic growth (SDG 8), it can also come at the expense of progress towards other goals, including climate action (SDG 13) and maintaining marine and terrestrial ecosystems (SDGs 14 and 15). Delivering the SDGs will take much more than delivering GDP growth alone: it requires a wealth management strategy that recognizes all of society's assets—produced, human and natural—and which exploits their interdependencies. Combined, these capital assets determine the level of prosperity that can be sustained into the future, and are known as an economy's inclusive wealth (IW).

The inclusive wealth index of the United Nations Environment Programme

UNEP's Inclusive Wealth Reports (UNU-IHDP and UNEP 2012; UNU-IHDP and UNEP 2014; Managi and Kumar 2018), published every four years, evaluate national capacities and performance on ensuring sustainability and long-term well-being of the population. The reports detail results of the Inclusive Wealth Index (IWI) – UNEP's metric for measuring intergenerational human well-being.

The IWI is a holistic indicator of economic progress, as it combines natural capital accounting with estimates of produced and human capital stocks, to provide an overall picture of the productive base of countries, giving their IW. Produced (also called manufactured) capital refers to investment in roads, buildings, machines, equipment and other physical infrastructure. Human capital comprises knowledge, education, skills, health and aptitude. Natural capital includes forests, fossil fuels, fisheries, agricultural land, sub-soil resources, rivers and estuaries, oceans, the atmosphere and ecosystems more generally. Putting a price on these assets with multiple benefits allows us to measure a country's real wealth – its true well-being.

The IWI provides a framework for assessing the economic growth and development of nations beyond that of GDP (Managi and Kumar 2018). The uniqueness of the IWI arises from its stock-based (capital) approach to measuring changes in national wealth. This approach contrasts with—though is complementary to—GDP, as the IWI measures the stock of all capital that contributes to the production of economic flow outputs. The IWI enables nations to understand their capacity to deliver the SDGs, and provides a statistical infrastructure capable of measuring both the means (IW) and the outcomes (SDG indicators). It presents an opportunity to explicitly define the COVID-19 recovery in terms of achieving the 2030 Agenda on Sustainable Development, the Paris Climate Agreement, the SDGs and the Beyond GDP movement.

In a 'stocks and flows' model, capital assets are stocks, and the goods and services provided by the assets are flows. A tree is a stock, its fruit is an annual flow of goods, while its leaves provide a continuous flow of services by pulling carbon dioxide from the atmosphere to store as carbon. The effective management of these capitals results in the ultimate purpose of an economy – social well-being. Ultimately, we aim to remove the word 'inclusive' from the IWI and call it what we really mean: wealth (Inclusive Wealth Report [IWR] 2018).

Social capital is also acknowledged as critically important to a nation's wealth, and includes degree of trust, strength of community, transparency of institutions and the overall ability of societies to overcome problems. An economy's institutions and politics are factors that determine the social value of its assets because they influence what people are able to enjoy from them. In the present IWI methodology, social capital is not directly measured but embedded in other capital types (see Figure 1.1).

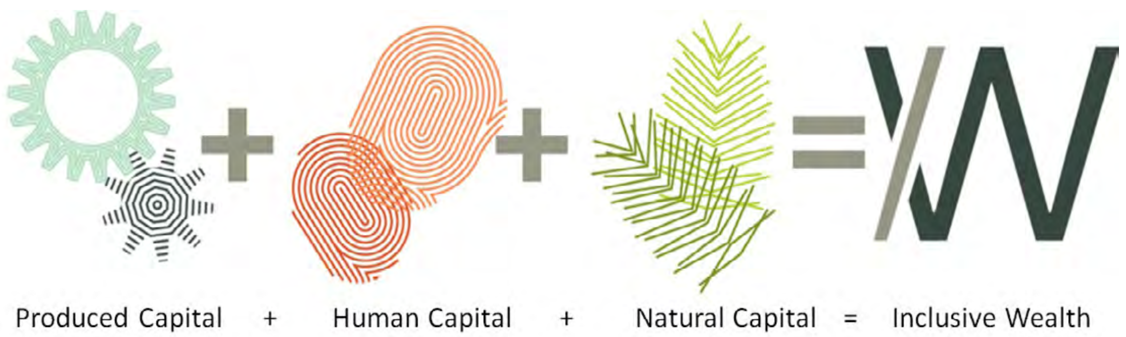


Figure 1.1: Capital components of the Inclusive Wealth Index

Why is inclusive wealth needed?

Humans are embedded in the biosphere, and the functions of nature we rely upon are dependent on biodiversity and natural systems such as climate, ocean currents, nutrient cycles and hydrological cycles. Our sustenance and survival depend directly and indirectly upon them. This dependence typically results in overexploitation for consumption and production, which in turn threatens the sustainability of the resource base. The negative externalities of natural resource over-exploitation and environmental degradation often fall disproportionally on developing countries, which further drives them to use their natural capital at an unsustainable rate. As renewable natural capital expands, income inequality decreases and, conversely, income inequality rises within countries as their natural capital is exploited.

Wealth and sustainability. The 'wealth theory of sustainability' emerges from the notion that future consumption depends on future productive capacity, which in turn depends on current net investment in capital (e.g. Dasgupta 2001). It provides a clear wealth management rule: endowing future generations with the potential to be 'at least as well off as the present', requires that total wealth is non-declining over time. Following initial empirical contributions by Pearce and Atkinson (1993a), wealth accounting research seeks to measure the extent to which individual countries adhere to the sustainable capital management rule.

Wealth and sustainability are related, but not synonymous. Formally, wealth describes a level whereas sustainability describes a change over time. To understand the importance of this distinction, imagine two countries: Country A has high levels of IW per capita but manages the wealth poorly such that it degrades over time. Country B has lower levels of IW per capita but manages the wealth such that it is preserved over time. We can say that country A is both wealthier and behaving unsustainably, whereas country B is less wealthy but behaving sustainably.

Inclusive wealth and the Sustainable Development Goals

In 2015, the General Assembly of the United Nations (UN) formally adopted the 2030 Agenda for Sustainable Development, which entered into force in 2016. It provides a framework for 'peace and prosperity for people and the planet, now and into the future' (UN 2015). The centrepiece of Agenda 2030 is the 17 SDGs. As Sachs (2012, p. 2206) emphasized, the SDGs "aim for a combination of economic development, environmental sustainability and social inclusion". Attaining the SDGs can therefore be viewed as sustainable development in its broadest sense, through achieving progress across the various economic, social and environmental goals. There is a strong environmental dimension to the SDGs. Most of the targets are directly or indirectly related to the status of natural capital. The overarching message of the SDGs is that nations must keep their natural capital stocks intact if the world is to meet these goals (see Figure 1.2).

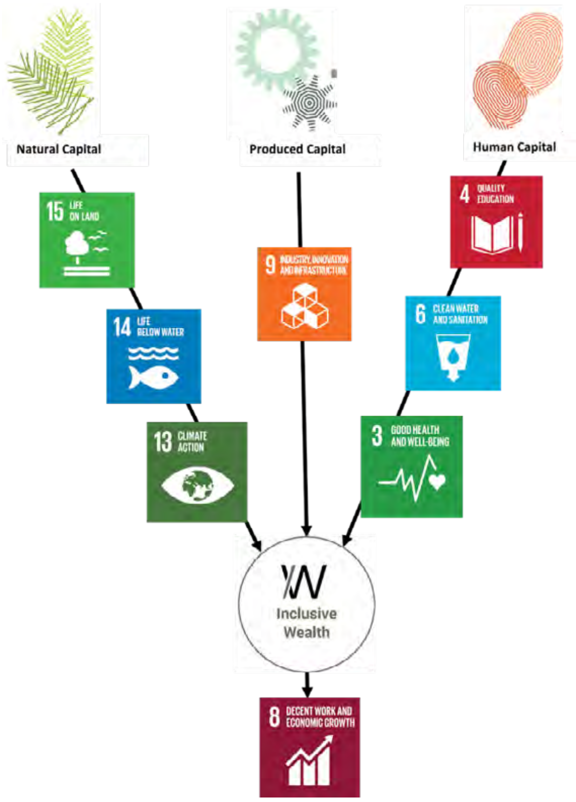


Figure 1.2: Inclusive Wealth Index and the Sustainable Development Goals

The SDGs only briefly mention the need for a System of National Accounts (SNA) that goes beyond GDP: SDG Indicator 17.19 speaks of developing "measurements of progress on sustainable development that complement gross domestic product". The IWR 2018 shows that natural capital declined in 127 of the 140 countries, even as the global economy grew (in GDP). Without the use of the IWI, governments have little capacity to check whether the economic measures they take to meet international agreements jeopardize the sustainability of those goals. If IW (adjusted for population and the distribution of wealth) increases as governments try to meet the SDGs, the SDGs will be sustainable; if it declines, the SDGs will be unsustainable. SDGs could be reached but are not sustainable in the long run if the development paths that nations choose to follow erode their productive capacities beyond repair.

Combined, the 17 SDGs, 169 targets and 232 unique indicators provide the benchmark against which national and global sustainability will be measured. They are the North Star of the international community (Wackernagel *et al.* 2017). But to what extent do the SDGs truly re-orient and provide a new direction for the global political economy?

Amidst many competing and complementary definitions (Böhringer and Jochem 2007; Atkinson *et al.* 2014), the SDGs and associated indicators effectively 'reveal' the global community's adopted definition of sustainable development. The goals are intended to represent a new direction, a re-orientation of the global political economy towards a system that delivers for people, planet and prosperity (Griggs *et al.* 2013). Inherent within them is an acknowledgement that development is a multidimensional challenge requiring integrated progress across multiple objectives for all countries (Obersteiner *et al.* 2016; Stafford-Smith *et al.* 2017; Breuer *et al.* 2019). But for all their strengths, the SDGs also face serious challenges. A perennial objection, common to all alternatives and complements to GDP, is essentially an argument for business as usual. Its logic is succinct. If the new measure is well correlated with GDP, it offers little new information. If it is not, then it ignores too much relevant information. Either way, per capita GDP is still the best measure available. A parallel question posed by Thomas Schelling (1992) concerns whether poor countries should sacrifice growth to reduce e.g. climate change, or whether they should increase per capita income at all costs and face the environmental and related consequences later, as richer economies.

Combined, these challenges pose two fundamental questions for the SDGs:

1. Does SDG performance genuinely go 'beyond GDP'?

2. If SDG performance is the globally agreed definition of sustainable development, should countries attempt to achieve it by a narrow focus on per capita GDP growth, or should they also pursue broader environmental and social objectives?

A recent working paper from the Bennett Institute for Public Policy demonstrates that the SDGs are fairly robust to these challenges. Analysing data from the SDG Index and Dashboards (Sachs *et al.* 2019), Agarwala (2021) shows that per capita GDP explains about 50 per cent of the variation in SDG scores across countries, with the remaining 50 per cent described by other factors that are uncorrelated with per capita GDP. This indicates that whilst per capita GDP is the single strongest predictor of SDG performance, it can only explain about half the variation in SDG scores across countries. Moreover, any development strategy that focused solely on per capita GDP growth would at best be a half measure.

Complementarities. Mobilizing IW in pursuit of the SDGs requires more than simply accumulating stocks of assets. It requires investment strategies that capitalise on the synergies and complementarities between assets. Just as the SDGs are designed to be pursued simultaneously in a coordinated manner, making the most of IW requires considering the full portfolio of wealth, not just individual elements within it.

Inclusive wealth and the conventional system of national accounts

In an early effort to embed sustainability within official statistics, Nordhaus and Tobin (1972) made three core adjustments to GDP. They distinguished between intermediate and final output, shifted the focus from production to consumption, and developed a preliminary measure of 'net investment'. The focus on consumption rather than output was thought to place greater emphasis on welfare (Nordhaus and Tobin 1972, p. 4). Perhaps the more important contribution was the idea that measures of sustainable economic welfare must adjust for the depletion of capital (net investment), and that this was not adequately reflected in the existing SNA.

Leading economists have supported calls to move beyond GDP for at least half a century (Coyle 2015). Arguments for doing so can largely be grouped into three broad categories. First, established macroeconomic statistics fail to adequately reflect changes in human well-being, and in the worst instances can lead decision-makers to pursue welfare reducing policies (see the various works of Amartya Sen, capably reviewed in Hamilton (2019), but also Easterlin (1974; 2010) and Layard (2011)). Second, by focusing on income flows rather than capital stocks, official statistics such as GDP omit considerations of sustainability, providing a potentially misleading view of the long-run viability of an economy. Third, although the standards and guidelines governing the calculation of official statistics are constantly under review, they have failed to keep pace with the changing nature and structure of economic activity. There is growing concern that international trade and transboundary externalities are (i) increasingly important factors in the global economy; and (ii) poorly reflected in official statistics.

There are two fundamental relationships between wealth accounts and the existing SNA:

1. **Wealth accounts complement and extend the SNA, providing a forward rather than backward look.** Wealth accounting is forward-looking in the sense that it measures the productive base that will allow for the provision of goods and services from the present onwards, rather than measuring the consumption and wellbeing that has occurred in the period prior to the calculation. Capital investment (in all types of capital – produced, human, natural and social) and depreciation can indicate a net-position of the productive base of an economy. For evaluating short run economic policy, GDP has served admirably, but ignoring capital depreciation is indefensible in economic evaluation in the long run.

2. **Wealth accounts allow for experimentation and relax some of the constraints and restrictions governing the System of National Accounts.** In implementing the SNA, National Statistical Offices are often charged with focusing on the accounts for activity occurring within a country's economic boundary. Dasgupta (2021) discusses this further in *The Economics of Biodiversity*, pointing out that the unilateral degradation of natural assets can have implications well beyond a nation's borders. For instance, the degradation of vast, interlinked ecosystems like the high seas, cannot be accounted by a single nation. Wealth accounts necessarily have a broader scope because certain components of wealth (e.g. global public goods such as the climate system and biodiversity) are not limited to the same geographical and political scope. In essence, the market valuation is unable to address humanity's engagement with public goods related to the biosphere, because nature's processes do not satisfy the technical conditions on production possibilities that are required for markets to function well.

Inclusive wealth and the System of Environmental Economic Accounting

Natural capital assets are well suited to accounting, bio-economic modelling, balance sheets, risk registers and capital maintenance. The United Nations System of Environmental Economic Accounting (SEEA) has been developed to ensure these tools are consistently developed, comparable across time and place, and that economic and environmental data are integrated to provide a comprehensive view of the growth accounting with global statistical standards (UNEP 2020). Adopted by the global community as an official statistical standard in 2012, the SEEA central framework measures emissions, stocks, uses of individual natural resources (e.g. water, energy, mineral ores and emissions to air) and transactions related to environmental management (Hein *et al.* 2020). The SEEA provides a framework for measuring links between the ecosystems and the provisioning, regulating and cultural services they provide, with economic and societal well-being.

Although SEEA uses the same statistical concepts, definition and classification consistent with SNA, it enables official statistics to go beyond GDP and cover the environment-economy nexus. Monetary values, based on exchange values, complement SNA monetary values, and can be used to help analyse the contribution of natural capital to the economy, or to compare the costs of ecosystem degradation with increases in economic output. The SEEA is flexible and can be easily adapted to countries' priorities and policy needs. The thematic areas of SEEA are agriculture, forestry and fisheries, air emissions accounts, energy, environmental activity account, ecosystem accounts, land accounts, material flow accounts and water. As of 2020, 100 countries have begun to compile data consistent with the SEEA framework. The framework can derive indicators like the IWI to produce deeper insights into changes in the natural environment and biodiversity, changes in wealth stocks and in income generators.

Globally, many SEEAs remain in the early stages of development. Reaching the full potential of comprehensive accounts to improve economic, welfare and environmental outcomes will take decades. But examples from around the world are now emerging to demonstrate the real-world uses of these accounts in developing current policy. The bottom line is that natural capital accounts are already revealing important environmental-economic relationships that standard macroeconomic accounts do not.

Box 1.1: The Dasgupta review

One of the most significant milestones in the IW field was the publication in 2021 of The Economics of Biodiversity: The Dasgupta Review, commissioned by the Treasury of the United Kingdom of Great Britain and Northern Ireland and led by Professor Sir Partha Dasgupta (Dasgupta 2021).

The review is significant in many ways. That it was commissioned by a finance rather than environment ministry demonstrates that natural capital is now on the agenda for those at the heart of economic and financial decision making. This entails an implicit acknowledgement that IW and sustainability are about the efficient and effective management of capital, not just about environmental policy. For economists, the Dasgupta review's significance comes in the form of a direct challenge to over half a century of economic thought that has largely excluded nature from models of the macroeconomy. But it also presents a way forward.

The review demonstrates that the economy—from the smallest subsistence farmers to the largest companies on the planet—exists and operates within the context and confines of the natural world. This means that economies, and those who operate within them, cannot escape what happens in nature. Degrading natural capital constricts the operating space for all economic activity and erodes the foundations upon which human well-being depends. Of all the components of wealth, natural capital is the only asset that is in worldwide decline.

Despite its title, the Dasgupta Review goes well beyond biodiversity and natural capital. It highlights the importance of social trust and institutions, and calls for a transformation in the way we measure economic progress, already notably observed with the adoption of the United Nations System of Environmental Economic Accounts – Ecosystem Accounts by the United Nations Statistics Commission in March 2021.

The global financial system presents an important pathway to change. Moving towards a 'green recovery' post-COVID-19 pandemic, the financial system will have to direct investments in a 'green' direction, for example by taking full account of the investment risk posed by loss of natural assets or climate change. Central banks, financial regulators and accounting bodies must develop appropriate global financial and reporting standards.

The Dasgupta review summarises options for change to place nations on a more sustainable path, recognising that economic outcomes cannot be permanently detached from environmental ones. However, the most important change will be a change in attitudes. The unsustainable is never sustained; the uncertainty is about how, not whether, it comes to an end. The present global economy is unsustainable. In this context, the review emphasises the role of education, ensuring that younger people grow close to nature and do not think of it as a separate sphere.

The components of inclusive wealth

Produced capital

Definition. Produced capital refers to infrastructure as follows[20]: homes, machines and equipment and information and communications technology. It includes energy infrastructure, ranging from coal-fired power plants to solar farms, water treatment facilities and distribution networks, and transport systems including public transit, roads, ports and airports. For businesses, it includes factories, machines, computers and office buildings. For communities, it includes hospitals, social housing and public buildings. The World Bank's comprehensive wealth accounts also include the value of built-up urban land (World Bank 2018). Accounting standards already exist for valuing and measuring changes in produced capital stocks at the national and business level. As such, produced capital is perhaps the easiest component of wealth to incorporate into wealth accounts. For a more detailed explanation of how produced capital is measured under the inclusive wealth accounting framework, refer to Annex 1 of the IWR 2023 Annexure.

How produced capital supports the SDGs. Produced capital remains a cornerstone of development and is central to delivering the SDGs. Well-designed infrastructure investments can support targets relating to climate change, energy, water, transport and information and communications technologies. However, significant trade-offs can also arise, particularly where poorly designed investments lock in carbon-intensive infrastructure for decades.

An in-depth review of the links between produced capital and the SDGs by Thacker *et al.* (2019) revealed that infrastructure has impacts across all 17 SDGs, and relates either directly or indirectly to 72 per cent (121 out of 169) of the SDG targets. The largest direct influences are on SDG 6 (Clean Water and Sanitation) and SDG 7 (Affordable and Clean Energy). However, there are five SDGs (3, 6, 7, 9 and 11) for which infrastructure is shown to impact 100 per cent of the targets (see Figure 1.3). In total, there are 15 SDGs for which infrastructure impacts more than 50 per cent of targets.

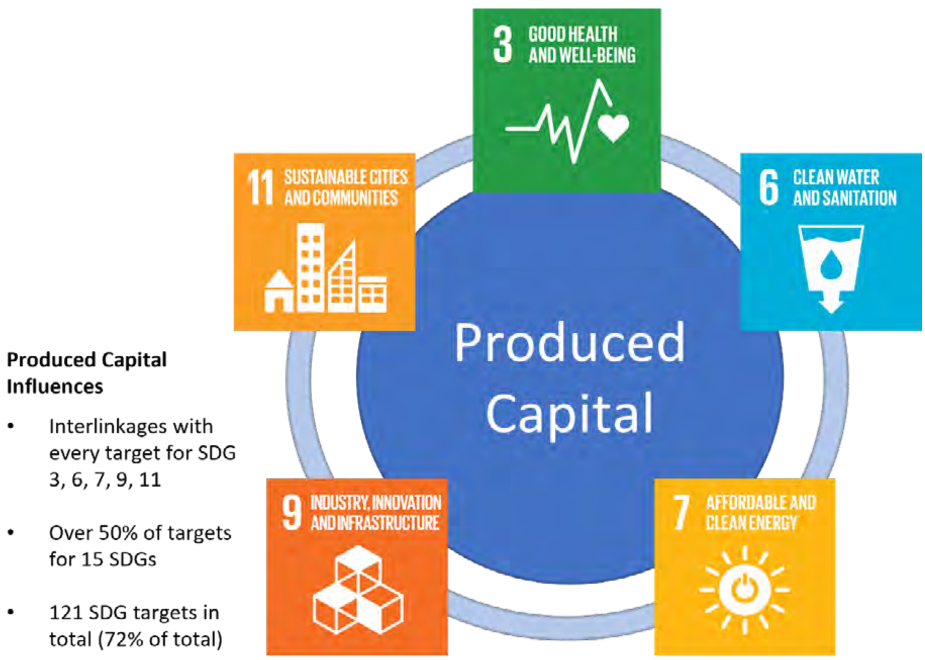


Figure 1.3: Produced capital and the SDGs

20 The terms produced capital and infrastructure are used interchangeably.

Produced capital impacts SDG performance through several channels (see Figure 1.4). Focusing on SDG 6 (Clean Water and Sanitation), the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene estimates that 2.2 billion people lack access to safe drinking water, and 4.2 billion people do not have access to safe sanitation (UNICEF and WHO 2019). In the vast majority of cases, this is not due to a lack of water resources—many of those without safe drinking water live within walking distance of a river—but rather a lack of treatment facilities, supply infrastructure and sanitation facilities (Joint Monitoring Programme for Water Supply, Sanitation and Hygiene [JMP] 2021). Target 6.3 focuses on reducing pollution to improve water quality. Infrastructure supports this target directly, as effective wastewater treatment facilities and solid waste infrastructure are needed to separate pollutants from waterways. But there are further, indirect effects as well. Operating the water supply and sanitation infrastructure requires energy inputs, meaning target 6.3 also depends indirectly on energy infrastructure.

Similarly, effective water supply and sanitation infrastructure directly underpins SDG 3 (Good Health and well-being), as access to safe, clean water is a major determinant of human health. Globally, there are major gaps in water, sanitation and hygiene infrastructure: one third of health care facilities lack basic hand-washing facilities in the location where care is provided, and one in ten have no sanitation services. Ultimately, 1.8 billion people rely on health-care facilities that lack basic water services, and 800 million people use facilities with no toilets (WHO and UNICEF 2020).

It is important to remember that whilst many SDG targets specifically call for produced capital investments (e.g. Target 4.a.1 on the proportion of schools with access to electricity, internet, computers, facilities for disabled students, drinking water and handwashing and single-sex sanitation facilities), many of the links between produced capital and SDG outcomes are less explicit. For instance, achieving SDG 3 can be undermined by transport infrastructure that increases air pollution, or poor water and sanitation infrastructure that leads to disease transmission.

Box 1.2: Violence against women and girls: how produced capital helps in mitigation

Globally, one in three women will experience some form of physical or sexual violence in their lifetime. The built environment—that is, produced capital—plays a crucial role in mitigating this violence, as well-planned public infrastructure can reduce the incidence of harassment and violence against women and girls. This is true in countries at all stages of development. Well-planned public spaces with adequate lighting, and reliable, safe transport, provide more secure living and working environments as well as social infrastructure and economic opportunities.

In developing countries, the role of produced capital in reducing violence against women and girls (SDG 5.2) and addressing their disproportionate burden of domestic work (Target 5.4) is even stronger.

There are key linkages between SDG 7 (Affordable and Clean Energy) and produced capital. In the renewable energy transition, produced capital in the form of wind turbines, hydro-electric dams, lithium batteries and connection infrastructure will be essential. Relatedly, materials science is advancing markedly, particularly in the area of carbon sequestration. Methods are being developed to optimise the potential of carbon-sequestration of concrete by cutting out the need for calcium-based cement (a key ingredient in traditional concrete) (Antunes *et al.* 2022).

Among others, three significant factors influence wealth and social well-being but are not covered by familiar capital assets. These are carbon damage, oil capital gains and total factor productivity. These are calculated and treated as 'adjustments' in the IWI methodology. With regard carbon damages, they can be mostly seen as an exogenous change in social well-being, and calculation involves the following key steps: i) obtain the total global carbon emissions for the period under analysis, 1990 to 2014; ii) derive the total global damages as a function of the emissions; and iii) allocate the global damages to countries according to the potential effect of global warming in their economies.

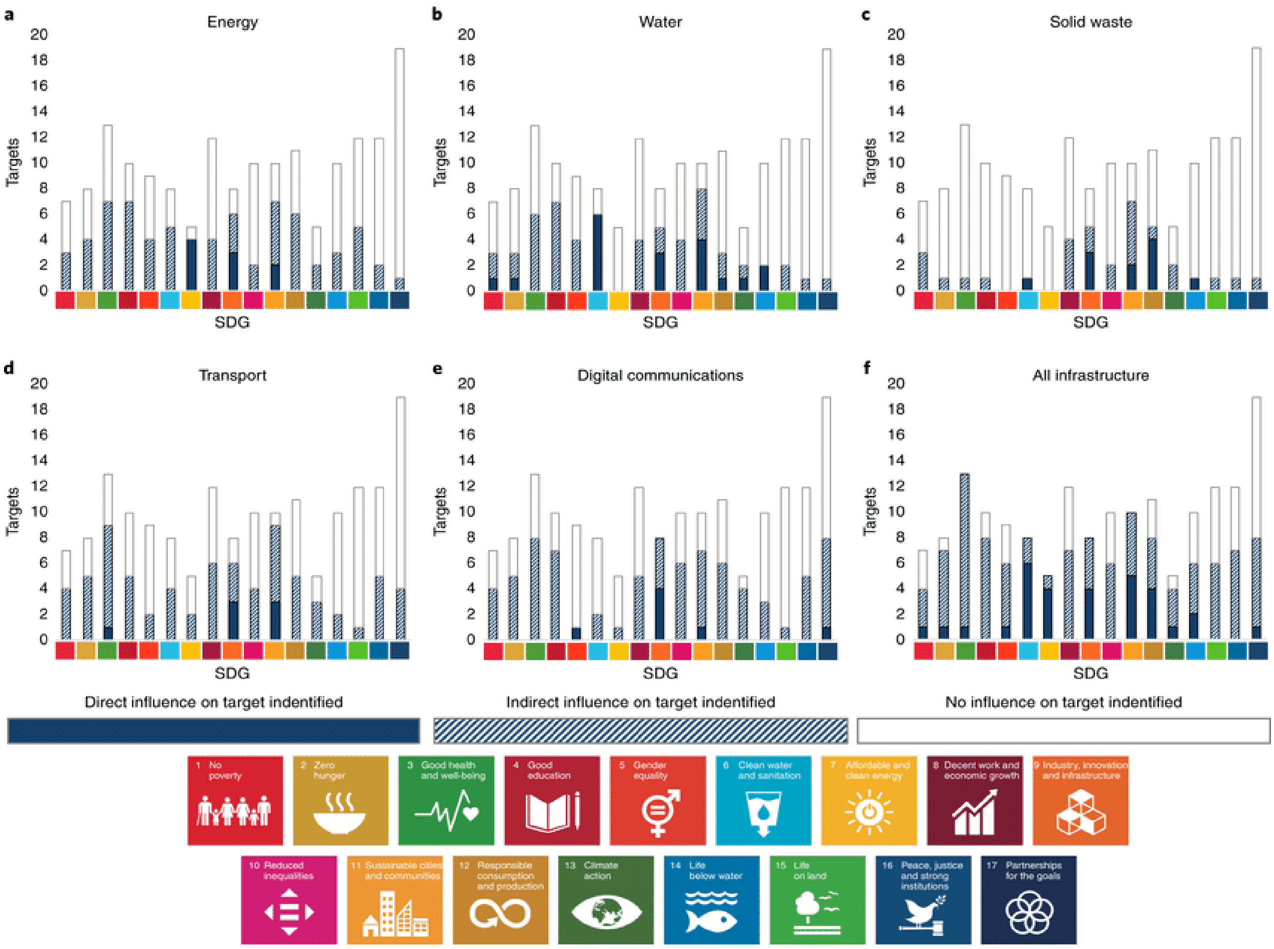


Figure 1.4: Direct or indirect influences from five categories of infrastructure on SDG targets
(Source: Thacker et al. 2019)

Notes: (a)–(f): Each goal is subdivided according to the number of targets, and each target has been assessed to establish direct or indirect influences from provision of the five categories of infrastructure considered in this analysis: energy (a), water (b), solid waste (c), transport (d) and digital communications (e). All infrastructure (f). shows the combined influence on SDGs and targets of the five infrastructure sectors: here a target is included if it can be influenced by one or more of the five infrastructure sectors; in cases in which a target is both directly and indirectly influenced by different infrastructure systems, it is classified as direct.

Mansell *et al.* (2020), demonstrate how concern for SDGs can be incorporated into infrastructure planning at the project level. There are two key links. The first relates to project delivery – how the design, construction and materials impact SDG targets such as emissions, pollution and ecosystems. The second relates to the impacts of the completed project – how it supports the community and relevant stakeholders (e.g. does it improve mobility and therefore access to markets, or does new transport infrastructure simply increase air pollution and further fragment the natural territories of wild species).

Human capital

Definition. Human capital is the knowledge, skills, competencies and attributes (e.g. health) embodied in individuals that facilitate the creation of personal, social and economic well-being (OECD 2001). These characteristics are generally slow-moving variables. Although changeable, they remain stable once acquired.

How human capital supports the Sustainable Development Goals
Human capital has been identified not only as a fundamental factor of production, but also as a critical determinant of sustainable and inclusive growth (SDG 8)[21], and manifests itself mainly through two channels, health and education, which correspond respectively to SDG 3 (Good Health and Well-Being) and SDG 4 (Quality Education).

SDG 3: Good Health and Well-Being. The health dimension of human capital is particularly pertinent today, as, in 2019, the world economy ground to a halt with the emergence of the COVID-19 pandemic. The majority of the existing human capital literature focuses on education, while health factors remain relatively underexplored (Hokayem and Ziliak 2014). However, recent developments in human capital measurement that incorporate health factors are encouraging. For example, in addition to the World Bank's Human Capital Index first published in 2018 (World Bank 2018) and Lim *et al.* (2018) created a human capital measure that uses expected years lived to capture the health dimension.

Bleakley (2010) argues that the correlation between health and other development outcomes is circular and cumulative. For instance, adult height had previously been assumed to be exogenous to labour productivity and wage, because one's height is essentially predetermined well before the wage-earning age. However, much of our physiological and cognitive development takes place during our childhood. Schultz (2002) points out that, apart from genetic and hormonal factors, adult heights are also affected by a range of early childhood nutrition and health conditions. Therefore, adult heights should be treated as potential influencers on wage returns through the channel of health human capital. Also, as suggested by the Ben-Porath (1967) model, early intervention in the formation of human capital generates the most significant economic returns over the lifetime.

Similarly, Hokayem and Ziliak (2014) point out that poor health at a later stage in life also depresses the number of healthy days both for work and consumption of goods and leisure. It, in turn, affects formal schooling and on-the-job experience. Therefore, health should be endogenized into labour supply and income over the life cycle. Health is also complementary to the development of other forms of human capital[22]. Becker (2007) reasons that there exists complementarity between investments in health and different ages. If someone expects to survive specific future periods, then there is an incentive for them to survive to these periods. Therefore, for a country with a high child mortality rate, individuals may feel reluctant to spend additional resources in childhood that would raise survivorship at older ages. Both the child mortality rate and expected years lived are used as sub-indicators for the Human Capital Index.

Another example considers the complementarity between health and schooling[23]. While educational costs tend to incur at early ages, individuals only receive returns at later ages. An increase in survivorship at later ages thus has a positive impact on education returns.

21 SDG 8: Promote inclusive and sustainable economic growth, employment and decent work for all.

22 Zivin and Neidell (2013) offer a comprehensive review of the relationship between natural capital and health HC.

23 See Becker (1964; 1993), Meltzer (1992) and Ehrlich (2000) for more examples of complementarities between health and education.

Higher survivorship not only induces more investment in beneficial goods (e.g. training and good habits)[24], but also discourages harmful goods (e.g. bad habits and additions). The accumulation of education also improves survivorship through wealth effects and better access to health-related information. Educated mothers are more likely to seek pre/post-natal care and immunize their children, which significantly lowers the child mortality rate (Centre for Global Development 2006).

These complementarities suggest that policymakers must design a policy mix that covers multiple dimensions to achieve inclusive and sustainable growth. Policy interventions at early ages would increase the probability of survival for individuals. Such individuals tend to be more educated and enjoy higher earnings during their lifetime. As a result, they are more likely to discount the future less and save more, form beneficial habits and have better survivorship rates at an older age.

SDG 4: Quality Education. Education has been the primary focus of the human capital literature. It is responsible for the accumulation of an individual's knowledge, skills, abilities and other characteristics. At the macro level, it is generally assumed that individual knowledge, skills, abilities and other characteristics can be linearly added to more aggregated levels. Educational indicators, such as school enrolment, are also used to track cross-country SDG performance.

Empirically, education and training are among the most important determinants of human capital and one's income. At the micro-level, returns to human capital are mostly measured using private income and earnings. Polacheck (2007) estimated that, on average, an additional year of schooling leads to a 10 per cent increase in individual earnings. At the macro-level, the positive spill over effects are reflected by increasing productivity levels. Hanushek and Woessmann (2015) estimated that the annual GDP level could be 28 per cent higher over the next 80 year, should all youth living in lower-middle-income countries meet the goal of universal basic skills[25] by 2030. Similarly, the annual GDP of upper-middle-income countries could be raised by 16 per cent.

Over previous decades, the world witnessed rapid progress in educational attainment. Globally, the proportion of 25 to 29-year-olds with at least six years of schooling was only 50.1 per cent in 1970. This rose to 83.2 per cent in 2018, and is expected to reach 89.4 per cent by 2030. The improvement mainly comes from developing countries, as the advanced economies, central Asia and Eastern Europe, already had universal primary attainment in the 1970s. Development aid together with debt relief played an essential role in driving such positive change (McArthur 2013). However, challenges remain to further close the gender gap and inter-regional disparities (Friedman *et al.* 2020).

Apart from quantity supplied (educational attainment), SDG 4 also emphasises quality of education and training, which could bring even more profound improvement in the development process. According to Hanushek and Woessmann (2015), should there be one standard deviation improvement in the educational achievement, the long-run growth in per capita GDP will increase by one per cent on average[26]. However, there still exists a deficit of 1.9 million teachers globally, especially in developing countries (Didham and Paul 2015). Quality of teaching content and teacher competency also remain a concern.

Buckler and Creech (2014) argued that educational quality is not just reflected by better test performance - it should focus on what and how people learn, the relevance to today's challenges and how it influences the choices of current and future generations. Education for Sustainable Development (ESD) thus provides an essential and practical tool to influence the behaviours of all relevant stakeholders. ESD integrates the principles, values, policies and practices required to achieve SDGs into all aspects and levels of learning. Its themes range from climate change and responsible consumption to poverty alleviation and social justice.

24 For example, higher survivorship probabilities could lower the discount on future utilities. As a result, more income will be saved for future consumption.

25 The minimum level is defined as the baseline Level 1 of performance on the PISA scale.

26 It is measured using the average score on all international tests between 1964 and 2003 in mathematics and science. It mainly covers the primary and secondary schools.

However, according to Didham and Paul (2015), there still lacks a systemic and consistent means to properly monitor and evaluate the progress of ESD.

Despite having the same level of educational attainment and quality education, performance may still differ significantly due to the effects of behavioural factors, such as incentives and motivation. Policymakers or firm managers should better understand how individual and group behaviours react to different mechanism designs.

Like health, education has also shown strong complementarities with social justice and civic participation, which are important components of social capital. Higher levels of school enrolment ratio are associated with a higher level of income per capita and economic growth, but also found to be correlated with a lower risk of civil conflicts (Collier and Sambanis 2005). Women account for the majority of the agricultural workforce in developing countries. Countries with greater shares of educated females enjoy higher agricultural productivity (Centre for Global Development 2006). The cross-country evidence suggests that poverty elasticity of agricultural growth is estimated to be two to four times greater than non-agricultural growth (Idan *et al.* 2014).

These positive impacts are not limited to formal education. Informal education, such as learning-by-doing and enabling environment that encourages lifelong learning, also provide a strong mechanism to support social changes (Latchem 2014).

Natural capital

Definition. Natural capital refers to stocks of environmental assets that benefit people by generating flows of welfare-enhancing environmental goods and services. Stocks include fish in oceans and rivers, standing timber, mineral and fossil fuel deposits and a stable climate. Some applications take a portfolio approach, noting that ecosystems are natural capital assets that contain and combine multiple individual forms of capital (water, standing timber and biodiversity). The term 'natural capital' provides both a powerful metaphor and an organizing intellectual framework for viewing nature through the economist's lens. The chief motivation for thinking in terms of natural capital rather than 'the environment', is to apply our understanding of capital theory, capital valuation, management of net investments and the utilization of capital services to generate human well-being (Binner *et al.* 2017).

A common objection to the notion of natural capital is that it represents a neoliberal attempt to commoditize nature, price it and open it up to exploitation in markets. This is steadfastly not the case. The motivations for conserving nature are many: doing so is integral to achieving the SDGs, the Paris Climate Agreement[27] and meeting the targets set out in international commitments on biodiversity such as the Convention on Biological Diversity. There are religious, spiritual and ethical motivations, including a commitment under the Brundtland Commission, to a style of sustainable development that meets the needs of the present without undermining the capacity of future generations to meet theirs (Bruntland 1987). There are standing commitments under domestic and international law, and governments are increasingly facing High Court cases brought by young citizens for failing to safeguard the natural world. Even the principle of the rule of law now depends on maintenance of natural capital.

However, economics provides an additional, complementary motivation for investing in, maintaining and restoring nature: nature is fundamental to economic prosperity. Components of natural capital interact with and impact the returns of all other assets, public and private. Air quality impacts the health and productivity of the labour force, a stable climate governs the efficient operation of just-in-time supply chains, and healthy soils and biodiverse ecosystems promote crop pollination whilst reducing pests and diseases. Even if the legal, moral, religious and cultural motivations for safeguarding nature could be set aside, the maintenance of natural capital is justified purely on economic grounds.

27 The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

Substitutability between capitals

The key tenets of the theory of IW are that multiple forms of capital make up the productive base, or IW of an economy, and that sustainability requires the value of this broadly defined IW to be non-declining over time. Sustainability in the IW framework does not require that every type of capital must be sustained. Known as weak sustainability, this approach allows the stock of natural capital to be consumed along a sustainable development path, by sufficiently increasing the stock of other forms of IW (e.g. produced, human or social capital) (UNU-IHDP and UNEP 2014; Managi and Kumar 2018) (see Box 1). That is, what matters is the management of the overall portfolio of wealth, not just the individual assets within it. For instance, if human capital in the form of scientific discovery can support the development of drought-resistant crops, this can serve as a partial substitute for natural capital in the form of water availability. Whilst substitution options may be limited, recognizing these opportunities is important to delivering the SDGs. Of course, not all capital is equally substitutable, and there are critical natural capital stocks that comprise Earth's life support systems which cannot be replaced by technology and skills.

Box 1.3: Weak or strong sustainability?

Debate continues around strong or weak sustainability in sustainable development. 'Weak sustainability' allows natural capital to be continually depleted (including the point of exhaustion), so long as sufficient investments are made in alternative forms of capital. In this way it accepts the full substitutability of natural capital with produced or human capital. Strong sustainability argues that this natural capital substitutability should be very limited, given the critical life support functions that natural capital provides to human well-being. This paradigm itself has two variants, one calling for the overall value of natural capital to be maintained (but permitting substitution between types of natural capital), and the other identifying critical thresholds of specific natural capital stocks which must be maintained to preserve functioning global life support systems. Which paradigm best describes reality is a question that remains unresolved.

Next steps for implementing the Inclusive Wealth Index

Policymakers, governments, political appointees in relevant ministries or relevant parliamentarian offices, advisors to heads of state, businesses and the economics press will need support to understand how wealth accounts can be and are being used in the real world. It is important to note that the 'if we build it, they will come' assertion is wrong. It is not enough to construct wealth accounts, rather they must be integrated into decision-making across government, business and public conversation about the economy.

By showing how countries around the world can make use of natural capital accounting in policy development and target setting, policy evaluation and monitoring, and economic modelling and analyses, this report demonstrates the need for more detailed and extensive information to support national capital accounting.

Production versus consumption-based accounts

Most wealth accounting efforts employ territorial accounts that describe trends in natural capital stocks within a country's national borders, and are therefore relevant for calculating domestic per capita natural capital depletions. Trade enters solely through the effect of net exports on national savings. This reports argues that international trade is a large and growing share of the global economy, rising from just 24 per cent of gross world product in 1961, to 64 per cent in 2011 (World Bank 2018). There is therefore justification for re-examining the extent to which territorial natural capital accounts are fit for purpose when measuring national and global sustainability in an increasingly globalized world. Indeed, the influential Sarkozy Commission noted that a measurement approach "centred on national sustainability may be relevant for some dimensions of sustainability, but not for others" (Stiglitz *et al.* 2009).

A key strength of the SDGs is that they explicitly recognise the role that globalization plays in driving and addressing social, economic and environmental challenges of sustainable development. Several of the goals and indicators deal directly with natural resource flows and material footprints. This report focuses on developing the evidence base for measuring progress towards SDG 12 to "ensure sustainable production and consumption patterns" (Sachs *et al.* 2019). The goal rightly recognises the diverging natural capital footprints of resources used in production versus consumption activities, and marks the need for accounting mechanisms that can measure not just the domestic, but also the global nature of sustainability.

One policy lesson from wealth accounting is that nations could pursue the development of two simultaneous and complementary natural capital accounts, one from the traditional production- or territorial-based perspective, and another from the consumption-based perspective. Production-based accounts record resource depletions that take place within a country's borders over the course of a year, regardless of where those resources are ultimately consumed. Consumption-based accounts record resource depletions embodied within a country's final demand, regardless of where in the world those depletions actually took place. Examining both sets of accounts simultaneously provides a more complete understanding of an economy's contributions towards both national and global sustainability, provides insights into dependencies on domestic versus global resource stocks, is crucial to understanding resource security concerns, and may identify opportunities for joined-up bilateral and international resource policy.

02 The wealth of nature in the Inclusive Wealth framework

Introduction

Natural resources provide immense benefits and significance, both explicitly and implicitly, which are crucial for the progression of the economy and human welfare (Islam and Managi 2019). However, global economic development is depleting natural resources, diminishing ecosystem services, degrading the environment and compromising the sustainability of humans in the biosphere (Arrow *et al.* 2012). Natural capital accounting is therefore a vital part of natural resource management, and directly benefits a nation's welfare and utility.

Valuing natural capital in economic terms can ensure a more accurate calculation of growth rates, the amount of natural resources a society has, how those resources are distributed among stakeholders (Azqueta and Sotelsek 2007; Islam *et al.* 2019) and can ultimately support countries to achieve sustainable development. Economic indicators that omit the depletion and degradation of natural capital are misleading (Barbier 2014), and may ultimately compromise the sustainability of humans in the biosphere. Yet, the pricing of natural capital has remained elusive and its value is often ignored within traditional economic models (K.J. Arrow *et al.* 2012). This neglect stems from the absence of a framework to enable appropriate comparisons with traditional forms of capital. The lack of prices for valuing natural capital stocks continues to hamper progress toward including natural capital in social benefit–cost analyses or the accounts used to measure social progress (Hamilton and Clemens 1999; K. J. Arrow *et al.* 2012; UNU-IHDP and UNEP 2014), and is a major barrier to implementing the United Nation's advocated sustainability metric (World Bank 2011; Pearson *et al.* 2013; UNU-IHDP and UNEP 2014; Polasky *et al.* 2015).

Natural capital has three social values with varying combinations: intrinsic, use and option (Dasgupta 2007). Hence, a declining level of natural capital may cause a decreasing level of the economy's productive base, which in turn will lead to a decreasing level of well-being in the future generation (K.J. Arrow *et al.* 2012). Based on the characteristics of its services, Hinterberger *et al.* (1997) differentiate natural resources into three components: non-renewable resources, renewable resources and assimilative capacity of the ecosphere. The first two components provide resource-based services (goods), while the latter includes life-support function services (Hinterberger *et al.* 1997). Furthermore, in a broader definition, Barbier *et al.* (2008) argue that nature also provides intangible services for cultural benefits, such as for religious purposes or heritage.

Barbier (2015) attributed the structural imbalance in most economies to the under-pricing of natural capital. As a result, the net proceeds from natural capital conversion are insufficient to make new substantial investments in produced and human capital. This has resulted in massive exploitation of natural resources in an unsustainable manner. There is a little empirical evidence to point to this unsustainable progress for various regions in the world. To address this, the IWR 2023 focusses on the regional composition and distribution of natural capital in the Group of Twenty (G20), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and Caribbean (LAC), Middle East and North Africa (MENA), South Asia (SA) and Sub-Saharan Africa (SSA) regions (see Appendix 2 for more detail on the regional categories applied in IWR 2023). The natural capital analysis in this chapter covers 166 countries, and is based on the data in the period from 1990 to 2019, to identify opportunities and challenges for countries to achieve sustainable growth.

Composition of natural capital

The world's natural capital consists of approximately 76 per cent renewable and 24 per cent non-renewable categories, as indicated in Figure 2.1. Over the last three decades, the world's natural capital, both renewable and non-renewable, decreased by more than 28 per cent on average. The declining rate of renewable natural capital was almost 1.16 per cent per annum, and of non-renewable natural capital was approximately 1.10 per cent per annum. However, in the last 10 years, renewable capital showed a positive growth rate of 0.34 per cent per annum.

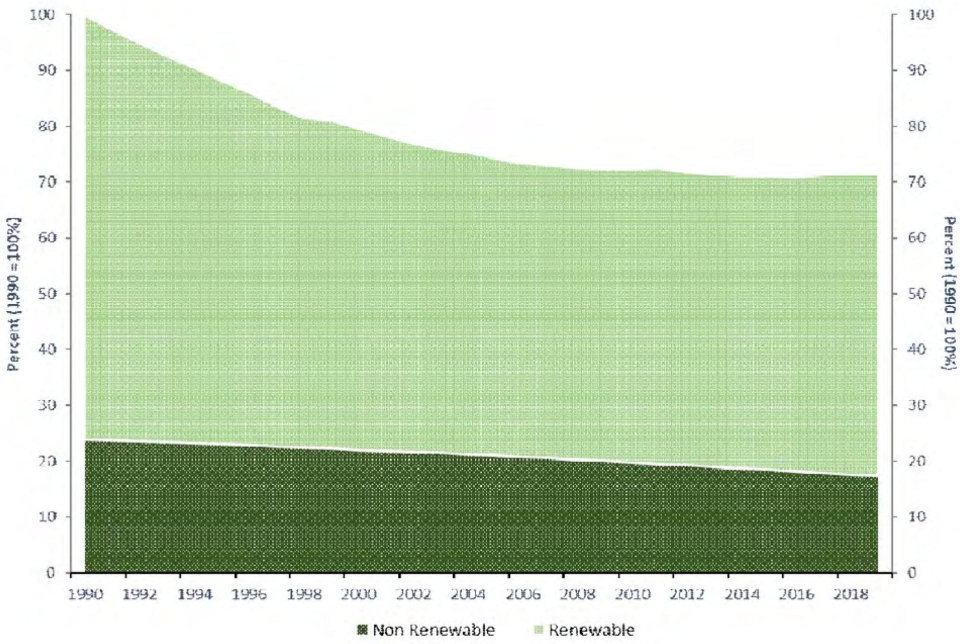


Figure 2.1: Trend of global natural capital, 1990–2019

From 1990 to 2019, 41 of 166 countries meaningfully increased their renewable resources. The United States of America is among countries with positive growth of renewable natural capital. In the same period, Malta, Cuba and Kyrgyzstan experienced positive growth in renewable natural capital of over one per cent. As shown in Figure 2.2, in per capita terms, only 21 countries reported a positive renewable natural capital growth rate during the study period.

