KYUSHU UNIVERSITY

INCLUSIVE WEALTH REPORT 2018

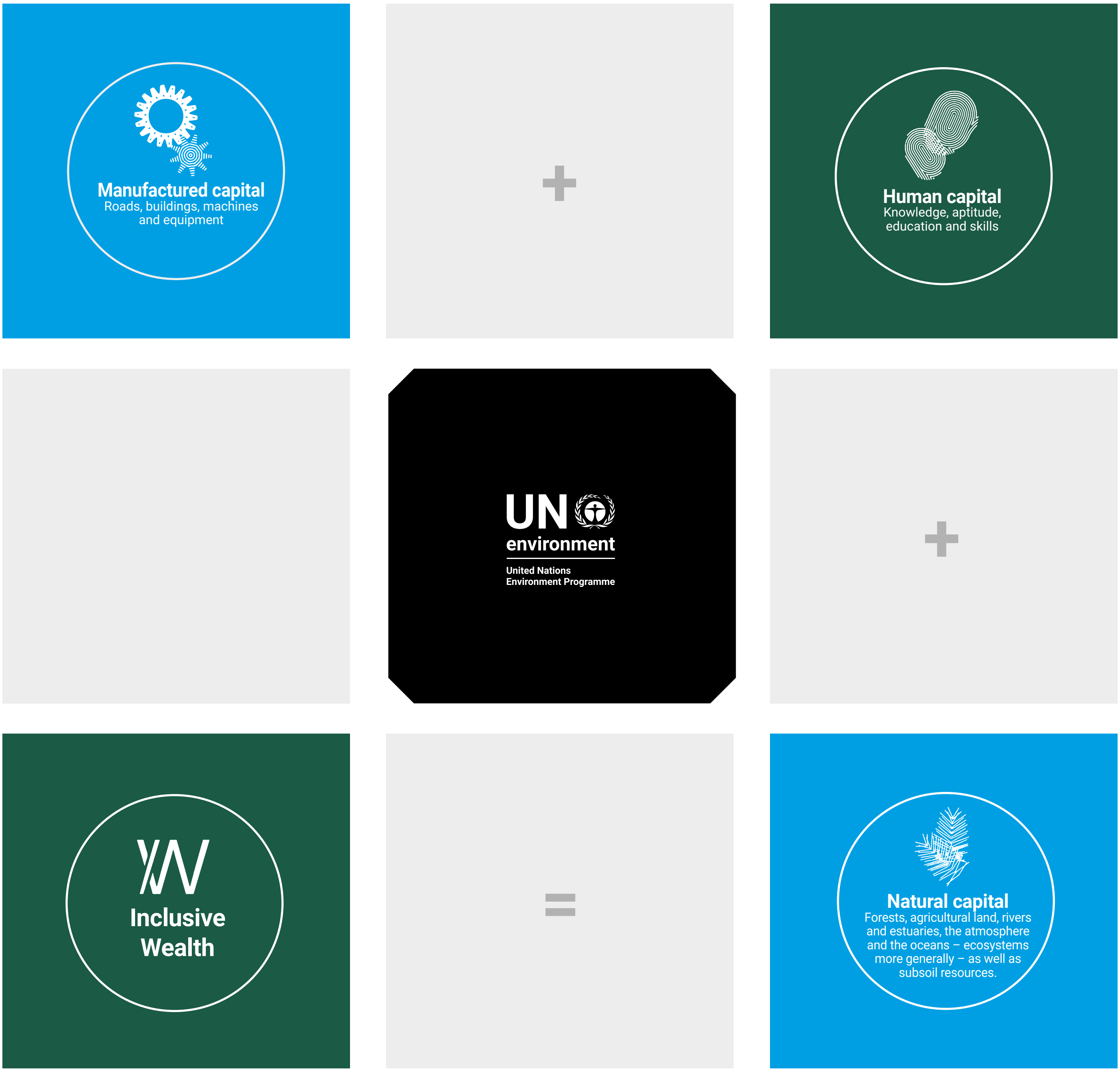
Measuring sustainability and well-being

UN environment
United Nations Environment Programme

2018 | Measuring Sustainability and Well-Being

WHAT IS INCLUSIVE WEALTH?

The Inclusive Wealth Report (IWR) is a biennial effort led by UN Environment 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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FOREWORD TO IWR 2018

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The global growth experience since the end of the Second World War has offered two conflicting messages. On the one hand, if we look at the state of the biosphere (fresh water, ocean fisheries, the atmosphere as a carbon sink and, more generally, ecosystems), there is strong evidence that the rates at which we are utilizing them are unsustainable. For example, the rate of biological extinctions globally today is 100-1,000 times the average rate over the past several million years (the 'background rate'). The mid-20th Century years are acknowledged to have been the beginning of an era that environmental scientists now call the Anthropocene (Vosen, 2016), massively altering the processes that define the biosphere.[1]

On the other hand, it is argued by many that just as previous generations in the West invested in science and technology, education, machines and equipment to bequeath to us the ability to achieve high living standards, we in turn, can make investments that will assure still higher living standards in the future. *Commentators* routinely praised the years immediately following the Second World War as the start of the Golden Age of Capitalism.[2]

We should not be surprised that the Anthropocene and the Golden Age of Capitalism began at about the same time. We should also not be surprised that the conflicting signals of the past 65 years do not receive much airing by economic commentators. That is because contemporary models of economic growth and development, in large measure, ignore the workings of the biosphere (Helpman, 2004).

Recently, a group of economists studied the tension inherent in these conflicting intuitions by appealing to the idea of 'sustainable development'; a term coined in the famous Brundtland Report (World Commission on Environment and Development, 1987). By sustainable development the Commission meant "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In this reading, sustainable development requires that, relative to their respective demographic bases, each generation should bequeath to its successor at least as large a productive base as it inherited from its predecessor. For if a generation were to follow the prescription, the economic possibilities facing its successor would be no worse than those it faced when inheriting productive assets from its predecessor.

This raises the question of how the productive base is to be measured. We are therefore in need of an index whose movements over time track the sustainability of development programmes. The authors of the *Inclusive Wealth Report (IWR) 2018* show that prominent attempts at constructing ways to assess the sustainability of development programmes have been unsatisfactory because they did not arrive at their indices from a well-articulated notion of sustainable development (Ch. 1).[3]

In recent years, a number of authors have shown that, if by sustainable development we are to mean that welfare across the generations should not decline over time, the index that measures an economy's productive base should be an inclusive measure of wealth.[4]

The authors of *IWR 2018* follow that line of thought and extend the empirical reach of *IWR 2012* and *IWR 2014*. They develop the idea of inclusive wealth, uncover the logic underlying its use in sustainability analysis, and then put it to work in tracking the inclusive wealth of nations.

Inclusive wealth is the dynamic version of income. It is the accounting value of an economy's stock of manufactured capital, human capital and natural capital (hence the qualifier 'inclusive'). Wealth is a stock, whereas income is a flow. In a stationary economy, the two amount to the same thing, but they can point in different directions when an economy is not in a stationary state. The authors of *IWR 2018* find that 44 out of the 140 countries in their sample have experienced a decline in (inclusive) wealth per capita since 1998, even though gross domestic product (GDP) (read, 'income') per capita increased in all but a handful of them. The tension I alluded to is expressed quantitatively in this volume.

In this essay, I offer an account of the logic and pertinence of inclusive wealth in both sustainability and policy analysis that parallels the authors' reasoning in this volume. My hope is that the two parallel accounts will give a better flavour of the significance of the exercise undertaken in *IWR 2018*.

1 See Waters *et al*. (2016). Ehrlich and Ehrlich (2008) is an excellent account of the rise of human dominance over the biosphere and the speed with which it has come about in comparison to evolutionary timescales.
2 Micklethwait and Wooldridge (2000), Ridley (2010) and Norberg (2016) are a sample of books with that message.
3 IWR 2018 follows two previous Inclusive Wealth Reports (IWR 2012, IWR 2014) with the same intent.
4 See Dasgupta and Maler (2000), Arrow et al. (2004) and Arrow et al. (2012, 2013).

Framework for Economic Evaluation

Assessing the sustainability of economic programmes is different from prescribing policy. Although both evaluate change, they differ as to the type of change. In the former, change corresponds to the passage of time; in the latter, change is initiated at a point in time by choice of policy. In either case, the change is a 'perturbation' to the economy; so we will often use that term.

Sustainability analysis and policy analysis involve exercises in what is commonly known as economic evaluation. I shall refer to the person engaged in economic evaluation as the *social evaluator* (or *evaluator*, for short). She/he could be a citizen (thinking about the state of the country/economy before casting her vote on political candidates); an ethicist employed to offer guidance to the national government; a member of the local council; or the proverbial man on the Clapham omnibus, reflecting on the state of the world on his way back from work; and so on.

The criterion proposed in the Brundtland Report for sustainability analysis differs from the one that has usually been adopted for policy analysis. The former takes the means for promoting the ends of development as its point of interest (in the Brundtland Report those means are the economy's productive capacity), whereas the latter is based directly on ends (promoting human well-being).[5] In order to bring the two types of analysis in line with each other, we need to re-construct the idea of sustainable development in terms of ends. When we have done that, we will discover that prescribing policy and assessing sustainability involve the same exercise.

Let us call the ends our social evaluator seeks to advance, social well-being. Because our evaluator considers not only the well-being of people who are present but that of future generations too, social well-being can also be thought of as intergenerational well-being; so I will use the terms interchangeably.

Ends and Means

There are two points I want to demonstrate here in intuitive terms:

(1) Evaluation in terms of social well-being is equivalent to evaluation based on the means that further social well-being.
(2) Policy and sustainability analyses amount to the same exercise.

In what follows, I give a sketch of the pair of equivalences. The equivalences provide the foundations of economic evaluation. I shall call the pair of equivalences *Proposition*. However, because of its centrality in intergenerational ethics, it is useful to first study the intuition behind it.

Ends are antecedent to the means. One can articulate ends even without asking whether they can be realized, but it makes no sense to talk of means if the ends they are meant to advance are not first articulated. The equivalence between ends and means, which I am alluding to does not deny the antecedence of ends. What *Proposition* says is that if the means to a set of ends have been identified, it does not, in principle, make any difference whether we examine the extent to which the ends have been (or are likely to be) furthered by a perturbation to an economy; or, alternatively, whether we estimate the degree to which the means to those ends have been (or are likely to be) bolstered by that perturbation. The two point in the same direction. We should imagine also that the equivalence would hold as tightly in a society where the ends are far from being met owing to misallocation of the means or unjustified usurpation of the means, as it would in a society where they are met as far as is possible under the prevailing scarcities of the means. Nor should it make a difference whether the perturbation is caused because of a shift in policy or whether it occurs because of the passage of time; in either case, the task is to evaluate the perturbation. Both theory and experience show, however, that it is commonly easier to measure the means to the ends than it is to measure the ends themselves. It will prove useful here to indicate why.

The items that appear in documents put before the social evaluator are goods and services. Feasibility reports on investment projects, for example, contain quantitative estimates of the assets that are required at the investment stage (for instance, the number of pieces of equipment, labourers and acres of land to be cleared). They also contain the labour hours and material inputs that are expected to be required each year, and the flow of outputs the authors hope will be forthcoming over the project's life. Similarly, proposals for changes in the rate of taxation contain information about their likely impact on the flow of goods and services, expressed in terms of employment (labour of various skills), savings and investment, and redistribution of incomes. Those items are the 'means'; they are not themselves the ends. Social evaluators are expected to make use of that information in order to judge whether the investment project or tax change is socially desirable. In order to do that, they have to value the goods and services in terms of the ends. They have to do this because goods and services acquire the status of means only when the ends to which they are the means have been articulated. As in the case of private investment decisions, they would attempt to value the goods and services in units of a suitably chosen commodity, expressed in a monetary currency. Moreover, they would know that the value of a commodity depends on its location, intended use, the date and circumstances in which it is to be used as an input or produced as an output, and the persons affected. Nevertheless, once they ask why a commodity's value depends on those features, they are well on their way to the required analysis.[6]

5 Policy prescription, as practised in welfare economics, has the ends explicitly in sight. See, for example, Graaff (1962) and Atkinson and Stiglitz (1980).
6 There are goods that serve as both ends and means. Health is a prime example. As the two aspects of health can be kept separate, the dual feature of health does not cause a problem for economic evaluation.