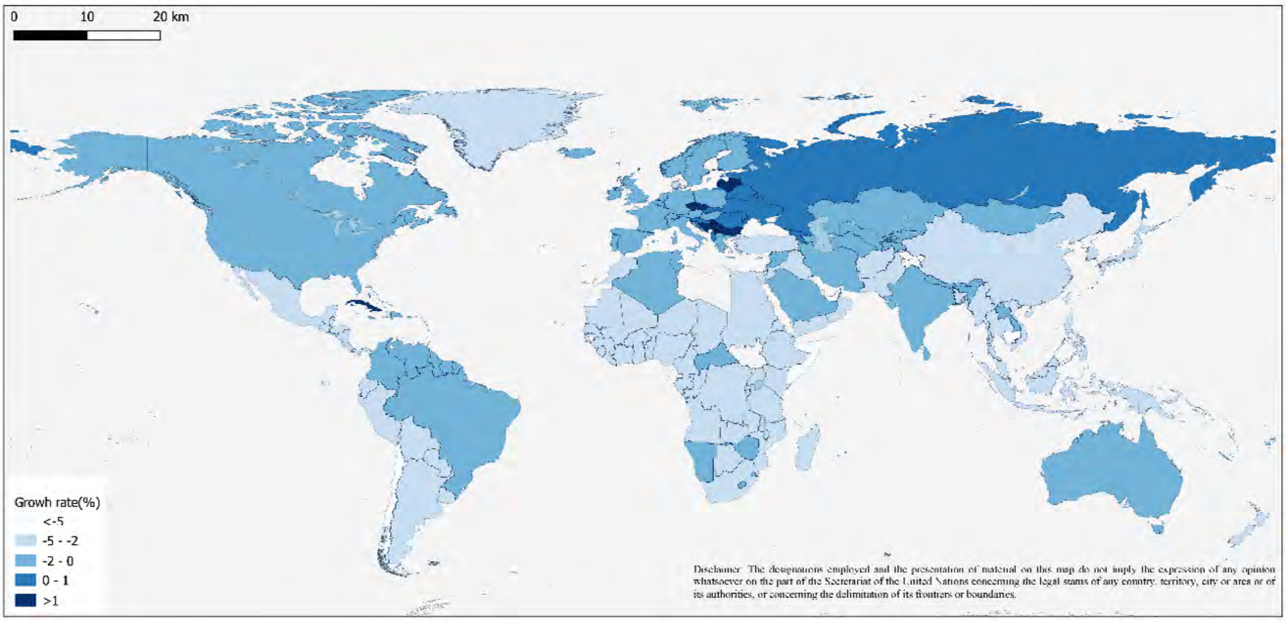


Figure 2.2: **Average annual growth rate of renewables per capita, 1990–2019**

2.2.1 Agricultural land

According to FAO categorization, agricultural land comprises cropland and pastureland. The results in Figure 2.3a show that 69 countries experienced growth of cropland, although only 20 of these showed a positive growth rate per capita. In particular, 45 countries experienced one per cent growth or more in cropland over this period, while only ten countries achieved one per cent growth or more on a per capita basis. Australia is one of the countries that experienced growth in cropland and cropland per capita by over one per cent during the study period. As indicated in Figure 2.3b, 64 countries reported positive growth of pastureland, 13 of which showed positive growth per capita.

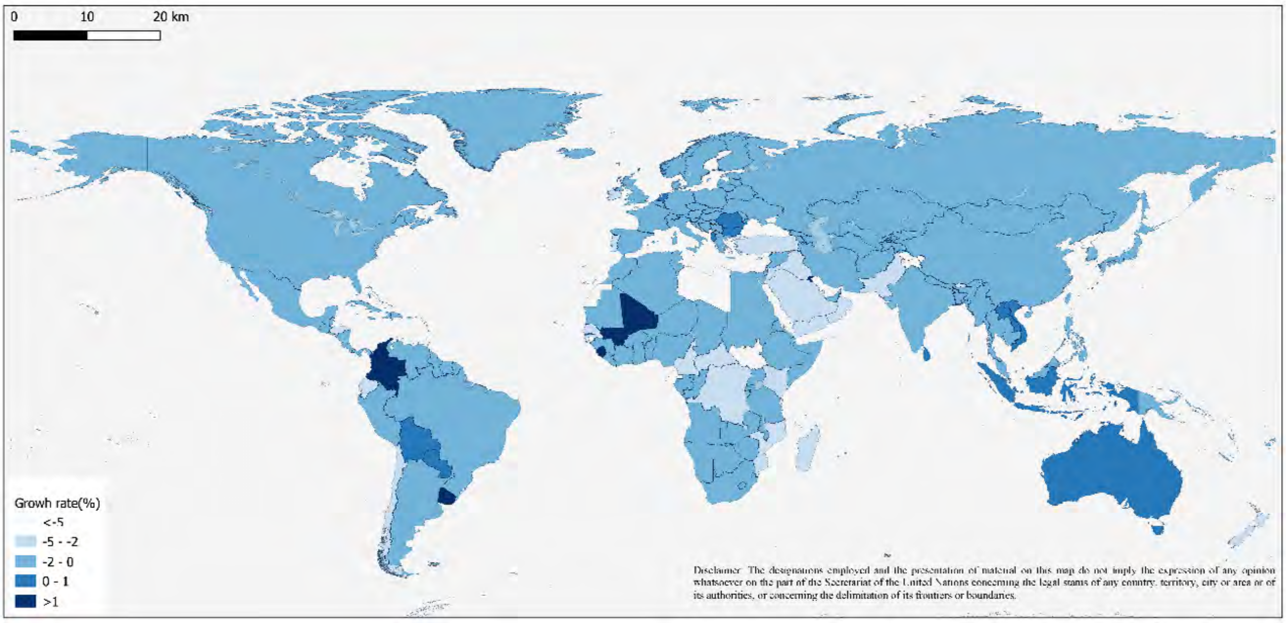


Figure 2.3a: **Average annual growth rate of cropland per capita, 1990–2019**

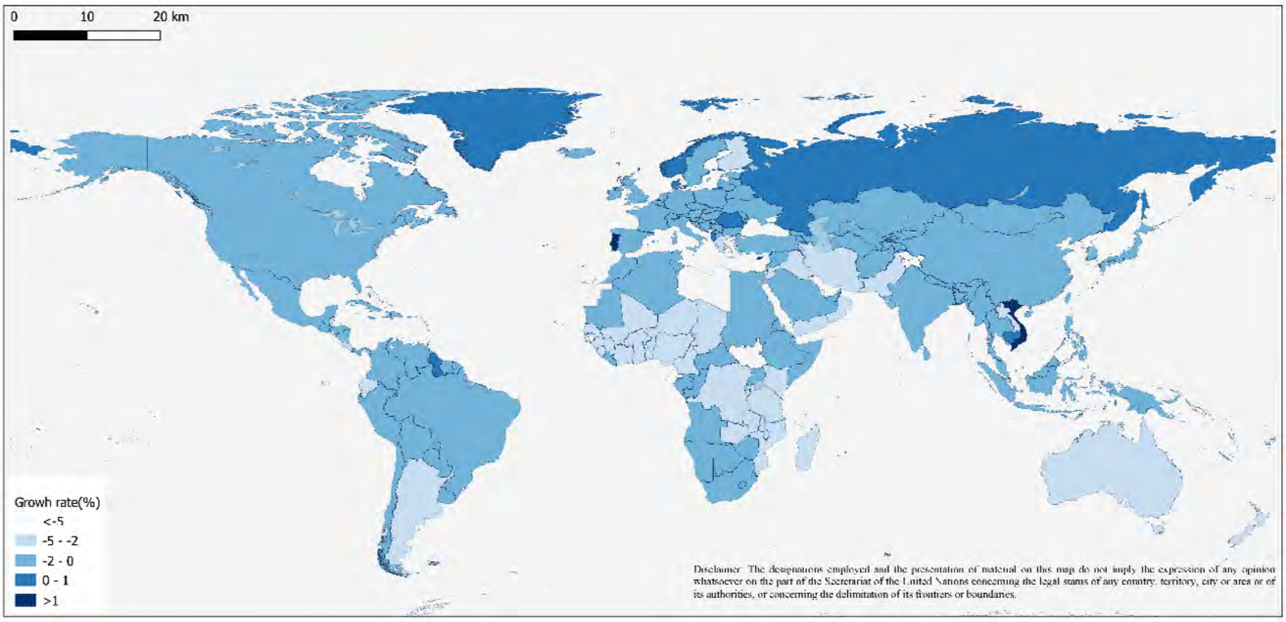


Figure 2.3b: Average annual growth rate of pastureland per capita, 1990–2019

2.2.2 Forests and fisheries

In this report, forest resources consist of timber and non-timber forest resources, accessed by the population of the country. Timber and non-timber forest resources generally move in the same directions because they are directly connected to the total forest surface of a country. The growth of forest resources was positive for Japan, the Russian Federation, Australia and some European Union countries. However, the decline of forests in China, India, Indonesia, Brazil, the United States of America and Canada is creating pressure on their sustainable development.

Figure 2.4 shows that only 32 of 166 countries experienced growth in forest resources per capita, whereas 20 countries reported a more than 1 per cent growth rate. Ireland had a more than five per cent growth in forest resources per capita from 1990 to 2019. In contrast, Denmark had a three per cent reduction in forest resources during the same period.

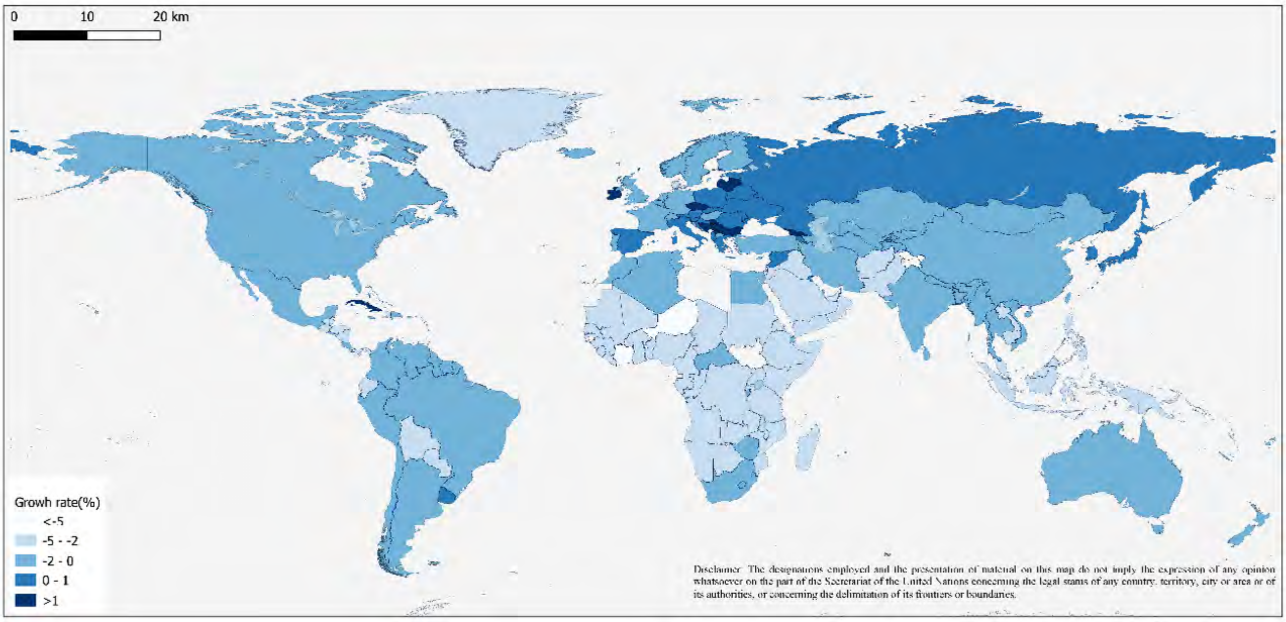


Figure 2.4: Average annual growth rate of forests per capita, 1990–2019

Fisheries are a small but essential part of natural capital, and are one of the most important renewable resources that directly relate to the food security of nations. Fish stock can be managed as a renewable resource by limiting the harvest of endangered species and harvesting abundant species. Within each country, there is enormous variation in fish stock and species, but most nations showed a decreasing trend in fishery stocks. Overall, only 11 countries successfully increased fishery wealth, while 112 countries reported a negative growth rate of fishery wealth, and 44 countries reported no fishery wealth. Figure 2.5 indicates the growth rate of global fishery wealth per capita, between 1990 to 2019.

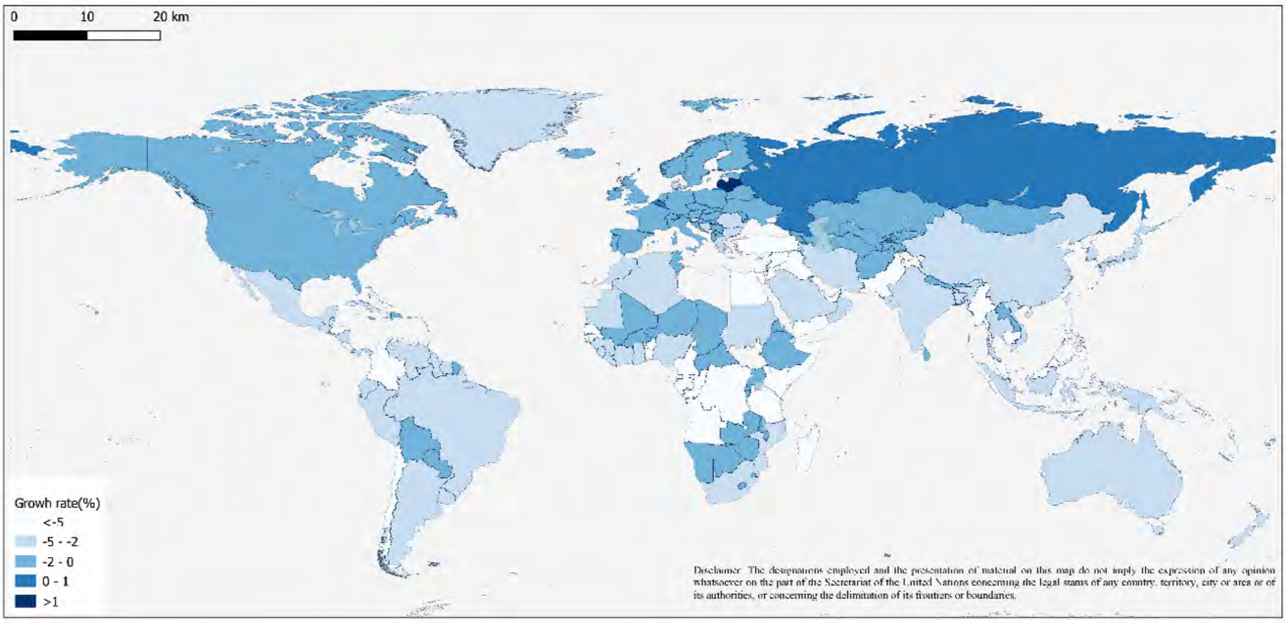


Figure 2.5: Average annual growth rate of fisheries per capita, 1990–2019

Fossil fuels and minerals

Fossil fuels remain inputs for the energy system of most countries. In this estimation, fossil fuels consist of three main components - oil, natural gas and coal. Countries with abundant fossil fuel resources are greatly reducing their stock value over time, as shown in Figure 2.6.

Oil is the most widely used fossil fuel and contributes significantly to global natural capital. It is widely considered a carbon-intensive source of energy, and its non-renewable characteristics result in a gradual decline of this resource. In the reporting period, 54 of 166 countries reported more than a five per cent depletion rate per capita for oil component, including France, Qatar and the United Arab Emirates.

Natural gas and coal are other current sources of energy and account for a significant proportion of global natural capital. Natural gas has a lower carbon content than oil and coal, which improves our carbon damage adjustment of the IWI. Gas utilization is also increasing due to its geopolitical diversity, reflected in a negative growth rate of more than five per cent reported in 24 countries. A number of countries have a significant global coal reserve, including Indonesia, South Africa and Australia. In this estimation, several countries, including China, Indonesia and South Africa showed a more than two per cent negative growth in coal per capita wealth.

Although minerals are the smallest contributor of natural capital for nations in terms of capital stocks, they make a significant contribution toward sustainable development, including in support of the cleaner energy transition. In our analysis, 48 countries reported negative growth in mineral wealth from 1990 to 2019. Notably, several countries, including Togo and Papua New Guinea, reported a more than five per cent mineral depletion.

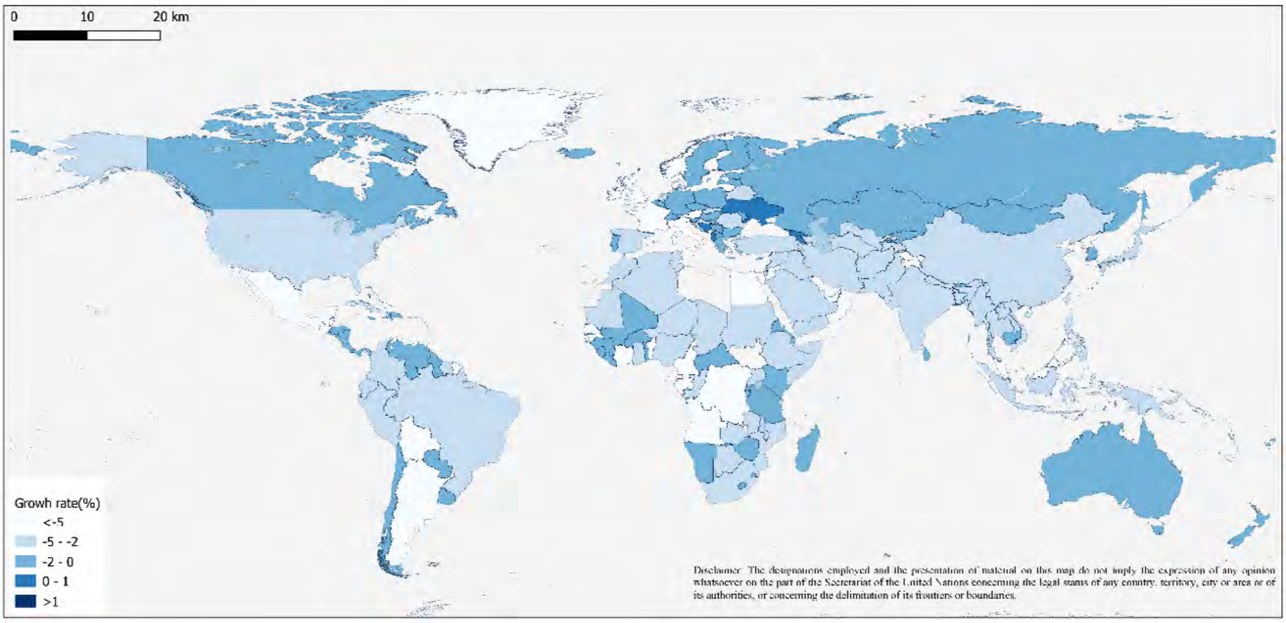


Figure 2.6: Average annual growth rate of fossil fuel per capita, 1990–2019

Distribution of natural capital

Over the last three decades, overexploitation of nature has led to a significant decline in global stock of natural capital. Between 1990 and 2019, the world's natural capital declined by approximately 29 per cent.

In 1990, the G20 countries dominated the world's natural capital, with a total share of more than 60 per cent, as indicated in Figure 2.7. This was followed by LAC and ECA regions, with a total share of 21.69 per cent and 5.34 per cent, respectively. However, between 1990 and 2019, LAC were the largest contributor to global natural capital decline, with a more than 54 per cent drop in natural capital stock. Accordingly, in 2019, LACs' share in the global stock of natural capital dropped to only 13.77 per cent. The EAP region also showed a significant loss of approximately 45 per cent of natural capital, decreasing this region's contribution to the world's stock of natural capital from 3.53 per cent in 1990 to 2.72 per cent in 2019. The G20 countries showed a comparatively smaller decrease of less than 20 per cent of natural capital, resulting in an increase of its share in the world's natural capital of more than 7 per cent in 2019. Consequently the G20 countries maintained their global domination of natural capital. The lowest decline in natural capital stock was found in SSA. With around 16 per cent loss of natural capital, SSAs contribution to the global natural capital stock increased slightly from 3.75 per cent in 1990, to 4.39 per cent in 2019. Increases in the share of natural capital stock by around 0.2 per cent and 0.3 per cent were also found in ECA region and MENA region, respectively. Finally, a rather stagnant share of natural capital of around 0.8 per cent was observed in SA region, despite its approximate 21 per cent loss of natural capital.

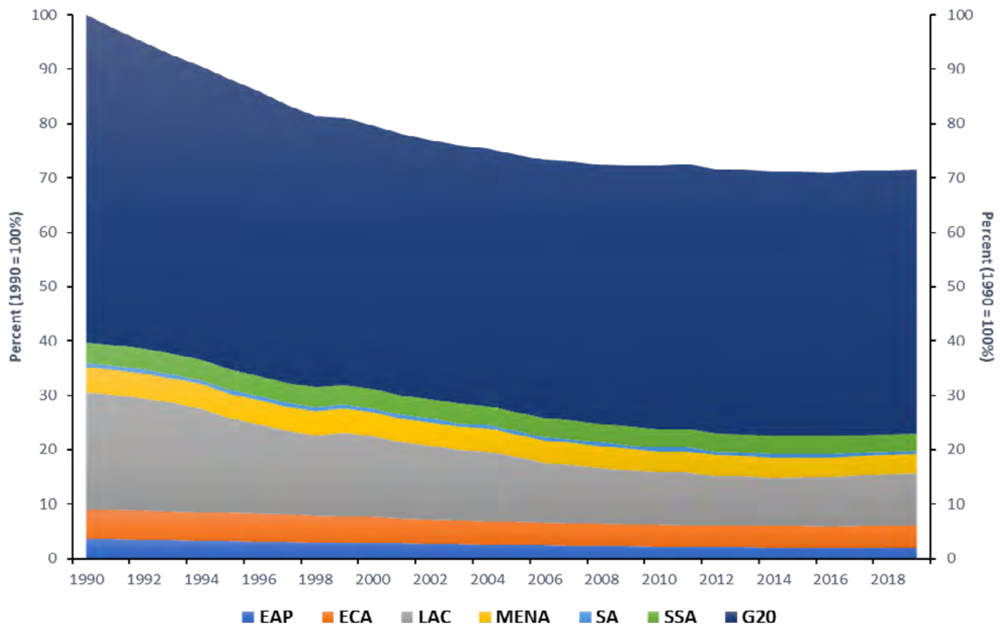


Figure 2.7: Distribution of natural capital by region, 1990–2019

The following are regional analyses of per capita natural capital and per capita IW. For each region, the Figures classify the growth rate of per capita natural capital and per capita IW into four quadrants (Q1–4). Q1 portrays the most desirable situation, where growth in per capita total wealth and per capita natural capital were both observable, suggesting both strong and weak sustainability. Q2 represents a decline in per capita total wealth and a growth in per capita natural capital. Q3 represents the most undesirable situation, where both per capita wealth and per capita natural capital declined. Finally, Q4 depicts a condition of weak sustainability, where growth in per capita total wealth was not followed by growth in per capita natural capital.

G20 countries

The findings in Figure 2.8 for the G20 countries show that between 1990 and 2019, most of the G20 countries (15 of 19) experienced a declining trend of per capita natural capital, but achieved an increased trend of wealth, suggesting that these countries followed a sustainable development path from the weak sustainability perspective. Four countries (Argentina, Indonesia, Saudi Arabia and South Africa) exhibited a decline in both per capita total wealth and per capita natural capital, suggesting that the declining stock of natural capital was not being sufficiently compensated by net increases in other forms of capital.

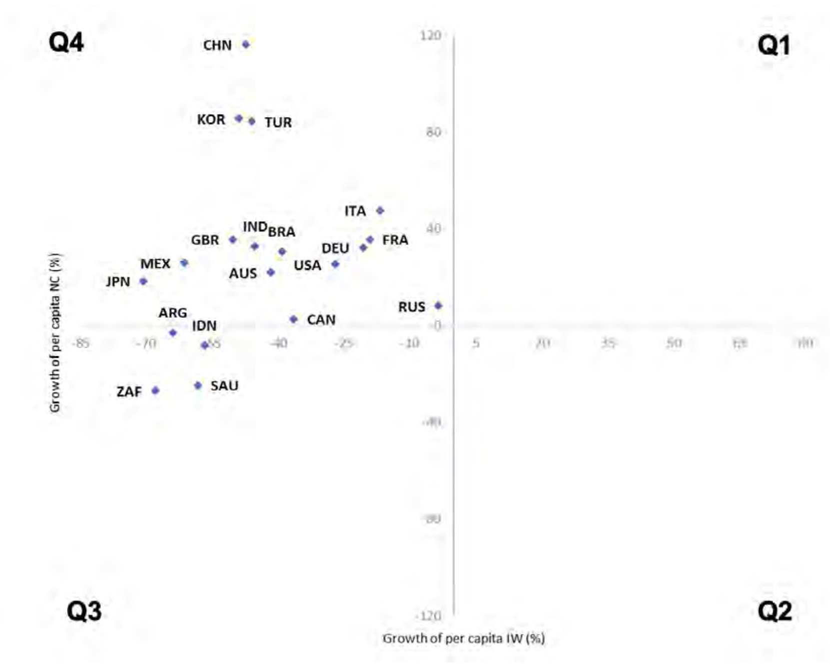


Figure 2.8: **Per capita changes in natural capital and IW in the G20 countries, 1990–2019**

Latin America and the Caribbean

Figure 2.9 shows that all countries in the LAC region experienced a noticeable decline in per capita natural capital. However, 50 per cent of LAC countries (12 of 24 countries) compensated for this loss by net increases in other forms of capital. Hence, showed weak sustainably, as indicated by increasing per capita IW. Peru, Chile and Ecuador—resource-rich countries in the LAC region—experienced the largest decline in per capita IW. This was not entirely unexpected since those countries suffered a great loss in their natural capital by more than 50 per cent over the last three decades. Colombia—among the top five resource-rich LAC countries—was the only country that followed the trajectory of sustainable development. In addition to the relatively low declining rate of natural capital, the positive growth of per capita IW in Colombia came from the enormous growth of human and produced capital, which grew by more than 81 per cent and 103 per cent respectively, between 1990 and 2019.

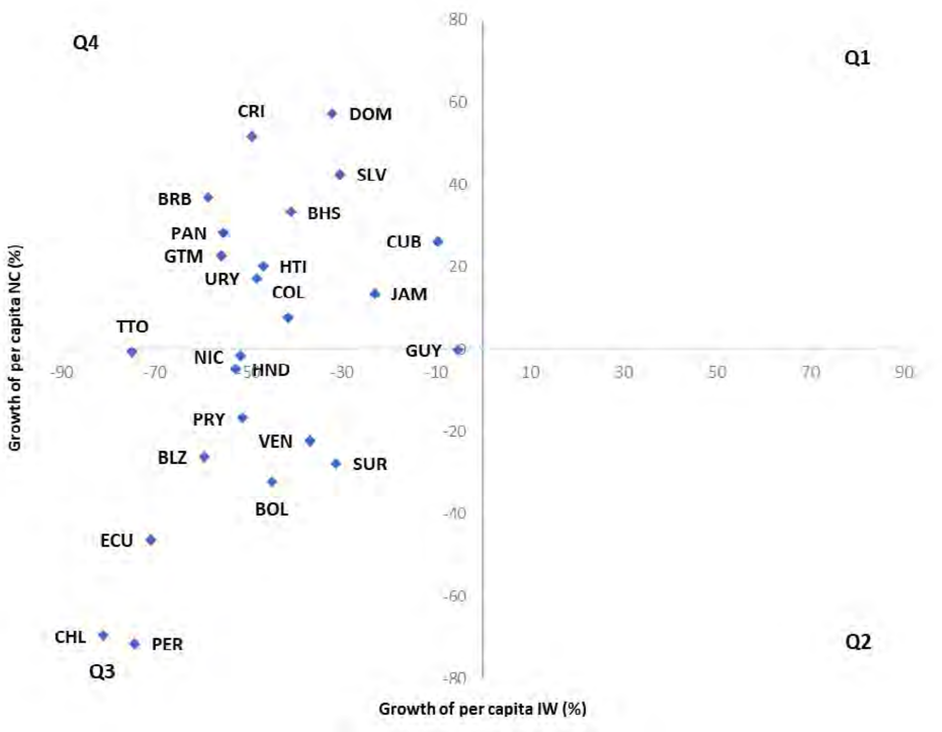


Figure 2.9: **Per capita changes in natural capital and IW in the LAC region, 1990–2019**

Europe and Central Asia

As indicated in Figure 2.10, in terms of per capita growth, the ECA region showed impressive performance - only three of 40 countries showed declines in both per capita natural capital and per capita IW. Twelve countries successfully increased both per capita natural capital and per capita IW, and thus showed strong sustainability. With the exceptions of Estonia, Latvia and Lithuania, the growth in per capita natural capital in these countries was driven by declining population levels, rather than increasing aggregate natural capital stock. The findings also show that 25 countries increased their per capita IW, despite a declined level of per capita natural capital, indicating weak sustainability.

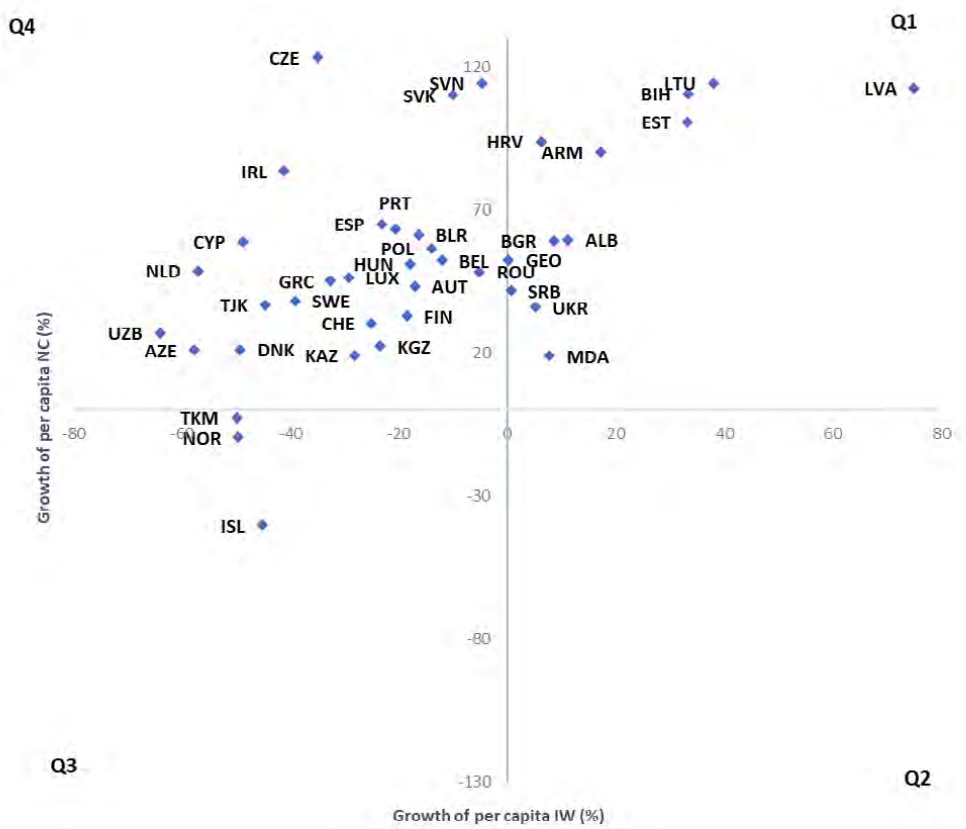


Figure 2.10: Per capita changes in natural capital and IW in ECA region, 1990–2019

Middle East and North Africa

MENA countries are facing the combined pressures of significant natural resource decline and rapid population growth. The impact of population growth is clearly visible in Figure 2.11, where the rate of natural capital per capita showed a greater decline than the aggregate natural capital. Nonetheless, nine countries increased their per capita IW, and thus showed weak sustainability. Malta was the only country in the MENA region that had a positive growth in natural capital. This sign of sustainability is even more promising as both per capita natural capital and per capita IW in this country increased.

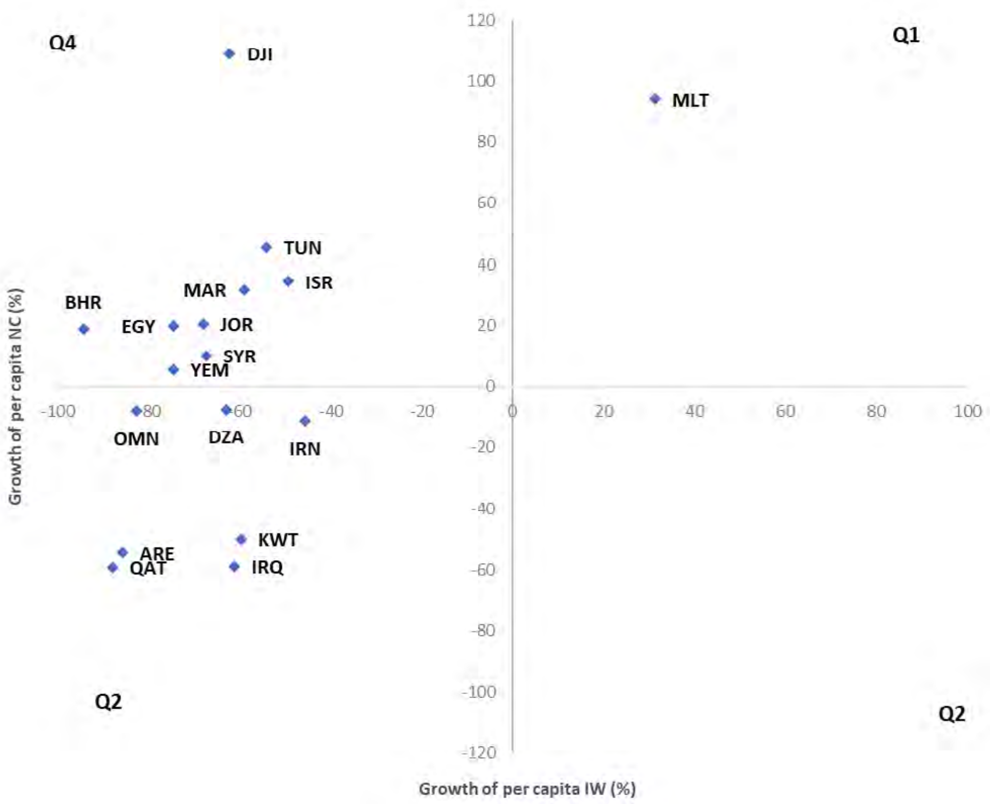


Figure 2.11: Per capita changes in natural capital and IW in the MENA region, 1990–2019

East Asia and the Pacific

The intense pressure from population on natural resources in the EAP region is clearly portrayed in Figure 2.12. For instance, despite the positive growth in aggregate natural capital reported in Fiji and the Lao People's Democratic Republic, these two countries failed to achieve positive growth in per capita natural capital. Hence, all countries in EAP region experienced a declining per capita natural capital. Nevertheless, notwithstanding the declining per capita natural capital, seven countries in the EAP region were able to increase per capita IW, implying sustainability in the weak perspective.

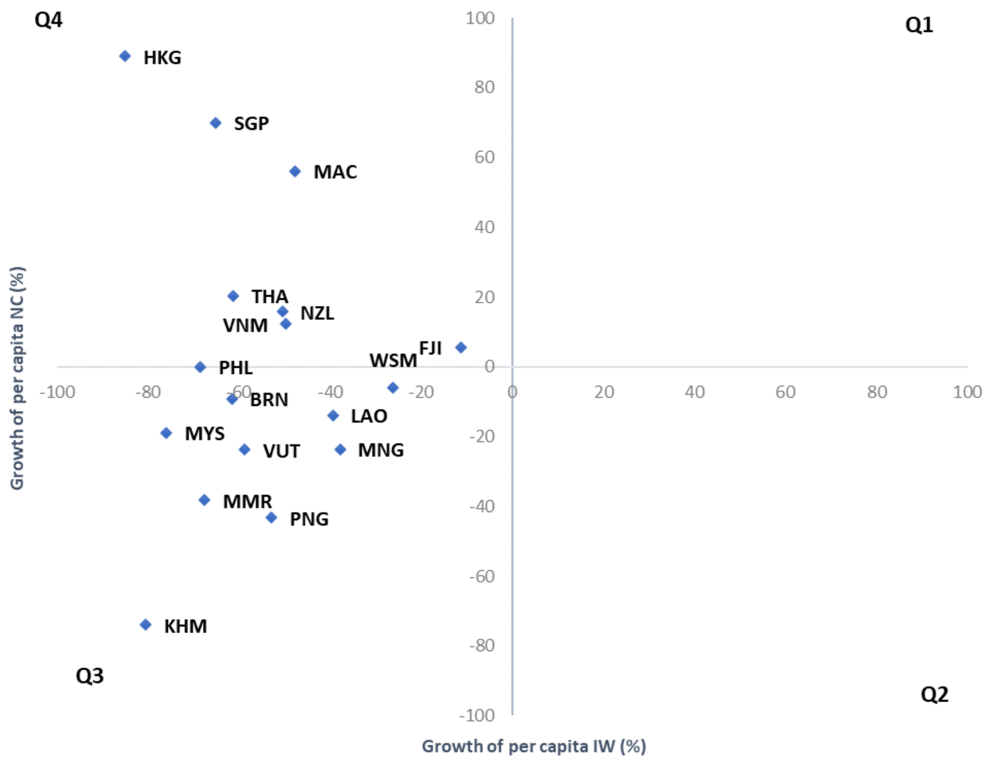


Figure 2.12: **Per capita changes in natural capital and IW in the EAP region, 1990–2019**

Sub-Saharan Africa

The impact of rapid population growth on natural resources in the SSA region can be depicted from the decline in per capita natural capital. Figure 2.13 shows that despite the positive growth of aggregate natural capital in Burundi, Mali, Namibia and Eswatini, no country in SSA experienced a positive growth in per capita natural capital. Per capita natural capital also showed a greater decline relative to aggregate natural capital, which suggests increased pressure of population growth on natural capital. From the weak sustainability perspective, only eight of 42 countries in SSA region increased per capita IW. The highest gain in per capita IW was found in Mauritius, while the biggest loss was observed in Somalia.

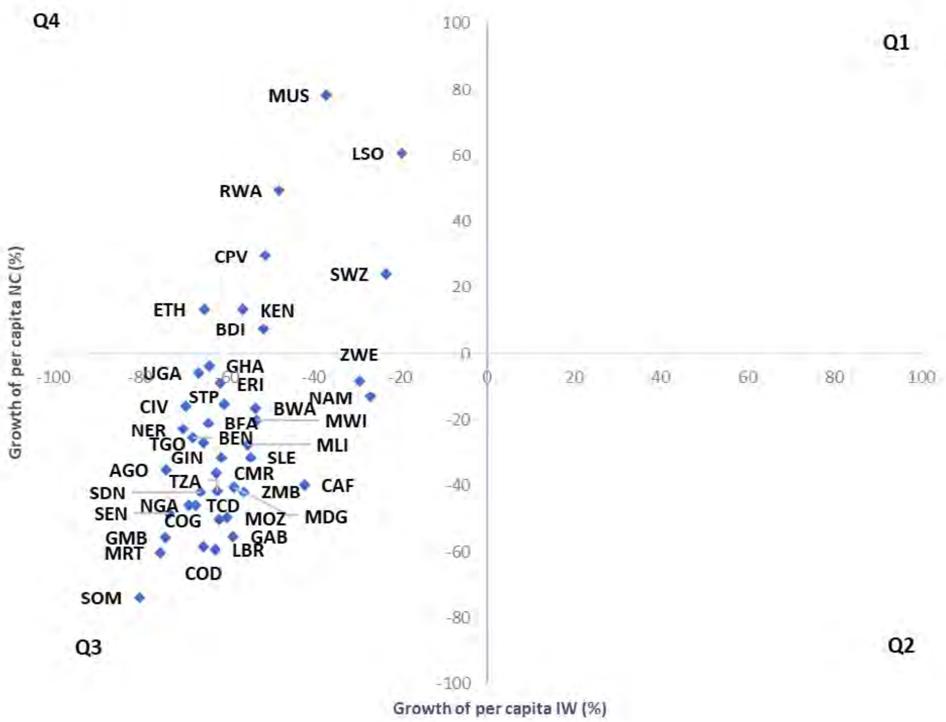


Figure 2.13: **Per capita changes in natural capital and IW in the SSA region, 1990–2019**

South Asia

Figure 2.14 shows that all countries in SA region experienced a negative growth in per capita natural capital, implying that pressure from population growth on natural capital was also observed in SA region. In Bhutan and Nepal, the positive growth of natural capital in aggregate terms failed to catch up with their fast-growing population. In the framework of weak sustainability, three countries in SA region deviated from the sustainable development path, because the loss in natural capital was not sufficiently compensated by net increases in other forms of capital, which led to a declining level of IW. A rather impressive performance was found in Bangladesh, where, despite the significant loss in natural capital, Bangladesh increased its per capita IW by more than 70 per cent over the period from 1990 to 2019.

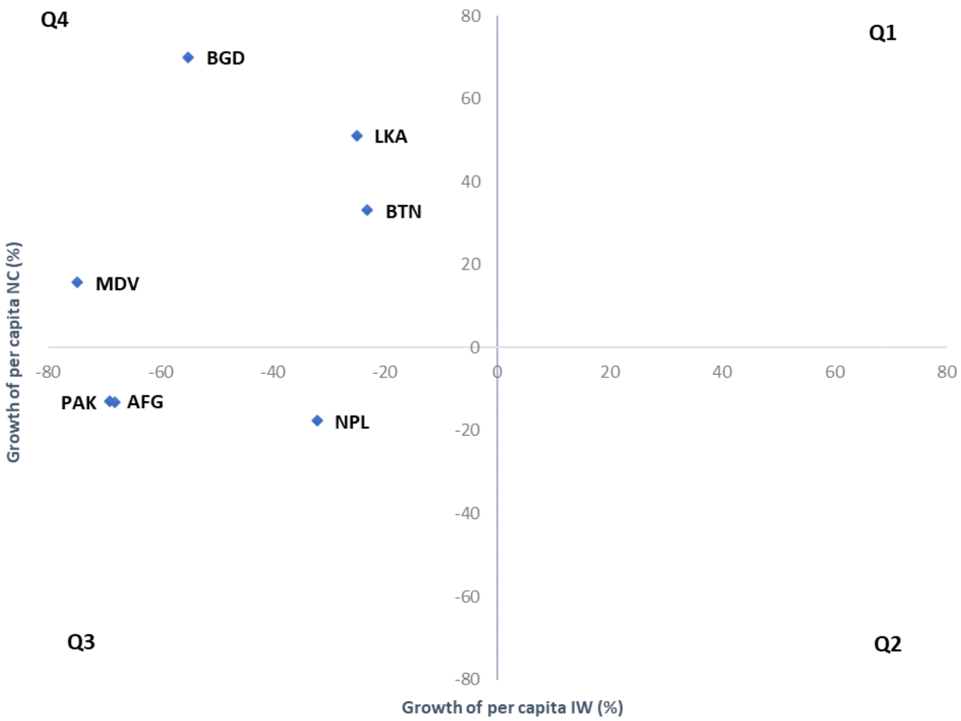


Figure 2.14: **Per capita changes in natural capital and IW in the SA region, 1990–2019**

Incorporating coastal ecosystems in the assessment of natural capital

Like other renewable natural capital components, coastal ecosystems such as mangroves, salt marshes and seagrass meadows provide various ecosystem services that are essential for human wellbeing. However, coastal ecosystems are rapidly deteriorating globally, due to pressures from population growth, land conversion and climate change. It is thus vital to consider coastal ecosystem services in natural capital assessments. By considering coastal as an integral component of natural capital, their sustainability will not be overlooked.

This analysis identifies two categories of coastal ecosystem services: i) provisioning services, which are related to the supply of food and raw material, such as resource harvests and water; and ii) regulating services, which are related to the actions of filtration, purification, regulation and maintenance of air, water, soil, habitat and climate - such as coastal protection from natural disaster and carbon sequestration. The monetary values of these two services are then calculated following Barbier *et al.* (2011) and Tuya *et al.* (2014). The potential contribution of coastal ecosystems to the existing value of renewable natural capital is also estimated.

Results of the analysis, as indicated in Figure 2.15, show that coastal ecosystems can notably augment the renewable capital in a country by more than 10 per cent. This example was found in Cuba and Qatar. A rather significant increase in renewable natural capital of around 5–10 per cent was found in the United Arab Emirates and Belize. Additionally, 13 of 100 countries in the study saw a modest increase in renewable natural capital by 1–4.99 per cent. Remaining countries in the study showed a slight in increase in this renewable natural capital of less than one per cent.

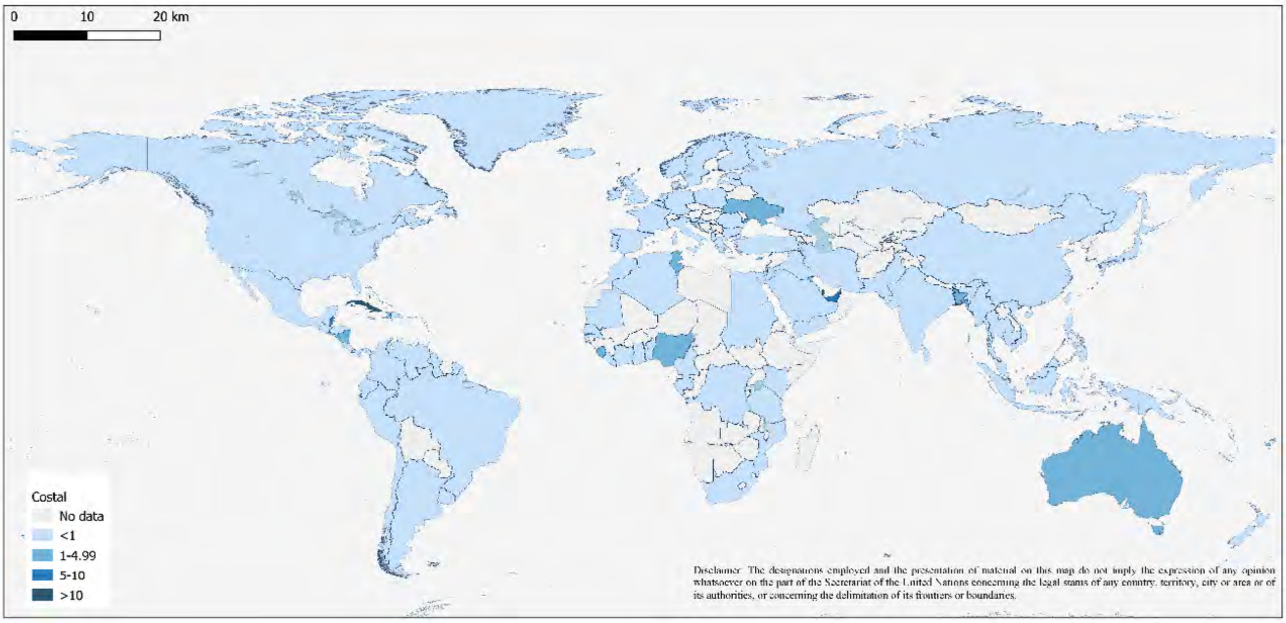


Figure 2.15: Contribution of coastal ecosystems on renewable natural capital

One of the most indispensable services from coastal ecosystems is their outstanding ability to sequestrate and store carbon from the atmosphere, which is essential for climate change mitigation. Coastal ecosystems have a considerably higher comparative rate of carbon to that of forest ecosystems (Bertram *et al.* 2021). Carbon sink potential was calculated from both forest ecosystems and coastal ecosystems, and coastal ecosystems were evaluated for how they can contribute to the existing carbon sink potential of forest ecosystems. The carbon sink potential of forest ecosystems was calculated following Pugh *et al. (*2018), while the carbon sink potential of coastal ecosystems was obtained from Bertam *et al.* (2021).