Development experts have been known to view matters otherwise. Authors of the annual *Human Development Report* of the United Nations Development Programme (since 1990) have routinely criticized national governments and international organizations for prescribing policy and assessing economic performance on the basis of quantitative indicators that reflect the means, not the ends. They say that to use GDP and its distribution for those purposes is to confuse means for ends, and they caution against the use of GDP as an index of economic achievement on grounds that it is a measure of a country's opulence, not well-being (UNDP, 1994: 14-15). However, I have never read a publication in which GDP was taken by its authors to be an end in itself. Moreover, it is not a mistake to seek to identify success (or the lack of success) in achieving ends in terms of an index of opulence. This is the message of *Proposition*. The point is not that opulence misleads, but that we should search for the right measure of opulence. GDP misleads when used in social evaluation not because it is a measure of the means, but because it is not the *right* measure of the means.

We have now identified a reason it is better to evaluate change in terms of the means for achieving the ends than by examining the extent to which the ends are met by the change. It is a reason of convenience, not of principle. Of course, the intuition behind the theoretical equivalence between evaluation in terms of ends and means, respectively, has to be supported by a formal argument, with a pointer showing the way the means should be valued in terms of the ends. The authors of *IWR 2018* construct approximate ways for doing that for a number of assets, including human capital.

IWR 2018 reveals that the hardest task for the social evaluator is to determine the way the ends are reflected in estimates of the social worth of the means. That is especially hard because the ends include the well-being of future persons, and they include the value of Nature as we transform it over time by our activities. The reasoning involved in bringing the interests of people in the distant future into decisions over the deployment of today's means is intricate, often non-intuitive. That is why the social evaluator is often obliged to rely on (informed) conjecture. This is because there are matters on which there can be no data.

Inclusive Wealth and Social Well-Being

In Chapter 1 of *IWR 2018*, the authors show that if the ends are summarized in the idea of intergenerational well-being, the corresponding measure of the means is the economy's productive capacity, a notion that is central to economic evaluation irrespective of whether the ends are reached and interpreted by the social evaluator.

The intuition behind it is this: An economy's productive capacity reflects the opportunities open to its members. So it is a measure of the extent to which social well-being can be furthered. At a practical level, however, the relationship between social well-being and productive capacity is not immediate. Intergenerational well-being includes not only the well-being of those who are present today, but also the well-being of people in the future. Put another way, it is an aggregate measure of the flow of personal well-beings across time and generations. In contrast, an economy's productive capacity is specific to the time at which it is measured. *Proposition* says that by an economy's productive capacity we should mean an inclusive measure of its *wealth*.

To better appreciate the notion of wealth that *IWR 2018* advances, imagine someone is asked to estimate their personal wealth. The individual would most likely turn first to financial assets (savings in the bank, stocks and bonds) and the properties they own (house and belongings, for example). And they would use the market values of these assets to compute wealth. If pressed, they would acknowledge that their future earnings at work should be included. They would estimate that part of their wealth by making a forecast of the flow of their (post-tax) earned incomes and adding them over the working life that is ahead of them, using perhaps a market interest rate to discount future earnings. If they were pressed no further, they would probably stop there and agree that their earned incomes represent returns on the human capital they have accumulated (sociality, education, skills, health). They would also agree that wealth is important to them because it determines the opportunities they have to shape their life - the activities they can engage in, the commodities they can purchase for pleasure, and so on. But they would probably overlook that their taxes go to pay for the public infrastructure they use, and they would almost certainly not mention the natural environment they make use of daily, free of charge.

The notion of wealth the social evaluator is interested in is far wider than that. For the individual, wealth is the social worth of the economy's entire stock of assets. Assets are often called by a more generic name, "capital goods", so we may use the terms interchangeably. Assets offer potential streams of goods and services over time; the more durable an asset, the more lasting is the potential stream. Time is built into an asset. That explains why an economy's wealth at a point in time is able to reflect the flow of well-being across time and the generations.

The social value (or accounting price) of an asset is the worth of the stream of goods and services a society is able to obtain from it. A mangrove forest is a habitat for fish populations. It is also a recurrent source of timber for inhabitants, and it protects people from storms and tsunamis. An economy's institutions and politics are factors determining the social value of its assets, because they influence what people are able to enjoy from them. The value of a building is not independent of whether society is at peace.

An asset's accounting price can be very different from its market value. The difference between an asset's accounting price and its market price reflects a distortion in the economy and should be eliminated if possible. To give an example, as the market price of fish in the open seas is zero, fishermen harvesting them ought to be charged for doing so. The charge, or tax, in this case is the accounting price of fish in their natural habitat. It may even be judicious to impose a quota on fishing, but quotas are only an extreme form of taxation (zero tax per unit caught up to the quota, a prohibitive tax beyond it).

An economy's inclusive wealth is the accounting value of its stock of assets. It is useful to confine assets to: (i) manufactured capital (roads, buildings, machines, equipment), (ii) human capital (knowledge, aptitude, education, skills), and (iii) natural capital (forests, agricultural land, rivers and estuaries, the atmosphere and the oceans – ecosystems more generally – and subsoil resources such as soil nutrients).

Capital goods are to be distinguished from an economy's social environment, which is the intangible medium in which goods and services are produced and allocated across persons, time and generations. The social environment consists of the laws and norms that provide people with incentives to choose one course of actions rather than another; it includes the workings of social and economic institutions such as families, firms, communities, charities and government; and it includes the play of politics. The social environment is the seat of mutual trust. A strengthening of trust facilitates enterprise and exchange, thus enhancing personal well-being.

The social environment is not quantifiable, but as it shapes events, its consequences are often quantifiable. It influences the engagements we undertake, such as the rates at which we consume goods and services, save and invest, borrow and lend, engage in social activities, and so on. Political scientists say that economic development co-evolves with the social environment; by which they mean institutions and politics adapt to the state of the economy as surely as the economy responds to its institutions and politics. That is another way of saying that the mix of capital goods co-evolves with the economy's social environment.[7] Seemingly innocuous changes to the geography of voters' constituencies are known to influence political outcomes, which in turn influence the shape of institutions, and thus the policies that are chosen. Small differences in religious sensibilities (small, that is, to the sensibilities of outsiders) can make enormous differences to the development of attitudes and thought. And so on. For any conception of social well-being, an economy's stock of capital assets and its social environment, together with a forecast of things to come, determine the accounting price of each capital good. The accounting value of an economy's stock of capital goods is its inclusive wealth.

Proposition

Assets are stocks, not flows. They offer goods and services to us, which are flows. A tree is a stock, and the fruit it bears is an annual flow of goods. Moreover, the carbon dioxide its leaves inhale is a continuous flow of services to us. Output is a flow (so many dollars-worth of goods per year), whereas wealth is a stock (so many dollars-worth of capital goods, period). The pair of equivalences we have been describing can now be summarized in the following proposition.

Proposition: Any perturbation to an economy that increases social well-being across the generations raises inclusive wealth as well. Similarly, any perturbation that lowers social well-being across the generations reduces inclusive wealth.

The simplest way to illustrate *Proposition* is to recognize that investment projects are perturbations to the economy. If a project is accepted, the future trajectory of the economy is different from what it would be if the project were not accepted. The common method for evaluating projects is to estimate the present value of social profits accompanying them. *Proposition* implies that a project's present value of social profits is its contribution to wealth. An economy's assets and social environment, taken together, comprise its productive capacity. Inclusive wealth is a measure of that capacity.

I have stated *Proposition* in its starkest form. We should read "wealth" for "wealth adjusted for its distribution among people and for population size". *IWR 2018* does that and considers a form of intergenerational well-being where inclusive wealth per capita is the correct index for both sustainability and policy analysis.

Proposition says that inclusive wealth and social well-being are linked by an unbreakable bond and can be stated in the reverse order. That is, if inclusive wealth increases (no matter what the cause of the rise happens to be), social well-being (the well-being of contemporary people and the potential well-being of future generations) increases. Similarly, if inclusive wealth declines (no matter what the cause of the fall happens to be), social well-being declines. Being respectively the ends and the means to those ends, social well-being and inclusive wealth are not the same of course; but they move in tandem.

Because *Proposition* is an "if and only if" statement, it has no empirical content. But it has powerful implications for empirical work and theoretical reasoning. It says, for example, that governments should instruct their statistical offices to prepare wealth accounts and track movements in wealth through time to check whether social well-being has risen under their proposed policies. The change in (inclusive) wealth over a period of time, say a year, is called "net investment"; that is, investment net of the wear and tear of capital assets and the degradation of natural capital. *Proposition* can be read as saying that, controlling for population change

7 Putnam (1993), Landes (1998), and Mokyr (2002, 2016).

and the distribution of assets, economic development is sustainable over a period of time if net investment in the economy's stock of assets is positive during the period. That is net investment in the *aggregate*, which means that even if stocks of some capital goods were to decline (in quantity or quality, or both), net investment would be positive if sufficient investment were made towards the accumulation of the remaining assets. Whether investment in manufactured capital and human capital can be always be relied upon to compensate for the degradation and depletion of nature remains a cause of disagreement between growth economists and environmental scientists. But analysing data from the past to infer what lies ahead can lead us astray with tragic consequences.

Proposition puts into perspective recent controversies over the objects of interest in distributive justice. For example, whether they should be personal well-beings or whether they should be resources or opportunities.[8] As I understand it, those controversies arose in response to John Rawls' theory of justice (Rawls, 1972). *Proposition* can be used to show that Rawls was entirely right to frame the principles of justice as fairness in terms of the distribution of primary goods (Rawlsian primary goods are the means to personal well-being; they are not themselves a person's well-being). His philosophical move was to identify the circumstances in which agreement over the basic structure of society is to be reached and be committed to. Rawls saw the circumstances as being those in which each person is shrouded by a thick veil of ignorance of what his/her life from its earliest stages has in store for him/her. The objects chosen under the veil were derived in Rawls' theory, they were not given ab initio. It can be argued that when they are aggregated in an appropriate way, Rawlsian primary goods read as inclusive wealth.[9]

The practical significance of *Proposition* was lost on the framers of the Sustainable Development Goals (SDGs), which were adopted by the United Nations General Assembly in September 2015. The UN has made a commitment to attain the goals by 2030. Seventeen in number, the goals range from poverty eradication and improvements in education and health, to the protection of global assets that include the oceans and a stable climate. Each is of compelling importance. However, neither the SDGs nor their background documents mention the need to move to a System of National Accounts that contains estimates of wealth. Without that move, however, there would be no way for governments to check that the economic measures they take to meet the international agreement would not jeopardize the sustainability of those goals. If wealth (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. It could be that the goals are reached in the stipulated time period but are not sustainable because the development paths nations follow erode productive capacities beyond repair. The supporting documents of the United Nations SDGs do not tell us how to check that the goals are being met in a sustainable way.

The Theory-Practice Divide

Economic evaluation is not for the purist. There would be weaknesses in the evaluator's work no matter how they go about it. They know that. They worry that the basis on which they have estimated accounting prices is ethically inadequate, that they have neglected vital features of life; and they are conscious of cutting corners when measuring items they are trying to measure. The evaluator also knows that they must justify (to themselves at the very least) the approximations they have been forced to make in the act of measurement. Rather than express their estimates as exact figures, they know they should offer them as bands. They are, moreover, aware that people would be wary of figures for wealth in the aggregate, derived from a numerical rendering of social well-being. They would want a sensitivity analysis of wealth estimates, based on alternative weighting systems on the items of ethical significance. The evaluator could do that by working with alternative specifications of ethical parameters; which is to say alternative values of accounting prices. What they would arrive at is a menu of figures for wealth, each corresponding to a particular specification of facts, theories and values.

Restricting the ends to the well-being of people across the generations is questionable. The social evaluator will want to respond to the suggestion that nature has a value over and above the services it provides to humanity. They will also be responsive to the thought that animal life has a value that is not based solely on their welfare (to think it does would not account for the special role species conservation plays in our ethical sensibilities), nor on the "rights" animals may be assumed to have. Understandably, *IWR 2018* does not enter such matters. For these are early days in the art and science of economic evaluation, done correctly.

8 See Dworkin (1981a-b), Cohen (1989), Barry (1990), and Sen (1992, 1999, 2009) among many others.
9 I provide the argument in a book I am preparing under the title, Time and the Generations.