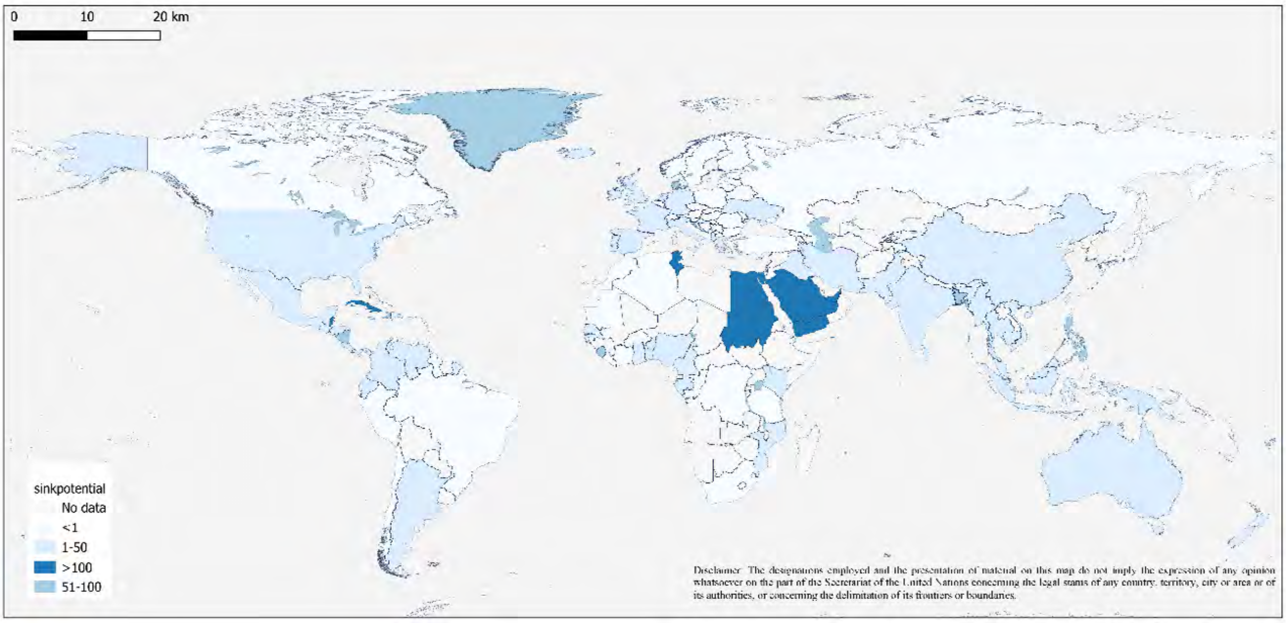


Figure 2.16: Contribution of coastal ecosystem on carbon sink potential

Results of the analysis, as shown in Figure 2.16, indicate that the coastal ecosystems can increase the carbon sink potential in a country by more than 100 per cent in countries that have a very small or no forest area, as was found in eight countries in the MENA region, as well as Cuba and Belize. Additionally, coastal ecosystems may increase the carbon sink potential in nine of 100 countries by 51–100 per cent, and by 1–50 per cent in 53 of 100 countries.

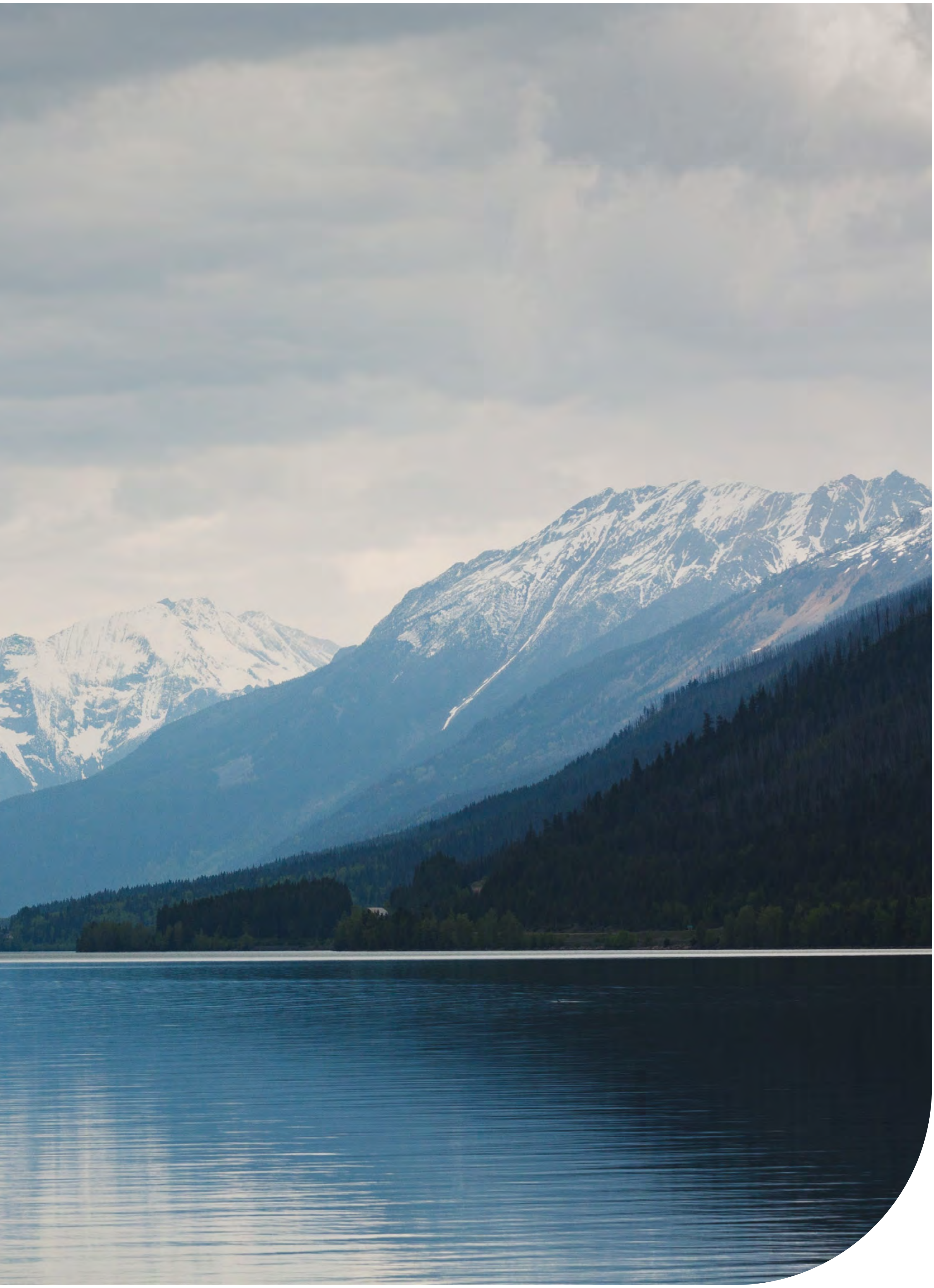
Conclusion

Natural capital accounting highlights the value of the natural environment as an asset for current and future generations. Measuring the value of natural capital is essential to accurately assess whether resource use is sustainable, particularly given the dramatic change in economic indicators when the depletion and degradation of natural capital is considered.

Globally, governments, financial institutions and corporations have begun to incorporate natural capital into their policies and practices. Although it is not possible or appropriate to monetize all ecosystem services or social values, an enhanced capacity to account for natural capital can improve policymaking processes (Schaefer *et al.* 2015). Regions throughout the world are recognizing the value of natural capital and are taking steps to account for and conserve it. For example, evidence that natural capital is the source of nearly one-third of the wealth of low-income countries is focusing greater attention on conservation and sustainable development activities (World Bank 2011).

This chapter has identified that in the last three decades, overexploitation of nature has led to a significant decline in the world's stock of natural capital. Relative to 1990 levels, global natural capital has declined by approximately 29 per cent (2019). In addition, coastal ecosystems globally are rapidly deteriorating, due to population growth, land conversion and climate change, putting the sustainability of coastal ecosystems at high risk.

Society must urgently limit further degradation of the environment and work towards its reparation to ensure its viability for present and future generations (Gifford and Nilsson 2014; Bronfman *et al.* 2015). By including natural capital in economic accounts, we can better understand human-environmental interactions at the macro-level (Zhang *et al.* 2020). The analysis of regional natural capital composition and distribution detailed in this chapter can inform policymakers to identify appropriate pathways towards sustainability for their countries.



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03 Progress towards the Sustainable Development Goals and natural capital in emerging market and developing economies

Introduction

Many studies have expressed alarm over the accelerating environmental impacts from global economic development in recent decades. Since 1970, trends in agricultural production, fish harvest, freshwater use, bioenergy production and harvest of materials have increased, in response to rising demand from population and income growth (IPBES 2019; Dasgupta 2021; Barbier 2022). Over this period, the global human population has more than doubled (from 3.7 to 8 billion people), and per capita GDP has more than quadrupled, which have served to magnify the environmental burden of consumption and production worldwide (IPBES 2019). Indeed, the expansion of energy use, carbon dioxide emissions and fisheries production have outpaced the enormous growth in global population (Le Quéré *et al.* 2018; British Petroleum [BP] 2019; Barbier 2022)

Such environmental impacts have been especially prevalent in emerging market and developing economies (EMDEs), many of which are located in tropical zones[28]. Land use change, habitat destruction, ocean and coastal ecosystem decline and biodiversity loss are primarily driven by the ongoing demand for agricultural production, mining, the ocean economy and timber in EMDEs, especially in tropical regions (IPBES 2019; Dasgupta 2021; Duarte *et al.* 2021; Barbier 2022;). As a consequence, tropical natural forests have declined by 11 percent since 1990 (FAO 2015). At the same time, we have experienced a 70 per cent decrease in the populations of mammals, birds, fish, reptiles and amphibians (World Wildlife Fund [WWF] 2020).

If economic development in EMDEs is coming at the expense of natural capital and the environment, then this could jeopardize the attainment of long-term sustainability objectives. The 17 SDGs can be viewed as sustainable development in its broadest sense, however if EMDEs are making gains towards some of the key economic and social SDGs, but falling further behind with environmental goals, then the overall sustainability of their development efforts may come into question.

Several studies suggest that this may be the case. Barbier and Burgess (2019; 2021), have employed economic welfare analysis to determine whether countries since 2000 have achieved net gains from progress towards all 17 SDGs. Across representative countries, low-income economies and the world, they found considerable net costs associated with falling behind on the five 'environmental' goals: SDG 11 Sustainable Cities and Consumption, SDG 12 Responsible Consumption and Production, SDG 13 Climate Action, SDG 14 Life Below Water and SDG 15 Life on Land. Other assessments have also found similar trade-offs between the environmental goals (SDGs 11–15) and other SDGs (Nilsson *et al.* 2016; von Steckhow *et al.* 2016; Pradhan *et al.* 2017; Sachs *et al.* 2020 and 2021; United Nations [UN] 2021).

28 In this chapter emerging market and developing economies (EMDEs) refers to low and middle-income countries. The World Bank divides economies among income groups according to 2020 gross national income (GNI) per capita. The groups are: low income, USD 1,045 per capita or less; lower middle income, USD 1,046 to USD 4,095 per capita; upper middle income, USD 4,096 to USD 12,695 per capita; and high income, USD 12,696 per capita or more.

This pattern of development could have implications for the post-COVID recovery in EMDEs. The pandemic has impacted all three dimensions of sustainable development: economic, social and environmental (Sachs *et al.* 2021; UN 2021). But unless economic development encompasses improved management of the environment and natural capital, then EMDEs will return to an economic trajectory that embraces trade-offs, rather than complementarities, among economic, social and environmental goals. This will not only lower overall welfare gains of their populations, but also contribute to climate change, biodiversity loss, deteriorating oceans and other global environmental risks (Barbier 2022).

To explore these issues further, this chapter estimates the changes in net welfare that reflect progress from 2000 to 2019 towards the 17 SDGs for 80 EMDEs. These overall net SDG impacts are then compared with three different measures of environmental and natural capital changes for these economies: the net environmental impacts associated with SDGs 11–15, natural resource depletion as a share of national income and per capita natural capital change.

The next section presents the welfare analysis of progress towards the 17 SDGs in the 80 EMDEs from 2000 to 2019, comparing these gains to the environmental losses associated with SDGs 11–15 over the same period. This is followed by an examination of natural capital depletion, which shows that many EMDEs from 2000 to 2019 also experienced considerable natural capital losses. The policy implications are then discussed and the chapter concludes with exploring future research issues.

Welfare analysis and environmental impacts

The analysis of this chapter is based on the approach developed by Barbier and Burgess (2019; 2021) to estimate the welfare effects of progress in attaining one SDG, while accounting for interactions in achieving other SDGs. This approach is derived from standard economic methods for measuring the welfare effects arising from changes in imposed quantities (Lankford 1988; Freeman 2003). In essence, this analytical framework allows estimation of the 'willingness to pay' in dollar terms by a representative individual for an improvement in one SDG indicator, while considering any positive or negative changes in other SDG indicators. As many assessments have shown, since 2000 there has been considerable variation from country to country in the progress towards attaining the SDGs, as well as comparatively between richer and poorer economies. Furthermore, progress in attaining any individual goal may have led to the reduction (or increase) of achievement in other goals (Nilsson *et al.* 2016; von Steckhow *et al.* 2016; Pradhan *et al.* 2017; Barbier and Burgess 2019; Sachs *et al.* 2020; Barbier and Burgess 2021; Sachs *et al.* 2021; UN 2021). In order to conduct the welfare analysis, it is necessary to choose a representative indicator for each goal. This requires indicators that are broadly available for all 80 EMDEs, and from 2000 to 2019. Table 3.1 summarizes the 17 SDGs and the main indicators used to measure progress towards each goal. For the purposes of the analysis SDG 1 (No Poverty) is chosen as the benchmark indicator.

Table 3.1: **The 17 SDGs and their indicators for assessing progress**

Sustainable Development Goal	Indicator*
1. No Poverty	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)
2. Zero Hunger	Prevalence of undernourishment (% of population)
3. Good Health and Well-Being	Maternal mortality ratio (per 100,000 live births)
4. Quality Education	Adolescents out of school (% of lower secondary school age)
5. Gender Equality	Lower secondary completion rate, female (% of relevant age group)
6. Clean Water and Sanitation	People using at least basic drinking water services (% of population)
7. Affordable and Clean Energy	Access to clean fuels and technologies for cooking (% of population)
8. Good Jobs and Economic Growth	Adjusted net national income per capita (annual % growth)
9. Industry, Innovation and Infrastructure	Manufacturing, value added (% of GDP)
10. Reduced Inequalities	Gini index
11. Sustainable Cities and Communities	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)
12. Responsible Consumption and Production	Adjusted net savings, excluding particulate emission damage (% of GNI)
13.Climate Action	CO_2 emissions (metric tons per capita)
14. Life Below Water	Total fisheries production (metric tons)
15. Life on Land	Forest area (sq. km)
16. Peace, Justice and Strong Institutions	Political stability and absence of violence/terrorism (-2.5 to 2.5)
17. Partnerships for the Goals	Debt service (% of exports)

Notes: *All indicators are available from the World Bank's World Development Indictors https://databank.worldbank.org/source/world-development-indicators except for political stability and absence of violence/terrorism, which is from the World Bank's Worldwide Governance Indicators https://databank.worldbank.org/source/worldwide-governance-indicators#. GDP = gross domestic product. GNI = gross national income. Adjusted net national income is GNI minus consumption of fixed capital and natural resources depletion, where the latter is the sum of net forest, energy (fossil fuel) and mineral depletion valued at their respective unit rent. Adjusted net savings are equal to net national savings plus education expenditure and minus energy depletion, mineral depletion, net forest depletion and carbon dioxide. This series excludes particulate emissions damage.

The analysis estimates the change in per capita welfare from any reduction in 2000 to 2019 poverty rates, and adjusts this to take account of any gains or losses that may occur when simultaneously achieving each of the other 16 SDGs. Full details of the methodology can be found in Barbier and Burgess (2019; 2021). Here, the main steps are briefly outlined.

The first step is to assess the change in each indicator level associated with a goal for the 80 EMDEs. Actual changes in value in the original units of each indicator from 2000 to 2019 are translated into percentage change in these values over this period. The percentage change is constructed so that a positive value represents an improvement (gain) in attaining an SDG, whereas a negative value represents a decline (loss)[29].

The second step is to transform the indicator changes into a measure of willingness to pay for any improvement or decline using a numeraire measure of income for the average individual in each country. The numeraire chosen is the adjusted net national income (ANNI) per capita (constant 2015 USD) in 2000[30]. ANNI per capita serves as a proxy for the (Hicksian) income necessary to compensate the average individual in an EMDE for a change in the indicator level of any SDG. As shown by Arrow *et al.* (2012), national income that accounts for the net depreciation of an economy's natural, human and produced capital is a measure of the sustainable income generated each year by the economy. Using ANNI per capita in 2000 as the numeraire essentially assumes that an individual would be willing to pay one USD of this sustainable income for a one per cent improvement in the indicator for any SDG goal, or alternatively be willing to accept one dollar sustainable income to compensate for a one per cent decline in any SDG indicator.

For each of the 80 EMDEs, this approach is used to estimate the welfare gain or loss of progress over the period 2000 to 2019 in achieving SDG 1 No Poverty (henceforth called SDG 1 welfare impact), the net welfare gain or loss in achieving all 17 SDGs (net SDG welfare impact) and the net welfare gain or loss for SDGs 11–15 (net environmental impact). Table A3.1 in Appendix 3 lists the results for each of the 80 EMDEs. Figure 3.1 summarizes the results for all countries – the 13 low-income economies, the 36 lower middle-income countries and the 31 upper middle-income economies. For a full list of countries/economies included in the four income groups in IWR 2023, see Appendix 4.

On average, there was a significant welfare gain of USD 1,412 per person associated with poverty reduction (i.e. progress towards achieving SDG 1) across all 80 EMDEs from 2000 to 2019. The biggest welfare gain occurred in upper middle-income economies, which amounted to USD 2,854 per capita. In lower middle-income economies the gain was just USD 633 per capita, and in low-income economies it was USD 128 per capita. In fact, all 13 low-income economies managed to reduce poverty, thus registering some welfare gain from achieving progress towards SDG 1 from 2000 to 2019. More detail on this can be found in Table A3.1 in Appendix 3.

29 For example, in Bolivia, the poverty rate in the population declined from 28.6 per cent in 2000 to 3.2 per cent in 2019. Although this represents a fall of -88 per cent in the poverty rate, it is a positive improvement in achieving SDG 1 No Poverty. So, in the quantitative assessment, this translates to a gain of 88 per cent in the indicator level to show improved progress over 2000-2019 in attaining SDG 1. Note that for two indicators averages over the period are used to show changes: for SDG 8, the average annual percentage growth over 2000-2019 in adjusted net national income and for SDG 12, the average over 2000-2019 of adjusted net savings as a percentage of GNI. For Bolivia, adjusted net savings averaged 8.9 per cent of GNI over 2000-2019; therefore, this represents an 8.9 per cent gain towards SDG 3 over this period.

30 Available from the World Bank's World Development Indictors https://databank.worldbank.org/source/world-development-indicators

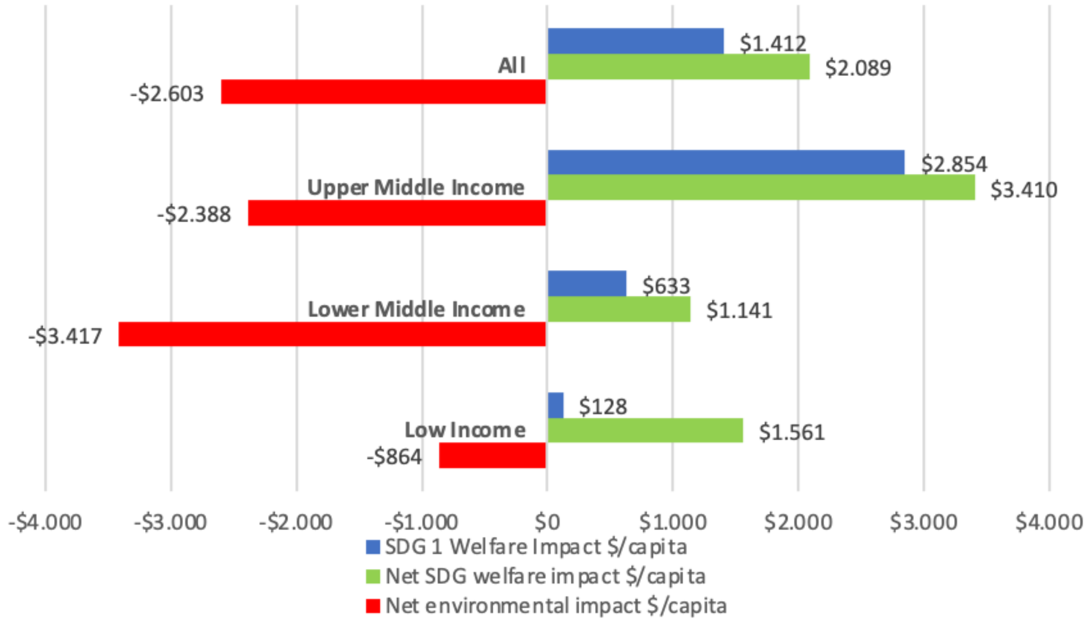

Figure 3.1: Poverty, SDG welfare and environmental impacts, 2000–2019

Notes: Refers to the average of all 80 emerging market and developing countries listed in Table A3.1 in Appendix 3, Upper Middle Income comprises the average of the 31 upper middle-income economies, Lower Middle-Income the average of 38 lower middle-income economies and Low Income the average of 13 low-income countries.

The net SDG welfare impact measures the overall welfare gain or loss in achieving all 17 SDGs from 2000 to 2019. On average, all economies and income groups had a positive net SDG welfare impact, with the largest gains occurring, on average, in middle as opposed to low-income economies. Thus, for the 80 EMDEs, the estimated per capita net welfare benefit from making progress towards the 17 SDGs amounted to USD 2,089 per capita. The per capita net welfare gain was USD 3,410 for the 31 upper middle-income economies, USD 1,141 for lower middle-income economies and USD 1,561 for low-income economies.

With the exception of Colombia, Costa Rica, Gabon, Panama, Thailand and Ukraine, EMDEs generally incurred significant welfare losses from failing to meet the five environmental goals SDGs 11–15 (see able A3.1 in Appendix 3). The net environmental impacts per capita were USD 2,603 on average for all 80 economies. USD 2,388 for upper middle-income economies, USD 3,417 for lower middle-income economies and USD 864 for low-income economies (see Figure 3.2). These environmental losses are more than half the overall net SDG welfare gains from progress towards the 17 SDGs for low-income economies, and around three times the net SDG welfare gains for lower middle-income economies.

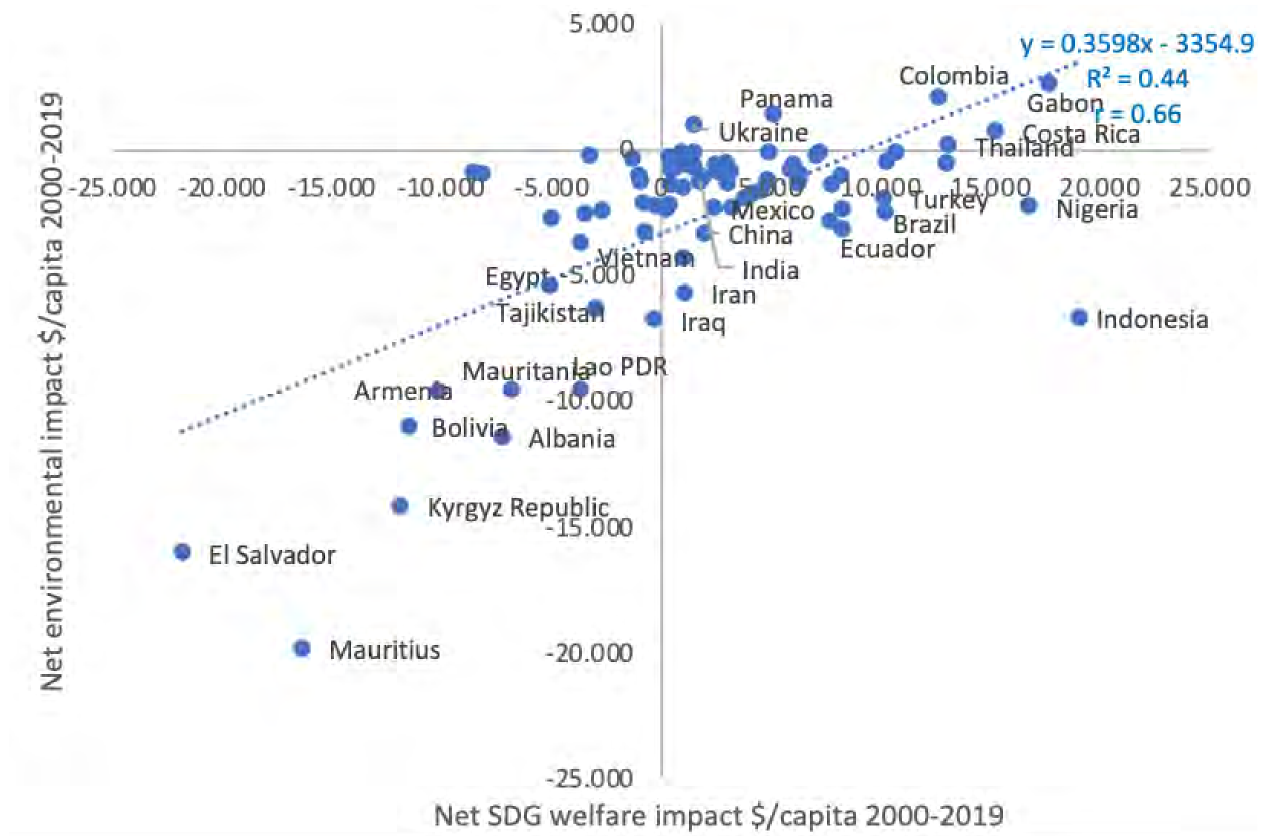

Figure 3.2: **SDG welfare and environmental impacts, 2000–2019**

Notes: Based on Table A3.1 of Appendix 3.

Progress towards SDGs 11-15 often determined whether or not a country experienced an overall SDG welfare gain, as well as the size of any gain or loss. Figure 3.2 shows that net SDG welfare impacts are correlated (*r* = 0.66) with net environmental impacts from 2000 to 2019 for the 80 EMDEs. Countries with higher SDG welfare gains over this period tended to have lower environmental losses. The six countries that registered positive environmental impacts—Colombia, Costa Rica, Gabon, Panama, Thailand and Ukraine—also had positive net SDG welfare gains. In comparison, all countries that had net SDG welfare losses from 2000 to 2019 experienced environmental losses, and as shown in Figure 2, those with the highest net SDG welfare declines also had some of the largest losses associated with SDGs 11–15.

In sum, for most EMDEs, it appears that any overall welfare gains from progress towards the SDGs from 2000 to 2019 were overshadowed by the considerable losses associated with SDGs 11–15. These goals cover a broad range of environmental targets, such as controlling greenhouse gas emissions, particulate matter and other pollutants, managing forests and other terrestrial ecosystems and improving ocean and coastal habitats. Thus, for many EMDEs, progress towards fulfilling Agenda 2030 over the past two decades has come largely at the expense of the environment. Moreover, those EMDEs that experienced overall net SDG welfare losses from 2000 to 2019 displayed some of the highest losses with respect to SDGs 11–15. That is, environmental impacts are becoming so large and widespread in some EMDEs that their populations are becoming significantly worse off, not better off, from economic development. Long-term progress towards the SDGs will depend on improved management of the environment in these economies.

3.1.2 Natural capital impacts

The capital approach to sustainability recognizes that the wealth underlying all economic activity and well-being comprises three types of assets: human, produced and natural capital (Dasgupta 2009; Arrow *et al.* 2012; Managi and Kumar 2018; Barbier 2019). According to the capital approach, viewing these three forms of capital as the real wealth of an economy is important for determining sustainable development, which requires that the per capita welfare of an economy does not decline over time (Dasgupta 2009; Arrow *et al.* 2012; Barbier 2019). In effect, one can think of progress towards the 17 SDGs, such as the net SDG welfare impact of this chapter, as an approximate measure of this goal. That is, economies displaying a positive gain in per capita net welfare benefit from making progress towards the 17 SDGs may be on a more sustainable development path.

However, there could be a problem for economies that are experiencing rapid declines in their natural capital, regardless of whether or not their net SDG welfare impact is positive. Unlike human and produced capital that can be built up by investment activity over time, an economy's endowment of natural resources tends to be depleted more quickly than it is replenished naturally or through direct human efforts. As a consequence, while produced and human capital may increase over time, natural capital typically declines. It follows that, for economies experiencing significant depreciation in natural capital, attaining the sustainability criterion of non-declining per capita welfare may be at risk. High rates of natural capital depletion may undermine long-term progress towards the SDGs, as poorer economies may have difficulty in accumulating sufficient human and produced capital to keep their overall IW from declining.

Consequently, in addition to determining the net SDG welfare impact from 2000 to 2019 for the 80 EMDEs, it is important to know the extent to which any such progress towards the 17 SDGs is accompanied by changes in their natural capital stocks. This chapter considers two measures: the average rate of natural resources depletion from 2000 to 2019, and the change in natural capital per person from 2000 to 2014.

The World Bank's rate of natural resources depletion is expressed as a percentage share of the gross national income (GNI) of an economy[31]. This indicator measures how much natural capital is 'used up' in producing GNI in a given year. It is an attempt to measure the depreciation, in value terms, of key, mainly marketed natural resources used in production. Thus, the World Bank's measure of natural resources depletion is the sum of net forest depletion, energy depletion and mineral depletion. Net forest depletion is unit resource rents times the excess of roundwood harvest over natural growth. Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime (capped at 25 years). It covers coal, crude oil and natural gas. Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime (capped at 25 years). It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite and phosphate. Averaged from 2000 to 2019, the rate of natural resources depletion gives an indication of how quickly an economy is depleting its key natural resources relative to the GNI produced each year over this period.

A second measure is natural capital per capita, which is estimated from 1990 to 2014 for 140 countries in the IWR 2018 (Managi and Kumar 2018). In the IWR 2018, natural capital consists of fossil fuels (oil, gas and coal), minerals (bauxite, copper, gold, iron, lead, nickel, phosphorous, silver, tin and zinc), forest resources (timber and non-timber), agricultural land (cropland and pastureland) and fisheries. Natural capital per capita indicates how much natural capital is available for assisting production and supporting livelihoods for each individual in an economy in a given year. Thus, the change in natural capital per capita from 2000 to 2014 is a direct measure of how much of this natural wealth per person has been depleted over this period to support economic activity.

31 The source of this indicator is the World Bank's World Development Indictors https://databank.worldbank.org/source/world-development-indicators.

Table A3.1 in Appendix 3 lists the average rate of natural resources depletion from 2000 to 2019, and the change in natural capital per capita from 2000 to 2014 for each of the 80 EMDEs. Table 3.2 compares these two measures with the SDG 1 welfare impact, the net SDG welfare impact and the net environmental impact for all 80 EMDEs, the 13 low-income economies, the 36 lower middle-income economies and the 31 upper middle-income economies.

Table 3.2: Summary of poverty, SDG welfare, environmental and natural capital impacts

Income Group	SDG 1 welfare impact $/capita 2000-2019	Net SDG welfare impact $/capita 2000-2019	Net environmental impact $/capita 2000-2019	Average natural resource depletion (% of GNI) 2000-2019	Natural capital change $103/ capita 2000-2014
Low Income	128	1,561	-864	6.4	-2.7
Lower Middle	633	1,141	-3,417	4.0	-4.2
Upper Middle	2,854	3,410	-2,388	3.0	-12.3
All	1,412	2,089	-2,603	4.0	-7.1

Notes: All refers to the average of all 80 emerging market and developing countries listed in Table A3.1 in Appendix 3, Upper Middle comprises the average of the 31 upper middle-income economies, Lower Middle the average of 38 lower middle-income economies and Low Income the average of 13 low-income countries.

Among the 80 EMDEs, poorer countries display the highest rates of natural resource depletion (see Table 3.2). From 2000 to 2019 average natural resource depletion as a share of GNI was 6.4 per cent in low-income economies, 4 per cent in lower middle-income economies and 3 per cent in upper middle-income economies. Across all 80 EMDEs, the average was 4 per cent.

In comparison, upper middle-income economies experienced the largest declines in natural capital from 2000 to 2014 of USD 12,300 per person (see Table 3.2). Lower middle-income economies had decreases of USD 4,200 per capita and low-income economies of USD 2,700 per person. On average across all 80 EMDEs, natural capital fell by USD 7,100 from 2000 to 2014.

In sum, large declines in natural capital per capita and high rates of natural resource depletion should be a concern for many EMDEs. The substantial rate of natural capital depreciation in low-income economies is especially worrisome, given that many of them depend significantly on natural resources for development and have scarce human and produced capital. But it is also disconcerting that many EMDEs that appear to have a positive net SDG welfare impact from 2000 to 2019, including gains in attaining SDG 1 No Poverty, have done so through substantial natural capital loss. However, there is another concern. The two measures of natural capital used in this chapter are likely to considerably underestimate the depreciation of natural capital, as they do not include any changes in ecological capital, such as marine and terrestrial ecosystem loss and damages, nor other significant environmental impacts.

The above analysis clearly shows that net environmental impacts were pervasive and significant from 2000 to 2019 across most of the 80 EMDEs). Thus, any progress towards the SDGs in the two decades leading up to the 2020-21 COVID-19 pandemic has come largely at the expense of natural capital—especially ecological capital—and the environment.

Implications for post-pandemic policies

As EMDEs recover from the health and economic crises of the COVID-19 pandemic, they face two challenges. First, as this chapter has emphasized, their long-term progress towards the SDGs will hinge on improved management of natural capital and the environment. Second, in the short to medium term, these economies must cope with increasing fiscal constraints, rising debt and considerable economic uncertainty.

EMDEs face significant economic challenges. Rising public debt, slow growth and inflationary pressures have increasingly restricted the ability of many governments to spend on long-term recovery (IMF 2021; World Bank 2022). During the pandemic, key development objectives, such as poverty alleviation, decarbonization and structural transformation, have been put on hold. Both the slow economic recovery from the pandemic and the increased public spending and debt, forced by the need to adopt emergency health and economic measures, have severely limited the fiscal space of EMDEs to adopt long-term policies, pricing reforms and investments to 'green' their recoveries from the pandemic.

These unique challenges require EMDEs to formulate a post-pandemic strategy that translates into immediate sustainability and development progress. Given likely fiscal and spending constraints, it is also critical that EMDEs find innovative policy mechanisms to achieve sustainability and development aims in a cost-effective manner. Such strategies require identifying policies that can yield immediate progress towards several SDGs together, rather than sacrificing some goals to achieve others, and aligning economic incentives for longer term sustainable development (Barbier and Burgess 2020). Policies should also raise or save revenue, generate the necessary funding for any additional investments and have a proven track record.

A range of innovative policies meet these criteria. These include 'subsidy swaps', investment in natural capital, social protection and safety nets, sustainable intensification in agriculture and job and skills training (Barbier 2020). Given the priority for impactful policies that create synergies with other SDGs, there are three major policies that EMDEs can adopt immediately to achieve these objectives without significant additional financial support from the international community, or increasing fiscal burdens.

First, fossil fuel subsidy swap is a proven strategy that could be implemented relatively easily in EMDEs, whereby the savings from a partial and limited reform of coal, oil and natural gas consumption subsidies are allocated to fund clean energy investments (Bridle *et al.* 2019; Barbier and Burgess 2020; Sanchez, Wooders and Bechauf 2020). As argued by the International Energy Agency (IEA) (2021), the post-pandemic recovery period is an ideal time to reduce fossil fuel subsidies, as continuation of these subsidies contributes to excessive use, pollution, illnesses and deaths, and in EMDEs they remain a serious roadblock to adoption of clean energy. For example, a 10–30 per cent subsidy swap from fossil fuel consumption to investments in energy efficiency and renewable energy electricity generation could 'tip the balance' between fossil fuels and cleaner sources of energy (Bridle *et al.* 2019). A study of 26 countries, which includes many EMDEs, finds that such a policy could substantially reduce greenhouse gas emissions by 2030 (Global Subsidy Initiative [GSI] 2019).

A fossil fuel subsidy swap could also be used to facilitate greater dissemination and adoption of renewable energy and improved energy efficiency technologies in rural areas. A number of different programs in EMDEs worldwide have already achieved this (Pahle, Pachauri and Steinbacher 2016; Suriyankietkaew and Nimsai 2021; Zaman *et al.* 2021). One possibility is the expansion of solar energy 'safety nets', aimed especially at the millions of poor rural households that live in remote areas and are still without access to energy (Zaman *et al.* 2021). These are targeted social assistance programs to provide solar power as an off-grid solution and solve lack of access to energy for poor rural households in remote locations. Off-grid solar energy not only improves livelihoods and welfare, but could also improve the resilience of the rural poor to adverse environmental and economic shocks, including the ongoing COVID-19 pandemic and similar outbreaks. Both Bangladesh and India have piloted such schemes, which provide clean energy access to remote rural households through free distribution of solar home systems and solar lamps (Zaman *et al.* 2021).

A fossil fuel subsidy swap to support energy efficiency and renewable energy in rural areas would also have important equity gains. In EMDEs, mainly wealthier, urban households benefit from fossil fuel consumption subsidies, whereas rural households increasingly comprise the extreme poor (Castañeda *et al.* 2018). Across 20 EMDEs, the poorest fifth of the population received on average just 7 per cent of the overall benefit of fossil fuel subsidies, whereas the richest fifth gained almost 43 per cent (Arze del Granado *et al.* 2012).

A second policy is a tropical carbon tax (Barbier *et al.* 2020). This is a levy placed on fossil fuel imports and consumption in tropical countries, with some of the proceeds allocated to increase investments in natural climate solutions, aimed at mitigating carbon emissions and conserving, restoring and improving land management to protect biodiversity and ecosystem services. Natural climate solutions are a relatively inexpensive way of reducing tropical land use change, which is a major source of greenhouse gas emissions. For example, cost-effective tropical natural climate solutions can mitigate 6,560 106 tonnes of CO_{2e} in the coming decades at less than USD 100 per 103 tonnes of CO_{2e}, which is about one quarter of emissions from all tropical countries (Griscom *et al.* 2020).

Such a policy already exists in Costa Rica and Colombia – two countries that have reduced net environmental impacts from 2000 to 2019 (see Table A3.1 in Appendix 3). For example, Colombia's policy amounts to an effective carbon tax of USD 5 per tCO_2 on all fossil fuels. It yielded revenues of USD 148 million in 2017 and USD 91 million in 2018, of which 25 per cent is used to manage coastal erosion, reduce and monitor deforestation, conserve water sources, protect strategic ecosystems and combat climate change. A further five per cent of the revenues is allocated to strengthen Colombia's national system of protected areas. In Costa Rica, the policy also funds a payment for ecosystem services scheme targeted to districts with high levels of poverty, and it assists smallholder farmers and indigenous peoples in submitting requests for funds. Around 40 per cent of beneficiaries in Costa Rica are communities that live below the poverty line (Barbier *et al.* 2020).

If 12 other major tropical EMDEs adopt a policy similar to Colombia's, they could raise USD 1.8 billion each year between them to invest in natural habitats that benefit the climate (Barbier *et al.* 2020). A more ambitious policy of taxation and revenue allocation could yield nearly USD 13 billion each year for natural climate solutions.

But such a policy does not have to be confined to tropical countries. EMDEs in more temperate regions can also adopt a similar policy. For example, for the EMDEs in Europe and Central Asia, two important priorities are landscape protection and restoration, especially in ecological fragile mountain zones, and nature-based solutions to reduce disaster and climate risks, especially from floods and droughts (Agostini and Kull 2020; Baeumler, Kerblat and Ionascu 2021; Lvovsky and Abate 2021). Such investments also have the potential to improve rural livelihoods through boosting employment and income opportunities, reducing health risks and enhancing beneficial ecosystem services, such as watershed protection, control of flooding and prevention of land degradation and topsoil loss. Both priorities could be easily funded in the same way that Costa Rica and Colombia have done; by placing a small carbon levy on fossil fuel imports and consumption, with some of the proceeds allocated to increase investments in protecting and restoring mountain landscapes, and in nature-based solutions.

A third policy is improved management and distribution of resource revenues. Investing the savings of resource revenues is considered critical to the long-term sustainability and development success of EMDEs with abundant natural capital (Venables 2016; Barbier 2019; Barbier 2020; Lashitew *et al.* 2021). Equally important is developing a sound fiscal strategy for managing resource revenues, as fluctuations in these revenues often translate directly into changes in public spending and capital investments (Basdevant, Hooley and Imamoglu 2021). Volatility of resource revenues, especially through commodity price 'booms' and 'busts', may also undermine the economy and public sector priorities through impacting the financial sector of resource-rich economies. Such commodity price shocks often lead to financial sector fragility, and sometimes even instigate crises, by affecting credit and loans, lowering bank liquidity and reducing bank profits. These effects can in turn lead to lower growth rates, government revenue and savings, while increasing unemployment, debt in foreign currency and fiscal deficits (Kinda, Mlachila and Ouedraogo 2016; Mlachila and Ouedraogo 2017).

Especially in EMDEs facing fiscal constraints and rising debt due to the COVID-19 pandemic, such impacts can seriously undermine the ability of a country with abundant natural capital to adopt a post-pandemic green recovery strategy. To avoid this, improved fiscal management of resource revenues needs to be included as an additional element of such a strategy. A key aim would be to shield or delink green recovery public spending and investments from volatility in resource revenues through ensuring that there are sufficient revenues for these priorities during periods of commodity price 'busts', while saving revenue during price 'booms' for the future expenditures need in the later stages of the recovery (Basdevant, Hooley and Imamoglu 2021).

In addition, economies might consider additional policy actions to improve more equitable distribution of resource revenues. One ambitious and novel distributional policy is oil for cash (Moss, Lambert and Majerowicz 2015). This involves redistributing any windfall resource revenues directly to the general population through a regular, universal and rules-based cash payment. Implementing this policy requires creating a separate fund to receive windfall revenues, establishing allocation rules for dividing revenue income between the public budget and the dividend payments, and formulating clear rules for paying universal, regular and transparent dividends directly to citizens. The American state of Alaska and the Canadian province of Alberta already have such a redistribution scheme for their resource revenues, and some EMDEs, notably Mexico and Brazil, have been experimenting with cash transfer payments to households.

Conclusion

The evidence presented in this chapter suggests that, for the vast majority of EMDEs, progress since 2000 towards the 17 SDGs of UN Agenda 2030 has come largely at the expense of natural capital and the environment.

On average, all 80 EMDEs and income groups analysed had a positive net SDG welfare impact from 2000 to 2019. But these SDG welfare gains were often accompanied by adverse environmental impacts and natural capital depletion. Many of the largest per capita losses during this period occurred from the failure to make progress towards the five environmental goals, SDGs 11–15. These per capita environmental losses were largest, on average, for upper middle-income economies, followed by lower middle-income economies and then low-income economies. Declines in natural capital per capita were also larger for middle-income, as opposed to low-income economies. However, the rate of natural resource depletion from 2000 to 2019 was highest among low-income economies, followed by lower middle-income economies and then upper middle-income economies.

These results suggest that global development from 2000 to 2019 has led to substantial welfare losses from environmental damages and significant natural capital depletion for many EMDES, which has been especially critical for low-income countries. Long-term progress towards the SDGs will require improved management of natural capital and the environment in these economies, by identifying and implementing policies that can yield immediate progress towards several SDGs together, rather than sacrificing some goals to achieve others. Although a range of policies can achieve this objective, this chapter has suggested three that can do so without significant international financing or imposing additional fiscal burdens: fossil fuel subsidy swaps, tropical carbon taxes and improved management and distribution of resource revenues.

Lastly, as this chapter has shown, concerns over the environmental sustainability of the current pattern of global development are fully justified. The substantial welfare losses from environmental damages and natural capital depletion for many EMDEs is bad not only for the welfare of their populations but also for the planet. Currently, there are four global environmental risks that need urgent attention: climate change, land degradation and biodiversity loss, deteriorating oceans and costs and rising freshwater scarcity.

Cooperation on tackling these problems will require all economies, including EMDEs, to address the under-pricing of nature, foster collective action and promote inclusive and sustainable development (Dasgupta 2021; Barbier 2022). Long-term progress towards the SDGs in EMDEs will require the implementation of a comprehensive policy strategy to improve management of natural capital and the environment, aided by financial and technical support by the international community.

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04 Natural capital and inequality

Introduction

Human societies throughout the world are facing increasing and multi-faceted threats, from the climate and biodiversity crises to rising inequalities between the rich and poor. Environmental crises and wealth inequality are often regarded as separate problems with different drivers. However, there are close and important interlinkages between the two that countries must address to ensure the well-being of current and future generations.

Research shows that inequality in its many forms may be at least partially driven and exacerbated by the systemic under-pricing of natural capital. Barbier (2015) noted that for many current global problems associated with the imbalance of assets, a key underlying feature is the under-pricing and undervaluing of natural capital[32], leading to its rapid depletion and degradation. When the rate of return on capital exceeds the rate of economic growth in the long term, unequal distribution results in a concentration of wealth in the hands of a few and leads to economic instability (Piketty 2015). This encourages wealth inequalities, particularly in many natural resource-abundant countries, and acutely affects the most impoverished communities in the world, particularly women and girls. A wealth-based framework that is inclusive of natural capital can help to minimize the effect of economic growth on environmental degradation, by acknowledging environmental assets as imperative for economic activity and sustainable development.

The demands for natural resources arise externally in resource-rich, low- to lower-middle-income countries. To increase their participation in global value chains, resource-rich and particularly, rural areas of these countries are forced by market pressure to use and deplete their natural capital at a much faster rate than can be supported by their institutional capacity and natural renewal rates. As a result, these countries often bear the disproportionate negative externalities of an accelerated rate of natural resource consumption and overexploitation. The livelihoods of populations in these countries depend primarily and often directly upon forests and environmental resources. Hence, ensuring their access to natural resources and associated ecosystem services has tremendous implications for reducing multidimensional poverty and inequality (Angelsen *et al.* 2014).

With the SDGs, countries have committed to pursuing economic growth that is both inclusive and sustainable. SDG 8 (Decent Work and Economic Growth) can be addressed by following the framework for Inclusive Wealth, which aims for efficient global resource management through progressive and sustainable ways of contributing to comprehensive economic growth. All categories of capital improvement in the Inclusive Wealth framework correspond with the SDG 8 objective, as well as having strong interlinkages with other SDG goals, whether they be related to environment, infrastructure, health or social justice. Utilizing the IWI as a key indicator of economic progress provides a holistic analytic framework for understanding some important trade-offs in pursuit of SDG objectives and targets (Dasgupta *et al.* 2015; Managi 2016; Managi 2019; Dasgupta *et al.* 2021). Tracking IW helps a nation achieve inclusive economic growth with decent employment for all, whilst guiding divestment in economic activities that result in environmental degradation and biodiversity loss.

32 The Natural Capital Committee (2014) defines natural capital as composites of nature's elements that directly or indirectly create value to people, all ecosystems, biodiversity and species and all-natural processes and functions.

This chapter provides some analytic foundations from which a focus upon institutionalising inequality of natural capital and income might be mainstreamed to contribute to sustainable development strategies. SDG target 8.4 urges developed countries to take the lead in adapting to sustainable economic growth and jobs. This chapter analyses the natural capital of countries to understand how natural capital and inequality interlace. Countries have committed to pursuing economic growth that is both inclusive and sustainable. The analysis here considers several inequality measures in relation to a detailed natural capital database to understand the relationship between natural capital and inequality.

This chapter analyses the nexus between natural capital and inequality, and investigates whether the inclusion of natural capital in the wealth accounts of nations significantly affects existing wealth inequality estimates. The relationship between inequality and natural capital is deduced by utilizing data from the Inequality-adjusted Human Development Index, inequality in income statistics, data on the loss in the HDI due to inequality, the Gini Index and the updated database on natural capital. In summary, this work provides an analytic foundation for policymakers to holistically address questions of inequality within and across countries over time.

The chapter begins with the methodological background for measuring the natural capital of nations. This is followed by a brief overview of inequality, its linkages with natural capital, and implications for the post- COVID-19 recovery. Commonly used inequality metrics are then discussed and assessed for whether they integrate or acknowledge natural capital in their measurement. The next section provides an empirical analysis of the relationship between natural capital and inequality. The chapter concludes with remarks on the key findings and their policy implications.

Measuring natural capital

This report considers both non-renewable resources (fossil fuels and minerals) and renewable resources (agricultural land, forests and fisheries) as natural capital. According to the latest reserve estimation, the inventory change for non-renewable resources is the negative of the amount consumed (withdrawn) during the period. The shadow price of this capital is assumed as their rent value, as it is assumed that the value of the resource is completely external and depends on resource use. Renewable resources are calculated at their market and non-market value. Consistent with the IWR 2014, the ecosystem services values of forests are updated based on the Ecosystem Services Assessment Database (Van der Ploeg and de Groot 2010). Consistent with the IWR 2018, fishery capital stock are estimated as part of renewable natural capital. To simplify evaluation of fishery resources, it is assumed that fish stocks belong to countries where harvesting occurs.