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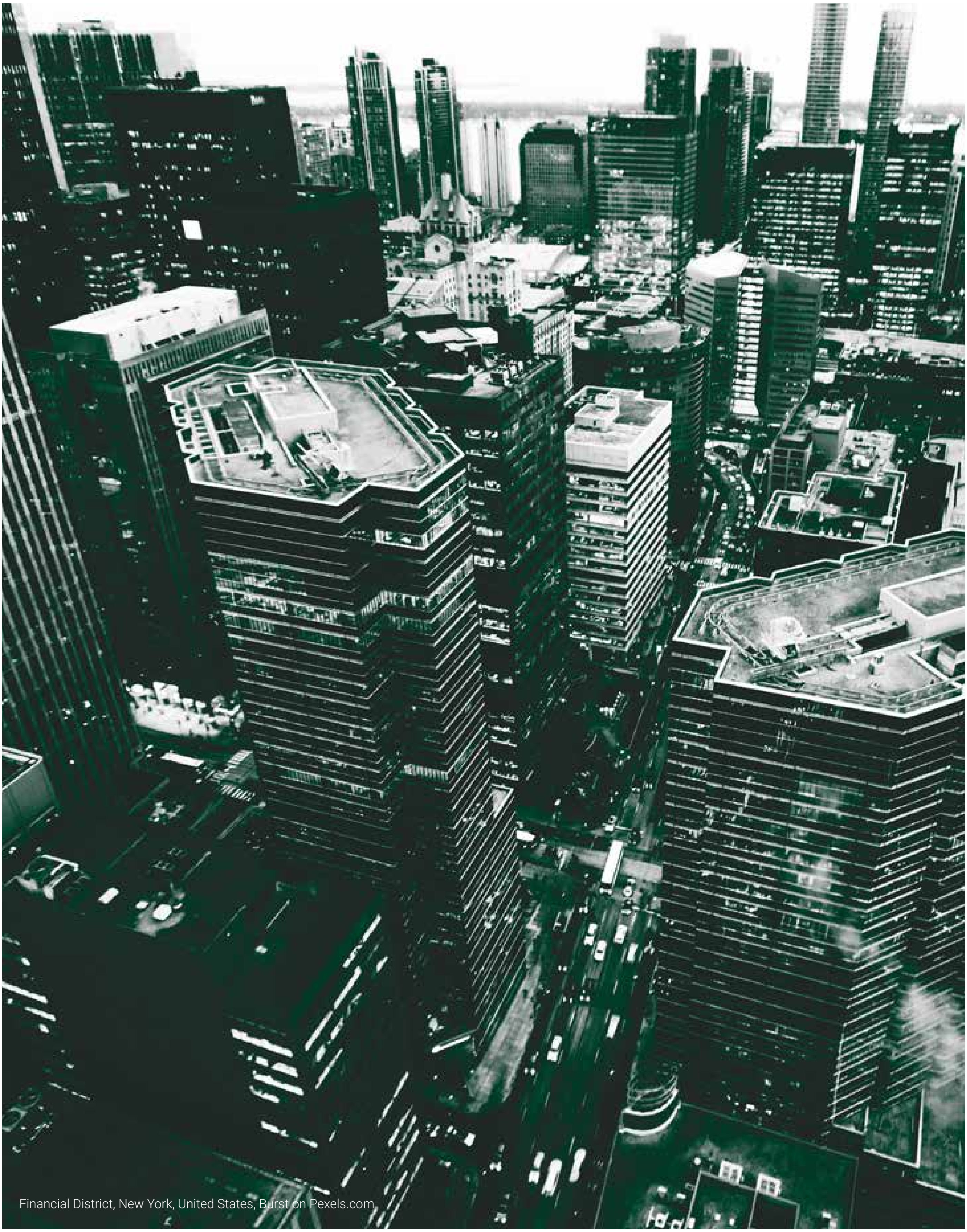

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EXECUTIVE SUMMARY - INCLUSIVE WEALTH INDEX 2018

A holistic wealth of nations

Ever since the end of the Second World War, countries have tended to measure economic progress in terms of gross domestic product (GDP). When GDP increases, a nation assumes its economy is doing well. Governments focus on boosting GDP and improving the efficiency of production to increase the size of their economies. The larger the economy, the more goods and services are available for consumption, so the thinking goes. But the problem is that GDP is a poor way to keep count of wealth. This is partly because GDP is a measure of income and not wealth. GDP puts a value on a nation's goods and services rather than on its stock of natural, physical and human assets. If the ultimate aim of an economy is to promote well-being, then GDP is a poor measure of human progress.

There is another problem with equating economic progress with GDP: it fails to account for what a nation loses as its economy grows. Economic growth and more efficient production often go hand in hand with a rise in, for example, air and water pollution. Economies may appear to be growing when measured using GDP, but if we look at the state of the biosphere today (fresh water, ocean fisheries, the atmosphere as a carbon sink), there is strong evidence to suggest that the rates at which we are using them are unsustainable. The rate of biological extinctions today is 100 to 1,000 times the average background rate of the past several million years. Climate change is another example of an ill that has arisen in spite of – or perhaps because of – economic growth, as measured by GDP. The Aral Sea offers a more specific example of what can happen when we fail to account for natural capital when we pursue short-term economic gains. Water diversions for cotton and rice production caused the surface area of the Aral Sea to fall so dramatically that ships could no longer reach the shores of existing cities, transforming a once economically vibrant water body into one with virtually no economic value.

The mid-20th Century marks the beginning of an era that environmental scientists call the Anthropocene, an epoch in which humans have massively altered the workings of the biosphere. And yet, over the same period, the investments of previous generations in science and technology, education and health have improved living standards in many parts of the world. Many refer to this period as the golden age of capitalism. If we invest more and grow our economies, we can improve these living standards even further, so the argument goes. It should come as no surprise that the Anthropocene and the Golden Age of Capitalism began at about the same time. It is clear that economic growth and other forms of human progress, as traditionally measured, have come at a tremendous environmental cost — one that threatens the future sustainability of our economies.

If we are to fully appreciate this cost then we need a better measure of economic progress and social well-being, one that assesses a nation's ability to look after its wealth in a way that safeguards it for future generations. This is why the Inclusive Wealth Index (IWI) was born. At its heart, the IWI is a way of measuring a country's overall well-being. Unlike GDP, it also provides a tool for countries to measure whether they are developing in a way that allows future generations to meet their own needs. This is what we mean when we call something sustainable – each generation must bequeath to the next as large a productive base as it inherited from its predecessor. If a generation follows this prescription, then the economic possibilities available to its successor would be just as good as the ones it enjoyed. Conversely, if countries fail to look after their capital properly, then the next generation will be worse off. The IWI measures exactly this. It acts as a tool to assess whether a country's social well-being, or inclusive wealth, is improving and whether this progress will last. Ultimately, the IWI aims to measure a nation's capacity to create and then maintain human well-being over time.

To do this, the IWI tracks the progress of 140 countries that make up the lion's share of the global economy (US$56.84 trillion) and population (almost 6.89 billion people). Fifty countries with small economies were left out of the report because it was too difficult to obtain reliable data. The IWI looks at each country's stock of assets – its manufactured, human and natural capital – and assesses the changing health of these assets over a quarter of a century, a massive data set that covers almost an entire generation. A country's economy may appear to be doing well – its GDP may be growing – but at what cost? The IWI answers this question. The Inclusive Wealth Report (IWR) 2018 shows that 44 out of the 140 countries have suffered a decline in inclusive wealth per capita since 1992, even though GDP per capita increased in all but a handful of them. This means that these countries are not on a path to sustainable development, even if their economies, according to GDP, appear to be growing. They are depleting their stocks of natural, human or physical capital at rates that will leave future generations worse off.

A country's inclusive wealth is the social value of all its capital assets, including natural capital, human capital and produced capital. We call this the country's productive base. It is an index of a country's production potential. If a country's IWI is either increasing or stable over time, then we can say its growth is sustainable; its economy is making progress without harming the well-being of future generations. Worryingly, the IWR 2018 shows that growth in inclusive wealth per capita, with adjustments (for total factor productivity, carbon damage and oil capital gains), indicates that only 81 of the 140 countries, or 58 percent, are on a sustainable path.

BOX 1 – What do we mean by "inclusive" wealth?

Some economists caution against the use of GDP as an index of economic achievement. They say it is a measure of a country's opulence and not its well-being. But the point is not that opulence misleads; it is that we need to measure opulence, or wealth, correctly. That's where inclusive wealth comes in. It is the measure, through the ages, of human well-being. It totals up the value of an economy's stock of manufactured capital, human capital and natural capital. Manufactured, or produced, capital means things like roads, buildings, machines, equipment and other physical infrastructure. Human capital means things like knowledge, education, skills, health and aptitude. Natural capital means forests, fossil fuels, fisheries, agricultural land, rivers and estuaries, oceans, the atmosphere and ecosystems, like subsoil resources, more generally. These three types of capital lead to the ultimate purpose of an economy – social well-being. They are called the productive base of the economy.

To work out the social value of an asset you need to total up the goods and services that a society obtains from it. This allows us to determine how the well-being of a society is affected by an asset. A mangrove forest, which is an example of an asset, is a habitat for fish that we then eat. It is also a source of timber. And it protects people from storms and tsunamis. Likewise, 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. Assets are stocks, not flows. They provide us with goods and services, which are flows. A tree is a stock; its fruit is an annual flow of goods, while its leaves – by inhaling carbon dioxide – provide a continuous flow of services. Putting a price on these assets allows us to measure a country's real wealth, its true well-being. Ultimately, we should simply drop the word "inclusive" from IWI and just call it what we really mean: wealth.

Why measure the real wealth of nations?

The IWI has enormous implications for economic policymaking. Using the IWI can help countries scale up resource efficiency by providing policymakers with an overview of changes in the productive base of a country. It provides insights into whether current growth is sustainable or is based on an overexploitation of natural capital. This information can help leaders develop policies that promote sustaining growth while better managing human and natural capital. The results from the previous IWR in 2014 have already shown that investing in human capital would be the most beneficial for countries with high rates of population growth. It also demonstrates the benefit of investing in natural capital, in particular agricultural land and forests. By placing a value on everything from roads to rivers, the IWI allows policymakers to better manage their countries' assets in ways that protect them for future generations.

The IWI is also a vital tool for countries seeking to meet the goals laid out in the 2030 Agenda for Sustainable Development. Can we achieve all the Sustainable Development Goals (SDGs) without having to make trade-offs? Will countries have sufficient resources to achieve poverty reduction while at the same time having enough resources left to build schools and train teachers, for example? Even if all of the goals are achieved by 2030, the critical question is whether these gains can be maintained. Will we achieve all the goals but exhaust our resources in the process? The IWI helps policymakers answer these tricky questions.

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 planet's forests, agricultural land, rivers and estuaries, the atmosphere and oceans. The overarching message is that nations must keep their natural capital stocks intact if the world is to meet the goals. Yet this is clearly not the case: the IWI report shows that natural capital declined in 127 of the 140 countries, even as the global economy grew.

Unfortunately, the SDGs only briefly mention the need for a System of National Accounts that goes beyond GDP. SDG 17 (Indicator 17.19) speaks of developing "measurements of progress on sustainable development that complement gross domestic product". Without this, there will be no way for governments to check whether the economic measures they take to meet the international agreement jeopardize the sustainability of those goals. The IWI provides governments with a way of checking this. If inclusive wealth (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. It could be that the goals are reached but are not sustainable in the long run because the development paths that nations choose to follow erode their productive capacities beyond repair.

One understated variable in the SDGs is population. The world has seen the fastest growth in human population ever witnessed in human history. Most countries have failed to take into account dramatic population growth in policymaking. In fact, many countries have initiated population-boosting policies, fearing the demise of a workforce that they believe is required to maintain economic activity. There are major consequences to these types of policies in a world where resources are finite and increasingly scarce. Previous Inclusive Wealth Reports (IWRs) have shown conclusively how countries can move from being sustainable, when computed in absolute terms, to being unsustainable when population growth is factored in. Policymakers must begin to understand the impact of population growth on the productive base. If they fail to do so, they will struggle to achieve the SDGs.

Ultimately, we hope the IWI will improve the ways in which resources are allocated in the imperfect economies in which we live. We believe this database will record both the changes in and the sustainability of capital assets in the 21st Century – and beyond. We hope it will eventually help solve the global problems laid down by the SDGs and the Paris Agreement on climate change, ambitious targets that require a way of tracking our progress towards them.

BOX 2 – The big debate

How to put a price on the services that ecosystems provide is a controversial topic. Many ecosystem services can be evaluated by the market. Beekeeping is an obvious example. Bees make honey, which fetches a price on the market. But they also pollinate fruit trees, a service that is difficult to price. Similarly, a forest's contribution to flood control and climate regulation, and its carbon storage services are difficult to put a price on, even though these services are valuable to humans, animals and other life forms. Ecosystems that provide us with services, like clean air and water that are difficult to price, are known as "critical capital". Ecologists say that the IWI fails to properly take into account critical capital. They also say that a country's IWI can appear healthy even if its natural capital and/or critical capital is being depleted. A country can chop down $100 billion worth of forest and yet, so long as it invests $100 billion in infrastructure, be no worse off according to its IWI. Ecologists say that this type of policymaking does not lead to strong sustainability because natural capital is being depleted. Most economists, however, allow for substitution across the three forms of capital. This type of substitution leads to what is called weak sustainability. The IWI allows for an increase in inclusive wealth per capita even though natural capital is being depleted: it can increase as long as the decrease in natural capital stocks is offset by enough of an increase in human and physical capital stocks. Reconciling the views of economists and ecologists should be possible if the context and character of resources are known. If one could identify and measure critical capital, and monitor the levels and growth of that capital, then it might be possible to develop a sustainability index of critical capital. But it is unlikely that a market value of this type of capital will enter GDP measures anytime soon.