Fossil fuels

The account scope for fossil fuels is coal, natural gas and oil. It starts from the current stock for a given resource, and counts backwards to past stocks and yearly production. This approach enables a consistent time-series dataset to be constructed that reflects a more recent accurate flow (extraction) variable. The corresponding stock in the study is in year $t-1$, $S(t-1)$ is derived from the production, $P(t)$ and the stock in year t, $S(t)$ by

$$S(t-1) = S(t) + P(t) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The shadow price of a non-renewable resource, p_S is the price net of extraction cost, often called rental price. Moreover, the marginal cost of extraction should be used for the corresponding remaining stock, but it is challenging to obtain. So, instead, it is assumed that the rental rate of the total price is constant (Narayanan *et al.* 2012).

Metals and minerals

Accounting for minerals follows the same methodology as for fossil fuels, the other form of non-renewable resource. For rental rates, sectoral rental rates of different mineral industries were retrieved from Narayanan (2012). The remaining data on reserves, extraction and prices were acquired from the United States of America Geological Survey (2015) dataset.

Agricultural land

Agricultural land is classified into cropland and pastureland. The methodology for accounting is applied to both classifications. The permanent cropland/pastureland area data was obtained from FAO (2015). Given that there is no market price for agricultural land, the shadow price of one unit of agricultural land is computed by the net present value of the annual flow of services per hectare that the parcel yields, in line with World Bank (2011) and past editions of the IWR. Specifically, rental price per hectare of cropland for country i in year t can be expressed as:

$$RPA_{it} = \left(\frac{1}{A}\right)\sum_{k=1}^{N} R_{ik}P_{itk}Q_{itk} \dots\dots\dots\dots\dots\dots (2)$$

A, R, P and Q are the harvested area in crops, rental rate, crop price and crop quantity produced, respectively. N stands for the number of crops, up to 159 ($k = 1, \dots, 159$) in the current study, and t is the year of analysis, from 1990 to 2014. To estimate the rental rate by crop group, FAO crop classification (HS) was mapped with the sectoral rental rates provided by Narayanan *et al.* (2012).

Note that the above rental price corresponds to an annual flow of services – it needs to be capitalized to employ it as the shadow price. Formally, the NPV of this rental price for country i in year t is written as:

$$p_{Ait} = \sum_{\tau=0}^{\infty} \frac{RPA_{it}}{(1+r)^{\tau}} = \frac{1+r}{r} RPA_{it} \dots\dots\dots\dots\dots\dots (3)$$

Discount rate *r* is set at 5 per cent per annum. Finally, to avoid unnecessary volatility in the social value of natural capital, year average of this price is taken for country i:

$$\overline{p_{Ai}} = \frac{1}{25}\sum_{t=1990}^{2014} p_{Ait} \dots\dots\dots\dots\dots\dots (4)$$

which is used as the shadow price of cropland.

The pastureland wealth calculation differs from cropland wealth because it is challenging to associate rents to the size of the land involved in the production process. Thus, the shadow price of pastureland was assumed equal to cropland, which is a limitation of the current accounting.

Forest

Current forest accounting follows the IWR 2014 methodology. Thus, the forest wealth is composed of timber value and non-timber forest benefits (NTFB).

Timber. The volume of timber resources commercially available is estimated. The total forest area, excluding cultivated forest, is multiplied by timber density per area and the percentage of total volume commercially available to quantify timber capital. The activity of cultivating forest is categorized as a production activity in the SNA. The exclusion of cultivated forest could be debated, as it contributes to timber and non-timber values. The cultivated forest is registered under produced capital in IWR 2014 and IWR 2017 to align with the above reasoning.

The computation of shadow prices follows IWR 2014 using the following five steps: i) the World Bank's (2006) method is followed to adopt a weighted average price of two different commodities—industrial round wood and fuelwood—and country-specific parameters. The weight attached to the different prices is based on the quantity of the commodity manufactured. In contrast, industrial round wood and fuelwood prices are obtained from the quantity produced and exported value; ii) the annual estimated values are converted from current to constant prices by using each country-specific GDP deflator; iii) Estimates by Bolt *et al.* (2002) on the regional rental rates for timber are used, and assumed to be constant over time; iv) the average price over the entire study period (1990 to 2014) is estimated, thereby obtaining the proxy value for the shadow price of timber; and v) timber value wealth is calculated by the quantity of timber, price and average rental rate over time.

Non-timber forest benefits. Forest capital yields many ecosystem services in addition to provisioning services in the form of timber production. Following the IWR 2014, these non-timber forest benefits are accounted for in the following manner: i) the country's total forest area under analysis, excluding cultivated forest, is retrieved from FAO (2015), denoting Q (ha); ii) the fraction individuals' access to the total forest area to obtain benefits is assumed to be γ. The ecological literature has stressed that only the portion of the forest contributing to well-being should be accounted for. For better assumptions, γ is assumed to be 10 per cent, following World Bank (2006); iii) the unit benefit of the non-timber forest resource to intertemporal social well-being is taken from the Ecosystem Service Valuation Database (ESVD) and the van der Ploeg and de Groot (2010) database. This is denoted by P (USD/ha/year). The average value per hectare should be different for temperate, boreal and tropical forests. Accordingly, the corresponding values are weighted by the share of each forest type in the country's total forest; and iv) to make this benefit into capital asset value, its net present value is taken, using the discount rate of r=5%. In short, the value of non-timber forest wealth is calculated as

$$\sum_{\tau=t}^{\infty}\frac{PQ_{\tau}\gamma}{(1+r)^{\tau-t}}=\frac{1+r}{r}PQ\gamma \dots\dots\dots\dots\dots\dots (5)$$

Fisheries

Fish capital stock is estimated as part of renewable natural capital. Relative to other natural capital classes, the estimation process of the fish stock is challenging. Unlike forest or agricultural land, for which computation is based on the area, the fish stock cannot be estimated on the habitat area. This is compounded by the mobility of the resource. In the current exercise, these challenges are solved by assuming that the fish stock belongs to the country where harvest occurs and the resource is loaded. The shortcoming of this assumption is illustrated as follows: if fishery biomass is loaded to country A, this does not necessarily mean that the fishery biomass belongs to country A. However, there is no sound alternative theory to allocate harvest to countries.

In renewable resource economics, there is a long tradition of assuming resource dynamics. The stock is the population growth net of harvest:

$$\frac{dS_t}{dt}=G(S_t)-H_t \dots\dots\dots\dots\dots\dots (6)$$

S_t denotes the renewable resource biomass stock; $G(S_t)$ is the growth function; H_t is the harvest. Population, whether it is a renewable resource or human being, is often assumed to follow a logistic growth function:

$$G(S_t)=rS_t\left(1-\frac{S_t}{k}\right) \dots\dots\dots\dots\dots\dots (7)$$

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

$$H_t = qE_tS_t \dots\dots\dots\dots\dots\dots (8)$$

where q is the catchability coefficient. E_t stands for the effort put in the production process, which is often proxied by the number of vessels or fishermen working hours. These two equations are combined to arrive at a well-known Gordon-Schaeffer model:

$$\frac{dS_t}{dt} = rS_t\left(1 - \frac{S_t}{k}\right) - qE_tS_t \dots\dots\dots\dots\dots\dots (9)$$

Either harvest function (1), or total resource dynamics (2) are used to estimate the fishery stock, S_t, t. Global fish stocks are commonly assessed by examining the trend in catch or harvest data. However, this catch-based assessment method has attracted much criticism (see for instance Daan *et al.* (2011)), either due to its technical or conceptual flaws. However, it is still considered the most reliable method for assessing fish stock (Froese *et al.* 2012; Kleisner *et al.* 2013), as the only data available for most fisheries is the weight of fish caught each year (Pauly *et al.* 2013). If effort and harvest data are known, and catchability coefficient q, then S_t can be estimated solely from the Schaefer production function.

However, given that there is limited global effort data, this method cannot be applied for IW accounting globally. Instead, the resource dynamics are used. However, there is no reliable data on r and k for most fish stocks. To overcome this constraint, Martell and Froese (2013) are followed and their algorithm applied to randomly generate feasible pairs (r, k) from a uniform distribution function. The likelihood of the generated (r, k) pairs is further evaluated using the Bernoulli distribution, which ensures that the estimated stock has never collapsed or exceeded the carrying capacity. Thus, the final stock lies within the assumed range of depletion.

In a case where the values of (r, k) are not obtainable, the stocks are simply estimated according to the following rules: i) if the year under study is after the year of maximum catch, then the biomass stock is estimated as twice the catch; otherwise; and ii) the biomass stock is estimated as twice the maximum catch, net of catch (2 x Maximum Catch – Catch).

Time series data of catch (tonnage and value) of each country's economic exclusive zone from 1950 to 2010 are obtained from the Sea Around Us Project (SAUP 2016). Stock are only evaluated if they satisfy the following requirements: i) a catch record of at least 20 years; and ii) a total catch of at least 1000 tons in a given area over the study period.

The natural capital and inequality nexus

Inequality is the state of not being equal, especially in status, rights and opportunities, and can occur within and among countries. Inequalities can be multidimensional and variable based on context, and include access to nature and natural capital. Analyses of inequality can inform solutions to reduce its prevalence and impact on society. The 'build back better' imperative of the post COVID-19 recovery is a strategy that aims to reduce the risks of future shocks and disasters for societies, and is closely linked to the reduction of inequalities, specifically gender and wealth inequalities.

Inequality is multidimensional and therefore not only observable through wealth and income measures. Inequality of all types are often bidirectionally linked to environmental decline and uneven access to natural capital. For example, poverty and income inequality are partially driven by the exclusion of natural capital from national accounts, and empirical studies have shown that income and wealth inequalities degrade natural resources due to over-exploitation. Although these kinds of bidirectionality are important, explicitly studying the ways in which inequality drives natural resource exploitation is beyond the scope of this chapter.

Climate change is both a direct and indirect amplifier of existing inequalities, as it directly threatens resilience, and contributes to the destabilisation of other planetary boundaries (e.g. ocean currents, biodiversity). Low-income countries are relatively more directly exposed to ecosystem degradation and biodiversity loss and experience greater negative impacts than higher-income countries. This is largely due to generally lower levels of infrastructural capacity to respond to, and endure, such threats. The increasing frequency and severity of climate-related events are likely to affect least-developed countries most acutely, further exacerbating inequalities within and among countries. Moreover, the impacts of climate change exacerbate gender inequalities, as women constitute 80 per cent of those displaced by climate change (UNDP 2016).

Natural capital is a significant and critical component of the productive base of an economy. However, natural capital differs from human capital or produced capital and operates according to its own complex laws and systems, involving, for example, elements of non-linearity, tipping points and non-substitutability. Renewable natural resources are generally regarded as sustainable, as they replenish naturally over time, whereas non-renewable resources are effectively irreplaceable, as their regeneration rates far exceed those considered in economic analysis. Multiple anthropogenic drivers put pressures on natural capital, such as population growth and the unprecedented rising demand for food, housing and transport. These compounding stressors placed on ecosystems and the assets and services they provide are expected to only increase in coming decades, greatly impacting the benefits to human society derived from natural capital. Protecting and improving remaining stocks of natural capital will, therefore, become even more critical for securing a sustainable and prosperous future for human societies.

The remaining section focuses on the current understanding of natural capital, wealth and income inequality, specifically reviewing previous studies on income and wealth inequality and how these interlink with natural capital.

Natural capital, inequality and economic growth

Natural capital and within-country inequality. Limited research has been conducted to show a causal relationship between the natural capital wealth of countries, and income and wealth inequality within those countries (Hamann *et al.* 2018). However, researchers and economists have argued that resource-abundance in countries exacerbates income inequality and slows the process of human capital development (Leamer *et al.* 1999; Fischer 2001; Carmignani 2013; Barbier 2019). For example, a study by Leamer *et al.* (1999) compared the economic growth experience of Latin America and East Asia, and demonstrated that, based on standard trade theory and cross-sectional empirical analysis, countries that are rich in natural resources fall behind in human capital development, leading to higher income inequality. For a more detailed analysis on human capital and inequality, please refer to Annex 2 in the IWR 2023 Annexure.

Natural capital and economic growth. 'Dutch Disease' is the concept that natural resource exports reduce the competitiveness of other exporting sectors, due to an increase in exchange rates (Sachs and Warner 1995). The term originated in 1977, where it was used to describe the impact of the large Groningen natural gas field on the Netherland's manufacturing sector (The Economist 1977). Gelb (1988), Auty (1990) and Gylfason *et al.* (1999) observed similar outcomes when analysing the economic growth experience of resource-rich countries post-World War II. However, Sachs and Warner (2001) argued that most resource-abundant countries experienced slowed or stagnated post-1970s, with slower growth rates than countries relatively poorer in natural resources. They used the term 'curse of natural resources' to describe this phenomenon (Auty 1993).

Consequences of excluding natural capital from national accounts. The rapid global economic growth and expansion of the last 70 years has been at the expense of biodiversity, climate stability and the health of natural ecosystems (Dasgupta 2021). Systemic under-pricing of natural capital has led to its overexploitation, and has further exacerbated structural imbalances in the global economy (Barbier 2019; Castello and Domenech 2002). The demand for natural resources is rapidly surpassing nature's capacity to supply and renew them; it is estimated that approximately 1.6 Earths are required to maintain current patterns of production and consumption. Nations and policymakers must dramatically alter the current trajectory of wealth accumulation at the expense of natural resources degradation, and the inequality exacerbating exploitation of labour. Action must be taken to ensure the rate of extraction and utilisation of ecosystems remains well within the range of their regenerative capacity; otherwise humanity risks their depletion beyond the point of recovery (Dasgupta 2021).

Income generated from wealth distribution is higher than income generated from labour distribution, due to the comparatively higher rate of return on wealth, than income (Piketty 2014). Numerous notable economists concur with Piketty's wealth inequality theory, though others critiqued his methodology (Rowthorn 2014; Solow 2014; Martins 2015; Harvey 2016). Rowthorn (2014), for example, notes that the constant rate of return assumed for all types of wealth ignores the fact that the wealth capitals that fluctuate with time and events, such as real estate, natural resources and oil. Furthermore, there is ongoing debate among theoretical economists around whether to conceptualise wealth and capital as stocks or flows. Harvey (2016) argues that Piketty's argument rests on a mistaken definition of capital, and that rather than being a 'thing', it is a process. This process is the circulation of money to make more money, often, but not exclusively, through the exploitation of labour power.

The Dasgupta Review: The Economics of Biodiversity discusses the link between rural poverty and degradation of local ecosystems. The review notes that poverty assessments, and discussions around inequality, often do not consider the important role of the biosphere, despite evidence that ecosystem services can significantly contribute to poverty alleviation (Dasgupta 2021). Poorer rural communities frequently experience the impacts of environmental decline most directly and acutely, due to the extent to which they depend directly on their services. It is estimated that ecosystem services and other non-marketed goods comprise between 50 per cent and 90 per cent of the total source of livelihoods among rural and forest-dwelling poor households – also termed the 'GDP of the poor' (TEEB 2010). This contrasts starkly with GDP estimates that globally, only around 4 per cent of countries outputs are accounted for by agriculture, forestry and fisheries (World Bank 2020).

Natural disasters and extreme shocks can exacerbate existing inequalities, reduce human capital, and result in an initial reduction in natural capital due to ecosystem degradation. The link between direct dependence on natural capital and inequalities is especially evident during natural disasters and extreme shocks, which most acutely affect lower-income communities – in both urban and rural settlements (Cutter 2006). For example, the increased prevalence of wildfires can directly impact community access to the wildlife they depend on for their livelihoods (Gustine *et al.* 2014; Hamaan *et al.* 2018; Laterra *et al.* 2018). In the unprecedented 2005 Mumbai floods, the losses experience by poorer people experienced were an estimated 60 per cent greater than their wealthier neighbours (Hallegatte *et al.* 2017). The severity of the impacts of natural disasters is frequently linked to the level of degradation of local ecosystems, which results in a reinforcing feedback loop of vulnerability in affected communities. For example, pastoralists are less able to withstand droughts if rangeland is already degraded, and mudslides and landslides are often driven and exacerbated by upstream deforestation and land-use change that result in land instability.

During the recovery phase, short-term job creation as part of the rebuilding process following natural disasters and extreme shocks can temporarily increase individual household income (Abdullah *et al.* 2016; Feng *et al.* 2016; Keerthiratne and Tol 2018). This would be accounted for in a nation's GDP. However, socioeconomic disparity following such events is generally exacerbated. For example, children may lose access to education as they leave school to help the household recover, access to safe drinking water may be compromised if water is contaminated by flooding (resulting in myriad risks to health), and housing and roads are less resilient in poorer communities. These impacts of natural disasters and extreme shocks on human and natural capital are not captured in traditional economic measures like GDP.

However, investing in human well-being by building human capabilities is of critical importance to SDG 1, (Eliminating Poverty), SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation) and SDG 10 (Reducing Inequalities). Breaking cycles of intergenerational poverty and deprivation remain critical elements for sustainability and resilience (Global Sustainable Development Report [GSDR] 2019).

Within economic theory, ecosystems can be conceptualised as capital assets that can yield a more than 19 per cent rate of return (Dasgupta 2021). In this framework, the conservation and restoration of degraded forests, land, wetlands and peatlands can increase the natural asset portfolio, protect against future natural shocks, create jobs for local communities and enhance income for households. The Payment for Ecosystem Services approach is one policy that can harness such benefits (see Box 4.1).

Box 4.1: Payment for Ecosystem Services and its potential for addressing inequality

Payment for Ecosystem Services is an approach to financing nature conservation that rewards providers of ecosystem services (i.e. private landholders) through subsidies or market payments. Payment for Ecosystem Services can compensate individuals for restoring forest land, refraining from fishing for a period of time to allow regeneration, or protecting certain areas of grasslands and wetlands (UNEP *et al.* 2008). These programmes have tremendous potential to alleviate poverty and reduce inequality, as well as improve rural areas and lifestyles. Many Payment for Ecosystem Services successes are articulated in terms of total economic benefits and avoided costs.

However, an evaluative study of The Sloping Land Conversion Programme in western China found evidence of the positive impacts on inequality alleviation (Li *et al.* 2011). The programme provides seeds and cash incentives for farmers in compensation for converting cropland to forest and grassland on steep slopes. The study's key findings indicated that the programme improved rural income, particularly for low- or medium-income households, and for those households located within or near nature reserves. The study concluded that households who participated in the programme experienced lower income inequality than households who did not, as evidenced by decreases in the Gini coefficient (lessened inequality). Although there are complexities involved in maintaining a fair distribution of benefits of Payment for Ecosystem Services, this study strongly points to the potential of natural capital accounting and associated programmes such as Payment for Ecosystem Services to address socioeconomic inequalities.

Natural capital, human health and inequality. A diverse and large portfolio of natural capital can increase resilience to shocks and protect human health and safety. Conversely, deforestation and over-exploitation of natural ecosystems are linked to the increased emergence and spread of, for example, zoonotic and water-borne disease outbreaks, with severe socioeconomic consequences (Grace *et al.* 2012). Epidemics have triggered worsening poverty and inequality (Furceri *et al.* 2020). The burden of zoonotic disease is significantly greater in developing countries, particular in tropical and subtropical regions. Zoonotic diseases comprise 25 per cent of the infectious disease burden in low-income nations, due to generally higher incidences of close contact with livestock and wildlife (Grace *et al.* 2012). A combined disease burden may occur where there is the likelihood of zoonotic disease coinfection with other pathogenic or infectious diseases, such as malaria, tuberculosis and HIV (Asante *et al.* 2019).

The links between ecological, human and economic health are starkly evident in the devastating impacts of the COVID-19 pandemic on global public health and the economy (Dasgupta 2021). The pandemic has revealed existing weaknesses across several sectors. Current research warns that the COVID-19 pandemic has and will continue to exacerbate economic and gender inequalities (de Haan and Sturm 2017; Furceri *et al.* 2020; IMF 2020; World Bank 2021). The wealth divide between rich and poor, both within and among countries, will continue to widen. Various estimates (IMF 2020; WEF 2020; World Bank 2021) project extreme poverty to rise by 100 million people, over half of which are women and girls (WEF 2021). Additional estimates show that the number of people facing food insecurity will double (UN 2020). The impacts of COVD-19 will significantly reduce progress towards the SDGs, particularly the goals of reducing inequality within and among countries. As the world continues to recover from the COVID-19 pandemic, the long-term impacts will be difficult to assess.

Managing diverse natural capital portfolios requires national accounts that include natural capital, better policy responses from governments and policymakers, and public policies that can influence economic growth and income and wealth inequalities. This section provides evidence of the assertion that global stock of natural capital is declining at unprecedented rates to meet rapidly increasing demands and extrinsic wealth accumulation, with dramatic impacts on wealth, well-being and inequalities within and among populations. This must be reflected in national and global accounts to inform future investments and decision-making with regard to natural assets and economic development.

Inequality metrics and natural capital accounts

The Gini Index

The most widely used inequality index is the Gini Index, which accounts for a nation's wealth and income distribution (UN DESA 2015). It compares a country's wealth or income distribution to a perfectly equal distribution (whereby every citizen is modelled to have equal wealth or income) at each percentile of the population. The Gini coefficient uses the Lorenz curve for its calculation, which is a graph that represents the wealth or income distribution of the people of a geographic boundary, plotted against the perfectly equal distribution (Gastwirth 1972). The Gini Index is the difference between the equal distribution and the Lorenz curve. The index ranges from zero to one: the higher the difference or the Gini Index, the higher the inequality, with the wealthiest tier of individuals gaining comparatively larger percentages of the total income of the population. The World Social Report of UN DESA and the United Nations Development Programme (UNDP) Human Development Report (2020) calculate the Gini Index of inequality using the World Bank's PovcalNet distribution of national accounts. World Inequality Lab created its extensive wealth and income distribution database by focusing on the share, in percentiles, of the national income captured by each group of a population, and combines income tax micro files, national accounts and household surveys systematically. The distribution focuses on concrete social groups, e.g. the bottom 10 per cent, to the next 10 per cent, to the next etc. (Alvaredo *et al.* 2020).

Inequality-adjusted Human Development Index

The G20 countries have committed to pursuing economic growth pathways that are inclusive and sustainable. However, according to Chen *et al.* (2020), rising income inequalities are evident in most of the G20 countries, while they are showing a decreasing trend in many low- and low-middle-income countries. Moreover, many G20 countries are struggling to harness their potential to earn high incomes whilst securing sustainable rates of natural resource use (Barbier 2020).

The 2020 Human Development Report (UNDP 2020) lists countries according to their Inequality-adjusted Human Development Index (IHDI). The IHDI captures the country's average HDI, with the added dimension of incorporating the negative impacts of inequality in health, education and income distribution on development. The index is expressed as a single number between zero and one. The greater the difference between the two indices (HDI and IHDI), the greater the loss to human development through inequality. In a hypothetical case of perfect inequality, the HDI and IHDI are equal. In Table 4.1, according to the IHDI ranking of 2019, the G2O countries experienced differing levels of progress in this regard. The highest overall loss of HDI due to inequality was found in South Africa, followed by India and Brazil. The lowest overall losses were found in Germany, Australia and the United Kingdom of Great Britain and Northern Ireland.

Table 4.1: IHDI and HDI ranking of the G20 countries

Rank	Country	IHDI	HDI	Overall loss of HDI due to inequality[33] (%)
Very high human development				
10	Germany	0.869	0.947	8.2
11	Australia	0.867	0.944	8.2
16	United Kingdom of Great Britain & Northern Ireland	0.856	0.932	8.2
17	Canada	0.848	0.929	8.7
18	Japan	0.843	0.919	8.3
23	France	0.82	0.901	9
24	South Korea	0.815	0.916	11
28	United States of America	0.808	0.926	12.7
High human development				
34	Italy	0.783	0.892	12.2
42	Russian Federation	0.74	0.824	10.2
44	Argentina	0.729	0.845	13.7
Medium human development				
57	Türkiye	0.683	0.82	16.7
67	China	0.639	0.761	16
74	Mexico	0.613	0.779	21.3
81	Indonesia	0.59	0.718	17.8
88	Brazil	0.57	0.765	25.5
Low human development				
104	India	0.475	0.645	26.4
107	South Africa	0.468	0.709	34

Note: Data for Saudi Arabia is not available

Source: Human Development Report (2020)

33 Percentage differences between IHDI value and HDI value.

The Inclusive Wealth Index and natural capital metrics

Several institutions including UNDP, World Data Lab and UN DESA, are working towards developing an inequality index that includes natural capital comparisons within and among countries. However, comparative analyses are limited by the lack of standardized natural capital accounting data among countries. This is particularly challenging as a number of the countries for which natural capital is a significant part of wealth do not report their value (Bauluz 2017). Even when natural capital is reported, different countries follow different accounting practices. For example, in Australia, the national government owns most of the natural capital. Similarly, in Canada, the public sector legally owns all natural resources. However, Canada's national statistics office (StatsCan) allocates the assets between private corporations and the government according to the flow of royalties and profits obtained from exploiting these resources. As a result, ownership of the total values of natural capital are allocated as follows: 25 per cent ownership by the Canadian government and 75 per cent ownership by corporations, in the period 1990–2016 (Kazi 2017).

The System of National Accounts 2008 provides a standardized, comprehensive and flexible statistical framework and set of definitions for national accounting across the world (UN STATS 2008). According to this framework, a nation's total wealth is the sum of private and public wealth. Private wealth is the household sector's net wealth, which is the sum of financial and non-financial assets owned by households, minus their financial liabilities[34]. Public wealth is the sum of financial and non-financial assets owned by government entities, minus their financial liabilities[35]. Natural resources or capital are endowments of a nation, so they are technically categorised as public wealth. However, natural capital is not clearly defined in the SNA, which divides natural resources into three main categories as follows:

1. land underlying building and structures

2. land under cultivation and mineral and energy reserves

3. land under cultivation (then further categorised by agricultural and forestry land)

The System of Environmental-Economic Accounting (SEEA) framework follows a similar accounting structure to the SNA, and integrates economic and environmental data to provide a comprehensive view of growth accounting with global statistical standards (UNEP 2020). Although SEEA uses statistical concepts, definitions and classification consistent with the SNA, it is flexible. Therefore, it can be easily adapted to countries' priorities and policy needs, and simultaneously provide a consistent framework. Thematic areas of SEEA include agriculture, forestry and fisheries, air emissions accounts, energy, environmental activity account, ecosystem accounts, land accounts, material flow accounts and water (SEEA n.d.) As of 2020, 100 countries are compiling data consistent with the SEEA framework.

The current IWI components of natural capital include renewable resources (agricultural land, forests and fisheries) and non-renewable resources (fossil fuels and minerals). As yet, comparable data for countries on ecosystem services are not available for incorporation into the IWI, though progress is being made in this field, mainly through the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA-EA)[36].

Economists and environmentalists have made tremendous efforts to identify the value and importance of natural capital from several aspects. Barbier (2017) extends the wealth accumulation model of Piketty (2014), to include net depreciation in fossil fuels, minerals and forests and produces two key indicators: the net national saving rate adjusted for natural capital depreciation, and the ratio of this rate to long-run growth. The stock of natural resources is depleted to meet the current human demand for wealth. Therefore, any

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34 This is the definition from the System of Environmental- Economic Accounting, 2012, UNSD, New York

35 Ibid.

36 Ongoing advances in wealth accounting hold great potential to include human development metrics and increased inequalities that humanity now face. Specifically, gender inequality remains pervasive globally and its close linkages with natural resources remains strong. Adopting integrated approaches such as those that include human capital disaggregated by gender and employment status, as undertaken by the World Bank, require further attention.

measure of national wealth that excludes natural capital depreciation likely exaggerates the actual increase in an economy's wealth over time (Barbier 2017).

Empirical findings linking natural capital and inequality

This study updates natural capital data using the methodology of the IWI framework. These estimates of natural capital are linked with the wealth inequalities following i) the 2020 Human Development Report (UNDP 2020), utilising the IHDI in particular; and ii) the Gini Index, as different inequality measures. To incorporate natural capital into an inequality measure, Barbier's (2017) concept is implanted by utilizing the available data of countries from 1990 to 2019. This analysis accounts for both non-renewable resources (fossil fuels and minerals) and renewable resources (agricultural land, forest and fishery) as natural capital.

The IWR 2018 (Managi and Kumar 2018) provides the natural capital data from 1990 to 2014. Figure 4.1 shows the distribution of different resource shares in the total global natural capital. In this figure, renewable resources are categorised as follows: i) forest resources (sub-categorised by timber and non-timber benefits); ii) fisheries (represented by the catch); and iii) agricultural land (cropland and pastureland). Non-renewable resources are composed of iv) fossil fuels (oil, natural gas and coal); and v) minerals (bauxite, copper, gold, iron, lead, nickel, phosphate, silver, tin and zinc).

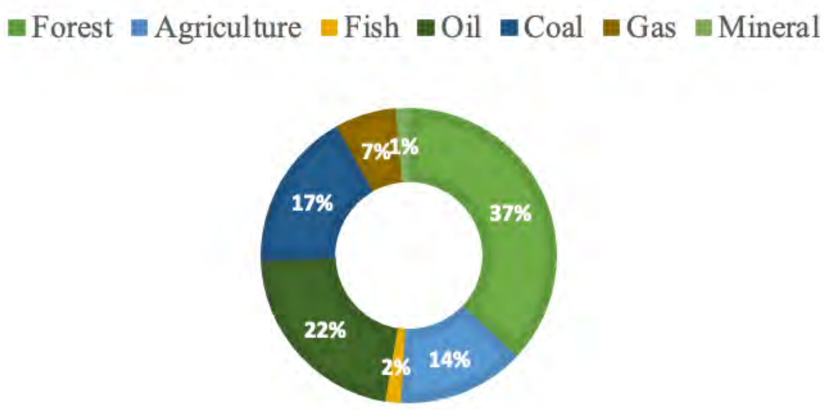

Figure 4.1: Average share of global resources in natural capital, 1990–2014 for 140 countries
(Source: Inclusive Wealth Report 2018, Chapter 3.1)

The share on a global scale of renewable and non-renewable resources is shown in Figure 4.2, consisting of 53 per cent and 47 per cent of the natural capital of nations, respectively.

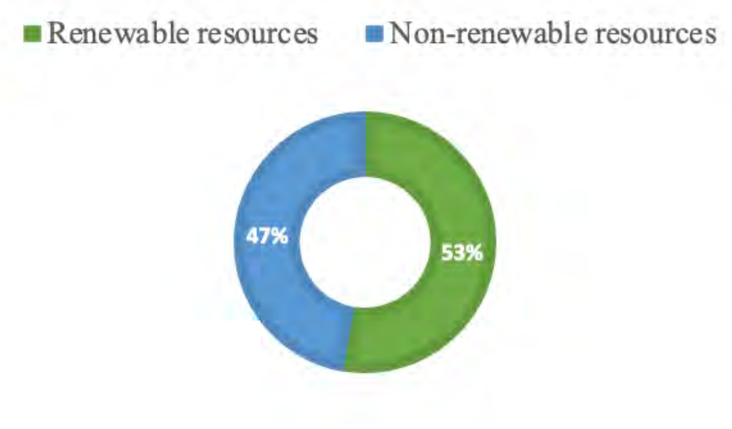

Figure 4.2: Average share of global renewables and non-renewable in natural capital, 1990–2014 for 140 countries *(Source: Inclusive Wealth Report 2018, Chapter 3.1)*

Reducing inequalities and ensuring no one is left behind are integral to achieving the SDGs, and SDG 10 specifically highlights the importance of reducing inequality within and among countries. Countries' tremendous focus on economic growth is dramatically depleting their natural capital, creating inequality in many growing economies. Figure 4.3a illustrates the global distribution of natural capital in 2019. Countries with high levels of natural capital are more likely to show increasing IW (see Figure 4.3b). However, this wealth increase is likely to increase inequality. Natural capital is correlated with the exacerbation of poverty and inequality in regions where population growth is high (see Figure 4.3c).

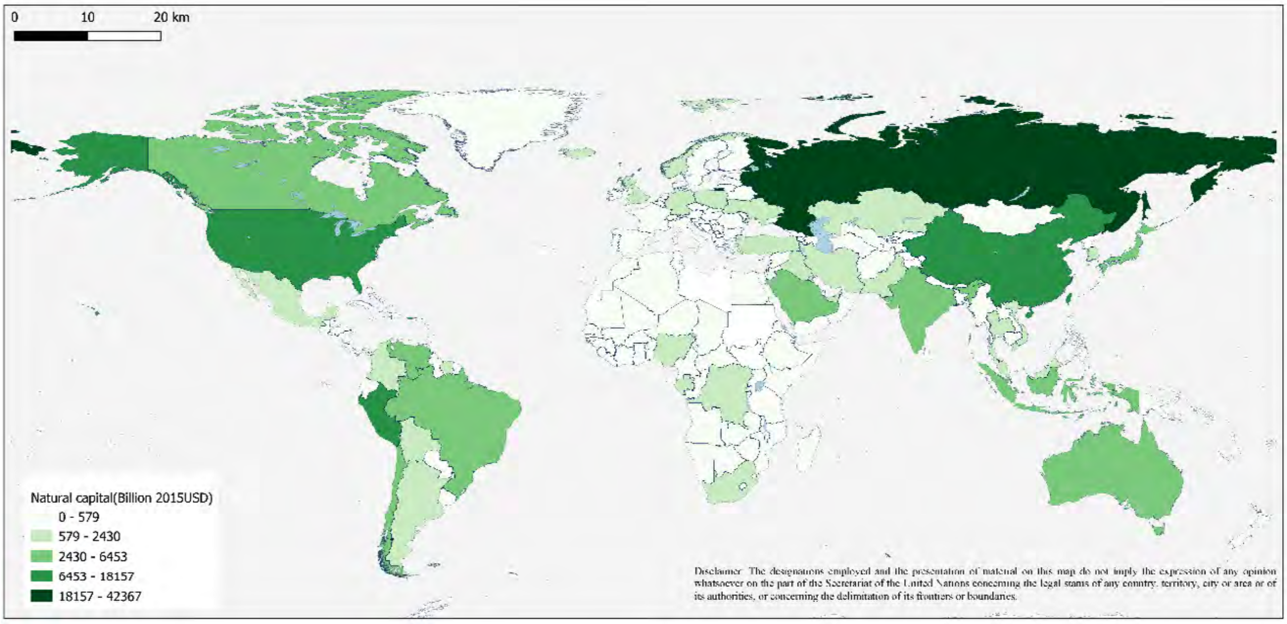

Figure 4.3a: Natural capital (billion USD), 2019

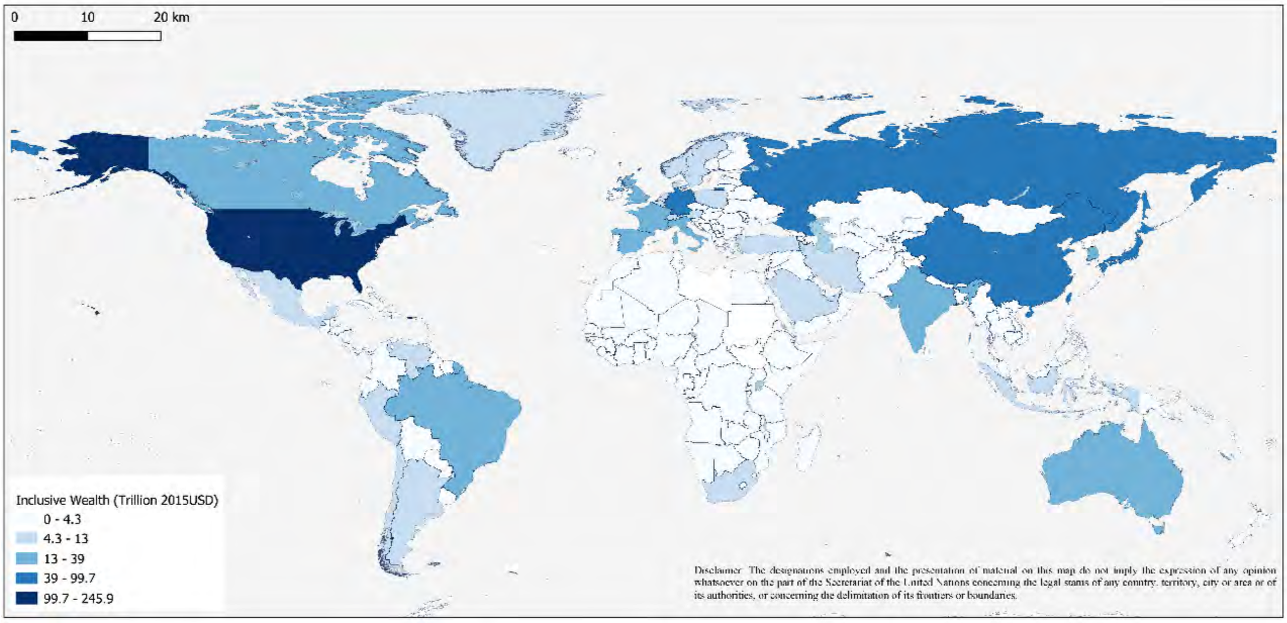

Figure 4.3b: Inclusive wealth (trillion USD), 2019

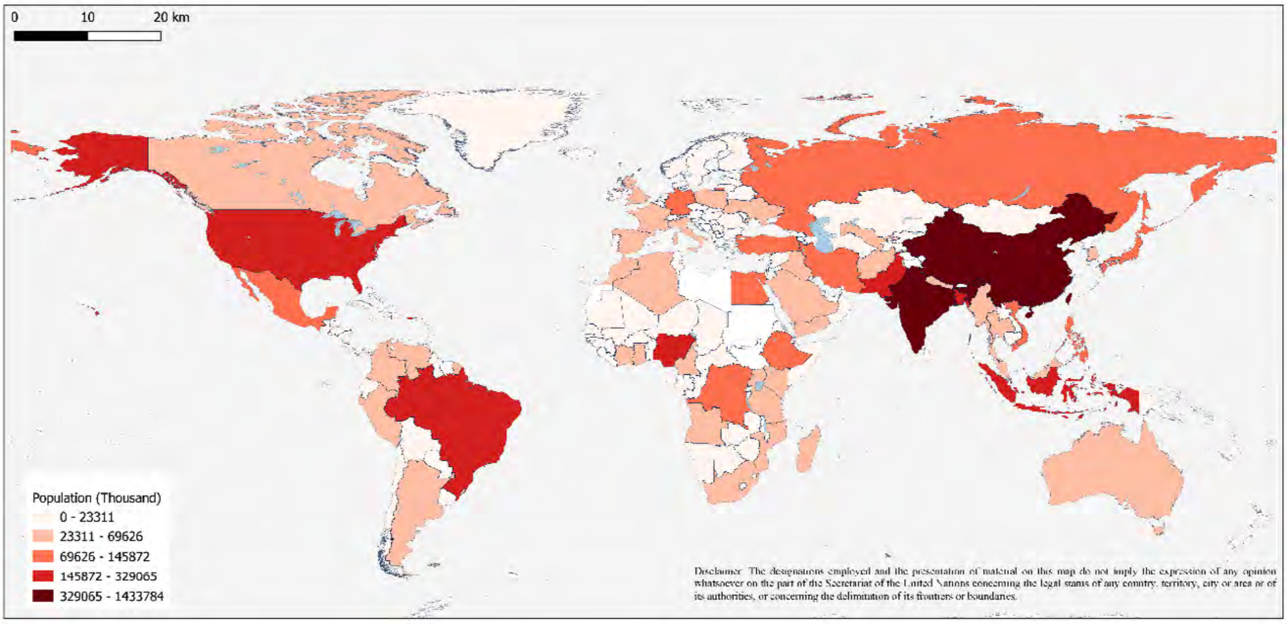

Figure 4.3c: Population (thousand), 2019

Natural capital and the inequality-adjusted Human Development Index

Loss of HDI due to inequality at the regional level is presented in Figure 4.4, which clearly highlights the trend of vulnerability to inequality of economically poor regions.

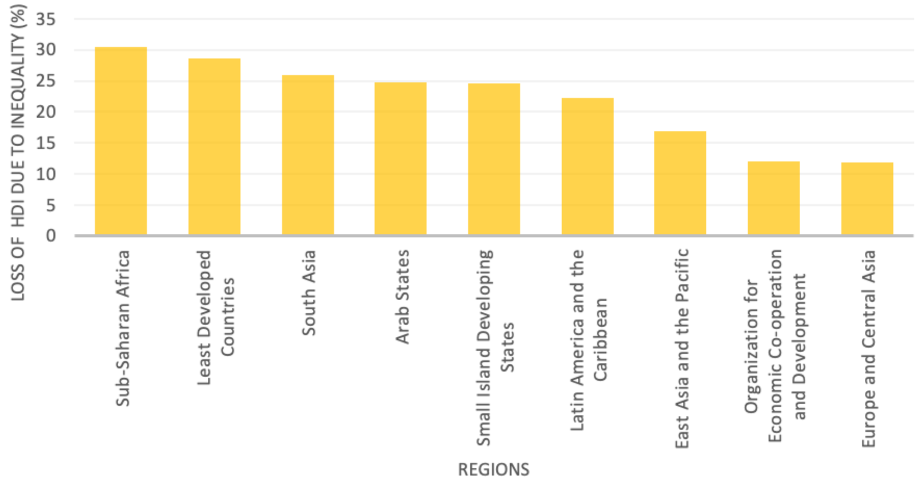

Figure 4.4: **Loss in HDI due to inequality, 2019**

The 2019 HDI rankings and HDI loss among countries due to inequalities is presented in Figure 4.5. Higher HDI rankings are found primarily among countries with higher welfare of the population and lower shocks from inequalities.

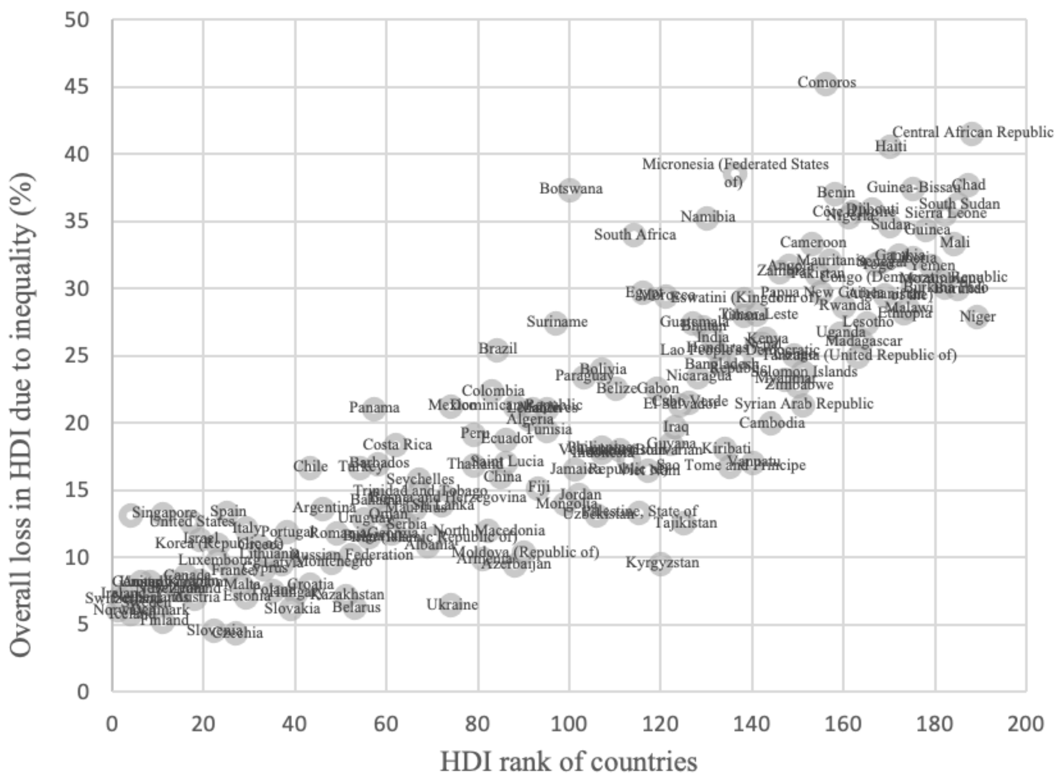

Figure 4.5: **Overall loss in HDI due to inequality, 2019 (or the most recent available year)**

The relationship between the IHDI and the growth of renewable natural capital for the G20 countries is illustrated in Figure 4.6. It shows that most of the G20 countries are facing negative growth of renewable natural capital. This includes many of the developed countries, which, although they have a high IHDI, are also experiencing a negative growth rate of renewable resources. Germany, the United States of America and France show the most favourable status: a high IHDI paired with positive rates of growth in renewable natural capital. Although Saudi Arabia and South Africa also show a positive rate of growth in renewable natural capital, their IHDIs are relatively low.

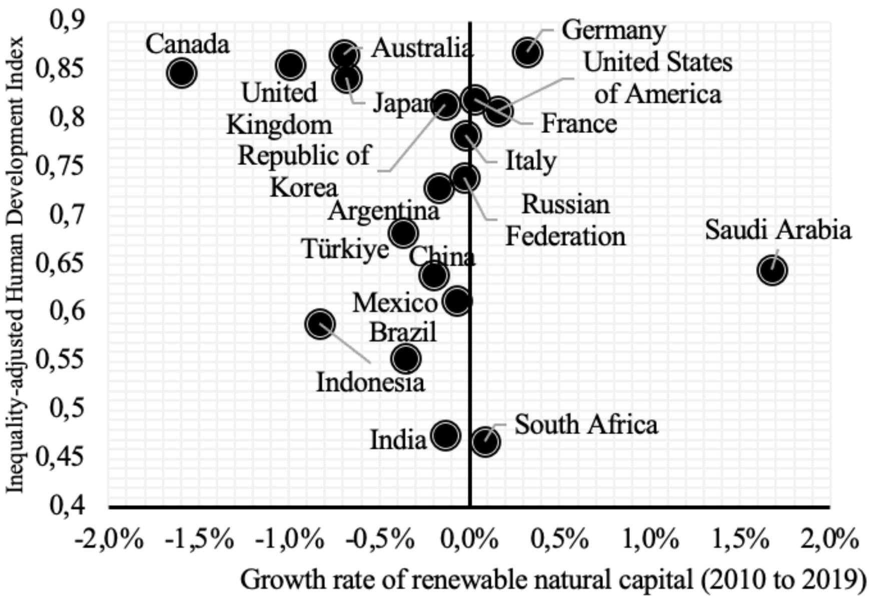

Figure 4.6: **Growth rate of renewable natural resources and the IHDI of the G20 countries, 2010–2019**

Figure 4.7 illustrates the relationship between the IHDI and the growth of total (renewable plus non-renewable) natural capital of the G20 countries from 2010 to 2019. The graph shows that Australia, Germany, Canada and the United States of America have a high IHDI and a slightly negative (0 to -1 per cent) natural capital growth rate. Although, the United Kingdom of Great Britain and Northern Ireland, France, the Democratic People's Republic of Korea and Japan also have a high IHDI, the growth rate of natural capital is negative (-4 per cent to -7 per cent) to a significant degree. Türkiye, Saudi Arabia and India show a moderate IHDI and negative (0 to -2 per cent) natural capital growth. The Russian Federation, China, Indonesia, Brazil, Mexico and Argentina have a moderate IHDI but significant negative (-2 per cent to -7 per cent) natural capital growth. South Africa is the only G20 country with a positive natural capital growth rate from 2010 to 2019. However, their IHDI is very low relative to the other G20 countries.

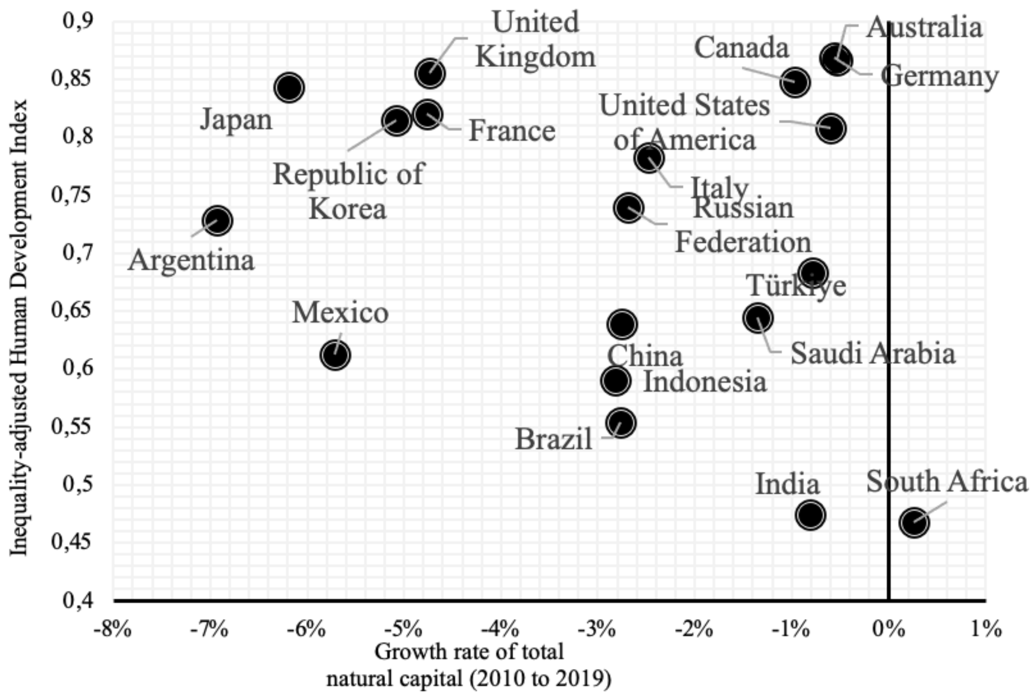

Figure 4.7: Growth rate of total natural capital and the IHDI of the G20 countries (2010–2019)

The relationship between the overall decrease in HDI due to inequality and the growth of renewable natural capital of the G20 countries is shown in Figure 4.8, and reflects the results illustrated in Figure 9. South Africa has positive natural capital growth but is losing a high percentage of its HDI score, due to the adverse impacts of inequalities.

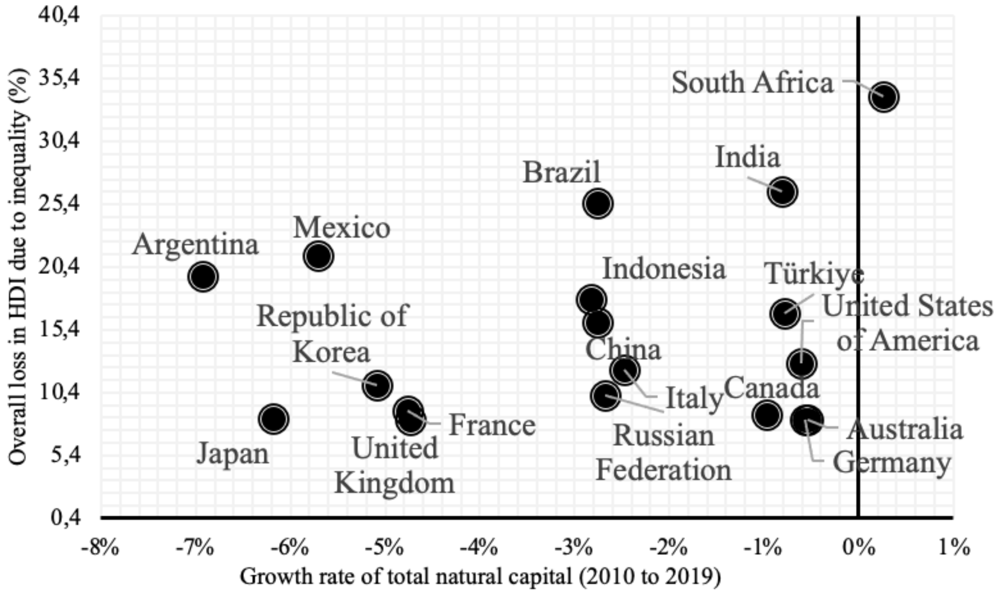

Figure 4.8: Growth rate of total natural capital and overall loss in HDI due to inequality of the G20 countries, 2010–2019

Natural capital and the Gini Index

Marine and coastal ecosystems provide many essential services to society that support basic needs and promote economic development, particularly for activities related to the fishing sector. However, a nearly three-fold rise in fisheries production over the past several decades has led to over-exploitation of fish stocks above maximum sustainable yields and threatening fishery collapse in some instances (UNEP 2019). At least one-third of fish stocks are now overfished, one-third to half of vulnerable marine habitats have been lost, and a substantial fraction of the coastal ocean suffers from pollution, eutrophication, oxygen depletion and is stressed by ocean warming (Duarte *et al.* 2020). If these marine fisheries patterns continue, the long-run capacity of the ocean to provide this essential food and livelihood resource will be seriously threatened.

As discussed previously, the over-exploitation of natural resources may significantly impact income inequality within countries. Poor and marginalized communities are particularly susceptible to human-induced environmental degradation and the loss of renewable natural capital, as their livelihoods are often directly and highly dependent on the abundance of natural resources. To provide one example: as the stocks of marine fish resources decline, the potential loss of earnings of poor and marginalised communities increases, leading to broadening income inequality within countries, all other variables being equal.

Figure 4.9 plots the Gini Index and marine fishery stock changes from 2000 to 2010, and from 2010 to 2018 for the G20 countries. It shows that the relationship between income inequality and marine resource abundance in the G20 countries is complex and not easily generalised. For instance, there is evidence that rising income inequality is correlated with the exploitation of marine fish resources for emerging economies countries, such as Indonesia and India. Contradicting patterns were observed in other developing countries, such as Argentina and Mexico, where declining levels of stock abundance were associated with decreasing income inequality. In developed countries, a non-uniform relationship between inequality and stock abundance was also observed. For instance, the United States of America, Germany and South Africa have managed to recover their stock abundance by controlling their catch volume. However, this was followed by an unexpected increase in their inequality index. Conversely, other developed countries, such as Australia, China and France, have successfully reduced inequalities in their countries at the expense of their fisheries capital.

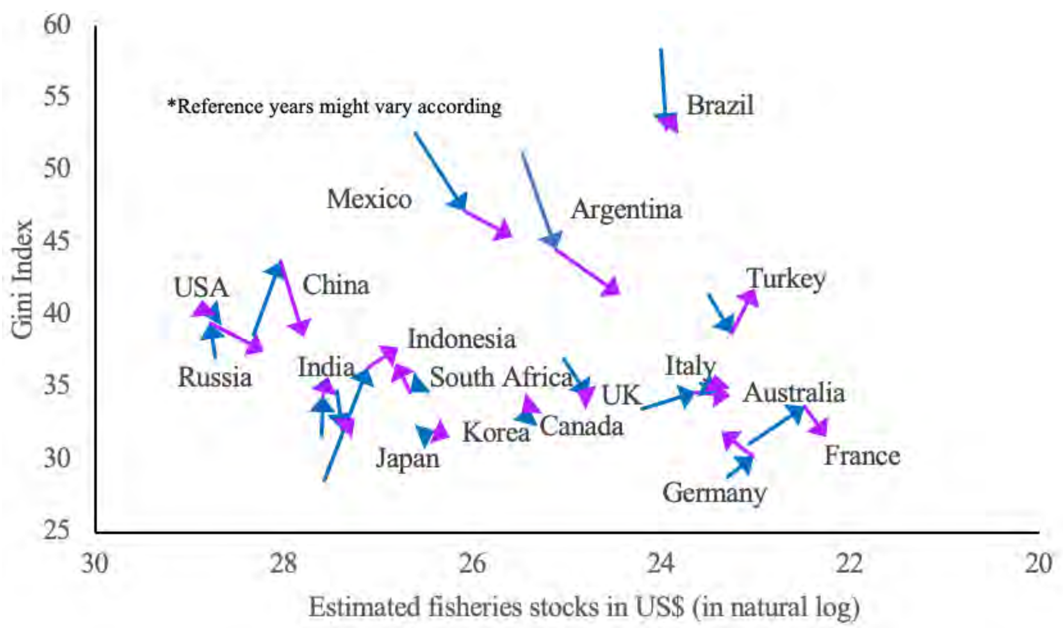

Figure 4.9: **Changes in value of fish stocks and the Gini Index of the G20 countries, 2000–2018**

The decreasing trend of fisheries capital is an inevitable consequence of the marine fisheries sector development. Although over-exploitation of marine fish resources is not closely bound with changes in inequality in the short run, it poses a serious threat for sustainability in the long run. Therefore, more stringent environmental regulations and better fisheries management systems need to be adopted to regulate and limit fish catch volume. However, such efforts are unlikely to bring about stock recovery in the short term (Sugiawan *et al.* 2017).

Figure 4.10 and Figure 4.11 depict the inequality in non-renewable natural capital minerals and fossil fuels, with changes in the Gini Index, respectively, from 1990 to 2019. These relationships vary significantly between countries. A statistical model with extended longitudinal data for many other countries is required to make a robust conclusion. Some countries, such as the United States of America, Indonesia and Germany, have increased the Gini Index while depleting non-renewable capital. Conversely, Mexico and Argentina have decreasing Gini patterns. The remaining countries, including the Russian Federation, China and Canada, have fluctuating Gini patterns.

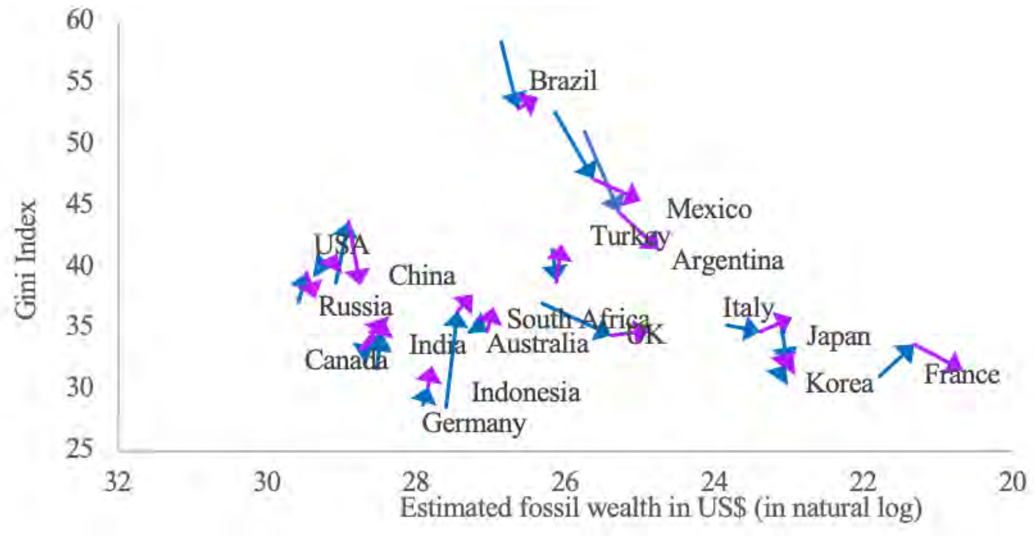

Figure 4.10: **Changes in fossil fuel wealth against the Gini Index of the G20 countries, 2000–2018**

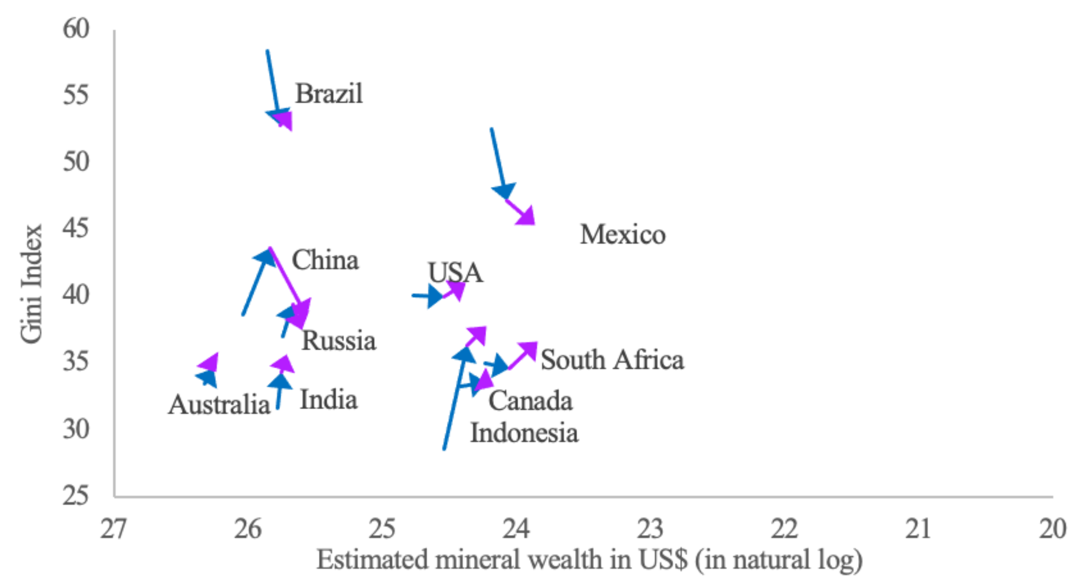

Figure 4.11: **Changes in mineral wealth against the Gini Index of the G20 countries, 2000–2018**

CO_2 is the primary greenhouse gas emitted through human activities. The burning of coal, natural gas and oil (non-renewable natural capital) for electricity and heat accounts for the largest source of global greenhouse gas emissions (Environmental Protection Agency [EPA] 2021). Figure 4.12 illustrates the inverse relationship between global natural capital stocks and CO_2 damage, as measured by the IWR 2018 (Managi and Kumar 2018). Following the methodology of Arrow *et al.* (2012), carbon damage is classified as primarily a change in social well-being that does not correspond with countries' level of emissions. Following the IWR 2014 (UNU-IHDP and UNEP 2014), the key methodological steps are as follows: i) obtain total global carbon emissions; ii) derive the total global damage as a function of the emissions; and iii) allocate the global damage to the countries according to the potential impact of global warming on their economies.

Figure 4.12 shows a strong inverse relationship between natural capital stocks and CO_2 damage, i.e. natural capital depletion results in an external cost (CO_2 damage) to human well-being. Despite this, CO_2 emissions are not routinely incorporated into market transactions, and no well-developed policies and institutions yet exist for doing so. Thus, current economic accounting and systems have not yet received accurate price signals or incentives to adjust production and consumption activities accordingly, to ultimately ameliorate the exploitative use of natural resources. The reinforcing feedback loop of this effect should not be overlooked: as natural capital depletion drives CO_2 damage, climate change is exacerbated, the effects of which tend to drive up the associated costs of over-exploitation of natural resources. This may significantly aggravate income inequality within and between countries.

Poorer and marginalised communities are more susceptible to human-induced loss of natural capital, as their livelihoods are highly dependent on the abundance of natural resources. For example, land degradation and loss of forests or rangelands leads to loss of biodiversity and a reduction in the livelihoods of communities dependent on them, and the impacts of climate change—e.g. more extreme weather events and increasing global temperatures—further inhibit the ability for these critical ecosystems to recover. It is increasingly apparent, therefore, that the depletion and overuse of natural resources may contribute considerably to increasing income and wealth inequality.

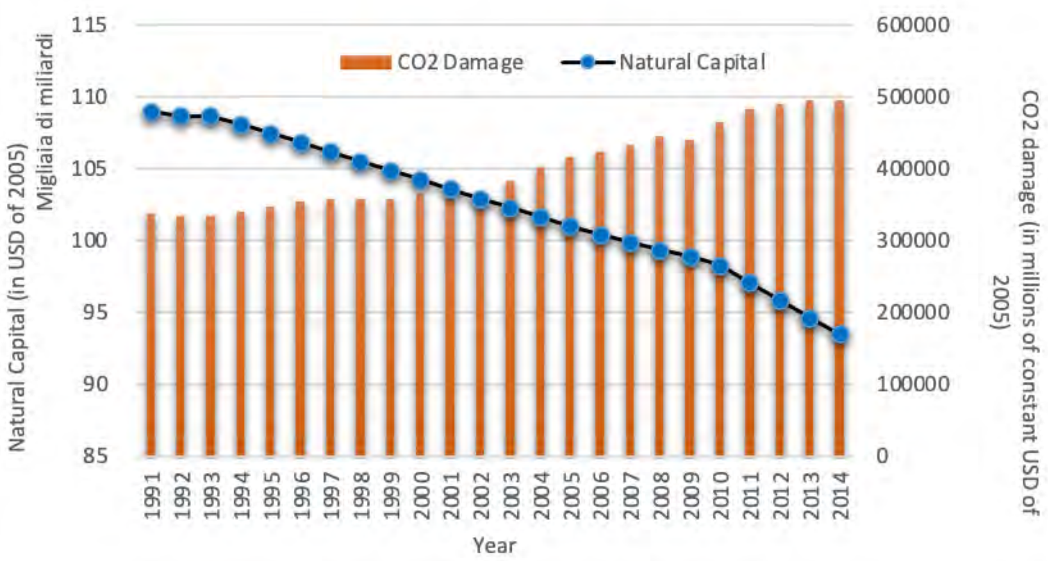

Figure 4.12: **Natural capital and CO_2 damage of the G20 countries, 1991–2014**

Conclusions

Climate change, the increasing frequency and severity of natural disasters and multi-faceted environmental decline affect the world's poorest most acutely; they are often directly dependent on natural capital and flows of ecosystem services for their food, shelter and household income. Furthermore, the under-pricing and over-exploitation of natural capital act as drivers that contribute to worsening economic inequality in many natural resource-abundant countries, particularly for the most marginalized.

In 1941, the 'Kuznets curve' theory suggested that nations would see an increase in income inequality at the earlier stage of economic growth, then a subsequent fall in income inequality (Kuznet 1941). A subsequent version of the Kuznets curve, based on environmental quality, found that patterns of certain pollutants followed a similar curve for some countries (World Bank 1992). Proponents of perpetual economic growth used the Kuznets curve idea to justify high economic growth objectives. However, more recent evidence overwhelmingly refutes the existence of a Kuznets-type curve (Van and Azomahou 2007; Liao and Cao 2013). Liao and Cao (2013) rejected the validity of the environmental Kuznets curve hypothesis for global CO_2 emissions, although they found a flattening trend in CO_2 emissions for high-income countries. In addition, in their longitudinal study of deforestation, Van and Azomahou (2007) found no evidence that deforestation rates decreased as GDP increased.

The results of this analysis are equivocal. All of the G20 countries (with the exception of South Africa) have experienced negative total natural capital growth during the past 20 years. Germany and France have experienced positive growth of renewable natural capital with a high IHDI. Saudi Arabia, South Africa and the United States of America have experienced high positive growth of renewable natural capital but with a low or very low IHDIs. Some developing countries such as India and Indonesia show proportionality between income inequality and the decline in marine fish resources. The United States of America, Indonesia and Germany have increased the Gini Index (representing worsening inequality) while depleting their non-renewable natural capital. However, Mexico and Argentina have decreased the Gini Index with a declining stock of non-renewable natural capital, and the rest have fluctuating relationships. A statistical model is needed to form a more a robust conclusion on the relationship between natural capital, economic growth and wealth equality.

It is evident that 75 per cent of the G20 countries show negative growth rate of renewable natural capital (only France, the United States of America, Germany, Saudi Arabia and South Africa have positive growth). All of the G20 countries except South Africa show negative rates of growth of total natural capital. However, there is no obvious correlation between this and IHDI. There is also no clear relationship shown between depletion of non-renewable natural capital and inequality as measured by the Gini Index. natural capital is not considered as a determinant of typical inequalities measures, and we did not find any evident correlation between inequality measures and natural capital depletion. Lastly, the chapter identifies a negative relationship between global natural capital stocks and CO_2 damage to societal well-being. Since CO_2-induced climate change is not accounted for in general economic growth-based indicators, economies do not have the correct price signals or incentives to adjust production and consumption activities to incorporate natural capital depletion and CO_2 emissions.

The under-pricing and over-exploitation of natural capital act as drivers that contribute to worsening economic inequality in many natural resource-abundant countries, particularly for those historically marginalised such as ethnic minorities and indigenous populations, women, children and young people. Moreover, increasing wealth inequality can trigger social conflicts in many less developed regions. Our global economy is at a crossroads. Earth provides enough resources to satisfy all our needs abundantly. However, unequal distribution of resources is mainly driven by the structure of our institutions, demonstrated by clearly observable and pervasive global wealth inequalities. Along with income inequality, natural capital inequality is a barrier to sustainable development. To ensure sustainability, it is necessary to decouple economic development from environmental degradation. A narrowly focused pursuit of economic growth that includes sacrificing natural resources is unlikely to reduce inequality.

The welfare of the future generations is dependent on what the current generation chooses to do about the management of our critical natural capital and ecosystems more broadly. Based on our analysis of natural capital and inequality conditions, we conclude that achieving SDGs is impossible without focusing on the environmental risks. It is therefore urgent for governments and policymakers to ensure sustainable natural capital management, and in doing so address a major driver of global inequalities.

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05 Key findings: Accounting for the inclusive wealth of nations

Introduction

This chapter presents key findings from the latest accounting of the IWI for 163 countries, and includes annual data from 1990 to 2019[37]. According to the UN (2020), this data coverage includes all major economies on all continents, accounting for approximately 98 per cent of the world's population and 99 per cent of global GDP. The IW empirical accounting in this chapter follows the established IW framework outlined by Arrow *et al.* (2012; 2013), and the practices of previous IWRs (2012; 2014; 2018). The data and empirical approach have been updated to provide a more comprehensive assessment of each capital type.

We consider that society's productive base consists of three types of capital – produced, human and natural (Dasgupta 2009; Arrow *et al.* 2012; Barbier 2019). In addition, after removing the effect of population growth, the IWI also considers three adjustments that affect IW. These are as follows: oil capital gains from changes in energy prices, carbon damages associated with climate change and total factors productivity.

Produced capital stocks are estimated based on cumulation and depreciation of past investments, using the perpetual inventory method. To improve the estimation accuracy, capital depreciation rates are assumed based on the investment structure of capital assets and their specified depreciation rate. Thus, we let the depreciation rate vary across countries and years. Human capital accounting is calculated by gender, based on the integrated life tables. A comprehensive evaluation of the education and health capital of the entire population are achieved by measuring education level based on expected years of schooling (EYS), and shadow price based on expected years of work. We have also expanded the national accounting coverage. The value of renewable capital calculates both the market and non-market value of ecosystem services. Fisheries capital is taken into renewable resource accounting. The scope of non-renewable resources covers three energy sources and ten mineral resources.

For the first time, in our adjustment determinants, we refer to the impact of blue carbon (carbon adjustment of coastal and marine ecosystems) for carbon damage estimation. Consistent with the IWR 2018, we calculate total factors productivity as a residual of production, but now extend natural capital as an explicit input factor for the production process.

The chapter is organized as follows: Section 5.2 applies the method of Arrow *et al.* (2012) to discuss the empirical construction of wealth accounts for each form of capital, including a brief overview of the calculation process for each capital. Section 5.3 then provides an analysis of these results. We emphasize analysis of per capita wealth changes, and discuss the relationship between human population, economic activity and natural capital depletion, an issue that has received widespread attention in previous decades (Daily and Ehrlich 1994; Arrow *et al.* 2004; Fischlin *et al.* 2007; Dasgupta 2013; Barbier 2019; Dasgupta 2021). We then conduct a structural decomposition analysis of human capital to discuss the impact of changes in population, education, gender and labour force participation on changes in human capital. This section also details regional inequalities in achieving sustainability,

37 For countries lacking complete inclusive wealth data, we continue to track their capital data. These data are shown in the chapters of analysis for each capital, but we exclude these countries in the total Inclusive Wealth Index dataset

by providing an analysis of regional per capita IW Gini index, and overall loss in HDI due to inequality. Section 5.4 considers practical considerations and limitations of the findings, and highlights underlying assumptions, extensions of existing work in the field and the key challenges in constructing wealth accounts. Finally, section 5.5 provides the conclusion.

The IW accounting framework provides empirical evidence grounded in the theoretical framework of welfare economics. Global and local changes in per capita wealth show that while population is an essential source of wealth, population size and its growth overshoot or undershoot affect the wealth shared by individuals for current and future generations. Most importantly, we show that population growth must be kept within the service capacity of natural ecosystems. natural capital management and conservation, whether local or global, is a resource that is not accounted for in traditional economic measurements such as GDP. This lack of attention will ultimately affect the sustainability of development, and result in 'The Tragedy of the Commons', due to freedom of unregulated public interest.

Methodology

Discounted wealth for the future

The development of the IW framework builds on the body of previous theoretical and empirical work. Dasgupta and Mäler (2000) and Arrow, Dasgupta and Mäler (2003a; 2003b) demonstrate the equivalence of movements in social well-being and IW. Dasgupta (2004) comprehensively discusses the concept of sustainable development and the role of the wealth/welfare equivalence theorem. Agliardi *et al.* (2012) extends this theorem by introducing a stationary stochastic process that drives consumption. Dasgupta (2014) and Irwin, Gopalakrishnan and Randall (2016) provide non-technical explanations of the wealth/happiness equivalence theorem and its extensions.

To explain the theoretical framework of the IWI, we consider arbitrary initial time point $s \geq 0$. Let $\underline{C}(s)$ denote a vector of consumption flow at time t, $U(\underline{C}(s))$ denote economy-wide utility flow. Then by denote V(t) as the social welfare for current and the future at s and can be presented as:

$$V(t) = \int_{t=s}^{\infty} \left[U\left(\underline{C}(s)\right) e^{\delta(s-t)}\right] ds \, , \delta > 0 \tag{1}$$

Where term δ indicates the discount rate of the utility flow by time, according to Equation (1), maximizing the intergenerational welfare V(t) requires forecasting the future utility flows. In other words, welfare maximization requires forecasting consumption, demographic changes and the use of natural resources. However, forecasting directly through this information is difficult due to market imperfections such as price distortions and externalities. Thus, considering the counterfactual resource reallocation mechanism, by mapping from the set of all possible capitals into the set of possible pairs of the utility flow for all $t > s$, it is possible to forecast intergenerational welfare based on whether the initial capital goods stock inherited at s are different from the current time point. Denote $\underline{K}(t)$ as the initial capital goods stock, assume the resource reallocation mechanism is time autonomous, then $V(t)$ is the function of t and $\underline{K}(t)$. We have:

$$V(t) = V(\underline{K}(t)) \tag{2}$$

Combining equations (1) and (2) yields

$$V\left((\underline{K}(t)\right) = \int_{t=s}^{\infty} [U\left(\underline{C}(s)\right) e^{\delta(s-t)}] ds \, , \delta > 0 \tag{3}$$

Here we discuss the composition of the capital portfolio $\underline{K}(t)$. There are many ways to classify capital assets. However, the empirical work requires the capital composition to be measurable. In this research, we carefully divide the capital portfolio into three divisions: productive capital (such as buildings, roads, ports, machinery and equipment), human capital (e.g. population, health, education, knowledge, skills) and natural capital (e.g. raw materials, ecosystem diversity). These three capitals constitute the production basis of the dynamic system (see Figure 5.1). Furthermore, social capital (e.g. institutions and practices) confer use-value on the above three capital goods. By denoting produced capital as M, human capital as H and natural capital as N, then there is $\underline{K} = \{M, H, N\}$.

Next, we discuss sustainable development under the principle of resource allocation mechanism. Ideal resource allocation means maximizing welfare. We write the perturbation at time t as $\Delta V(t)$, and assume that $\Delta V(t)$ is differentiable. Sustainability is expressed as non-decline welfare through intertemporal changes, so sustainability is maintained if:

$$\Delta V(t) = \Delta V(K(t)) = V\big(K(t) + \Delta K(t)\big) - V\big(K(t)\big) > 0 \tag{4}$$

According to the combination of initial capital goods stock K, Equation (4) also can be written as:

$$\Delta V(K(t)) = \frac{\partial V}{\partial t} + \left[\frac{\partial V(K(t))}{\partial M}\right]\Delta M(t) + \left[\frac{\partial V(K(t))}{\partial H}\right]\Delta H(t) + \left[\frac{\partial V(K(t))}{\partial N}\right]\Delta N(t) \tag{5}$$

Define

$$p_M(t) = \left[\frac{\partial V(K(t))}{\partial M}\right] \tag{6.a}$$

$$p_H(t) = \left[\frac{\partial V(K(t))}{\partial H}\right] \tag{6.b}$$

$$p_N(t) = \left[\frac{\partial V(K(t))}{\partial N}\right] \tag{6.c}$$

Where$p_i(t)$ is the social value or the shadow price of capital $M(t)$, $H(t)$ and $N(t)$ at time t. Let $r(t) = \frac{\partial V}{\partial t}$ be the shadow price of time at t. We can now use shadow prices as weights to construct an aggregate index of the economy's stock of capital assets. We use $W(M, H, N, t)$ to indicate the IW. The following equivalence between IW and well-being is expressed as:

$$W(M, H, N, t) = r(t) + p_M(t)M(t) + p_H(t)H(t) + p_N(t)N(t) \tag{7}$$

where $W(M, H, N, t)$ is also known as the IWI. While the changes in wealth, also called inclusive investment, are captured by assessing changes at t in capital assets over:

$$Inclusive\ Investment = p_M(t)\Delta M(t) + p_H(t)\Delta H(t) + p_N(t)\Delta N(t) \ \ (8) \tag{8}$$

IW provides a capital measure for sustainable development. It links the discounted present value of all future consumption possibilities to the weighted sum of the capital asset (or wealth) profile, which is the productive base of the economic outcome. Capital assets under the IW accounting framework are both intertemporal means of production and direct sources of human well-being that meet the consumption needs of the current population.

The linear functional form of IW gives the impression that, according to the wealth/welfare equivalence theorem, various capital stocks are assumed to be perfect substitutes for each other in production (Daly *et al.* 2007). However, nowhere in the derivation of the wealth/welfare equivalence theorem is it mentioned that one capital good could be substituted for another. The social value, or shadow prices, are a function of the stock of capital goods. The accounting price structure reflects how various capital goods are substituted in production. There may be a slight possibility of substitution between the main forms of natural and productive capital, or any other form of capital.

Although the theoretical model of IW has been solidly demonstrated, the process of summarizing the empirical accounting of various capital goods and confirming their shadow prices is challenging and cumbersome. In the following section, we discuss time-dependent exogenous adjustments to the IWI.

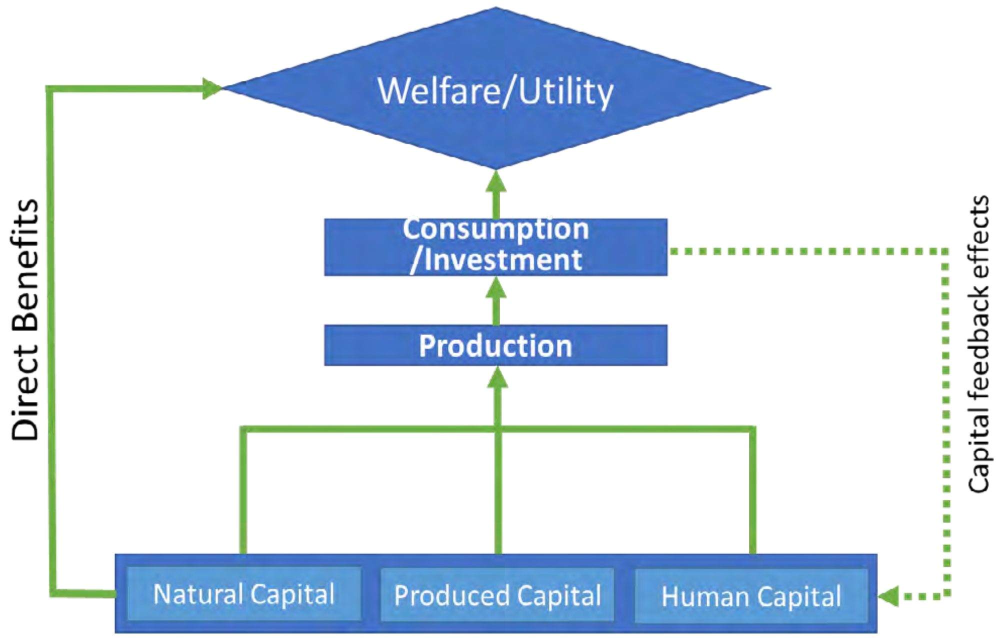

Figure 5.1: A three-capital model of wealth creation

The population-consumption-environmental nexus, regional inequality and technology progress

We consider time-varying exogenous adjustments of $r(t) = \frac{\partial V}{\partial t}$ and their impacts on local and global wealth and development sustainability. They are population change, transnational externalities and total factors productivity.

Population change. Population growth is exogenous to the wealth change. The assumption in Equation (3) considers a constant population, which is not realistic according to the rapid population growth in the past, and the considerable uncertainty in future population projections (Barbier 2019; UN population division 2019). Based on dynamic average utilitarianism, the intergenerational welfare V(t) can be expressed as:

$$V(t) = \frac{\int_{t=s}^{\infty} P(s)[U(c(s))e^{\delta(s-t)}]ds}{\int_{t=s}^{\infty} P(s)e^{\delta(s-t)}]ds} \quad (9)$$

Where $P(s)$ present the population at time s and $c(s)$ represents per capita consumption at time s. Denominator is discounted sum of population from the present to the future. By denoting the vector of per capita capital stocks as $\underline{k}(t)$, rewriting formula (9) to express total welfare as a function of population and per capita capital:

$$V(t) = V(k(t), P(t)) \quad (10)$$

It can be proven that $\frac{\partial V}{\partial t} = 0$ if the welfare change in Equation (10) is represented only by the capital stock per capita. Thus, development is sustained only if IW per capita which is valued at constant shadow prices does not decrease at t (Dasgupta 2001; Arrow *et al.* 2003).

It is assumed that population is a capital input in production, and thus output increases with population growth. However, in terms of output, increased population affects per capita consumption and welfare. Furthermore, economic development commonly ignores exogenous natural capital, and thus does not account for the adverse health effects of environmental damage (e.g. air pollution, climate change) and natural capital depletion. In the absence of effective management of natural resource private rights and conservation, free access to open natural resources is limitless, which exacerbates the negative feedback of population growth on total wealth, and ultimately results in the tragedy of the commons.

Dasgupta, Mitra and Sauger (2018) demonstrate that other things being equal, the tragedy of the commons occurs only if total population is sufficiently large relative to natural capital. Developing countries with limited natural capital management and high population growth struggle to accumulate sufficient human and produced capital to compensate for natural capital depletion. This may lead to IW loss, thereby exacerbating regional growth inequality (Dasgupta 2018; Sugiawana and Managi 2019; Kurniawan *et al.* 2021). The high natural capital and environment depletion rate that results from the population-environment dynamic may affect long-term progress towards achieving local and global SDGs.

Trans-national externalities. The global public impact of environmental externalities of climate change come from CO_2 emissions, and are independent of the wealth accumulation process. Let $G(t)$ be the stock of global public goods at t, where $G(t)$ is the concentration of CO_2 in the atmosphere. Let $k_n(t)$ be the stock of private assets owned by residents of country n. Then the intergenerational welfare can be expressed as the equation of $k_n(t)$, $G(t)$ and time t:

$$V_n(t) = V_n(k_n(t), G(t), t) \quad (11)$$

Similar to before, we can get

$$\frac{dV_n(t)}{dt} = r_n(t) + \frac{q_n(t)dK_n(t)}{dt} + g_n(t)\sum E_n \quad (12)$$

Where, $g_n(t) = \frac{\partial V_n(t)}{\partial G(t)}$ is the shadow price of the emission product G, and $\frac{dG_{n(t)}}{dt} = \sum E_n$ is the aggregated emission rate of each country. Equation (12) shows that a country's capital and emissions depend on shared principles and cooperation with all other countries, and also affect $r_n(t)$, $q_n(t)$ and $g_n(t)$. Equation (12) shows the impact of global public externalities on the wealth of countries, which is influenced by cooperation between countries and affects sustainable development. Globally, different frameworks have a common future but differentiated responsibilities. Reducing the global externalities of demographic change and environmental concerns must rely on transnational cooperation.

Total factor productivity. Technological progress is a time-vary exogenous positive factor and changes by country. Sustainability can be enabled by increasing productivity, even in the presence of declining wealth or increasing population. Here we denote total factors productivity as $A(t)$, output as $Y(t)$ and capital input as $F(K(t))$, assuming that $F(K(t))$ is constant return to the scale, under steady state:

$$C(t) = Y(t) = A(t)F(K(t)) \quad (11)$$

Here, we express the intergenerational welfare $V(t)$ as a function of $C(t)$ and t, the differential of $V(t)$ is:

$$\Delta V(A(t), K(t)) = \left(\frac{dV(A(t),K(t))}{dA(t)}\right)\left(\frac{dA(t)}{dt}\right) + \sum_i \frac{\partial V(K_i(t),A(t))}{\partial K_i(t)} \Delta K_i(t) \quad (12)$$

Let $q_{A(t)} = \frac{dV(A(t),K(t))}{dA(t)}$ represent the shadow price of total factors productivity, and the annual total factors productivity change rate is denoted as $\gamma = dA(t)/dt/A(t)$. The shadow price of welfare at t with consideration of the total factors productivity is:

$$\frac{\partial V}{\partial t} = A(t)/[\sum_i p_i K_i(t)] \quad (13)$$

In practice, total factors productivity is calculated as a residue of the production function, and here considers natural capital as a primary input to eliminate the impact of natural capital input on total factors productivity. In contrast, natural capital is not commonly considered in general economic accounting.

In addition to the above externalities, we also calculate the trade externalities of natural capital. In particular, we estimate oil price changes and the associated capital gains, by separating them from physical changes in the resource base. Oil exporting countries are positively affected by increases in oil prices. Conversely, the welfare of net oil importers tends to be negatively affected by higher oil prices, as their baskets of consumer goods and services shrink.

National inclusive wealth accounting

Empirical accounting of IW measures levels and changes in various capital stocks at the national level, and applies shadow prices to each capital. Furthermore, we need to aggregate these levels and changes to obtain estimates of total IW and total inclusive investment. Figure 5.2 provides a schematic diagram of how the three pillars of capital assets and adjustments shape the final IWI. The framework is similar to previous IWRs (2012; 2014; 2018). In this section, we describe how to implement these analysis elements. We further present the differences between the IWI empirical framework and past wealth estimation methods, as well as update and refine the data and methodology.

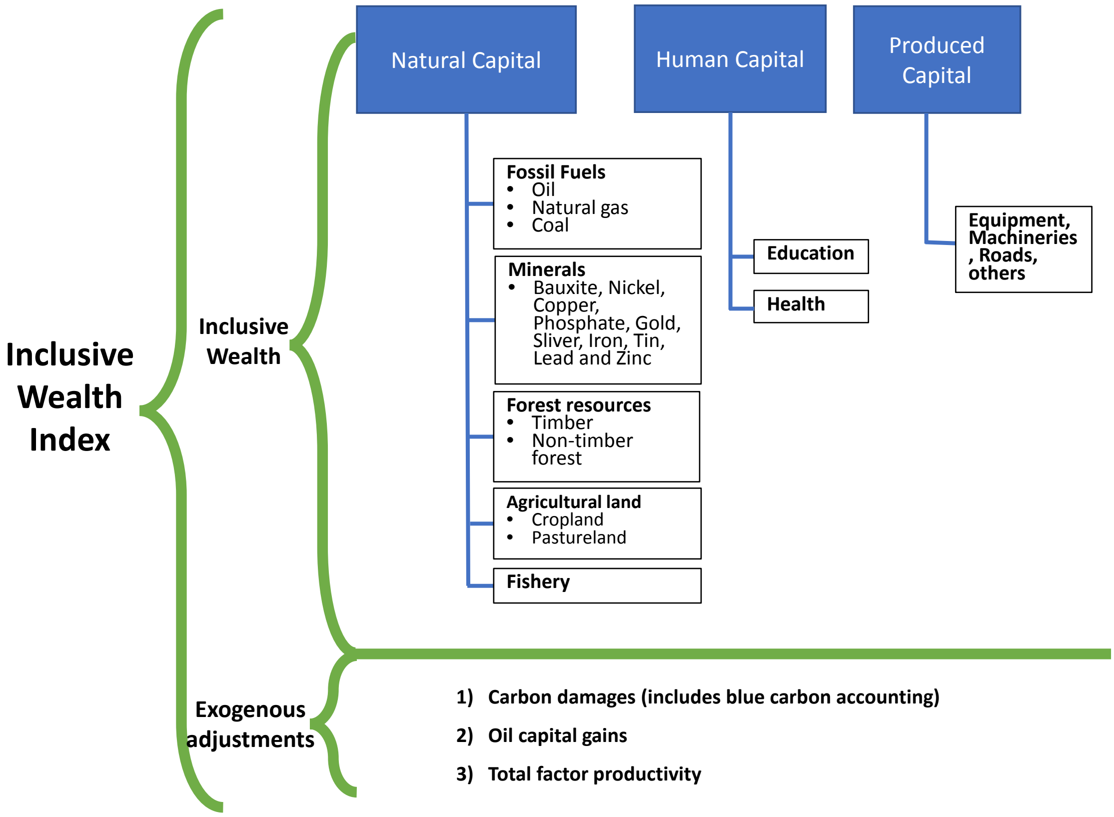

Figure 5.2: Schematic representation of the Inclusive Wealth Index and the Adjusted Inclusive Wealth Index

Human capital. IWR 2018, proposed alternative shadow prices for human capital (education and health), based on a nonparametric approach called frontier analysis. However, there was double counting when calculating health capital and education capital separately, and the results were not consistent with IWR 2012 and 2014. Therefore, for the latest human capital estimation, we adopt the cohort demographic information from the UN Population Division, to combine health and education factors. The essential difference between the latest accounting and previous IWRs (2012; 2014; 2018) is that first, we calculate human capital by gender; second, we determine education levels in the entire population based on expected years of schooling (EYS), instead of the mean years of schooling (MYS) used in past reports; and finally, the shadow price of human capital is measured based on expected years of work.

Expected years of schooling and expected years of work are estimated from the integrated life tables, which combine coherent age information on health, education and labour force participation. The estimation method is similar to classical Sullivan prevalence-based methods for evaluating life expectancy of the total population. The advantage of using EYS is that it can explain how long the total population average spends in school and can thus better confirm the adult (working) population's size. At the same time, the impact of changes in education investment on future education levels can also be better observed and discussed.

The shadow price of human capital is measured based on expected years of work. The logic of this calculation is that, for individuals engaged in employment activities, the remaining year of receiving compensation for education depends on labour market and health conditions. For the entire population, the shadow price of educational capital is equal to the sum of discounted present value of compensation (rent rate) over the average expected duration of working life. We assume rent rates are constant as the average value of the period in observation.

Moreover, the parameters of education, health and the labour market are stored in the cohort modelling process. This is essential for the next step of policy analysis. Both long- and short-term human capital changes can be discussed under this framework by selecting dynamic population projections and the various impact factors, e.g. health loss (Balakrishnan *et al.* 2019) due to air pollution, or education degradation due to out-of-school.

Produced capital. As with past IWRs, we calculate produced capital using the classic perpetual inventory method. This measures produced capital as a simple sum of total investment, by considering the capital depreciation incurred each period. Unlike previous IWRs, we use the variable capital depreciation rate by country and year to calculate the depreciation for produced capital. The varied depreciation rate is calculated based on produced capital investment structure provided by the Penn World Table 10.0 (Feenstra *et al.* 2015), and the United States Bureau of Economic Analysis (BEA) deprecation rates for capital assets (Fraumeni 1997). We consider the sustainability of resource allocation under the class of produced capital. The role of produced capital on the sustainable provision of future consumption capacity will be affected, due to differences in the allocation of produced capital investment in different assets and in their depreciation rate.

Natural capital. This report considers both non-renewable resources (fossil fuels and minerals) and renewable resources (agricultural land, forests and fisheries) as natural capital. According to the latest reserve estimation, the inventory change for non-renewable resources is simply the negative of the amount consumed (withdrawn) during the period. The shadow price of this capital is assumed as their rent value, due to our further assumption that the resource value is externally complete, and dependant on resource use. For renewable resources, we calculate their market value and non-market value. Consistent with IWR 2014, the ecosystem services values of forests were updated based on the Ecosystem Services Assessment Database (Van der Ploeg and de Groot 2010). Consistent with IWR 2018, fishery capital stock is estimated as part of renewable natural capital. Fishery resources evaluation is simplified by assuming that fish stocks belong to countries where harvesting occurs and the harvested resource is loaded.

Exogenous adjustments. Time-varying adjustments for IW exclude population change. We first calculate the impact of greenhouse gas emissions as the transnational externality of climate change. The cost of global greenhouse gas emissions is estimated per unit of CO_2 damage. Two types of global greenhouse gases are accounted for; carbon emissions from fossil energy sources and increased emissions from deforestation. We then follow Nordhaus's method to allocate carbon emissions to countries based on the proportion of the country's or region's GDP relative to global GDP. Particularly, we introduce the effect of blue carbon on carbon damage. However, given that blue carbon accounting only has one year of data, it is not reflected in the results analysis of this chapter. More specific analysis is found in chapter 2: natural capital analysis, of this report.

Following this, we allow for differences in total factors productivity between countries. By following IWR 2012 and 2014, we estimate the total factors productivity growth rate, which separates the contribution of produced and human capital to economic output, and considers the contribution of natural capital to economic growth. This estimate extracts the contribution of natural capital to production, and separates the true role that technological innovation and creativity play in production and other types of implicit capital not yet considered in building the nation's IW.

Finally, we consider the capital gains of oil exporters on depletable resource inventories, and the corresponding losses of oil importers. In a closed economy, price increases for an exhaustible resource are negligible due to price balance gains and losses for producers and consumers. However, in a group of interconnected open economies, exporters can expect higher prices (and thus greater control over future goods) and importers suffer accordingly. Conversely, importing countries may have fewer investment opportunities due to higher oil prices, which results in distribution of capital losses to consuming countries.

Estimating each capital requires multiple database information, and integrating all IW data into a time series is a key issue in IW accounting. Accounting coverage for the three capital types varies. Produced capital accounting covers 206 countries, human capital accounting covers 166 countries, and natural capital accounting covers 165 countries. The completed IW time-series data[38] covers 163 countries. This coverage surpasses previous IWRs, and accounts for 99 per cent of total global GDP and 98 per cent of the population. We provide two price forms of IW in 2015 constant US Dollar and convert to PPP.

38 The three capital datasets overlap but are not subsets of each other. For example, produced capital included regions and non-self-governing territories, which generally did not have information on the accounting of other capitals. Human capital accounting covers the Democratic People's Republic of Korea and North Macedonia, but these countries lack natural capital data.

The inclusive wealth of nations

This section outlines the key findings of empirical IW accounting from 1990 to 2019. In addition to comparing IW totals, per capita values and country results for each component change, we analyse the adjusted IWI (including adjusted total factors productivity, CO_2 damage and oil capital price gains). We then compare the IWI, HDI and GDP of countries to group them based on sustainability. For human capital, we use structural analysis to discuss the impact of each determinant on changes in human capital. Finally, we analyse regional wealth equality, by explaining the evolution of Gini coefficients of IW per capita and its components.

Performance of countries in reporting period based on wealth accounting

The average change of national IW, IW per capita, and adjusted IW per capita during the period 1990-2019 are depicted in Figures 5.3a, 5.3b and 5.3c. IW growth was positive in most countries during this period. Average growth in IW was negative in only 8 of the 163 countries – Myanmar, Cambodia, Chile, Ecuador, Iceland, Mauritania, Peru and Somalia (see Figure 5.3a where the red area indicates decline). Excluding population growth, 71 out of 163 countries (45 per cent) saw declines in per capita IW (see Figure 5.3b). These countries are mainly located in sub-Saharan Africa, Latin America and the Caribbean, and East Asia and Pacific. During the reporting period, 55 countries that previously showed a per capita IW decrease, saw growth in per capita wealth after adjustment. This is due to growth of total factors productivity. 17 countries saw a wealth decline even with adjustment of total factors productivity, oil capital gain and carbon damage cost (Brunei Darussalam, Central Africa Republic, Chile, Democratic Republic of the Congo, Congo, Ecuador, Gabon, Gambia, Madagascar, Mauritania, Peru, Saudi Arabia, Sierra Leone, Somalia, United Arab Emirates, Ukraine and Venezuela) (see Figure 5.3c).