What the data shows

The changes in the inclusive wealth (IW) of 140 countries are calculated by annual average growth rates over the past 25 years, and 1990 is set as a base year. The results show that the growth of IW is positive for a considerable number of countries. Top performers include the Republic of Korea, Singapore and Malta, among others. However, in a significant number of countries, the population is growing more quickly than the IW; thus, in these places we see negative per capita growth of wealth. In addition, some of the negative per capita growth of wealth occurred in countries that experienced absolute gains in wealth.

Top performers on the basis of per capita inclusive wealth for 1992–2014

IWI Ranking	Country	Average growth per head during 1992-2014
1	Republic of Korea	33.0%
2	Singapore	25.2%
3	Malta	18.9%
4	Latvia	17.9%
5	Ireland	17.1%
6	Moldova	17.0%
7	Estonia	16.0%
8	Mauritius	15.5%
9	Lithuania	15.2%
10	Portugal	13.9%

(Source: Inclusive Wealth Report 2018, Routledge, London)

For developing countries, although net wealth accumulation appears to have kept pace with income growth in recent years, the high rate of natural capital depreciation is troubling, especially in low-income economies where the problem appears to be worsening. The rate of natural capital depreciation has been, on average, five times greater in developing countries than in the rich Organization for Economic Cooperation and Development (OECD) economies. In low- and middle-income economies, other forms of capital investments have largely compensated for the rising natural capital depletion that has occurred since the late 1990s. Over the long run, these high rates of depreciation are bound to damage the sustainability of development efforts and to worsen inequality. A key focus of policies should be to improve the efficiency and sustainability of natural resource use so that natural capital depreciation in developing countries is diminished substantially.

The world economy faces two major threats: increasing natural resource degradation and the growing gap between rich and poor. These two threats are symptomatic of a growing structural imbalance in all economies, which is how nature is exploited to create wealth and how it is shared among the population. The root of this imbalance is that natural capital is underpriced, and hence overexploited, and the resulting proceeds are insufficiently invested in accumulating other forms of wealth, especially human capital.

The IWI 2018 report shows that the global growth rate of inclusive wealth between 1990 and 2014 was 44 percent, an average growth rate of 1.8 percent per year. However, this rate is almost half the annual average GDP growth rate over the same period, which stood at 3.4 percent. Overall, natural capital's share in IW has fallen since 1990, while the share of human capital and physical capital has steadily increased. The overall implications are that, given that stocks of natural resources are being depleted in order to produce and accumulate wealth, any measure of national wealth that excludes natural capital depreciation likely exaggerates the actual increase in an economy's wealth over time, especially in those countries where accumulation of other forms of wealth is failing to compensate for diminishing natural capital.

This suggests that income and wealth inequality may be worsening in rich countries, and in the global economy generally. If overall wealth accumulation net of natural capital depreciation as a share of national income is falling while private financial wealth is rising, then the gap between rich and poor will continue to widen in all economies. For the OECD high-income countries, the long-run convergence of adjusted net savings rates with natural capital depreciation rates should raise concerns about overall wealth creation and growing inequality in these economies. For these countries, policies to encourage more economy-wide investment in other forms of capital to raise adjusted net saving rates, and especially the long-run rate of net wealth accumulation relative to growth, are urgently needed.

Our results show that 135 of 140 countries show a growth in IW. However, this number drops significantly when adjustments for things like carbon damage and oil capital gains are factored in. With these adjustments, only 96 of the 140 countries (69 percent) experienced positive IWI growth rates. Fifteen countries are assessed as unsustainable by IW per capita adjusted: Bulgaria, the Democratic Republic of Congo, Gabon, Gambia, Greece, Croatia, Haiti, Jamaica, Laos, Latvia, Sudan, Serbia, Syria, Ukraine and Viet Nam. Of the 124 countries with positive growth in adjusted IW, 95 countries also experienced a positive trend for the IW per capita. The 29 remaining countries had eroded wealth on a per capita basis.

Turning to the breakdown of growth by asset, we find that produced capital increased at an annual average rate of 3.8 percent, while health- and education-induced human capital growth remained at 2.1 percent, and natural capital decreased by 0.7 percent. In short, investment in produced capital has increased. However, health, education and natural capital, in which we see enormous potential for future well-being, either grew modestly or even decreased.

On a global scale, the configuration of capital has been as follows: produced (21 percent), education (26 percent), health (33 percent) and natural (20 percent). It is remarkable that of the trio of capitals, the value decreased only for natural capital. A natural way to interpret this outcome is that produced capital and, to a lesser extent, human capital have been enhanced at the cost of natural capital (unsustainable agriculture and industrialization, for example, leading to better ports, roads and infrastructure, at least in the short term). Under a weak substitutability criteria, the world has been experiencing sustainable growth. Our guess, however, is that the world would likely not satisfy sustainability under a strong substitutability criteria (see Box 2).

Of 121 countries, 47 averaged negative rates of per capita IW between 1990 and 2010, placing these countries on an unsustainable path. Almost all of them are either developing or middle-income countries. Almost half of the countries are in sub-Saharan Africa. For almost all 47 countries, natural resources serve as an important source of GDP, and one can safely assume that the fall in per capita IW is linked directly to natural resource extraction (e.g. minerals and oil) or harvesting (e.g. forests). Also, population growth is high in most of these countries, which further serves to hamper sustainable growth.

Of the 74 countries that witnessed a rise in per capita IW, we find that even if a country's natural capital stocks are falling, these countries have offset the fall by reinvesting in physical and human capital, placing them on a sustainable path. China, for example, begins with a natural capital share of 42 percent in 1990, which falls to 21 percent by 2010, showing a major loss of natural capital. However, the rates of growth in China's human and physical capital stocks (relative to its decline in natural capital stocks) have offset these losses. This reinvestment in human and physical capital is one of the reasons China's IWI has outperformed all other countries. Interestingly, the report finds that it is possible to achieve per capita growth in both GDP and natural capital. Ten countries are doing well on this front, including Belgium, Armenia, Croatia, Russia and Slovenia. It is also interesting that many of the countries experiencing an increase in wealth and natural capital are former Soviet states. This may be because these countries are undergoing profound socio-economic changes. Populations in Central Asia and Eastern Europe are declining; the discovery of fossil fuels and the improved management of forest resources since Soviet times partly explain these changes. In addition, many of these countries are experiencing relatively fast growth in produced capital and human capital. Within Eastern Europe, five countries have suffered a decline in natural capital while also experiencing growth in GDP. One explanation is that forest resources in these countries – Bulgaria, the Czech Republic, Hungary, the Republic of Moldova and Poland – have declined along with the growth in the fossil fuel sector.