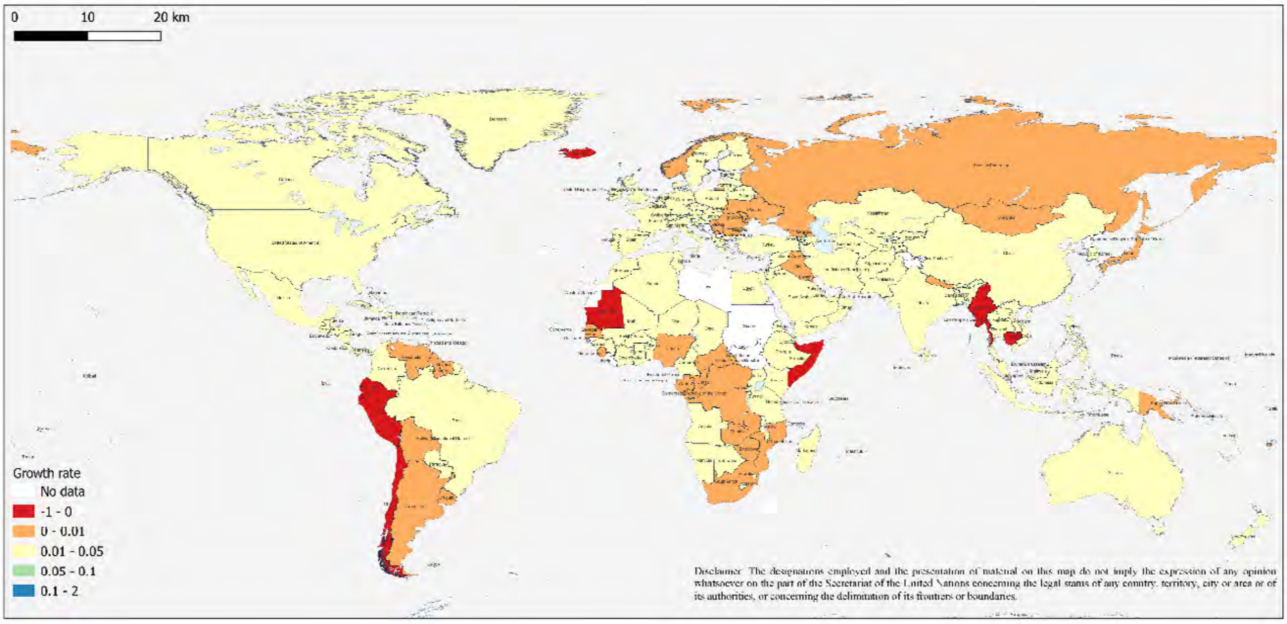

Figure 5.3a: Growth in Inclusive Wealth Index (unadjusted), 1990–2019

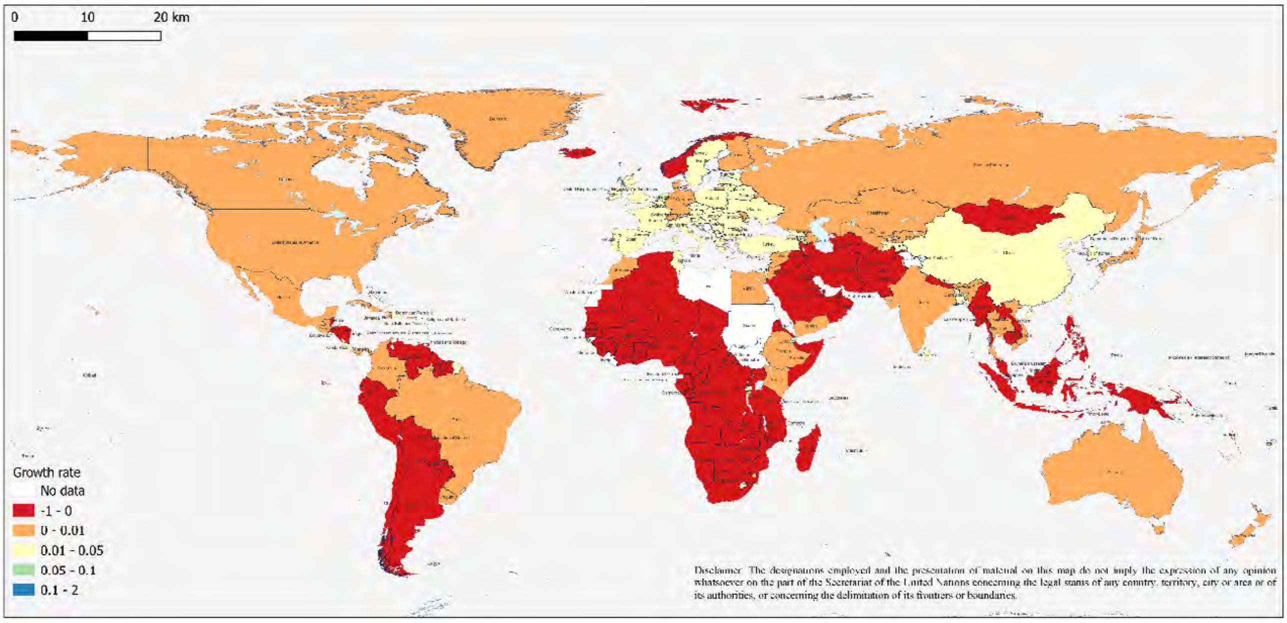

Figure 5.3b: **Growth in Inclusive Wealth Index per capita, 1990–2019**

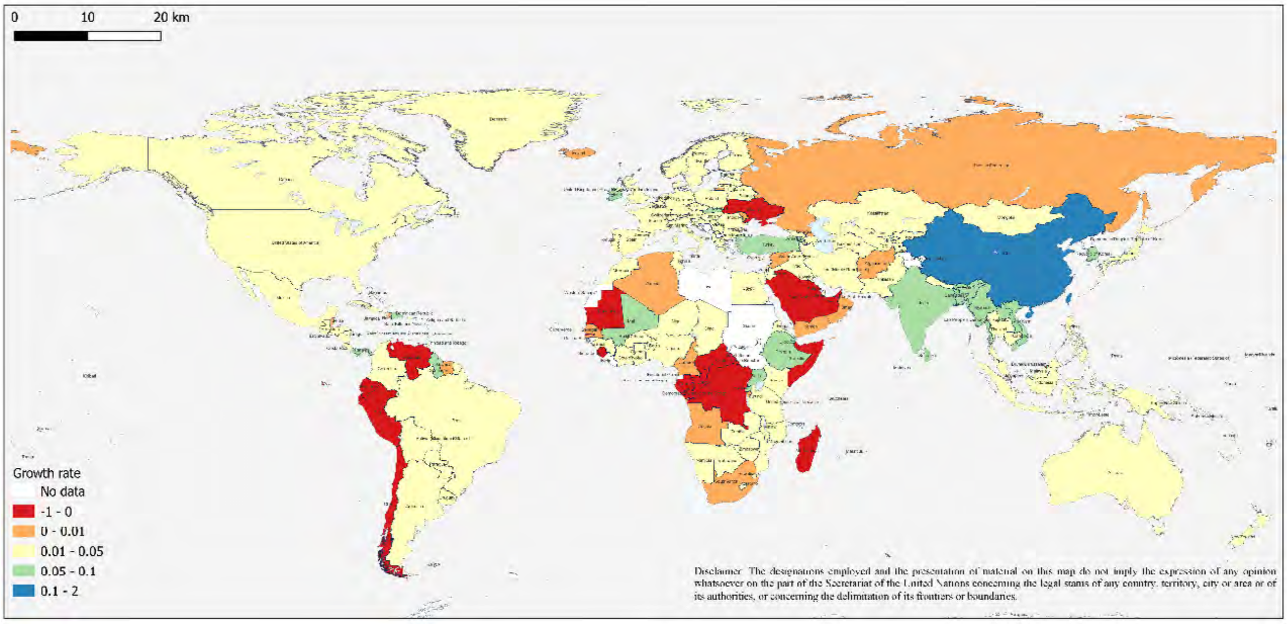

Figure 5.3c: **Growth in adjusted Inclusive Wealth Index per capita, 1990–2019**

Next, we categorized countries and regions by average IW and IW per capita change from 1990 to 2019 (see Figure 5.4). The horizontal axis indicates average change in IW, and the vertical axis indicates average change in IW per capita. Eight countries showed a decline in both total IW and IW per capita, as identified in Quadrant 3. Wealth growth was positive in the remaining countries (Quadrants 1 and 4), and 90 out of 163 countries (55 per cent) also increased per capita wealth (Quadrant 1). When adjusted for population growth, 63 countries (Quadrant 4) with declining wealth per capita are underinvested in wealth. Three of these are located in South Asia[39], 2 in Europe and Central Asia (Norway and Turkmenistan),

39 Afghanistan, Nepal and Pakistan.

8 in MENA[40], 31 in sub-Saharan Africa[41], 10 in Latin America and the Caribbean[42] and 9 are located in East Asia and the Pacific[43].

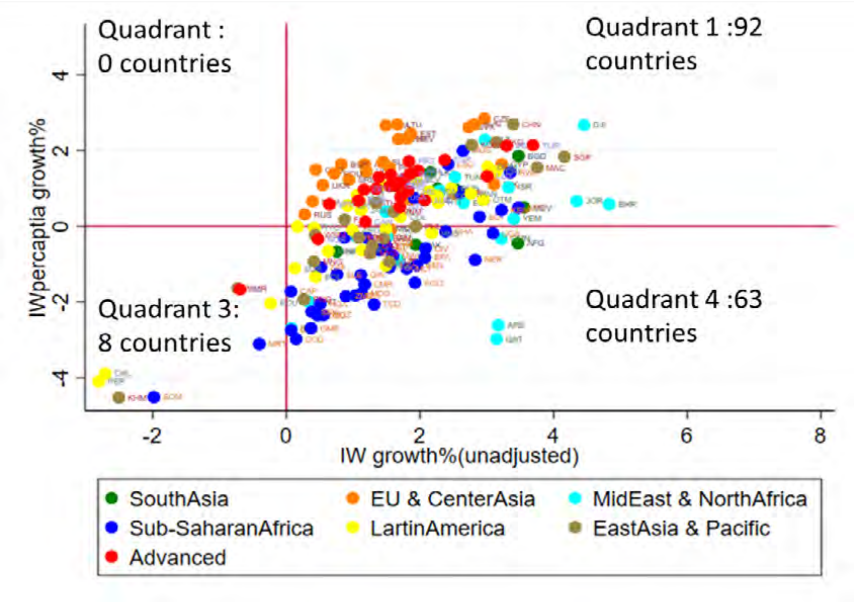

Figure 5.4: Annual average growth rate in total Inclusive Wealth and per capita term

We then decompose the contribution of population and per capita IW growth to total IW change, as shown in Table 5.1. Results were aggregated at the regional and income group levels. Overall, population growth was the largest contributor to IW growth. Globally, the average wealth increase was 1.64 per cent, of which 1.52 per cent was contributed by population growth. Europe and Central Asia were the exception to this finding, where the increase in total IW was primarily due to an increase in IW per capita (1.35 per cent for IW per capita growth and 0.31 per cent for population growth). Excluding per capita contribution, IW to total IW was positive in South Asia, East Asia and Pacific, and North America (0.52 per cent, 0.06 per cent and 0.45 per cent respectively) and negative in other regions. In Afghanistan, change in per capita IW contributed negatively (-0.47 per cent) to local wealth, despite average increases in per capita IW in South Asian countries. Generally, for all groups in Latin America and the Caribbean, and sub-Saharan Africa, IW per capita decline negatively contributed to the wealth of these regions. In the MENA region, the contribution of IW per capita was negative in high- and upper-middle-income countries groups (-0.66 per cent and -1.07 per cent, respectively) (Bahrain, Iraq, Israel, Jordan, Kuwait, Malta, Oman, Qatar, Saudi Arabia and the United Arab Emirates), but positive in low-income and lower-middle-income group countries (0.29 per cent and 0.86 per cent respectively). In East Asia and Pacific, low- and middle-income countries (Cambodia, Indonesia, Lao People's Democratic Republic, Mongolia, Myanmar and Vanuatu) faced underinvestment in wealth per capita, with IW per capita causing a 1.07 per cent decline in wealth in this group of countries.

40 Algeria, Iran (Islamic Republic of), Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

41 Angola, Botswana, Cameroon, Central African Republic, Chad, Congo, the Democratic Republic of the Congo, Benin, Eritrea, Gabon, Gambia, Ghana, Guinea, Côte d'Ivoire, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Zimbabwe, Togo, Uganda, Tanzania, Burkina Faso and Zambia.

42 Argentina, Bolivia, Belize, Guyana, Honduras, Nicaragua, Paraguay, Suriname, Trinidad and Tobago and Venezuela.

43 Brunei Darussalam, Indonesia, Lao People's Democratic Republic, Malaysia, Mongolia, Vanuatu, Papua New Guinea, Philippines and Samoa.

Table 5.1. Measuring countries' average annual growth rates, 1990-2019

Region	IW	Population growth	Inclusive Wealth Per Capita
South Asia	**2.52%**	**2.00%**	**0.52%**
Low income	3.46%	3.94%	-0.47%
Upper middle income	3.55%	3.05%	0.51%
Lower middle income	2.19%	1.50%	0.68%
Europe and central Asia	**1.66%**	**0.31%**	**1.35%**
Upper middle income	1.24%	0.03%	1.21%
Lower middle income	2.06%	1.11%	0.95%
High income	1.80%	0.32%	1.48%
Middle east and north Africa	**2.58%**	**2.68%**	**-0.10%**
Low income	2.45%	2.16%	0.29%
Upper middle income	2.21%	3.24%	-1.03%
Lower middle income	2.41%	1.58%	0.83%
High income	2.83%	3.50%	-0.66%
Sub-Saharan Africa	**1.42%**	**2.46%**	**-1.04%**
Low income	1.44%	2.71%	-1.27%
Upper middle income	1.22%	1.81%	-0.59%
Lower middle income	1.46%	2.38%	-0.92%
Latin America and Caribbean	**1.20%**	**1.31%**	**-0.11%**
Upper middle income	1.30%	1.32%	-0.01%
Lower middle income	1.63%	1.77%	-0.13%
High income	0.50%	0.77%	-0.26%
No definition*	0.63%	1.29%	-0.67%
East Asia and Pacific	**1.45%**	**1.39%**	**0.06%**
Upper middle income	1.71%	1.02%	0.69%
Lower middle income	0.53%	1.61%	-1.07%
High income	2.46%	1.31%	1.16%
North America	**1.44%**	**0.99%**	**0.45%**
Total	**1.64%**	**1.52%**	**0.12%**

Note: These region and income group classifications follow World Bank definitions. Venezuela has no income group definition.

Wealth change decomposition

The above breakdown of the contribution of population and per capita IW growth to countries' wealth growth provides a partial understanding of total IW change. In this section, we decompose and analyse the contribution of three capital stocks to wealth growth. Average annual changes in IW per capita and capital contribution to the change are shown in Figure 5.5. Between 1990 and 2019, 71 of 163 countries experienced a decrease in IW per capita. Of the 10 per cent countries with most significant reductions, nine are located in sub-Saharan Africa. Natural capital decline negatively affected IW per capita growth in 151 out of 163 countries except for Lithuania, Latvia, Estonia, Croatia, Armenia, Malta, Bulgaria, Albania, Georgia, Serbia, Ukraine and Moldova. This wide-reaching natural capital decline is a key factor in the decline in per capita IW.

All countries in East Asia showed significant negative impact of natural capital loss, except Hong Kong and Singapore. Moreover, ten (Myanmar, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Mongolia, Vanuatu, Papua New Guinea and Samoa) of the 23 countries in this region showed negative growth in per capita wealth. Cambodia, Papua New Guinea and Myanmar showed the most significant per capita wealth decline. The region's per capita wealth decline was due to natural capital extraction and insufficient accumulation of other capital.

Most countries and regions in Europe and Central Asia showed substantial human and productive capital accumulation, and the negative impact of natural capital losses was less than in other regions. natural capital per capita increased in 10 countries. In Iceland, Norway and Tajikistan, however, the loss of natural capital led to a reduction in per capita wealth.

IW per capita declined in 12 of 27 Latin America and the Caribbean countries. The rate of natural capital decline in these countries was much higher than the rate of capital accumulation in other countries in the region. In particular, while a large amount of natural capital was consumed in Peru and Suriname, these countries showed very little other capital accumulation.

In the Middle East and North Africa, four countries, or 10 per cent of countries in the region, experienced significant per capita wealth loss. These countries were Iraq, Kuwait, Qatar and the United Arab Emirates. Remarkable reductions in natural capital and insufficient accumulation of other capital led to wealth declines. In Djibouti and Malta, the fastest growing wealth per capita countries in this region, there were few or positive contributions from natural capital.

In North America, although wealth per capita showed an increase, the negative impact of natural capital losses in Canada was more significant than in the United States of America, resulting in a comparatively smaller increase in wealth per capita in Canada.

In South Asia, Afghanistan experienced a decline in wealth resulting from human and natural capital loss. Despite other capital accumulations in Nepal and Pakistan, the loss of natural capital resulted in a decline in eventual wealth per capita.

In sub-Saharan Africa, sizeable natural capital losses and low levels of other capital accumulation were responsible for a general decline in per capita wealth. Only eight countries accumulated wealth per capita (Mauritius, Lesotho, Rwanda, Cabo Verde, Eswatini, Ethiopia, Kenya and Burundi). At the same time, capital per capita, excluding natural capital, declined in countries with the most significant declines in per capita wealth in the region (Central African Republic, Gabon, Nigeria, Somalia and Togo).

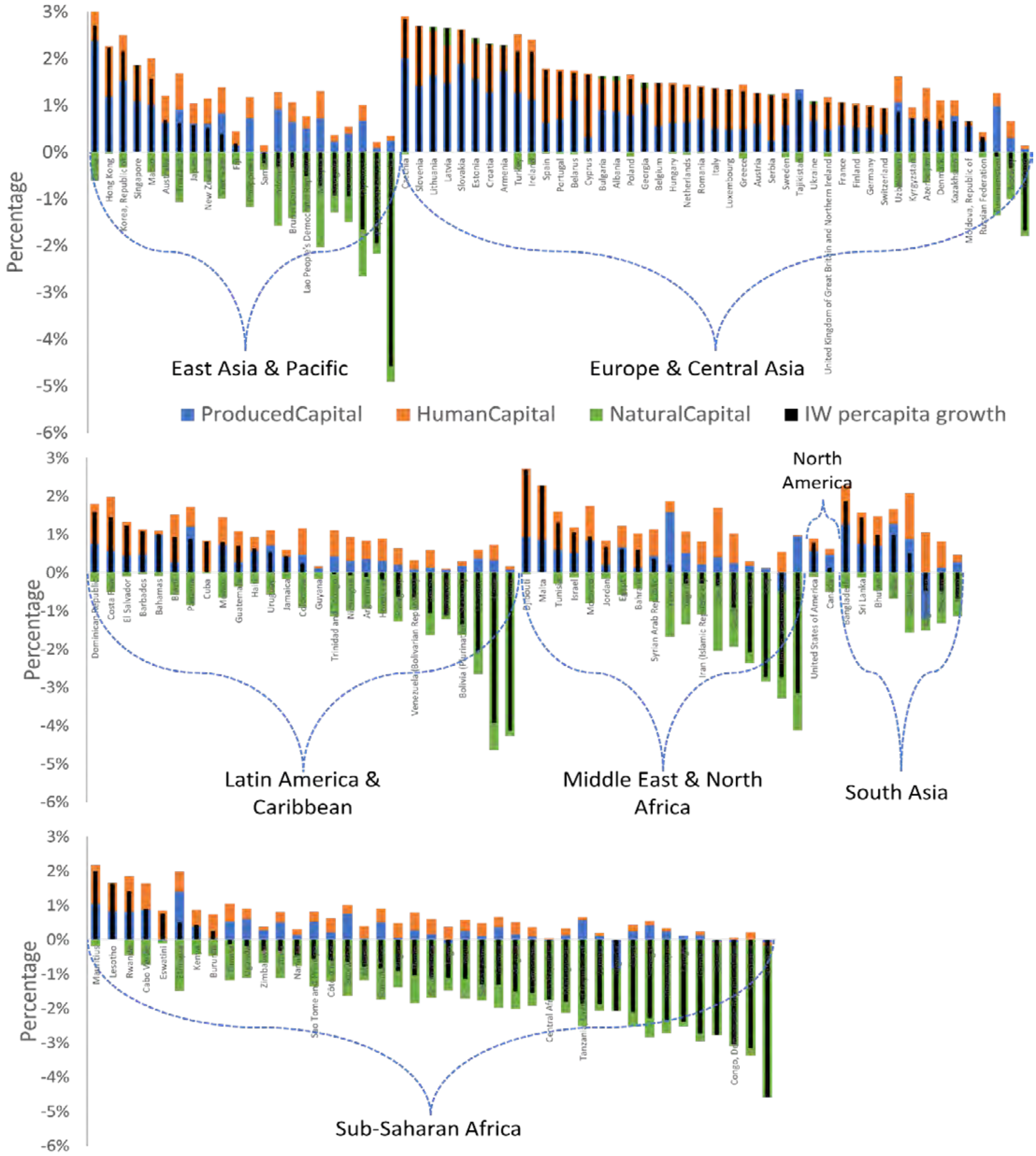

Figure 5.5: Annual average per capita growth rates disaggregated by capital form, 1990–2019

While investment in human and produced capital has caught up with population growth in most countries, the extent to which natural capital is increasingly depleted is of serious concern, and is related to the relative difference in the importance of each capital to countries. Suppose the depletion of natural capital can be compensated for by a faster accumulation of human and produced capital. In that case, the sustainability of IW can still be met. However, for some countries whose wealth is dominated by natural capital, if there is no effective accumulation of other capital, then the depletion of natural capital affects their sustainable development fundamentally.

Thus, we analyse the proportions of the three capital types in the total IW across countries. Figures 5.6a, 5.6b and 5.6c show the average percentage of each capital in each country's IW from 1990 to 2019. (Note that the percentage here only represents the proportion of capital in the country's total IW, and does not reflect the total size of the country's IW. If the total amount of wealth is small, even if the proportion of a particular capital is large, it does not mean that the capital stock level of the country is high).

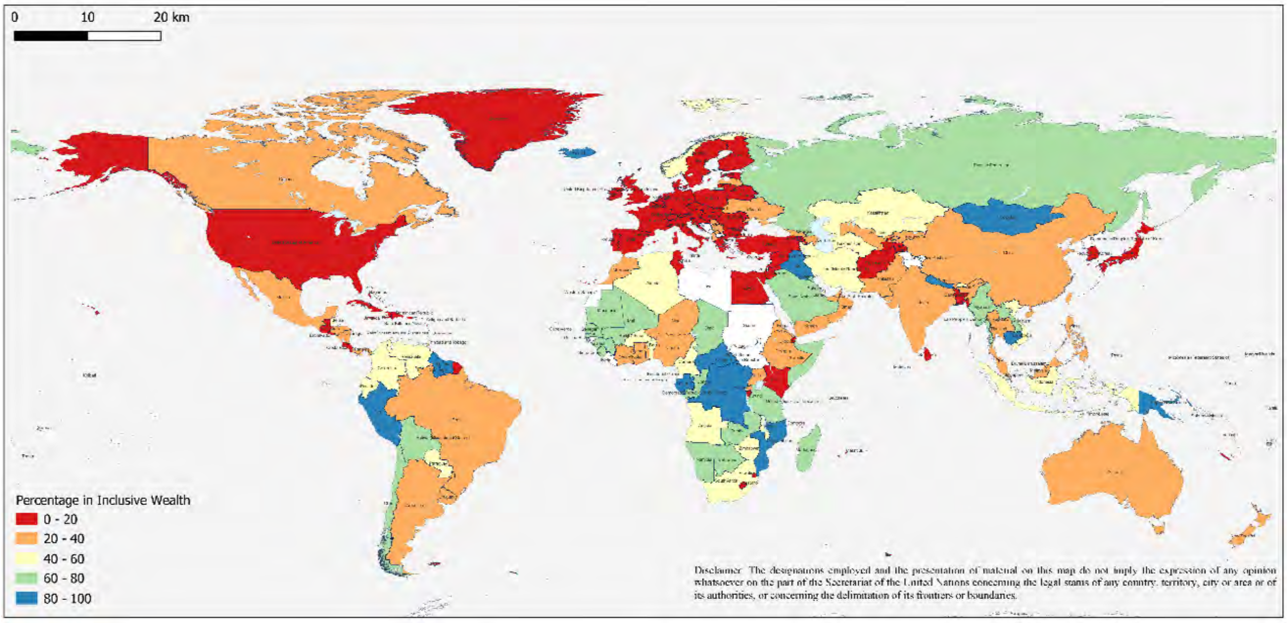

Figure 5.6a: **Percentage of natural capital in total wealth, 1990–2019**

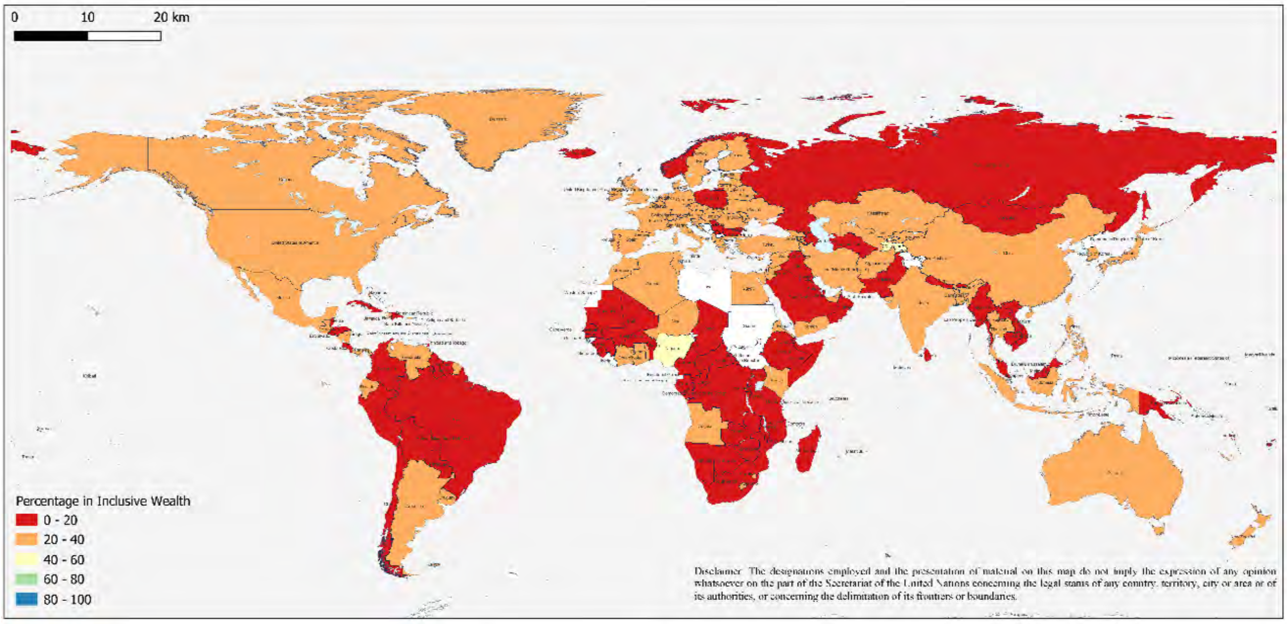

Figure 5.6b: **Percentage of produced capital in total wealth, 1990–2019**

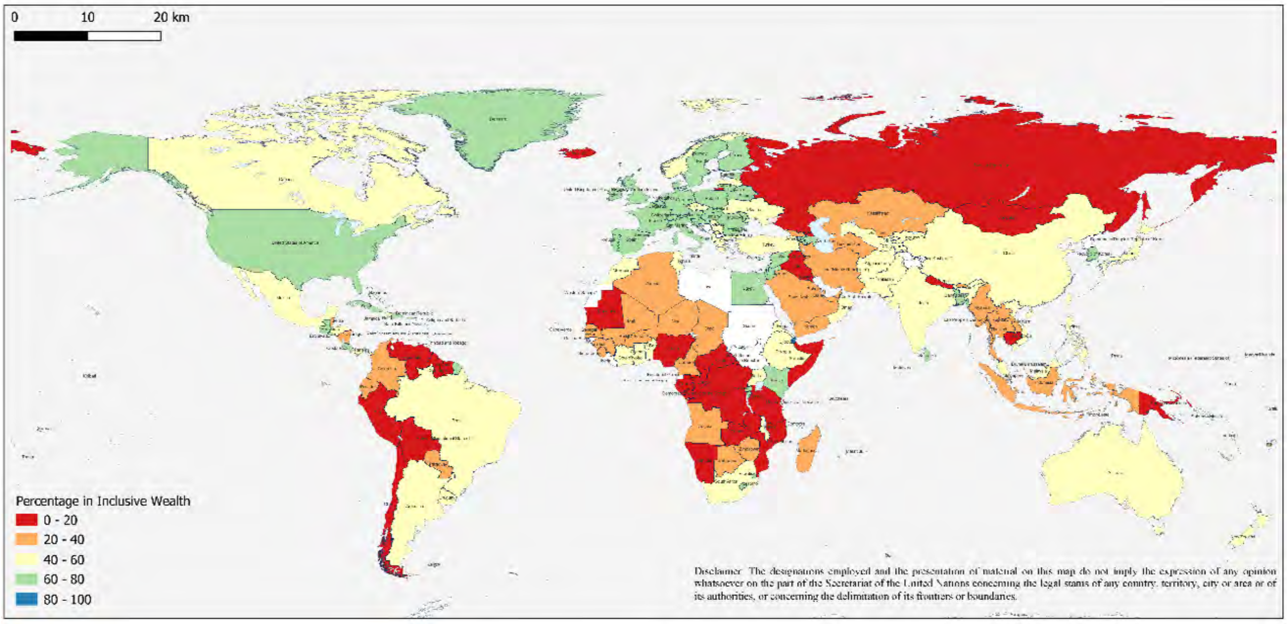

Figure 5.6c: Percentage of human capital in total wealth, 1990–2019

Natural capital accounted for more than 60 per cent of the total capital in 35 of the 163 countries (see Figure 5.6a). Of these, 18 countries are located in sub-Saharan Africa. Six countries are located in East Asia and the Pacific, five are located in Latin America and the Caribbean and six countries are located in other regions. The share of produced capital in total IW did not exceed 60 per cent for all countries (see Figure 5.6b). Nigeria and Tajikistan are the only countries with produced capital accounting for more than 50 per cent of their total IW in the past 30 years. Produced capital accounts for 30–40 per cent of the total IW in 21 countries, and 68 of 163 countries are with a ratio of produced capital to IW between 20–30 per cent. In the remaining 71 countries (44 per cent of all countries), produced capital accounts for less than 20 per cent of their total IW.

In 101 of 163 countries (62 per cent), human capital is the main source of wealth, and accounts for more than 50 per cent of the total IW in 76 of 163 countries (see Figure 5.6c). Human capital accounts for more than 60 per cent of total wealth in 54 countries. More than half of these countries are located in North America, and Europe and Central Asia (30 countries). Six countries are located in the Middle East and North Africa (Djibouti, Israel, Jordan, Malta, Syrian Arab Republic and Egypt), six in Sub-Saharan Africa (Burundi, Kenya, Lesotho, Mauritius, Rwanda and Swaziland) and six countries in Latin American and the Caribbean (Bahamas, Barbados, Costa Rica, Cuba, Dominica, El Salvador and Guatemala). In Hong Kong China the Republic of Korea, Singapore, Bangladesh and Sri Lanka, human capital accounted for more than 60 per cent of IW in East Asia and South Asia.

For most countries, the wealth combination was mainly from human or natural capital. In 60 countries with less human capital, their wealth was contributed by natural capital. The exceptions are Niger and Tajikistan, where produced capital accounted for about 50 per cent of the wealth. However, the contribution of wealth to total wealth growth is different. Table 5.2 shows contribution to capital in total IW at the relative percentage, aggregated at regional and income group levels. Negative values show the effect of reducing this capital on the change in IW. Global wealth accumulation was contributed by human capital increase, which accounted for 66 per cent of wealth growth. Produced capital growth contributed 55 per cent to wealth growth.

In contrast, natural capital depletion contributed 18 per cent to wealth reduction. In the Middle East and North Africa, and sub-Saharan Africa in particular, human capital contributed more than 80 per cent of IW growth (84 per cent and 88 per cent, respectively), while reductions in natural capital had a clear negative contribution to reductions in IW. The natural capital value of two regional income groups positively contributed to wealth: upper-middle-income countries in Latin America and the Caribbean and high-income countries in East Asia (contributing 38 per cent and 4 per cent respectively). The impact of natural capital reduction was greatest in upper-middle-income countries (Iraq and Jordan), reaching -264 per cent (these countries also had a considerable increase in human and produced capital).

Table 5.2: Relative contribution of human, produced and natural capital to growth by regions, and income group, 1990–2008 (%)

	Human Capital	Produced Capital	Natural Capital
South Asia	**67**	**38**	**-5**
Low income	91	10	0
Upper middle income	82	37	-19
Lower middle income	61	42	-3
Europe and central Asia	**48**	**60**	**-8**
Upper middle income	36	83	-19
Lower middle income	37	71	-8
High income	55	48	-3
Middle east and north Africa	**84**	**68**	**-52**
Low income	65	58	-23
Upper middle income	132	233	-264
Lower middle income	73	46	-19
High income	84	47	-31
Sub-Saharan Africa	**88**	**51**	**-38**
Low income	102	42	-44
Upper middle income	114	62	-76
Lower middle income	64	57	-21
Latin America and Caribbean	**58**	**32**	**10**
Upper middle income	44	18	38
Lower middle income	77	41	-18
High income	74	58	-32
No definition*	66	63	-28
East Asia and Pacific	**61**	**51**	**-12**
Upper middle income	72	66	-37
Lower middle income	56	41	4
High income	62	57	-19
North America	**55**	**52**	**-8**
Total	**66**	**52**	**-18**

Note: Venezuela has no income group definition according to latest World Bank.

Overall, countries' average human capital share over the study period clearly shows the importance of human capital to total wealth (accounted for 54 per cent of wealth, see Figure 5.7, left). This proportion has increased by 1 per cent over the past 10 years. By contrast, the natural capital share has fallen from 25 per cent of total wealth in the period 1992–2009, to 18 per cent in the period 2010–2019. The produced capital share increased from 22 per cent to 28 per cent between 2010 and 2019. Changes also show the increased contribution of human and produced capital to total wealth, and the continual decline of the share of natural capital (see Figure 5.7, right).

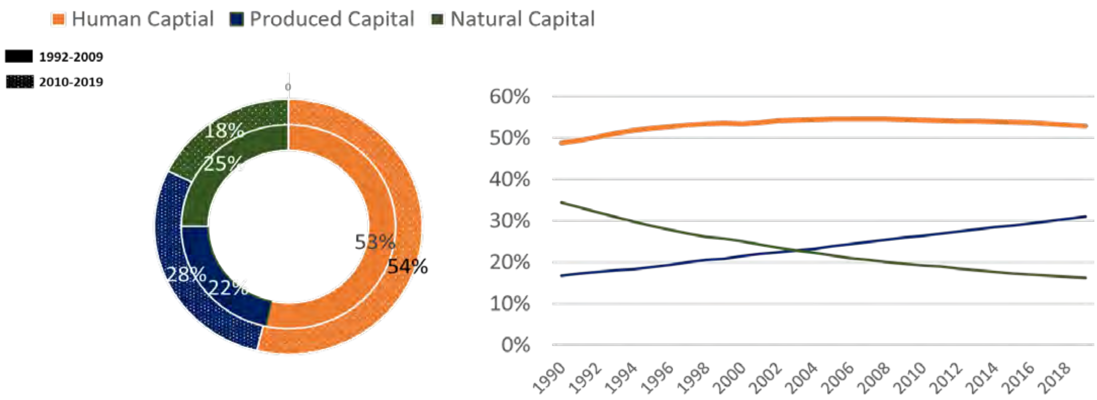

Figure 5.7: Developments in the composition of wealth by capital, 1990–2019

The relationship between countries' capital shares (see Figure 5.8) provides important implications: human capital accounts for a large proportion of wealth in most high-income countries (57 per cent average for high-income countries, 36 per cent average for low-income countries); while natural capital accounts for a large share of national wealth in low-income countries (49 per cent average in low-income countries, compared with 17 per cent average in high-income countries). Human capital's share of total national wealth shows minor variation by income group of countries (25 per cent average in high-income countries, and 15 per cent average in low-income countries). However, low-income countries may also have low proportions of natural capital and high proportions of human capital. It must also be noted that the proportion is only a relative value, and does not represent the absolute wealth of a country. Therefore, even if low-income countries have a high proportion of human capital, the actual total wealth will still be low.

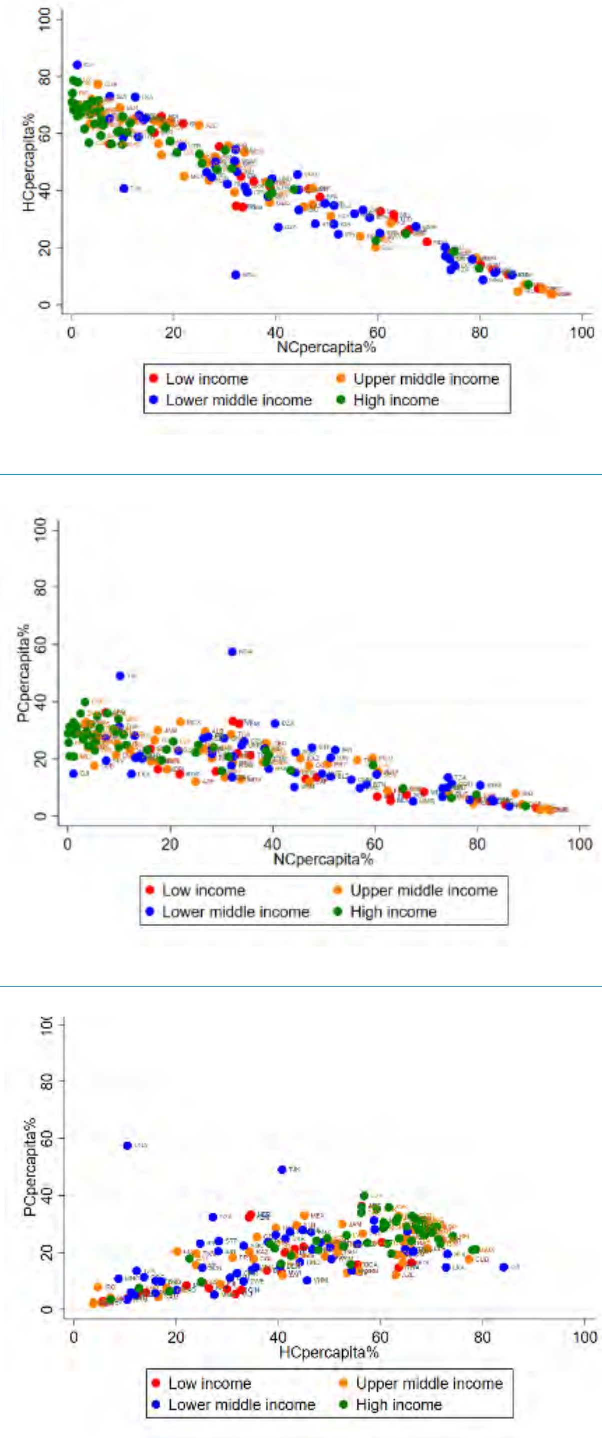

Figure 5.8: Developments in the composition of wealth by capital, 1990–2019

The above results do not infer the substitutability of one capital for the other in the development process. Although the depletion of natural capital is common in countries, this may not reflect the relative accumulation of human and productive capital in some countries. Conversely, some countries have achieved rapid accumulation of human and productive capital, with relatively minor depletion of natural capital. This evidence could mean differences in the marginal value of natural capital, and different paths to sustainable development for countries.

Changes in worldwide aggregated inclusive wealth

Here, we briefly summarize global IW changes during the period 1992–2019. The data all commence in 1992 as opposed to 1990, due to some missing values in 1990. Figure 5.9 depicts the overall transition of IW and its components in absolute and per capita terms. The results were compared with GDP and global population changes. Both IW and GDP are in constant 2015 USD.

Results show that total global IW has grown steadily during the reporting period. From 1992 to 2019, wealth increased by 49 per cent. However, the change in per capita wealth showed a decreasing trend. Per capita IW declined prior to 2005, and showed positive change after 2005, although in 2019 was still about 5 per cent lower than in 1992. Produced capital was the main source of IW growth, with per capita produced capital increasing by 92 per cent between 1992 and 2019. In the same period, per capita human capital increased by 38 per cent, while per capita natural capital reduced by approximately 50 per cent .

On average, human capital was the main source of wealth, accounting for 54 per cent of total global IW (last decade), followed by productive capital (28 per cent) and natural capital (18 per cent). Conclusively, relatively low growth in human capital, combined with significant losses in natural capital, largely explains the overall modest growth in global IW, despite the gains from increased productive capital.

It is also important to note that the most recent ten-year data show that the growth of GDP per capita no longer keeps pace with the growth of productive capital (in the past 20 years, the growth of the two has shown synchronicity). The accumulation of productive capital per capita continued to increase, but the increase in per capita GDP slowed down. On the other hand, growth disparities in GDP per capita and IW per capita have widened. These differences in progress measured in GDP imply the need to incorporate sustainability into economic assessments and policy planning.

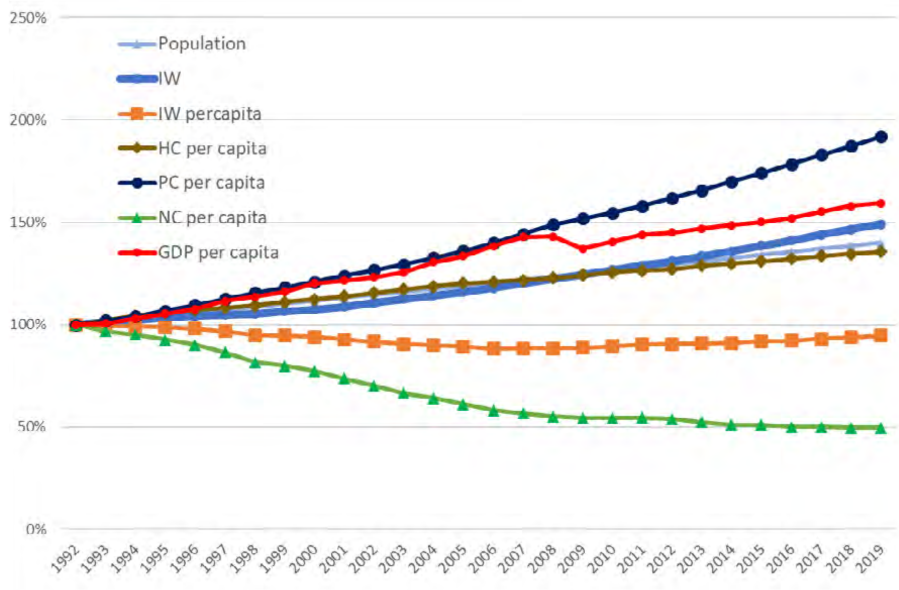

Figure 5.9: **Changes in worldwide inclusive wealth per capita and other indicators, 1992–2019**

Adjusted Inclusive Wealth Index

The impact of the three adjustments on countries' IW is shown in Figures 5.10a, 5.10b and 5.10c. The effects of oil capital gains and carbon damage are calculated on a per capita-to-per capita IW basis. Total factors productivity growth is additionally calculated as it shows an enhanced ability to provide a utility that cannot be explained by existing capital investments. Here, total factors productivity is calculated by considering human capital and produced capital. Natural capital is also assumed as the input of production.

Although 22 oil-exporting countries benefited from higher oil prices, 141 out of 163 countries suffered losses due to changes in oil prices. Furthermore, the wealth-increasing effect of oil income is not significant. Even in the top earners of Venezuela and Iran (Islamic Republic of), this gain contributed only 0.16 per cent and 0.11 per cent respectively of adjusted wealth growth. Conversely, their natural capital reduction contributed to their IW per capita decline by 1.1 per cent and 0.97 per cent respectively.

The total factors productivity in 160 of 163 countries contributed to adjusted IW growth. The results show that increased production efficiency can create more utility from less wealth input. Over the past 30 years, 15 countries have shown a total factors productivity growth rate of more than 5 per cent, nine of which are middle-income countries (Bhutan, Cambodia, China, Guyana, India, Iraq, Lao People's Democratic Republic, Myanmar and Viet Nam), five of which are low-income countries (Ethiopia, Mali, Mozambique, Rwanda and Uganda) and one of which is a high-income country (Qatar). However, in 15 countries, although total factors productivity increased, it still did not compensate for the decline in their per capita IW (Brunei, Central African Republic, Chile, Congo, the Democratic Republic of the Congo, Ecuador, Gabon, Gambia, Madagascar, Mauritania, Peru, Saudi Arabia, Sierra Leone, Somalia and the United Arab Emirates).

As the effects of climate change intensify, losses from carbon destruction are likely to become more intense in the future. At this stage, losses due to carbon damage have little impact on IW (no more than -0.03 per cent), but the impacts of climate change are widespread, with carbon damage losses occurring in 115 of 163 countries. Carbon destruction has had the most significant impact on wealth loss in the following countries: Bangladesh, Ethiopia, Djibouti, India, Ireland, Lesotho, Mali, Rwanda, Sri Lanka and Uganda.

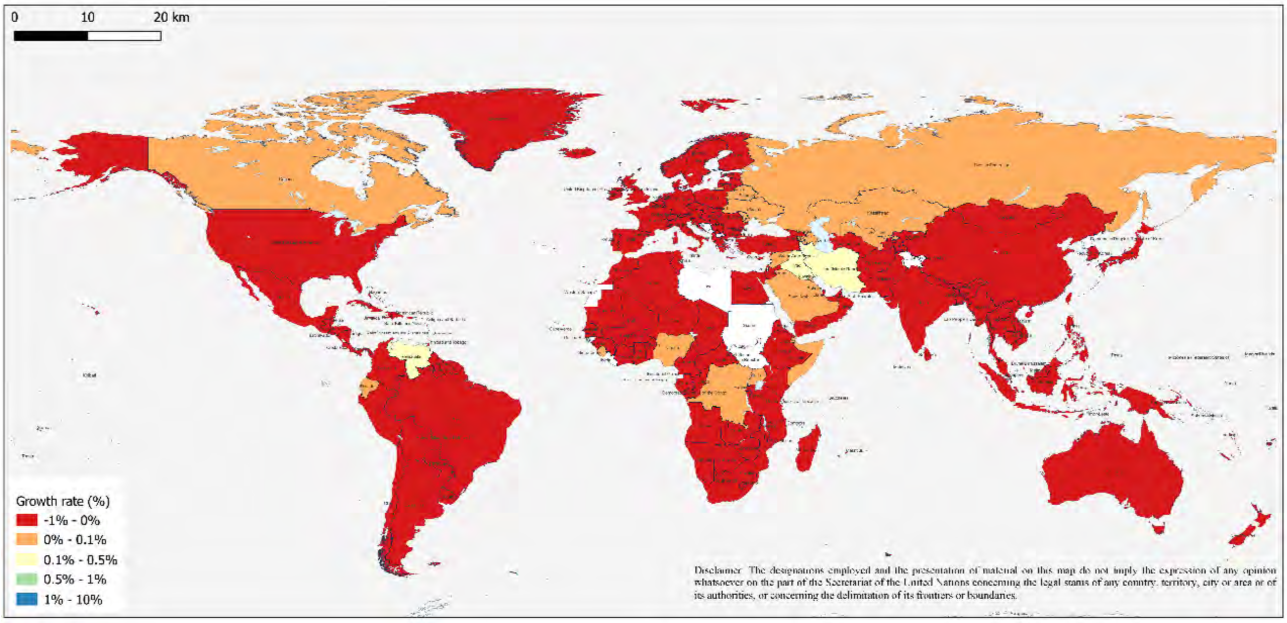

Figure 5.10a: The average growth rate of oil capital gains, 1990–2019

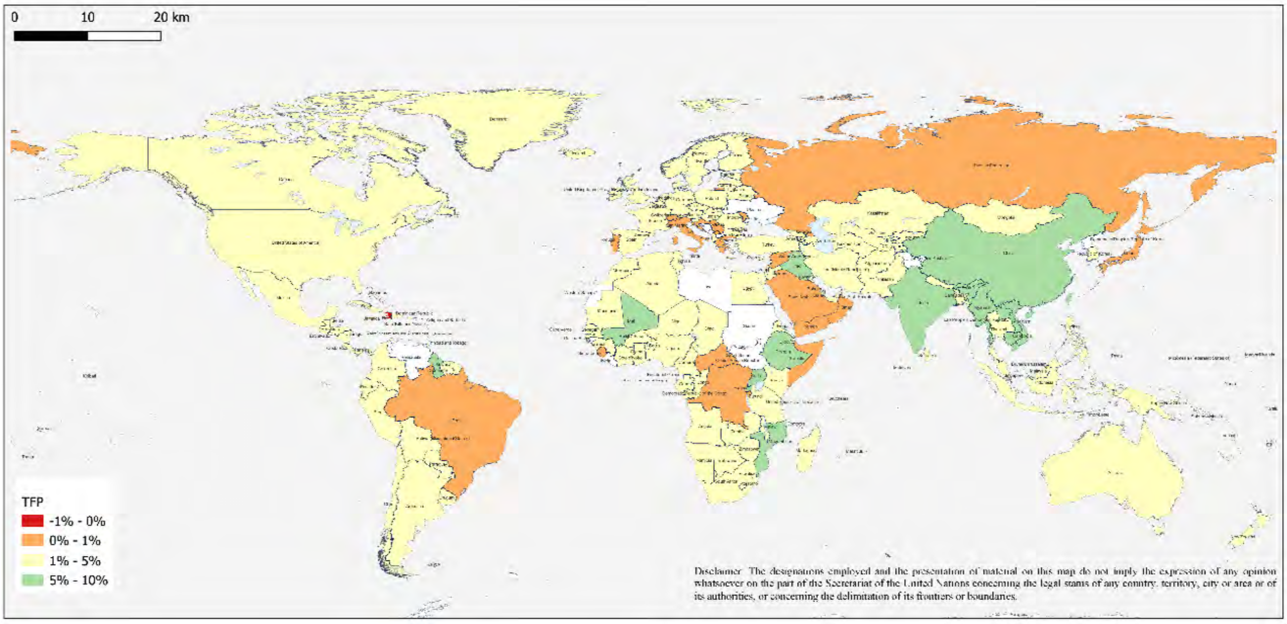

Figure 5.10b: Average growth rate of total factors productivity, 1990–2019

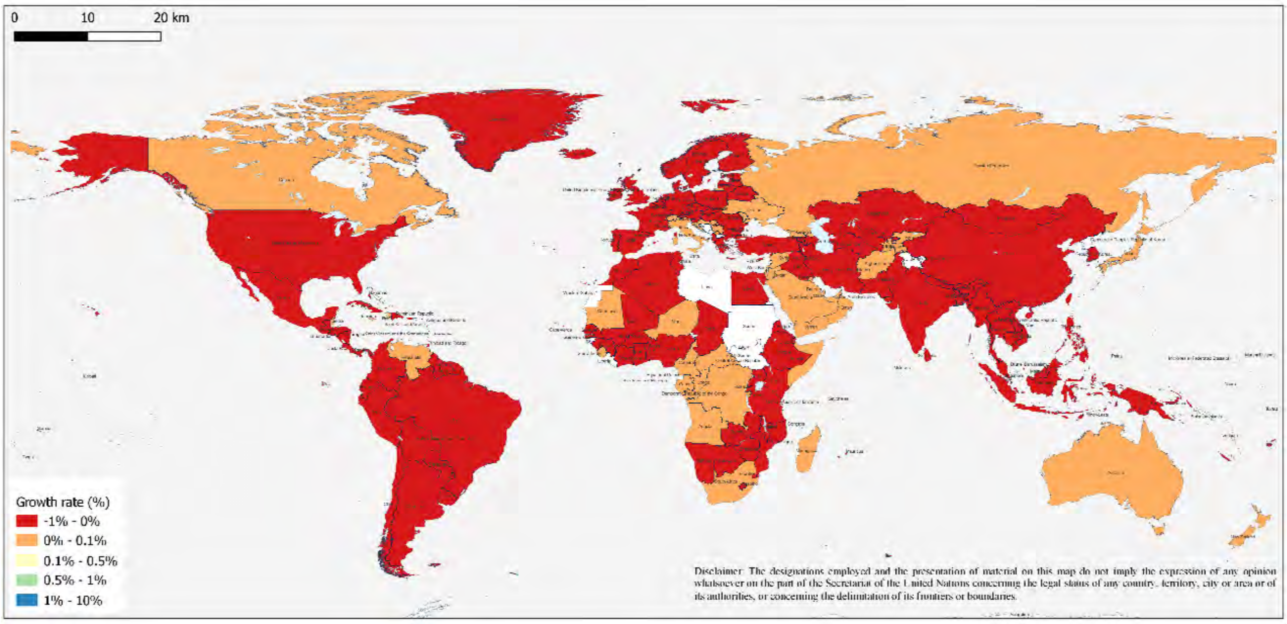

Figure 5.10c: **Average growth rate of carbon damage, 1990–2019**

Comparison of inclusive wealth, GDP and HDI?

This section compares IW to the two other commonly used indicators: GDP and the HDI. GDP measures the market currency value of all final goods and services produced by a given economy over a period of time. The HDI is the metric of sustainability that relates to a range of outcomes seen as critical to human well-being, life expectancy, education and income. By comparing the trends measured by GDP, HDI and IW, we can determine how these measures of progress converge or diverge when assessing country performance.

Figures 5.11a, 5.11b and 5.11c present these measures as average IW percent growth rates, GDP per capita, and HDI from 1990 to 2019. Results show that growth rates of IW per capita are generally bound in -4 per cent to 2 per cent, which are generally lower than the growth of GDP per capita and HDI. In measuring IW, natural capital depreciation leads to a slower pattern of growth path in most countries.

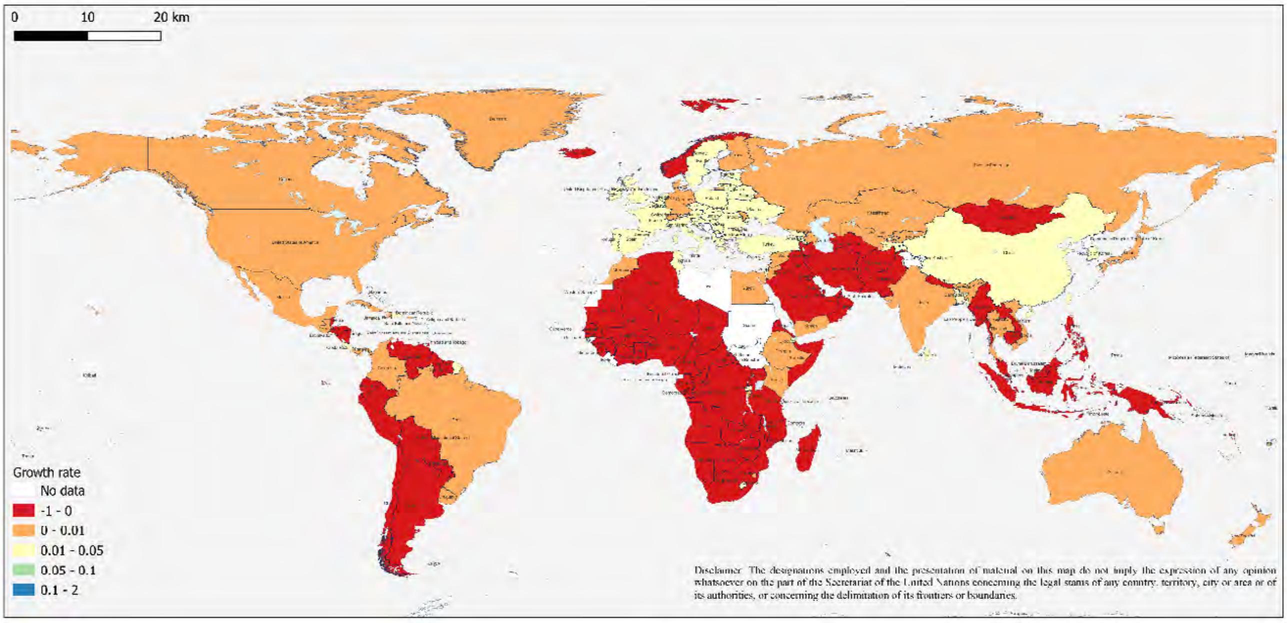

Figure 5.11a: **The annual average growth of the Inclusive Wealth per capita, 1990–2019**

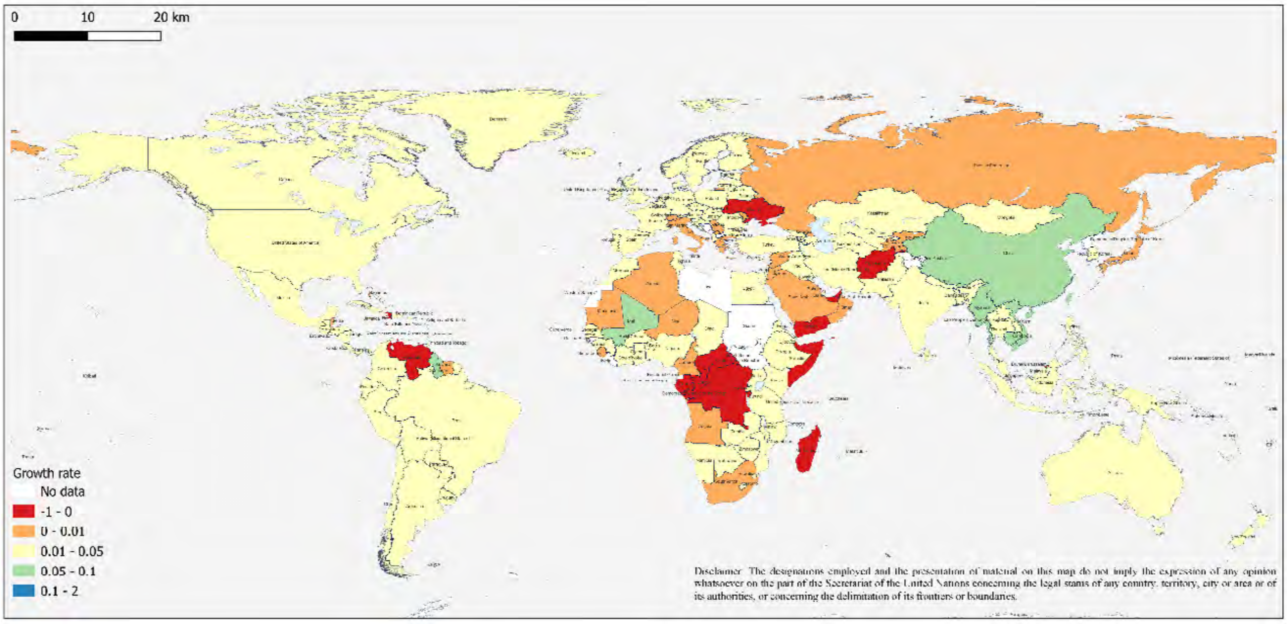

Figure 5.l1b: **The annual average growth of the GDP per capita, 1990–2019**

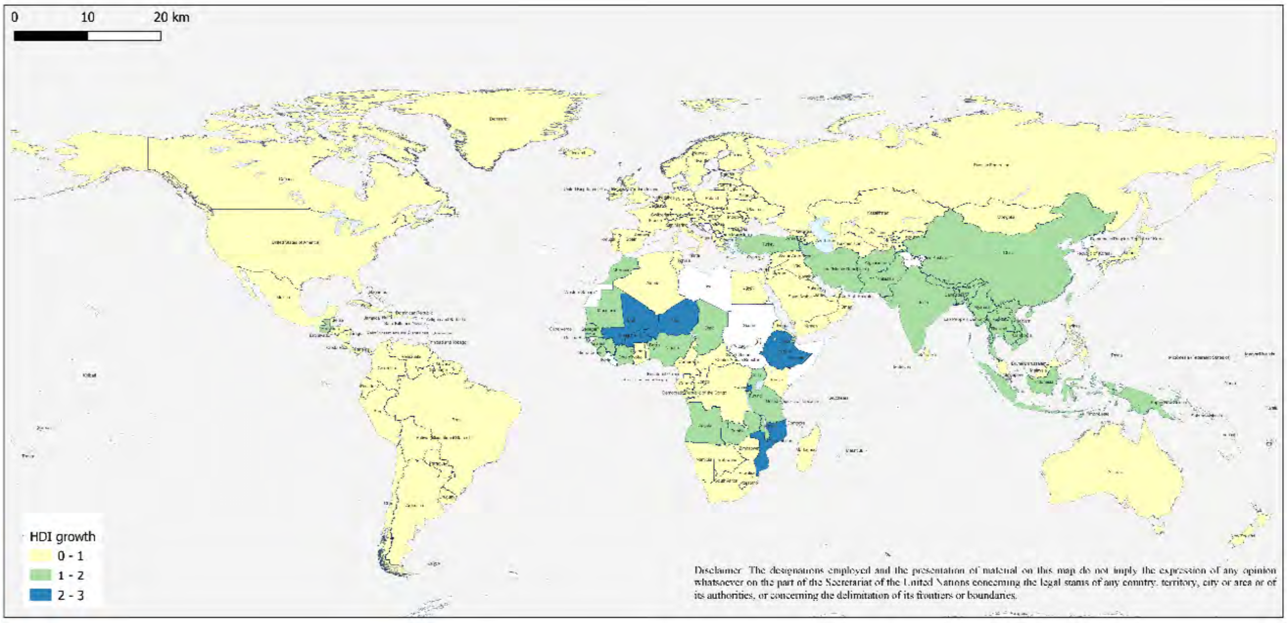

Figure 5.11c: Annual average growth of the HDI, 1990–2019

We found that 92 of 163 countries experienced growth in IW, while 149 countries have seen growth in GDP per capita over the past 30 years. All 163 countries showed positive HDI growth. We then group countries by income level and average IW, GDP and HDI growth, as shown in Figures 5.12a, 5.12b and 5.12c.

High-income economies mostly show positive developments (green dots show high-income countries). However, some high-income economies experienced negative per capita IW and GDP growth, including Brunei Darussalam and the United Arab Emirates. Both countries' main source of wealth is natural capital (and mostly fossil fuels). The depletion of non-renewable resources largely explains the negative growth in wealth. At the same time, the increase in human and productive capital is not enough to compensate for the loss of natural capital. There are five countries with negative GDP and IW growth in the low-income group. Four countries (Burundi, Haiti, Ukraine and Yemen) showed an increase in HDI and an increase in IW, but GDP per capita declined in these countries. These countries have achieved a large accumulation of human capital but need to increase the accumulation of productive capital.

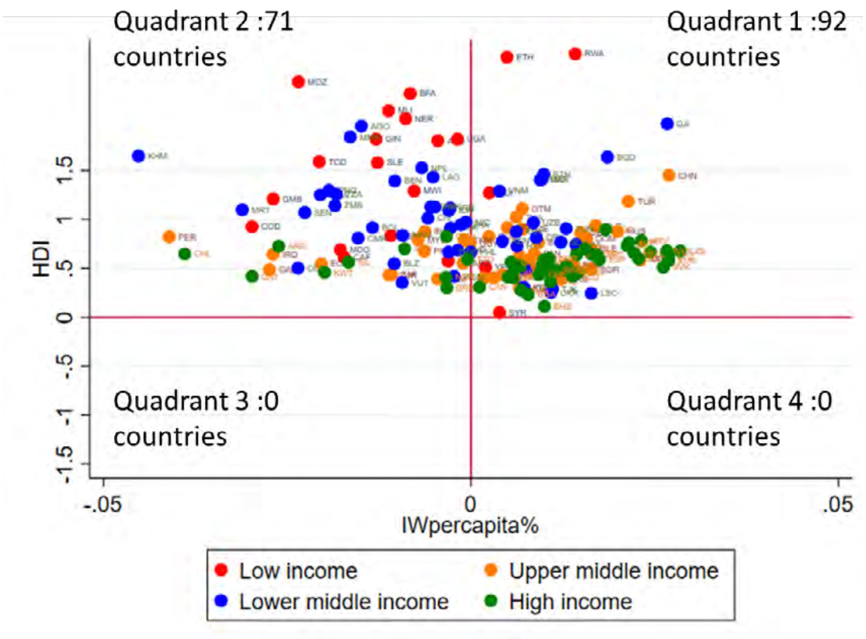

Figure 5.12a: Comparing annual average growth in per capita inclusive wealth with HDI, 1990–2019

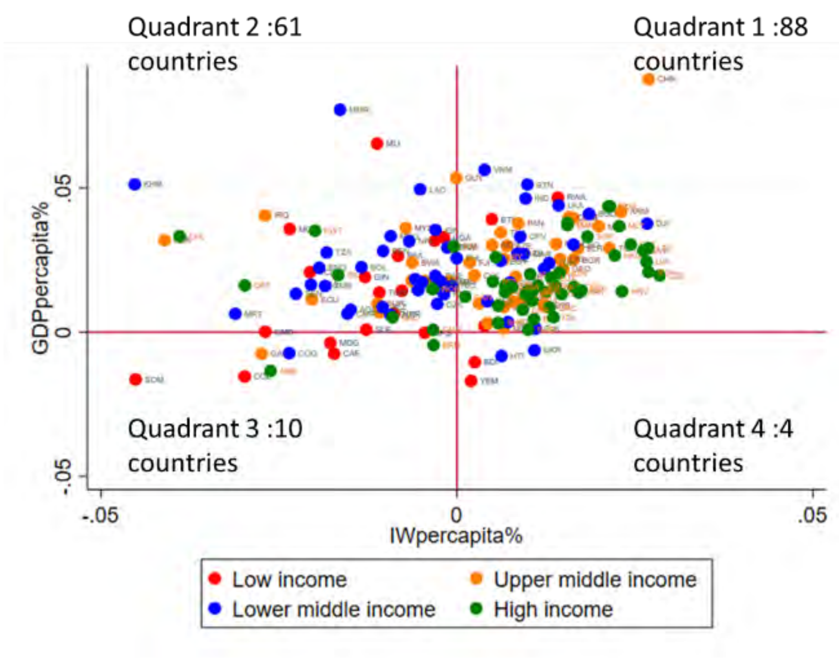

Figure 5.12b: Comparing annual average growth in per capita inclusive wealth with GDP per capita, 1990–2019

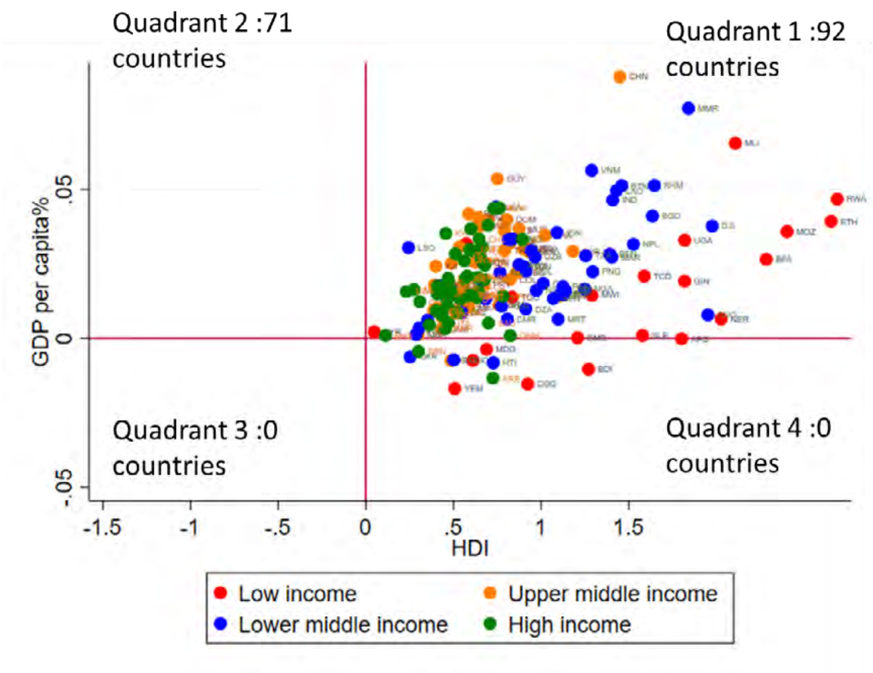

Figure 5.12c: Comparing HDI with GDP per capita, 1990–2019

Understanding human capital changes

This section analyses human capital changes in more detail. As evidenced in previous sections, human capital is the most important and largest source of IW in most countries. Over the past decade, almost every country has achieved educational improvements, measured in the Human Development Report (2020) by educational attainment. However, in wealth accounting, information on education, health, employment and differences in human capital compensation levels, all contribute to human capital changes. Based on the methodological framework, this section explores which input factors drive changes in the human capital account of IW. This enables better understanding of the relative importance of these determinants for human capital growth in different countries and regions.

The methodology used to calculate human capital consists of three terms[44]. 'Term I' indicates education level improvements. 'Term II' indicates the size of the adult (working) population that received an average level of education. 'Term III' indicates the shadow price of per unit human capital – the value of the average labour compensation per unit of human capital obtained in the average working lifetime. Here we calculate human capital separately for the male and female populations, to further disaggregate these terms by gender. For a full list of contribution by term and gender to country human capital growth from 1990 to 2020, see Table A5.1 in Appendix 5.

Table 5.3 illustrates the percentage change and influencing factors of human capital from 1990 to 2019. Results are present on a regional scale across five income groups. The first five columns (Gender and Term I, II and III) show the relative percentage of each factor's contribution to human capital change (adds up to 100). The last column shows the 30-year growth rate of human capital across regions and different income groups. See Annex 2 and 3 in the IWR 2023 Annexure, for a more specific analysis of human capital by region and income group.

44 The formulation used for estimating human capital follows the method described in Arrow *et al.* (2012) and Klenow and Rodríguez-Clare (1997) where $\text{Human capital} = \underbrace{e^{Edu\cdot\rho}}_{\text{Term I}} \underbrace{P5+edu}_{\text{Term II}} \underbrace{\int_{t=0}^{T} w e^{-\delta t}dt}_{\text{Term III}}$. ρ is the return on human capital; Edu is education attainment; P5+edu is the adult population; T is life's working period of the average person; w is compensation per unit of human capital and assuming constant for male and female across years. δ is discount rate.

The Term II (working population) made the largest contribution to human capital growth globally (53 per cent), followed by Term I, (improvement of education level), with an overall contribution rate of 31 per cent. Term III only had a 3 per cent average effect on human capital change.

The MENA region had the most significant growth in human capital (up to 177 per cent). In South Asia, sub-Saharan Africa, South America and the Caribbean, and East Asia, 30-year human capital growth rates exceeded 100 per cent (110 per cent, 173 per cent, 120 per cent and 116 per cent, respectively). Human capital growth rates in Europe and Central Asia, and North America were 58 per cent and 51 per cent respectively.

Theoretically, an increase in educational attainment will increase an individual's unit of educational capital, and affect the overall population at the average education completion age. Furthermore, a rapid increase of the total working-age population will affect the employment rate and thus affect the shadow prices. In the empirical study, in two high-income and upper-middle-income MENA countries (Qatar and Jordan), the shadow price contributed to human capital growth even with lower education levels and higher population growth. In low-income countries in the Middle East and North Africa, and in Europe and Central Asia, education levels and population growth were the main reasons for human capital, but the decline in the shadow price of human capital was a negative factor for local human capital changes.

Contribution from the 'Terms' reflect the complex economic and social context behind human capital accounting across countries, and the differences in human capital sustainability paths. In high-income advanced economies with a high level of human capital per capita, education was the main factor of increased human capital. For developing countries, population growth was the main source of human capital growth, and population growth was positively correlated with the rise in the shadow price of human capital. This may be related to economies of scale (growth of investment in produced capital), wherein activities of economic scale attract more people and provide more work. Consideration must be given to the drop in the shadow price of human capital caused by excess labour. Increased educational attainment does not affect labour force size or the shadow price of human capital. These results highlight the crucial role of improving education in increasing human capital.

The gender-disaggregated data on changes in human capital show that globally the male population contributed 54 per cent to the increase in human capital, and the female population contributed 46 per cent. However, in developed countries, the contribution of the female population to human capital is higher (55 per cent), than that of the male population. Regional data shows that the male population contributed 68 per cent to human capital in the MENA region and 59 per cent in South Asia. In Europe and Central Asia, South America and the Caribbean, and East Asia, the female population contribution to the increase in human capital was higher than for males. In sub-Saharan Africa, the proportion of contribution to the increase in human capital was the same for men and women. In general, areas with high incomes had higher increases in female human capital.

Table 5.3. Contribution to the changes in human capital at the regional level, period 1990–2019 (%)

Region	Male	Female	Term I	Term II	Term III	Average of HC change
South Asia	**59**	**41**	**33**	**63**	**4**	**210**
Low income	66	34	36	58	6	432
Lower middle income	52	48	44	55	1	144
Upper middle income	67	33	6	87	7	383
Europe and Central Asia	**45**	**55**	**65**	**33**	**3**	**58**
High income	43	57	69	26	5	63
Lower middle income	57	43	16	94	-10	66
Upper middle income	47	53	73	26	1	46
Middle East and North Africa	**68**	**32**	**19**	**77**	**4**	**277**
High income	71	29	15	80	5	400
Low income	83	17	33	80	-13	159
Lower middle income	56	44	36	57	8	174
Upper middle income	67	33	-11	105	6	211
Sub-Saharan Africa	**50**	**50**	**28**	**69**	**3**	**173**
Low income	51	49	33	65	3	192
Lower middle income	51	49	25	72	2	167
Upper middle income	48	52	14	82	4	122
Latin America and Caribbean	**47**	**53**	**27**	**66**	**6**	**120**
High income	44	56	27	65	8	75
Lower middle income	48	52	15	79	6	139
Upper middle income	47	53	33	61	6	128
Not classified	47	53	38	60	2	117
East Asia and Pacific	**48**	**52**	**34**	**65**	**1**	**116**
High income	45	55	32	64	5	121
Lower middle income	50	50	34	68	-2	122
Upper middle income	47	53	46	52	2	117
North America	**47**	**53**	**9**	**88**	**4**	**51**
Advanced	**45**	**55**	**54**	**41**	**5**	**74**
Developing	**54**	**46**	**29**	**67**	**3**	**146**
Total	**54**	**46**	**31**	**65**	**3**	**136**

Understanding the regional equity of inclusive wealth

Although IW measures intergenerational wealth equity in non-decline wealth assets, it does not address the equality of wealth allocation in the same generation. Globally, the world wealth continues to grow, but there are still 71 countries whose per capita IW has shown a downward trend in the past 30 years. If the IW of some countries continues to increase, while the wealth or well-being of other countries declines, can this be considered sustainable? We discuss the evolution of IW per capita dispersion to explore this question.

The global inequality of IW is identified through the Gini Index, which accounts for a nation's wealth and income distribution (UN DESA 2015). Figure 13 depicts IW per capita disparities from 1990 to 2019 in terms of the change of the global Gini coefficient.

In Figure 5.13, per capita IW inequality rose from 1990 to 2010, but declined after 2010. Overall, in 2019 global IW inequality was lower than in 1990. This result is attributed to a rapid reduction in produced capital inequality, due to the accumulation of produced capital, particularly in developing countries such as China and India. Human capital inequality rose in the 1990s, but stabilized after 2000. However in 2019, human capital inequality was the highest of all wealth.

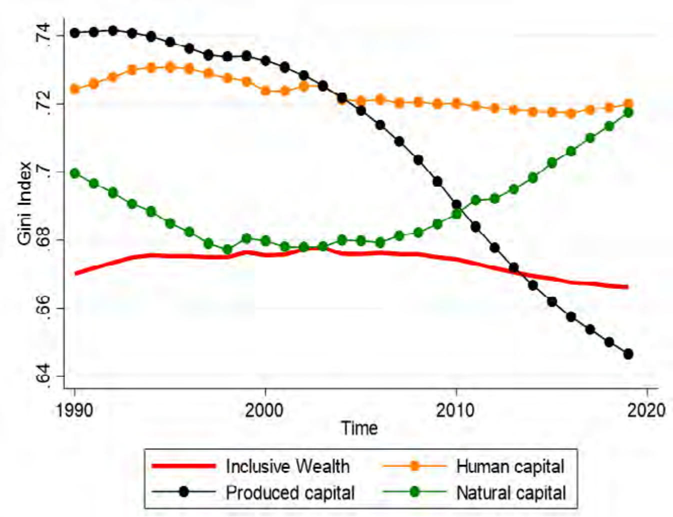

Figure 5.13. **Global Gini coefficient of Inclusive Wealth and its components, 1990–2019**

Although natural capital inequality declined prior to 2010, it increased significantly after 2010, and far surpassed 1990 levels. This result suggests a general and uneven depletion of natural capital. Figure 5.14 plots intra-regional natural capital per capita inequality as expressed by Gini Index, which shows the degree of natural capital per capita dispersion among countries and territories within a region. The higher the dispersion of per capita natural capital, the higher the Gini coefficient.

The results show that the Middle East and North Africa, South America and the Caribbean region, and Europe and Central Asia had the highest natural capital inequality (about 0.7) in 1990. Sub-Saharan Africa also had a high dispersion of natural capital per capita (greater than 0.6). South Asia and North America had the lowest dispersion of natural capital per capita (less than 0.2). Inequality in East Asia was approximately 0.4 in 1990. In the same period, inequality in the Middle East and North Africa slightly declined. Europe and Central Asia showed an intensifying trend after 2000. South America and the Caribbean showed significant mitigation of inequality prior to 2010, but increased again after 2010. In sub-Saharan Africa, inequality did not change significantly. Natural capital inequality in East Asia declined prior to the 2000s, but has shown a slow upward trend in the last decade. Similarly, South Asia and North America saw increasing natural capital inequality over the past decade, although overall natural capital inequality in these regions decreased since 1990.

The above results suggest that in regions with high per capita natural capital inequality, such as sub-Saharan Africa, the Middle East and North Africa, and Europe and Central Asia, the mitigation of inequality remains difficult. Despite improvements in natural capital inequality in Latin America and Caribbean, trends in recent years indicate that this mitigation is unsustainable. Low Gini Index levels in some regions indicate a reduction in inequality. However, recent trends suggest that this alleviation may not represent long-term change.

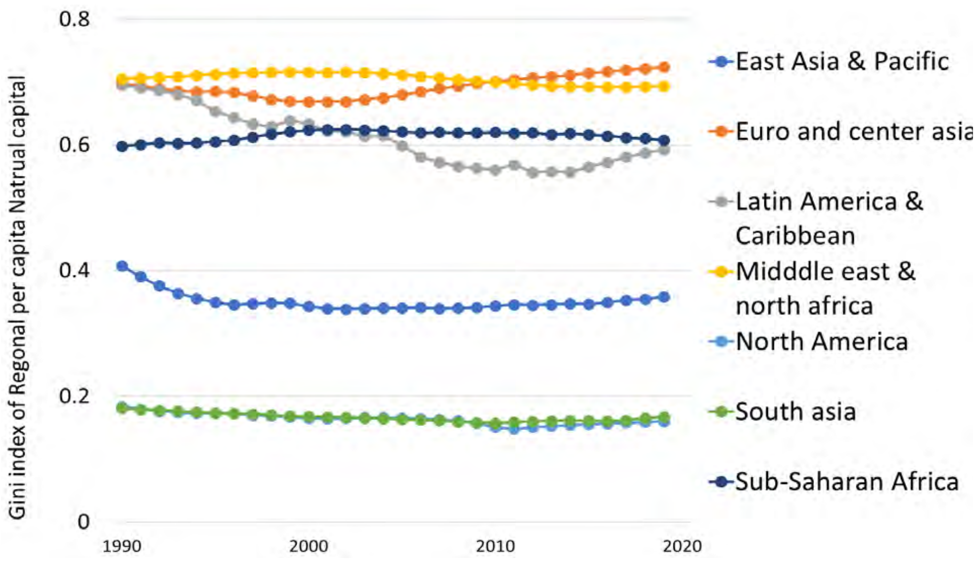

Figure 5.14. **Changes in the regional Gini coefficient of natural capital inequality, 1990–2019**

Inequality-adjusted Human Development Index and natural capital in the G20 countries

The G20 countries have committed to pursuing economic growth pathways that are inclusive and sustainable. However, according to Chen *et al.* (2020), rising income inequalities are evident in most of the G20 countries, compared to a decreasing trend in many low- and low-middle-income countries. Moreover, many of the G20 countries are struggling to harness their potential to earn high incomes, whilst securing sustainable rates of natural resource use (Barbier 2020).

The 2020 Human Development Report (UNDP 2020) lists countries according to their IHDI. This index captures society's average HDI, with the added dimension of incorporating the negative impacts of inequality in health, education and income distribution on development. The IHDI is expressed as a single number between zero and one. The greater the difference between the two indices (HDI and IHDI), the greater the loss to human development through inequality. In a hypothetical case of perfect inequality, the HDI and IHDI are equal.

Figure 5.15 represents the relationship between the IHDI and the growth of renewable natural capital of the G20 countries. Most of the G20 countries are facing negative growth of renewable natural capital, including many of the developed countries, which, although they have a high IHDI, are also experiencing a negative growth rate of renewable resources. Germany, the United States of America and France show the most favourable status: a high IHDI paired with positive renewable natural capital growth rates. Although Saudi Arabia and South Africa also show a positive renewable natural capital growth rates, their IHDIs are relatively low.

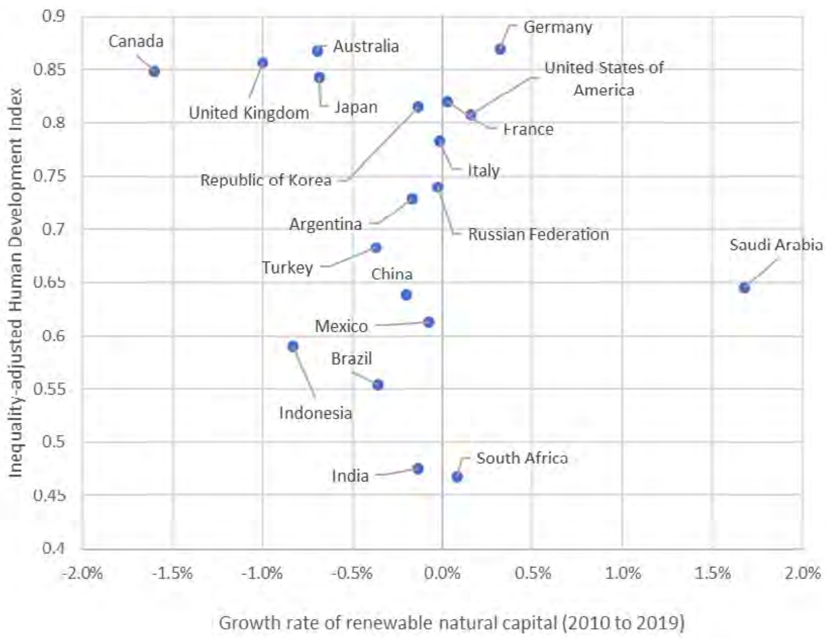

Figure 5.15: **Growth rate of renewable natural resources and the IHDI of the G20 countries, 1990–2019**

Figure 5.16 illustrates the relationship between the IHDI and the growth of total (renewable plus non-renewable) natural capital in the G20 countries from 2010 to 2019. Australia, Germany, Canada and the United States of America have a high IHDI and a slightly negative (0 to -1 per cent) natural capital growth rate. Although, the United Kingdom of Great Britain and Northern Ireland, France, the Republic of Korea and Japan also have a high IHDI, the growth rate of natural capital was negative (-4 per cent to -7 per cent) to a significant degree. Türkiye, Saudi Arabia and India show a moderate IHDI and negative (0 to -2 per cent) natural capital growth. The Russian Federation, China, Indonesia, Brazil, Mexico and Argentina have a moderate IHDI, and negative (-2 per cent to -7 per cent) but significant natural capital growth. South Africa is the only G20 country with a positive natural capital growth rate from 2010 to 2019. However, their IHDI is very low relative to the other G20 countries.

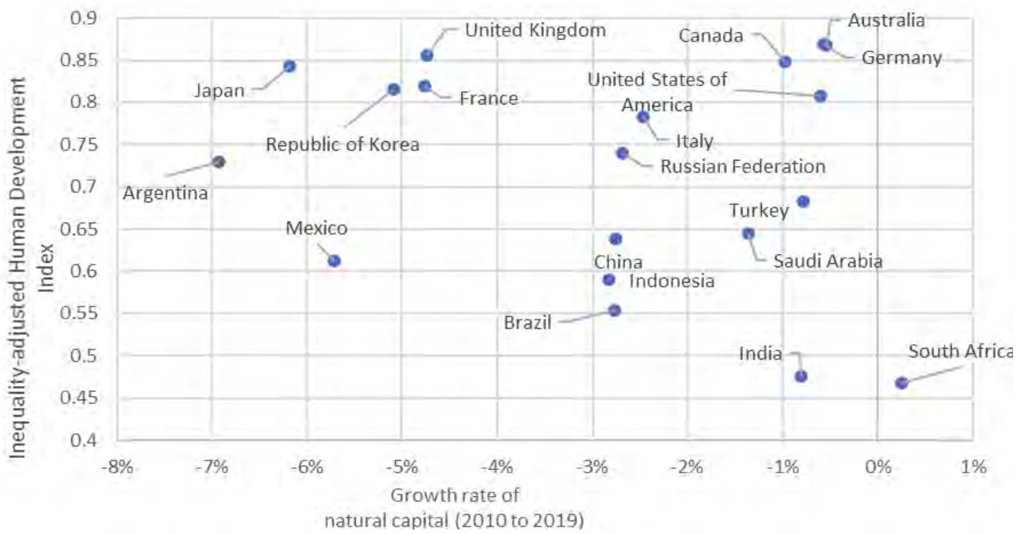

Figure 5.16: **Growth rate of total natural capital and the IHDI of the G20 countries, 1990–2019**

Figure 5.17 shows the relationship between the overall decrease in HDI due to inequality and the growth of renewable natural capital in the G20 countries. The results of this inequality analysis for the G20 countries are equivocal. All of the G20 countries (with the exception of South Africa) experienced negative total natural capital growth over the past 20 years. South Africa had positive natural capital growth, but lost a high percentage of its HDI score due to the adverse impact of inequality. Germany and France experienced positive growth of renewable natural capital with a high IHDI. Saudi Arabia, South Africa and the United States of America experienced high positive growth of renewable natural capital, but with a low or very low IHDIs.

The G20 countries must urgently act to develop policies that will enable more efficient use and management of natural resources within sustainable limits. A narrowly focused pursuit of economic growth that includes sacrificing natural resources is unlikely to reduce inequality in the G20 countries. To reset the path towards sustainability, it will be necessary to decouple economic development from environmental degradation. As the group of countries with the largest economies, the G20 countries declared they would prioritize and sustain green growth policies at the Mexico Summit in 2012. Without paying sufficient attention to rising wealth inequalities in the G20 countries, sustainable growth will not be achievable to ensure poverty reduction in the next decade. Along with income inequality, natural capital inequality is a barrier to sustainable development. This inequality is the key to explaining how the same level of natural capital growth can achieve different rates of poverty reduction in the G20 countries.

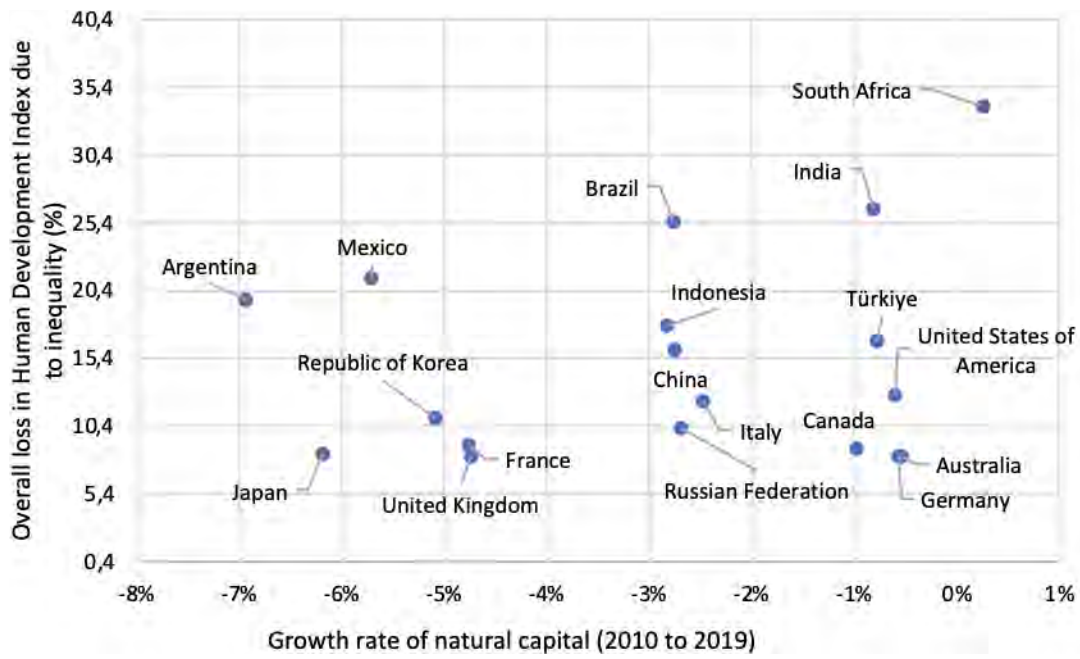

Figure 5.17: Growth rate of total natural capital and an overall loss in HDI due to inequality of the G20 countries, 1990–2019

The above analysis shows that while growth in both aggregate wealth and per capita wealth improved inequality in the distribution of wealth globally from the perspective of total IW, inequality in natural capital has not been effectively improved, and even showed an increasing trend in the last ten years. An emphasis on natural capital conservation policies and investments may mitigate such inequalities. However, countries must better collaborate to reduce the inequities that cause natural capital depletion, and its cross-generational welfare effects in capital-dominated, underdeveloped countries.

Practical consideration and study limitations

This section elaborates on specific challenges in the IWR 2023 wealth accounts, and presents considerations and limitations that should be considered together with the findings.

Values of several ecosystem services for natural capital are still missing due to a lack of data that interprets the dynamic of these essential services for human well-being. The estimates of mineral reserves is not complete, despite a prevalence of mineral extraction (or production) flow reports.

Our estimates of human capital are based on the integrated life tables. This calculation helps us consistently measure education, labour participation and healthy life expectancy across current demographics. However, in estimates disaggregated by sex, there is a lack of information on differences in human capital compensation between the male and female populations. Therefore, the shadow price of human capital cannot fully reflect the differences in the social value of different gender populations.

The major update for produced capital in the IWR 2023 is the use of the latest Penn World Table (2020) database of capital structure, and the flexible adjustment of capital depreciation rates across countries by year, based on the depreciation rates provided by BEA (1999). Capital stock is estimated at the constant price of USD. However, the inter-temporal basket of consumed goods and services may have different prices. The adjustment by purchasing power parity or inflation index may derive from various disparities across countries.

Other valuation issues may also arise when using a wealth measure at the inter-temporal framework level. For instance, in the interpretation of values used in non-timber forest accounts (natural capital), where the estimated benefits per unit of the forest is based on the global average. Using the marginal price at a specific period to value a complete forest stock ignores changes in willingness to pay over time, in those cases when the resource is being depleted. The average value may, in some cases, not be representative of all countries. These issues may impact conclusions when comparing wealth (or per capita wealth).

Despite these limitations, we believe that the trends we have observed in a wide range of capital assets, and their analysis, provide critical insight and knowledge into discussions of sustainable economic performance.

Conclusions

This chapter has assessed countries' performance in relation to changes in IW. The results show that while generally positive, IW growth across countries was well below GDP or HDI growth. While 159 of the 163 countries experienced growth in GDP per capita, and all had positive HDI, only 92 countries made progress on IW per capita. This result can be attributed to the lack of natural capital accounting in GDP and HDI. Many countries that increase GDP may simply be converting natural capital into current consumption. Depleting forests or extracting fossil fuel and mineral resources increases GDP in the short term. However, if resources are not adequately applied to build natural capital, this can jeopardise a country's human or productive capital and its future consumption potential.

Natural capital depreciation and population growth were the main factors of wealth decline per capita in most countries. Population growth was positive in 147 of the 163 countries, while natural capital declined in 151 of the 163 countries, from an average of 23 per cent before 2010 to only 18 per cent in the recent decade. Human capital was the largest contributor to per capita wealth growth in 101 of the 163 countries, accounting for 54 per cent of total wealth. This was followed by produced capital, accounting for approximately 28 per cent of total wealth.

When considering carbon damage, oil capital gains and total factor productivity adjustments for the IWI, results show that carbon damage and oil capital gains negatively impacted IW growth in most countries. Only a few (22) countries benefited from higher oil prices, while total factors productivity increases positively impacted IW growth in most countries.

Worldwide, labour force growth is the key factor in improving human capital. In developed countries, improving education is the most crucial source of human capital increase. However, in low-income countries, labour force growth may reduce labour opportunities and the shadow price of human capital. In short, improving education levels remains the most effective means of increasing labour costs.

This chapter has also assessed inequality in the distribution of IW, which improved globally over the study period. This result is due to accumulation of produced capital in developing countries, such as China and India. However, natural wealth inequality intensified among countries. Rising inequality in natural capital is reflected within and across regions. The comparative analysis of natural capital depletion and income inequality showed that the accumulation level of other capital was not proportional to natural capital depletion, or to changes in income inequality. In some low-income countries, such as Mexico and Argentina, where non-renewable natural capital declined, other capital accumulated insufficiently and income inequality also increased.

Global inequality in per capita natural capital has been increasing since 1998 (to Gini Index 0.72 in 2019 from 0.67 in 1998) showing deepening inequality in per capita natural capital across countries (Figure 5.13). This trend in inequality of per capita natural capital across countries since 1998 and the decline in per capita natural capita (Figure 5.9) are likely to continue because of shrinking nature and ever-growing population. Since natural capital is hard to be substituted by any form of capital, for long, inequality in per capita natural capital across countries and global decline in per capita natural capital might lead countries of the world to unhealthy competition in the future for access to critical natural resources like land, water forest, fish and extractives that may trigger conflicts. The global community needs to reverse the declining trend in natural capital which would in turn require investments in augmenting the renewable natural capitals through restoration and clean energy technologies via innovation, diffusion and deployment.

Changes in per capita wealth suggest that the rapid population growth rate over the past 30 years may be unsustainable, particularly in low-income countries (especially in sub-Saharan Africa). Global wealth loss requires a broader consensus among nations to better manage populations, strengthen the management and protection of public natural capital and eliminate regional inequalities. The results described in this chapter show the uneven wealth effects of population growth and natural capital depletion across regions. These findings provide insight into countries' development paths over the 30 years since 1990, and can inform the design and decision-making of future sustainable development pathways.

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06 The Inclusive Wealth Index and policy lessons for sustainable development in the post-pandemic era

IWR 2023 has provided an overview of the latest statistical results of the IWI, which measures intergenerational human well-being. This latest iteration in the IWR series aims to inform renewed momentum toward achieving the SDGs in the post-pandemic era, through comprehensive wealth analyses. The results in IWR 2023 can guide countries to develop, invest and manage their capital assets consistent with their own development pathways, and to effectively manage regional and global risks, including climate and environmental change and biodiversity loss.

What policy lessons are learned from the new Inclusive Wealth Index?

Identifying the external population-consumption-environment nexus

Cross-country wealth accounting clearly shows a global decline in IW per capita between 1990 and 2019, despite considerable wealth accumulation in some emerging countries (e.g. China and India). For most countries, produced capital accumulation over the last 30 years contributed significantly to GDP growth, and helped to address SDG 1 (Poverty), SDG 3 (Health and Well-being) and SDG 9 (Institutions, Innovation and Infrastructure). However, the accumulation of produced capital can result in a dramatic depletion of natural capital, exacerbated by rapid population growth. This wealth reduction is evident in 121 of 163 countries. When adjusted for population growth, this figure increases to 151 countries, meaning the vast majority of countries experienced a natural capital reduction-related wealth decline. In addition, all countries experienced different but significant increases in total factor productivity (TFP). However, this increase does not mean mitigation of natural capital depletion. The most severe depletion of natural resources was also found in countries with significant increases in TFP (over 5 per cent), such as Myanmar, Cambodia, Mozambique, Qatar, Chad and Chile.

As detailed by Dasgupta (2013), the externalities of the population-consumption-environment nexus are central to the sustainability of human well-being. While population growth was the leading cause of human capital-led wealth growth, it also resulted in excessive natural capital depletion due to the negative feedback of consumption. This global result implies that excessive population growth and depletion of natural capital make current production and consumption unsustainable, and directly relates to SDG 12 (Responsible Consumption and Production). It is thus vital for countries to pay close attention to current patterns of population growth, and to identify consumption that results in excessive natural capital depletion.

Ownership, investment and management of natural capital

Natural endowment conditions vary by country, however by analysing changes in natural capital composition, we found that the global loss rate of natural capital reached 28 per cent during the period 1990–2019. While 69 countries observed positive growth in agricultural capital amid the overall reduction trend in renewable resources, only 13 countries observed growth in agriculture land capital per capita. Declining agricultural land capital per capita points to the difficulty of achieving SDG 2 (Addressing Hunger). Conversely, only 32 countries experienced growth in per capita forest resources (related to SDG 15: Life on Land), and only 11 countries experienced growth in fishery resources (related to SDG 14: Life Below Water).

Energy resources are the most severely depleted non-renewable resource type, and 54 countries lost more than five per cent of their oil resources. This result shows the dependence of world economic growth on carbon-based fossil energy over the past 30 years. In addition, rising oil prices negatively impacted the wealth of most countries. Although oil reliance benefits only a few oil-exporting countries, greenhouse gas emissions due to carbon-based energy use show an upward trend in 115 countries. Carbon-based energy consumption affects sustainability goals including SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth) and SDG 13 (Climate Action).

Inappropriate pricing, extraction and management of natural capital can result in its excessive depletion. Negative growth in mineral resources was reported in 48 countries, with consumption exceeding five per cent in several African countries. It is assumed that reasonably efficient management of market values and ownership will lead to less depletion of mineral resources. However, this capital type has extremely high depletion rates in countries with poor proprietary rights and regulations.

Increasing demand for agricultural products due to population growth can result in positive investments in countries with a clear market value for agricultural land resources. However, other capitals, such as forest capital and fishery resources showed staggering losses in countries that lack market valuations and regulation of ecosystem value. Even with increases in agricultural land capital, this cannot offset the depletion of other renewable capital.

The IWR 2023 has added accounting for coastal reef ecosystems, which is a positive factor of natural capital. In countries with long coastlines and scarce other terrestrial natural capital resources, consideration of the value of coral reef can significantly increase their natural capital. This highlights the critical importance of effective policies to manage this capital.

The G20 countries account the world's largest share of natural capital (over 60 per cent) and 80 per cent of global GDP. The proportion of global natural capital held by the G20 countries has further increased during the reporting period, due to larger losses in low-income and low-development countries. Where the G20 countries have previously made policy commitments towards an inclusive and sustainable growth path, this has resulted in less natural capital depletion. Conversely, low-income, low-development nations with limited processes for natural capital valuation, management and investment showed severely depleted natural capital. This infers that excessive depletion of natural capital is related to inter- and intra-generational wealth inequities.

Intra-generational equity and natural capital depletion

Significant income and wealth inequalities exist between and within countries. As part of the COVID-19 pandemic recovery, countries must take urgent action to limit further widening of these wealth inequalities. However, achieving intergenerational wealth equity does not imply the sustainability of different groups within a generation. Our analysis of the relationship between natural capital depletion and intra-generational equity is directly related to SDG 10 (Reduced Inequalities).

Wealth inequality between countries, as measured by IW per capita, has narrowed in the past 30 years. However, capital differentiated data analysis shows that inequality in natural capital per capita concurrently widened across countries since the 2000s. Of the seven geographic regions in our analysis, Europe and Central Asia showed significant increases in inequality, although capital loss in this region was lowest. In other regions, natural capital inequality declined. This result suggests an increasing natural wealth imbalance between regions. In South America and the Caribbean, natural capital inequality per capita reduced. However, countries rich in natural capital (such as Chile) experienced significant natural capital depletion.

Within the G20 countries, when comparing intra-country income inequality with natural capital depletion, results show that intra-country income inequality increased, but natural capital depletion decreased. Conversely, although national income and overall income inequality increased in low-income and less developed economies, they experienced a more significant depletion of natural capital.

Free access to open natural resources can help local communities to increase their income and reduce income inequality through resource extraction. However, excessive consumption leads to resource depletion in the current generation. Natural resource extraction may only benefit particular groups in countries with strict ownership management. Without effective wealth redistribution measures, natural resource depletion may exacerbate social income inequality in the current generation.

Natural capital substitution is possible through accumulation of other forms of capital. Over the past 30 years, produced capital accumulation narrowed global per capita IW inequality. However, during the same period, per capita human capital inequality was not similarly reduced. This can be attributed to disproportionate investment in capital assets: the additional other capital does not compensate for the loss of undervalued natural capital. This is exacerbated by market distortions that result in a higher proportion of produced capital investment relative to human capital, and leads to greater natural capital depletion.

Education, health, gender and the social value of human capital

Global human capital grew steadily between 1990 and 2019. Although human capital accumulation was slower than produced capital, it accounted for the largest share of IW. Changes in human capital are related to SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 5 (Gender Equality) and SDG 8 (Decent Work and Economic Growth). Education, gender and work status were shown as explicit conditions in our human capital calculations, while health factors were implicit factors, affecting education level and years of work.

For the majority of countries, population growth was the most significant contributor to human capital growth, followed by education level improvement (measured as the expected years of school). To a lesser degree, the price of human capital (determined by shadow price per unit of human capital) and expected working years (determined by work and health conditions of workers) also contributed to human capital growth.

All regions except for Europe and Central Asia, experienced an increasing share of the world's total human capital, with the largest increase in low-income groups. However, high-income countries continue to have the largest share of human capital. The shadow price of human capital remains a major factor in this type of capital.

In advanced economies, Europe and Central Asia, growth in human capital per capita was larger for the female population than for the male population. However, the opposite was found in Latin America and the Caribbean, the Middle East, North Africa, South Asia and sub-Saharan Africa. The gender Gini coefficient shows that human capital per male value was larger than human capital per female. The distribution of human capital between men and women has become greater over time. Gender Gini coefficient values in the Middle East and North Africa are the highest in the world, followed by South Asia and sub-Saharan Africa. Inequality is also higher in Latin America, the Caribbean, East Asia and the Pacific than in advanced economies and Europe and Central Asia. Global human capital per capita increased due to significant improvements in education and health. Yet the results are uneven, with low education levels, particularly for women, in the Middle East and North Africa, sub-Saharan Africa and South Asia. The growth rate of human capital in all regions declined during the sub-period from 2010 to 2020, in contrast to the sub-period from 2000 to 2010. This more recent decline in human capital indicates the need for greater global investment in human capital.

Globally, the contribution of female human capital to the growth of world human capital is more significant than that of males, yet in regions with faster population growth, gender inequality is higher. In advanced economies, Europe and Central Asia, there is limited gender inequality of human capital. However, longer education years of females imply that women workers spend fewer years in the labour market than male workers.

In some regions and countries, changes in the value of human capital, determined by employment opportunities and health conditions, suppressed human capital growth. The human capital of the male population has an even larger negative effect. Suppose there is a lack of positive feedback on the price of human capital; this will affect the investment in human capital in these countries. In countries with low education levels, policymakers should prioritise interventions that improve human capital, strengthen human capital compensation and increase labour force participation rates for both men and women.

Investment in human capital affects the well-being of society, particularly for people living in poverty and other vulnerable groups. The challenge is that if the shadow price of human capital is weighted too low, this fundamentally weakens incentives for countries to improve education levels and health conditions, and may result in investment being shifted to other capitals with relatively higher weighted shadow prices.

Natural capital and SDGs in emerging market and developing economies

Prior to the COVID-19 pandemic, EMDEs made progress on poverty reduction and other SDGs, but also experienced considerable negative feedback. As part of the post-pandemic economic recovery, it is vital that renewed EMDE progress towards achieving the SDGs does not come at the expense of natural capital and the environment. Inappropriate investment and management of capital assets in these economies can threaten the sustainability of local and global development.

Our analysis of EMDEs shows that, on average, all 80 investigated EMDEs showed progress toward the SDGs. Yet the welfare gains of these SDGs were frequently accompanied by adverse environmental impacts and natural capital depletion, which negatively impacted progress towards the five environmental goals of SDGs 11 to 15.

The largest per capita environmental losses were seen in upper-middle-income, lower-middle-income and lower-income economies. Middle-income economies also showed larger per capita natural capital declines than low-income economies. However, natural resource consumption rates from 2000 to 2019 were highest among low-income countries, followed by lower- and upper-middle-income economies. The substantial welfare losses in low-income countries may harm local sustainability and lead to similar global impacts.

Long-term progress toward the SDGs requires improved management of natural capital and the environment. In their efforts to make immediate progress on multiple SDGs, EMDE policymakers must not sacrifice some SDGs to achieve others. Domestic policies, such as fossil fuel subsidy swaps, tropical carbon taxes and improved management and distribution of resource revenues, can help address this problem. In addition to these domestic policies, financial and technical support from the international community will support EMDEs to achieve the SDGs. Collaboration is required between all economies, including EMDEs, to address gaps in pricing and management of natural capital, to foster collective action and inclusive and sustainable development (Dasgupta 2021; Barbier 2022).

Recommendations

The IWI is a comprehensive accounting tool that can help policymakers measure an economy's sustainability. Analysing changes in their capital portfolios and investment profiles can help policymakers to better ensure their development progress and pathways maintain the sustainable wealth and well-being of current and future generations.

Recommendation 1: Apply the Inclusive Wealth Index to evaluate SDGs in national planning
The SDGs cover more than 240 socioeconomic indicators (United Nations 2015). GDP indicators based on the SNA are insufficient to measure the achievement of these goals. Multidimensional assessments—including social, environmental and economic aspects—are needed if countries are to achieve the SDGs (Bali *et al.* 2020; Halkos 2021).

The IWI provides a multidimensional standard to measure country's ability to achieve the SDGs (Desgupta 2019; Dasgupta, Shunsuke and Kumar 2022; Managi 2022). Previous IWRs (2014; 2018) show that IW can be directly linked to ten of the seventeen SDGs (Cook *et al.* 2021). This latest report has refined statistical accounting data and methodologies to include analysis covering SDG 4 (Quality Education), SDG 5 (Gender Equality) and SDG 10 (Reduced Inequality). These works prove that the IWI can be more widely applied to evaluate multiple SDG targets.

Some countries and researchers have begun to develop national and sub-national wealth accounts. India proposed introducing natural capital into national accounts based on IW theory (Desgupta 2019). The theorem was also applied by Tomlinson (2018) to Nigeria's recent economic history. Japan has established subnational IW account statistics that analyse the sustainability of regional welfare (Ikeda and Managi 2019). In China, IW at different precisions is now used for sustainability analysis (Jingyu *et al.* 2020; Zhang *et al.* 2020). IW accounts for Pakistan have already achieved reported results (Slam *et al.* 2022). The Association of Southeast Asian Nations (ASEAN) have also commenced discussions on IW (Managi *et al.* 2022).

We recommend that as countries work towards achieving the SDGs, their statistical offices begin compiling wealth accounts and tracking changes in wealth over time. Just as corporations create annual balance sheets, governments should prepare annual wealth accounts. This will provide more comprehensive data than GDP to better evaluate development progress and pathways.

Recommendation 2: Apply natural capital accounting and inclusive wealth to guide investment
In the IWR 2018, we proposed linking IW to national bond coupons. Governments can provide opportunities for institutional and other investors to mobilize their financial resources to invest in the capital components of IW (Managi and Kumar 2018). Barbier (2019) notes that natural resource-based sovereign wealth funds have emerged as a key financial instrument to compensate for the devaluation of resources through economy-wide investments.

The year 2021 marked several milestones in the IW research field. The most important of these was the publication of the Dasgupta Review of the Economics of Biodiversity, commissioned by the United Kingdom of Great Britain and Northern Ireland Treasury and led by Professor Sir Partha Dasgupta (Dasgupta 2021). This review shows that natural capital is now at the heart of the economic and financial decision-making agenda. The United Nations System of Environmental Economic Accounting - Ecosystem Accounting, adopted by the United Nations Statistical Commission in March 2021, further reflects that the emphasis on green capital must prioritise social trust, and that institutions must change the measurement of economic progress.

We recommend that governments optimize their investment strategies to better manage future pandemics and other global uncertainties. In the post-pandemic era, some countries imposed trade restrictions that led to supply shortages. Increasing capital asset liquidity will strengthen country resilience. The global financial system is a vital component of a 'green recovery' – central banks, financial regulators and accounting institutions should fully consider the investment risks associated with natural asset loss and climate change, and develop appropriate global financial and reporting standards. Furthermore, ESG investments must be steered: social equity is responsible for specific social and environmental management issues including renewable energy, energy efficiency, low-carbon transport, sustainable water, waste and polluted areas. Investment in projects that consider inclusiveness indicators should be prioritised.

Governments can provide opportunities for institutional and other investors to mobilize their financial resources to invest in the components of IW. We recommend governments set aside proceeds from the general budget to create a bond proceeds fund for reinvestment in capital assets, including IW.

Recommendation 3: Improve the valuation and scope of ecosystem assets accounting
The current economic system places enormous pressure on the natural environment. Indeed, natural capital is the only wealth component in decline globally (IWR 2014; IWR 2018; Dasgupta 2021). This can be attributed to a lack of systematic pricing and management of non-market values in natural capital, such as ecosystem services. The COVID-19 pandemic is evidence of the dramatic consequences when one element of an ecosystem is disrupted, and highlights the need to improve and expand statistics on ecosystem service estimates, particularly to identify key issues such as changes in biological populations and the service value of more ecosystem types.

It is critical that decision-makers recognize and integrate nature's multiple values and contributions if we are to reverse nature's decline. Greater satellite and related technologies could help address human welfare issues (Zhang *et al.* 2020; Li and Managi 2021). Solving problems such as disease transmission, air pollution and disaster management requires reliable datasets, including geospatial data, to better identify ecosystem services. All countries, but particularly those that lack traditional ecosystems, need to expand the scope of ecosystem services statistics to focus on different types of ecosystem functions. The evidence shows wealth can increase by nearly five per cent (e.g. Cuba) when coast line coral reef ecosystems are considered. This wealth benefits local and global welfare, as these ecosystem provides vital services such as carbon storage. We further suggest more investment in renewable natural capital assets in countries with lower wealth growth rates to substantially improve countries' wealth levels.

Recommendation 4: Apply human capital accounting to guide education and health institutions
Human capital accounts for the largest share of IW. It measures the current and future potential of a country and its people, and is a key determinant of sustainable and inclusive growth (SDG 8). Human capital manifests itself mainly through two prospects (health and education), which correspond to SDG 3 (Good Health and Well-Being) and SDG 4 (Quality Education). Most existing human capital literature focuses on education, while health as a factor remains relatively underexplored (Hokayem and Ziliak 2014).

There are two methods for measuring existing human capital—indicator-based measurement methods and monetary measurement methods—the latter of which emphasizes demographics. As the world recovers from the COVID-19 pandemic, all countries urgently need to identify the loss of health, in particular through the monetary measure of health. The Jorgenson-Fraumeni lifetime income method (Jorgenson and Fraumeni 1989) has been widely used in human capital research, including in the United States of America and China (Fraumeni 2021).

Human capital per capita in IW is measured as the average years of schooling and the total educational compensation earned during the average expected working years. IW measurement incorporates demographic data related to education, health and employment. This enables human capital statistics to capture the multiple dimensions of education, health and job opportunities, and to identify the cumulative correlations between health and other developments and complementarities between health and schooling.

We recommend policymakers apply this approach to human capital-related policies, as it can support policymakers to design a policy mix that spans multiple levels. Policy interventions that apply this approach can broadly increase probability of survival. Popularizing and guaranteeing primary education improves educational outcomes and reduces adult income losses. Identifying gender inequality issues in human capital is also essential, as this will influence future population growth trends.

Recommendation 5: Apply the Inclusive Wealth Index to guide the green technology transition

Achieving the SDGs by 2030 requires a holistic view of the challenges posed by uneven innovation and development capabilities. Green innovation is vital for countries to address global challenges and achieve sustainable development. The perspective that sees free market forces as "machines that generate a great deal of innovation and growth" (Baumol 2004) is directly challenged by the results of IW accounting. These results clearly show that without a compelling market valuation of capital value, investment in technological innovation will only be based on the market's interests. Under the inherent capital weight structure, production capital and related technologies lack mobility. Continuous biased investment causes high natural capital depletion, high pollution and increased greenhouse gas emissions. Thus, free market forces alone are insufficient to drive innovation in line with human welfare (Chang *et al.* 2002; Rock *et al.* 2009).

Furthermore, countries at different stages of socioeconomic development may have very different technological policy objectives and require very different tools for innovative analytical approaches. Industrialized countries may focus on policies that support technological progress to help their industries maintain or gain a competitive advantage in global markets. In contrast, policymakers in developing countries may focus on strategies that protect emerging domestic industries, or ensure the provision of basic social services. (Schwachula *et al.* 2014).

The IWI measures whether the global community is on a sustainable trajectory (Polasky *et al.* 2019). IW enables societies to measure total wealth, and better understand the future impacts of the SDGs (Dasgupta *et al.* 2015). Debates in the Intergovernmental Panel on Climate Change (IPCC) concerning the long-term sustainability of socioeconomic pathways, or the energy-growth nexus, depend heavily on assessing large-scale projects (Kurniawan and Managi 2018; Sugiawan and Managi 2019). Traditional measurement tools have a limited capacity to evaluate the impact of these global issues. We therefore recommend an IW approach be applied to future research on the effectiveness of sustainable technology policies.

The way forward

Building a consumption-based national wealth account

Territorial wealth and resources are increasingly consumed through multiple cross-border trades. Non-territorial wealth depletion requires accounting mechanisms that can measure the local and global nature of sustainability, from production to consumption. The IWI accounting framework is territory-based, in that it only assesses the impact of trade on wealth by calculating oil capital price gains from net exports.

To ensure accurate wealth accounting, open economies require two accounts - one from a traditional territorial production base and one from a consumption base. Production-based accounts record changes in a country's capital assets over a year, regardless of where those resources are consumed. Consumption-based accounts record the consumption of capital embodied in a country's final demand, irrespective of where in the world these consumptions occur. Examining these two wealth accounts provides a comprehensive understanding of an economy's dependencies on domestic and global resource stocks, and its contribution to national and global sustainability. This will also highlight resource security issues and help identify joint bilateral and international resource policy opportunities.

Considering population growth paths and intergenerational wealth scenarios

Rates of population undergrowth or overgrowth can result in wealth reduction, and are an essential component of current and future well-being. However, this is a complex process to understand. The theoretical model of IW adopts the dynamic general utilitarian model to consider the cross-generational population. It also applies population statistics based on the available utilitarian model in practical statistics. Regardless of which population growth model is applied, future population growth scenarios will affect total generational welfare and the excessive consumption of natural capital.

The interlinked cycles and iterations of health, education and economic conditions affect population size. Understanding the dynamic impact of local-to-global disturbances such as wars, pandemics and climate change disasters on population and welfare is critical for sustainable development.

We must therefore consider the impact of future demographic changes on intergenerational welfare. IW measurement builds dynamic and IW change scenarios through state-of-the-art population forecasting models. IW projections that consider population growth paths can support population growth policy interventions to achieve welfare sustainability across generations.

Similar implications apply to firms' decision making for sustainable investment. Product- and service-level environment, social and governance (ESG) impact assessments undervalue ESG problem across industries, despite the significant level of risk they present to companies. Evaluation based on product- and service-level ESG from IW could provide useful insights (Keeley *et al.* 2022).

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Appendices

Appendix 1: Risk-adjusted accounting prices

How does the risk of ecosystem collapse at the top end of a company supply chain translate into the company's risks? We study this by deriving the adjustment that firms should make to the value they attribute to ecosystem services[45].

Time is continuous, denoted by $t \geq 0$. Suppose a supply source (e.g. a wetland) of size S, yields benefit of P dollars per unit of the source to a firm. We begin by assuming P is constant. The discount rate the firm applies to future benefits from the supply source is r. We assume $r > 0$.

So long as supply source remains intact, the flow of benefits from it is PS at each moment. If the firm is certain that it would remain intact forever, the supply source would be worth PS/r to it. However, because ecosystems are being degraded everywhere, the firm fears that the source will collapse at an uncertain date. The case where the uncertainty is characterized by a Poisson process, with a hazard rate h, is trivial, as it means that the value of the supply source to the firm is PS/ (r +h). So, we consider a different scenario. We suppose that the source will collapse at a random date in the next T years. We study the case where the uncertainty is uniform. Formally, at t =0, there is a constant probability rate 1/T of the supply source collapsing.

But that's the distribution at t = 0. Bayesian updating tells us that conditional on the supply source surviving until t, the probability rate that it will collapse at any date in the interval [t, T] is 1/(T-t). Viewed from t = 0, the probability rate that the source will survive until t, is thus (T-t)/T. The hazard rate at t is 1/(T-t), which goes to infinity as t tends to T. We now apply this to calculate the risk-adjusted accounting value of the supply source.

As the probability that the supply source will exist until t is (T-t)/T, its expected worth to the firm is:

$$PS\left\{\int_0^T [e^{-rt}(T-t)/T]dt\right\} = [PS/r][1-e^{-rT}] - [PS/T]\left[\int_0^T\{te^{-rt}\}dt\right] \qquad (A.1)$$

Write the risk adjusted value of S as a function of T as F(T). Integrating the final term on the right-hand side to eq. (A.1) by parts yields:

$$F(T) = [PS/r][(1 - (1-e^{-rT})/rT] \qquad (A.2)$$

In short, the risk adjustment term R(T) is:

$$R(T)= [1 - (1- e^{-rT})/rT] \qquad (A.3)$$

45 I am grateful to Matthew Agarwal, who asked me how the risk of ecological collapse modifies accounting prices. Ideas of translating ecological risks into business risks appear in Dasgupta and Levin (2022).

It is simple to confirm that $dF(T)/dT > 0$. Thus, F(T) is a monotone increasing function of T in the interval [0, ∞). Moreover, $F(T) \to 0$ as $T \to 0$ and $F(T) \to PS/r$ as $T \to \infty$. Both limits are exactly as intuition would direct us to. Moreover, the risk-adjustment factor, R, lies between 0 and 1. That too is exactly what one would expect. The example, albeit stylized, has a general message. Risk of ecological collapse translates into a risk factor, between 0 and 1, on an ecosystem's value.

An extension of the model worth considering here involves abandoning the assumption that P is a constant. With the world's rainforests being razed to the ground to make way for cattle ranches, plantations and mines, we would expect the benefits from S to increase over time relative to our assumed numeraire, income. The simplest assumption is that P increases exponentially at, say, the rate $\beta > 0$, that is, $P(t) = P(0)e\beta t$. For clarity, assume that $r > \beta$. We may then replace r by $(r-\beta)$ in eq. (A.2)-(A.3). That is, the risk adjusted accounting price of the source is larger, the larger is β. Moreover, $P(0)SR/(r-\beta) \to P(0)ST/2$ as $\beta \to r$. That too is exactly what intuition would suggest.

A further extension involves coupled ecosystems. Consider a pair of symbiotic ecosystems S1 and S2 yielding benefit flows P1 and P2 per unit of the respective ecosystems. We could think of S1 as a mangrove forest and S2 as a coral reef. To avoid studying dynamics, we begin by imagining that adjustments in one to a perturbation in the other is instantaneous. Their symbiosis can then be represented by the function S2(S1), with $dS2(S1)/dS1 > 0$ and $S2(0) = 0$. The risk adjusted accounting price of the coupled system is then:

$$F(T) = [(P1S1+P2S2)/r][(1 – (1-e-rT)/rT] \qquad \text{(A.4)}$$

A simple extension of the coupled system would be a lagged response. Suppose that if ecosystem "S1" were to collapse at t, the coupled ecosystem "S2" would remain intact until t+L, at which moment it too would collapse. Define V(L) as:

$$V(L) = P2S2[0\int L(e-rt)dt] = P2S2(1-e-rL)/r \qquad \text{(A.5)}$$

It follows that:

$$F(T) = [(P1S1+P2S2)/r][(1 – (1-e-rT)/rT] + V(L)[1 – (1-e-rT)/rT] \qquad \text{(A.6)}$$

Applying eq. (A.5) in eq. (A.6) yields:

$$F(T) = [(P1S1+P2S2)/r][(1 – (1-e-rT)/rT] + P2S2(1-e-rL)[(1-e-rT)/rT] \qquad \text{(A.7)}$$

The ecosystems would be independent of one another if $L = \infty$. In which case eq. (A.7) reduces to:

$$F(T) = P1S1[1-(1-e-rt)/rT] + P2S2/r$$

Appendix 2: Countries/economies included in the seven regions

Advanced Economies (24 countries/economies):
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Türkiye, United Kingdom of Britain and Northern Ireland and the United States of America.

These are the same 24 countries included in the Barro-Lee (2018) data set advanced economies or countries category. The list of countries considered advanced by the International Monetary Fund (IMF) has changed over time; the only country classified as an advanced economy in this chapter that is not in the current IMF list is Türkiye. The IMF defines advanced economies or countries using three criteria: the level of per capita income, the extent of export diversification and the degree of integration into the financial sector into the global financial system. See https://www.imf.org/external/pubs/ft/weo/faq.htm#q4b.

East Asia and Pacific (20 countries/economies):
Brunei Darussalam, Cambodia, China, Fiji, Hong Kong, Indonesia, Korea (Democratic People's Republic of), Korea (Republic of), Lao People's Democratic Republic, Macao, Malaysia, Mongolia, Myanmar, Papua New Guinea, Philippines, Samoa, Singapore, Thailand, Vanuatu and Viet Nam.

Europe and Central Asia (28 countries/economies):
Albania, Azerbaijan, Armenia, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldovia (Republic of), North Macedonia, Poland, Romania, the Russian Federation, Serbia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

Latin America and Caribbean (27 countries/economies):
Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Columbia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela (Bolivian Republic of).

Middle East and North Africa (18 countries/economies):
Algeria, Bahrain, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen.

South Asia (8 countries/economies):
Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

Sub-Saharan Africa (41 countries/economies):
Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Congo, Congo (Democratic Republic of), Cote d'Ivoire, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, South Africa, Tanzania (United Republic of), Togo, Uganda, Zambia and Zimbabwe.

Appendix 3: SDG welfare, environment and natural resource impact in EMDE's by country

Table A3.1. SDG welfare, environmental and natural capital impacts in EMDE's by country

Country	Income Group	SDG 1 welfare impact $/ capita 2000-2019	Net SDG welfare impact $/ capita 2000-2019	Net environmental impact $/ capita 2000-2019	Average natural resource depletion (% of GNI) 2000-2019	Natural capital change $103/ capita 2000-2014
Burundi	Low	24	902	-67	22.0	-0.2
Congo, Dem. Rep.	Low	44	1,468	-100	5.3	-10.1
Gambia	Low	448	429	-775	1.6	-1.6
Liberia	Low	200	-8,144	-923	3.4	-4.9
Malawi	Low	13	-966	-1,219	5.1	-0.8
Mali	Low	66	985	-497	5.4	-4.0
Mozambique	Low	49	262	-2,324	0.9	-0.9
Niger	Low	148	1,367	-643	6.9	-0.4
Rwanda	Low	81	1,904	-1,036	5.7	0.1
Sierra Leone	Low	135	3,171	-791	3.0	-2.0
Sudan	Low	244	7,787	-1,388	3.2	-8.4
Togo	Low	46	10,680	-114	8.9	-0.5
Uganda	Low	163	444	-1,361	11.6	-0.9
Low Income		128	1,561	-864	6.4	-2.7
Angola	Lower Middle	-463	1,031	-1,475	16.6	-7.6
Bangladesh	Lower Middle	371	349	-2,146	0.7	-0.1
Benin	Lower Middle	25	3,263	-2,248	1.9	-2.0
Bolivia	Lower Middle	1,556	-11,469	-10,983	5.5	-22.7
Cameroon	Lower Middle	0	1,742	-1,118	3.8	-11.5
Congo, Rep.	Lower Middle	74	343	-243	32.6	-32.1
Cote d'Ivoire	Lower Middle	-300	2,569	-903	2.8	-1.4
Egypt, Arab Rep.	Lower Middle	-1,318	-5,082	-5,383	6.7	-1.3
El Salvador	Lower Middle	2,607	-21,856	-16,001	0.7	0.0

Eswatini	Lower Middle	857	7,038	-215	0.1	-0.1
Ghana	Lower Middle	685	6,284	-922	3.5	-0.8
Honduras	Lower Middle	553	-782	-3,256	0.3	-5.4
India	Lower Middle	274	1,765	-1,222	1.6	-0.8
Indonesia	Lower Middle	1,575	19,084	-6,668	4.3	-3.7
Iran, Islamic Rep.	Lower Middle	2,086	1,055	-5,681	6.8	-16.8
Kenya	Lower Middle	123	7,187	-111	1.7	-0.3
Kyrgyz Republic	Lower Middle	601	-11,903	-14,135	3.2	-0.2
Lao PDR	Lower Middle	401	-3,697	-9,520	2.6	-4.4
Mauritania	Lower Middle	776	-6,811	-9,523	6.6	-3.0
Morocco	Lower Middle	1,309	6,241	-1,321	0.3	-0.5
Myanmar	Lower Middle	565	7,714	-2,822	2.8	-1.3
Nepal	Lower Middle	396	3,776	-1,933	0.7	-1.7
Nicaragua	Lower Middle	1,045	2,372	-2,295	1.0	-1.8
Nigeria	Lower Middle	420	16,781	-2,225	6.7	-3.2
Pakistan	Lower Middle	838	2,470	-578	1.3	-4.4
Papua New Guinea	Lower Middle	570	-3,665	-3,668	11.7	-3.8
Philippines	Lower Middle	1,545	4,871	-1,189	0.9	-0.4
Senegal	Lower Middle	183	2,969	-504	0.4	-2.8
Sri Lanka	Lower Middle	1,460	3,041	-1,282	0.1	-0.5
Tajikistan	Lower Middle	901	-2,950	-6,321	1.0	-0.3
Tanzania	Lower Middle	211	5,896	-742	1.0	-0.5
Tunisia	Lower Middle	1,946	3,073	-864	3.5	-1.0
Ukraine	Lower Middle	898	1,485	1,004	1.2	0.4
Viet Nam	Lower Middle	753	1,032	-4,284	3.9	-1.0
Zambia	Lower Middle	-135	-851	-2,065	3.8	-11.1
Zimbabwe	Lower Middle	-585	-3,275	-180	2.0	-2.5
Lower Middle Income		633	1,141	-3,417	4.0	-4.2
Albania	Upper Middle	551	-7,262	-11,400	0.8	0.2
Argentina	Upper Middle	6,460	10,305	-458	2.9	-3.7
Armenia	Upper Middle	1,083	-10,163	-9,600	0.4	0.9
Brazil	Upper Middle	3,446	10,239	-2,489	1.7	-8.0
Bulgaria	Upper Middle	2,329	-3,442	-2,543	0.4	-1.9
China	Upper Middle	1,556	1,964	-3,304	2.3	-1.4

Colombia	Upper Middle	2,137	12,666	2,085	4.8	-17.0
Costa Rica	Upper Middle	5,673	15,240	743	0.4	1.6
Dominican Republic	Upper Middle	3,519	4,914	-106	0.5	-0.9
Ecuador	Upper Middle	2,451	8,256	-3,110	7.3	-7.3
Fiji	Upper Middle	3,418	-285	-2,219	0.4	-0.7
Gabon	Upper Middle	1,697	17,649	2,667	19.8	-250.2
Guatemala	Upper Middle	159	4,568	-1,625	1.4	-2.8
Iraq	Upper Middle	-405	-349	-6,751	10.1	-24.2
Jamaica	Upper Middle	1,576	-8,591	-890	0.2	-1.4
Jordan	Upper Middle	2,492	653	-710	0.2	-0.7
Kazakhstan	Upper Middle	2,055	6,037	-570	12.2	-14.8
Malaysia	Upper Middle	3,992	-2,677	-2,372	5.3	-8.4
Maldives	Upper Middle	7,291	-5,027	-2,727	0.0	-6.2
Mauritius	Upper Middle	3,651	-16,394	-19,808	0.0	-3.0
Mexico	Upper Middle	5,942	8,284	-2,308	3.3	-2.7
Namibia	Upper Middle	1,519	6,302	-1,177	0.9	-4.0
Panama	Upper Middle	5,090	5,097	1,449	0.0	-1.7
Paraguay	Upper Middle	2,636	4,156	-1,699	0.0	-5.9
Peru	Upper Middle	2,261	13,025	-481	4.5	-7.9
Romania	Upper Middle	1,856	1,456	-639	1.1	0.2
Russian Federation	Upper Middle	3,849	8,187	-991	8.0	-4.9
Serbia	Upper Middle	-72	-1,018	-976	0.7	1.6
South Africa	Upper Middle	1,562	-1,274	-335	2.6	-3.2
Thailand	Upper Middle	4,249	13,083	212	2.1	-0.9
Türkiye	Upper Middle	4,445	10,113	-1,883	0.1	-2.6
Upper Middle Income		2,854	3,410	-2,388	3.0	-12.3
All Countries		1,412	2,089	-2,603	4.0	-7.1

Notes: Indicator changes are for part, or the entire period indicated. Income group classification is based on the World Bank's Country and Lending Groups classification. Based on 2020 gross national income (GNI) per capita, the groups are: low income, USD 1,045 per capita or less; lower middle income, USD 1,046 to USD 4,095 per capita; upper middle income, USD 4,096 to USD 12,695 per capita; and high income, USD 12,696 per capita or more. Estimation of SDG 1 welfare impacts, net SDG welfare impacts and net environmental impacts is based on methods in Barbier and Burgess (2019 and 2021) and is applied to the indicators and sources of data from Table A.1. Natural resource depletion is the sum of net forest depletion, energy depletion and mineral depletion. Net forest depletion is unit resource rents times the excess of roundwood harvest over natural growth. Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime (capped at 25 years). It covers coal, crude oil and natural gas. Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime (capped at 25 years). It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite and phosphate. The source of this indicator is the World Bank's World Development Indictors https://databank.worldbank.org/source/world-development-indicators. Natural capital consists of fossil fuels (oil, gas and coal), minerals (bauxite, copper, gold, iron, lead, nickel, phosphorous, silver, tin and zinc), forest resources (timber and non-timber), agricultural land (cropland and pastureland) and fisheries. The source of this indicator is Managi and Kumar (2018).

Appendix 4: List of countries/economies included in the four income groups

High-income (51 countries/economies):
Australia, Japan, New Zealand, Brunei Darussalam, Hong Kong, Republic of Korea, Macao, Singapore, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bahamas, Barbados, Chile, Trinidad and Tobago, Uruguay, Bahrain, Israel, Kuwait, Malta, Oman, Qatar, Saudi Arabia, United Arab Emirates, Canada and the United States of America.

Upper-middle-income (42 countries/economies):
China, Fiji, Malaysia, Thailand, Türkiye, Albania, Azerbaijan, Armenia, Bosnia and Herzegovina, Bulgaria, Belarus, Georgia, Kazakhstan, Republic of Moldova, Romania, the Russian Federation, Serbia, Turkmenistan, North Macedonia, Argentina, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Guyana, Jamaica, Mexico, Panama, Paraguay, Peru, Suriname, Iraq, Jordan, Maldives, Botswana, Gabon, Mauritius, Namibia and South Africa.

Lower-middle-income (49 countries/economies):
Myanmar, Cambodia, Indonesia, Lao People's Democratic Republic, Mongolia, Vanuatu, Papua New Guinea, Philippines, Viet Nam, Samoa, Kyrgyzstan, Tajikistan, Ukraine, Uzbekistan, Bolivia (Plurinational State of), Belize, El Salvador, Haiti, Honduras, Nicaragua, Algeria, Djibouti, Iran (Islamic Republic of), Morocco, Tunisia, Egypt, Bangladesh, Bhutan, Sri Lanka, India, Nepal, Pakistan, Angola, Cameroon, Cabo Verde, Congo, Benin, Ghana, Côte d'Ivoire, Kenya, Lesotho, Mauritania, Nigeria, Sao Tome and Principe, Senegal, Zimbabwe, Eswatini, United Republic of Tanzania and Zambia.

Low-income (23 countries/economies):
Korea (Democratic People's Republic of), Syrian Arab Republic, Yemen, Afghanistan, Burundi, Central African Republic, Chad, Democratic Republic of the Congo, Ethiopia, Eritrea, Gambia, Guinea, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Somalia, Togo, Uganda and Burkina Faso.

Appendix 5: Contribution by term and gender to country human capital growth, 1990-2020

Table A5.1. Contribution by term and gender to country human capital growth, 1990-2020

Country	Code	Male			Female			SUM			
		Term1	Term2	Term3	Term1	Term2	Term3	Term1	Term2	Term3	Total
Afghanistan	AFG	117	170	0	37	82	26	154	252	26	432
Albania	ALB	9	3	0	21	2	3	30	5	3	38
Algeria	DZA	28	94	-3	26	35	24	54	129	21	204
Angola	AGO	52	79	3	36	84	6	87	163	9	259
Azerbaijan	AZE	7	35	0	13	30	4	20	65	4	89
Argentina	ARG	9	26	0	11	30	8	20	55	8	83
Australia	AUS	24	32	0	25	31	3	50	63	3	115
Austria	AUT	11	13	0	19	7	5	31	20	5	56
Bahamas	BHS	-13	40	1	-13	46	2	-26	86	3	63
Bahrain	BHR	9	271	-1	18	94	25	28	365	24	417
Bangladesh	BGD	37	45	0	48	34	-13	85	79	-13	151
Armenia	ARM	6	-6	-1	9	-1	-4	15	-7	-4	3
Barbados	BRB	2	13	0	19	10	1	22	23	1	46
Belgium	BEL	15	10	0	28	5	6	43	15	7	65
Bhutan	BTN	57	48	1	69	22	7	126	69	8	204
Bolivia (Plurinational State of)	BOL	-2	56	0	2	49	6	0	105	6	111
Bosnia and Herzegovina	BIH	24	-14	1	31	-14	6	55	-28	8	34
Botswana	BWA	13	58	1	14	61	4	28	120	5	152
Brazil	BRA	75	29	-1	71	30	8	146	59	7	212
Belize	BLZ	7	94	0	12	80	11	19	174	11	204
Brunei Darussalam	BRN	8	57	-1	11	50	8	19	108	7	134
Bulgaria	BGR	11	-10	0	15	-9	0	26	-20	0	7
Myanmar	MMR	26	19	0	28	22	-7	54	41	-8	88

Burundi	BDI	34	56	1	49	52	1	83	108	2	192
Belarus	BLR	10	0	0	11	0	1	21	-1	1	21
Cambodia	KHM	7	69	1	14	63	2	20	132	3	155
Cameroon	CMR	18	76	0	19	62	6	37	138	6	182
Canada	CAN	-2	26	0	-2	26	3	-4	52	3	50
Cabo Verde	CPV	33	68	-3	33	51	10	65	119	7	191
Central African Republic	CAF	10	40	0	13	32	0	23	73	1	97
Sri Lanka	LKA	13	16	0	15	23	2	28	39	2	69
Chad	TCD	26	95	0	27	82	2	54	177	2	233
Chile	CHL	32	41	0	36	35	15	68	76	15	159
China	CHN	32	19	-1	44	17	-1	76	36	-2	109
Colombia	COL	37	45	0	32	46	23	69	91	23	183
Congo	COG	-21	86	1	-10	75	5	-31	161	6	136
Congo, Democratic Republic of the	COD	29	81	0	33	68	1	61	150	1	212
Costa Rica	CRI	41	58	-1	41	52	19	82	110	19	211
Croatia	HRV	19	-8	0	29	-8	2	47	-16	2	33
Cuba	CUB	10	10	-1	11	10	6	21	20	5	46
Cyprus	CYP	47	40	0	50	41	6	97	81	6	184
Czechia	CZE	18	7	0	31	4	1	49	10	1	60
Benin	BEN	46	83	-1	53	60	6	99	143	5	246
Denmark	DNK	16	5	-1	29	3	-1	45	8	-1	52
Dominican Republic	DOM	26	38	0	35	38	9	61	76	8	144
Ecuador	ECU	1	62	0	2	58	12	3	119	12	134
El Salvador	SLV	12	20	0	13	25	4	25	45	4	73
Ethiopia	ETH	42	84	1	41	74	4	83	157	6	246
Eritrea	ERI	27	28	1	22	29	2	48	57	3	109
Estonia	EST	10	-5	0	24	-8	1	34	-13	0	22
Fiji	FJI	8	24	-1	10	18	10	19	42	9	70
Finland	FIN	10	8	0	15	6	1	25	14	1	40
France	FRA	9	8	0	11	10	3	20	19	3	41
Djibouti	DJI	42	63	2	36	34	34	78	98	36	211
Gabon	GAB	-25	84	-2	-24	67	-6	-49	151	-7	95
Georgia	GEO	9	-12	0	15	-15	0	25	-27	-1	-3

Gambia	GMB	15	78	-2	33	68	-5	48	147	-6	188
Germany	DEU	6	6	1	9	2	4	15	8	5	29
Ghana	GHA	37	69	-1	47	55	-1	84	124	-1	207
Greece	GRC	31	1	-1	28	3	6	59	4	5	68
Guatemala	GTM	16	70	0	22	55	3	38	125	3	166
Guinea	GIN	40	49	-2	38	45	1	77	94	-1	170
Guyana	GUY	11	9	-2	13	4	5	24	13	3	41
Haiti	HTI	4	38	0	6	39	4	11	78	4	93
Honduras	HND	9	81	0	14	72	16	24	153	16	193
Hong Kong	HKG	26	16	-1	30	35	5	57	51	4	112
Hungary	HUN	15	-2	1	20	-2	3	35	-4	3	35
Iceland	ISL	15	22	0	31	22	0	46	44	-1	89
India	IND	11	55	-1	23	26	-13	34	81	-13	102
Indonesia	IDN	18	39	0	23	35	2	41	74	2	117
Iran (Islamic Republic of)	IRN	36	93	-2	25	33	29	61	126	27	214
Iraq	IRQ	-28	135	0	-6	44	6	-34	180	7	152
Ireland	IRL	36	30	-1	43	27	11	79	58	11	147
Israel	ISR	12	58	1	17	56	8	29	114	9	151
Italy	ITA	17	5	-1	22	5	5	40	10	5	54
Côte d'Ivoire	CIV	19	70	-3	25	54	4	43	124	1	168
Jamaica	JAM	-5	23	-1	-5	24	-1	-10	47	-2	36
Japan	JPN	8	6	0	5	7	3	13	13	3	28
Kazakhstan	KAZ	14	7	0	14	9	1	28	16	1	45
Jordan	JOR	-9	187	-3	-4	77	22	-13	264	19	270
Kenya	KEN	-3	92	1	0	85	3	-4	178	3	177
Korea (Democratic People's Republic of)	PRK	-13	22	0	-10	21	0	-23	43	0	20
Korea, Republic of	KOR	18	28	0	20	23	4	38	51	4	93
Kuwait	KWT	-2	110	1	22	49	11	21	160	12	193
Kyrgyzstan	KGZ	8	29	0	6	30	-5	13	59	-5	67
Lao People's Democratic Republic	LAO	23	49	1	31	42	1	54	91	2	147
Lesotho	LSO	19	26	-1	20	15	-1	39	41	-2	79
Latvia	LVA	19	-16	-1	25	-17	0	43	-33	-1	9

Lithuania	LTU	13	-13	0	29	-15	1	42	-27	1	16
Luxembourg	LUX	22	40	0	18	33	11	40	72	11	124
Macao	MAC	19	71	1	38	72	11	57	143	12	212
Madagascar	MDG	24	77	1	25	76	1	49	153	2	204
Malawi	MWI	35	45	1	38	47	2	72	92	4	168
Malaysia	MYS	15	69	0	20	57	6	36	125	5	167
Maldives	MDV	1	256	0	23	76	27	23	332	28	383
Mali	MLI	42	75	5	36	59	16	78	134	20	232
Malta	MLT	19	26	0	28	17	21	47	43	21	110
Mauritania	MRT	42	90	-3	41	51	25	84	142	22	247
Mauritius	MUS	27	20	-1	32	18	8	58	38	8	104
Mexico	MEX	21	48	-1	25	42	11	46	90	10	146
Mongolia	MNG	32	33	1	33	37	1	65	70	2	137
Moldova, Republic of	MDA	-1	6	-4	-2	4	-5	-3	10	-9	-2
Morocco	MAR	50	42	-1	44	23	-2	94	64	-3	155
Mozambique	MOZ	45	62	2	53	59	1	98	121	3	223
Oman	OMN	91	341	-1	49	61	35	139	402	35	576
Namibia	NAM	13	47	0	16	52	6	30	99	6	134
Nepal	NPL	18	37	0	45	43	2	62	80	2	144
Netherlands	NLD	16	9	0	23	7	6	38	16	7	61
Vanuatu	VUT	11	61	0	13	60	-2	24	120	-2	142
New Zealand	NZL	15	26	0	27	27	3	42	53	4	98
Nicaragua	NIC	23	52	0	20	50	11	43	103	12	157
Niger	NER	36	124	0	30	88	42	66	212	43	320
Nigeria	NGA	-3	69	-2	4	52	6	2	121	5	127
Norway	NOR	16	16	0	27	12	0	42	28	0	70
Pakistan	PAK	26	88	0	21	37	20	47	126	20	193
Panama	PAN	7	54	0	10	51	11	16	106	11	133
Papua New Guinea	PNG	46	49	-8	38	46	-7	84	94	-15	163
Paraguay	PRY	23	55	0	28	47	4	51	102	4	157
Peru	PER	28	51	0	24	45	10	52	96	10	158
Philippines	PHL	14	55	-1	13	53	0	27	109	-1	135
Poland	POL	13	6	0	24	7	0	37	13	0	51
Portugal	PRT	23	4	-1	27	6	3	50	11	3	64

Qatar	QAT	-34	477	0	-4	129	7	-38	606	7	575
Romania	ROU	9	-6	0	13	-5	0	22	-11	0	11
Russian Federation	RUS	13	1	0	15	2	0	28	3	-1	30
Rwanda	RWA	38	44	7	49	41	10	87	85	17	188
Sao Tome and Principe	STP	20	53	0	22	43	5	43	97	5	145
Saudi Arabia	SAU	155	167	-3	60	44	18	215	211	15	441
Senegal	SEN	21	66	-4	37	56	-13	59	122	-16	164
Serbia	SRB	26	-4	0	34	-4	4	60	-8	4	56
Sierra Leone	SLE	43	40	3	51	29	4	94	69	7	171
Singapore	SGP	11	73	0	20	59	9	30	132	9	172
Slovakia	SVK	11	9	0	17	9	0	28	18	-1	46
Viet Nam	VNM	9	40	0	16	36	0	25	76	-1	100
Slovenia	SVN	25	6	2	39	2	4	63	7	5	76
Somalia	SOM	-17	74	1	-5	46	-8	-22	120	-6	92
South Africa	ZAF	9	48	-1	9	46	13	18	94	12	124
Zimbabwe	ZWE	-1	22	1	0	28	4	-1	49	5	53
Spain	ESP	22	18	-1	25	17	12	47	35	11	93
Suriname	SUR	3	30	-1	4	33	-1	7	63	-3	67
Eswatini	SWZ	15	41	-1	16	29	7	30	69	6	105
Sweden	SWE	16	9	0	34	5	-1	50	14	-1	63
Switzerland	CHE	10	19	0	19	16	2	30	35	2	66
Syrian Arab Republic	SYR	6	63	-1	11	23	-6	18	86	-8	96
Tajikistan	TJK	-5	57	-5	0	41	-15	-5	98	-20	74
Thailand	THA	40	17	-1	46	24	-2	86	41	-3	123
Togo	TGO	27	68	-3	40	51	-2	67	119	-5	181
Trinidad and Tobago	TTO	10	20	0	10	19	8	20	39	7	66
United Arab Emirates	ARE	49	513	0	6	143	28	55	655	29	739
Tunisia	TUN	16	49	-1	31	28	12	47	78	10	135
Türkiye	TUR	58	46	-2	60	31	1	118	77	-1	194
Turkmenistan	TKM	18	45	-1	12	43	-2	30	88	-3	115
Uganda	UGA	11	89	2	22	82	2	33	171	4	207
Ukraine	UKR	12	-6	-1	10	-6	-2	22	-12	-3	8
North Macedonia	MKD	15	9	0	18	7	4	33	16	4	53

Egypt	EGY	16	65	-1	22	31	-9	38	97	-10	125
United Kingdom of Great Britain and Northern Ireland	GBR	15	11	0	22	8	1	37	19	1	56
Tanzania, United Republic of	TZA	26	65	1	28	65	2	54	130	3	186
United States of America	USA	6	19	0	7	19	1	13	39	1	52
Burkina Faso	BFA	45	65	-1	51	54	-2	96	119	-3	212
Uruguay	URY	9	9	0	7	11	4	16	19	4	39
Uzbekistan	UZB	6	56	0	6	48	0	11	104	0	116
Venezuela (Bolivarian Republic of)	VEN	22	33	-1	22	36	3	44	70	3	117
Samoa	WSM	13	11	-4	7	10	-5	20	21	-8	32
Yemen	YEM	66	133	-1	22	35	-33	88	168	-34	222
Zambia	ZMB	23	62	2	9	74	3	32	136	5	173

Source: Authors' own calculations.

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