Overall, only 31 of the 140 countries experienced positive growth of natural capital. Forest resources, for example, increased in 55 of the 140 countries between 1990 and 2014. The growth of forest resources is positive for European Union (EU) countries, Japan and Russia. On the other hand, the decline of forests in Africa, Latin America, China, India, Brazil, the United States and Canada is creating pressure on their ability to develop sustainably. Broken down per capita, only 31 countries experience positive growth in forest resources. Singapore witnessed the largest per capita growth in forest resources, at 5 percent. At the bottom end, the United Kingdom suffered a 6 percent reduction in forest resources over the same period.

Our findings show that most countries (123 of 140) experienced a declining trend of natural capital while achieving an increasing trend of wealth between 1990 and 2014. Seven countries (Albania, Armenia, Estonia, Guyana, Lithuania, Russia and Slovenia) experienced the most desirable situation in terms of growth in wealth and natural capital. These countries are on a strong sustainable development path. Only five countries (Belarus, Ukraine, Serbia, Hungary and Latvia) experienced a decline in wealth while registering an increase in natural capital.

Overall, we find that only 15 countries have increased their fishery wealth. A worrying 92 countries reported a decline in fishery wealth (33 countries reported no fishery wealth). Only Canada and some European countries have seen their fish stock increase in the past 25 years. Worryingly, only 15 countries have witnessed a positive growth rate in cropland per capita. It is also worth mentioning that some countries that are presumably rich in natural capital are actually running out of it: less than 1 percent of wealth in Bahrain and the United Kingdom in 2014 came in the form of natural capital. This may be because both countries have depleted their oil capital over the past several decades.

It is worth noting that we have included non-renewable resources as a positive natural capital asset, rather than a negative one. Clearly, if you factor in the social costs of carbon emissions – air pollution, for example – fossil fuels may be considered stranded assets or liabilities. However, the shadow price of natural capital represents the marginal contribution it makes to social well-being. The mechanism we assume is the business-as-usual scenario currently pursued by the imperfect economies in which we live. In these imperfect economies, people still believe that the benefit of fossil fuel (its use in growing the productive base) outweighs its drawbacks (the social costs of carbon) in the market.

Interestingly, if we removed fossil fuels from natural capital accounting, then we would see an improvement in the growth of natural capital globally. This is because, at the global level, the decline in non-renewable resources is actually larger than the decline in renewable resources.

BOX 2 – The big debate

Not surprisingly, carbon damage as a share of IW produces a stronger effect on small countries because their IW tends not to be sufficiently large enough to absorb such shocks. The largest order of carbon damage with regard to IW is seen in Luxembourg (-0.6 percent), followed by Malta (-0.4 percent), the Maldives (-0.4 percent), Bahrain (-0.4 percent) and Barbados (-0.3 percent). Island nations are obviously the most vulnerable to climate change and are on the verge of non-existence. Some of these lie beyond the scope of the 140 countries studied for the IWI.

In absolute terms, carbon damage is relatively large in high-income countries such as Germany, France, the United Kingdom and the United States, among others. In per capita terms, carbon damage exceeds $500 in Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, the United Kingdom, Ireland, Iceland, Italy, Luxembourg, the Netherlands, Norway and Sweden. It is also interesting to note that some countries become better off due to climate change: Australia, Canada, Israel, New Zealand, Russia and Singapore actually gained as a result of global carbon emissions.

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ABBREVIATIONS

CO_2	Carbon dioxide
EDF	Expected damage function
EGP	Egyptian pound
EIA	Energy Information Administration
EPA	United States Environmental Protection Agency
ESVD	Ecosystem Service Valuation Database
ESW	Ecosystem service wealth
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographical information systems
GTAP	Global Trade Analysis Project
GTAP	Global Timber and Forestry Data Project
HC	Human capital
HDI	Human Development Index
IEA	International Energy Agency
IW	Inclusive wealth
IWI	Inclusive Wealth Index
IWIadj	Adjusted Inclusive Wealth Index
IWR	Inclusive Wealth Report
MEA	Millennium Ecosystem Assessment
MW	Megawatt
NAFSA	Association of International Educators
NC	Natural capital
NCC	Natural Capital Committee
NDP	Net domestic product
NIA	National income account
NPV	Net present value
NRC	National Research Council
NTFB	Value of non-timber forest benefits
NTFP	Non-timber forest products
OECD	Organization for Economic Cooperation and Development
ONS	Office of National Statistics
PC	Produced capital
PCE	Personal consumption expenditure
PIM	Perpetual inventory method
PISA	Programme for International Student Assessment
PLA	Physical amount of pastureland area available
PPI	Per capita income, adjusted by private consumption
PPP	Purchasing power parity
REDD	Reducing Emissions for Deforestation and Degradation
RICE	Regional Integrated Climate-Economy
RPA	Rental price per hectare
SEEA	System of Environmental and Economic Accounts
SEPA	State Environmental Protection Administration
SNA	System of National Accounts
STEM	Science, technology, engineering and mathematics
TEEB	The Economics of Ecosystems and Biodiversity
TFP	Total factor productivity
UN	United Nations
UN-DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNECE CES	United Nations Economic Commission for Europe – Conference of European Statisticians
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-OWG	United Nations – Open Working Group
USSR	Union of Soviet Socialist Republics
VARG	The Value at Risk or Gain
VSL	Value of a statistical life
VSLY	Value of a statistical life year
WAVES	Wealth Accounting for Valuation of Ecosystem Services
WCL	Wealth in cropland
WDR	World Development Report
WHA	Wealth per hectare
WPL	Wealth in pastureland
WTO	World Trade Organization
WTP	Willingness to pay

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PART I: WHAT DOES THE DATA SAY?

CHAPTER 1: ACCOUNTING FOR THE INCLUSIVE WEALTH OF NATIONS: KEY FINDINGS OF THE IWR 2018

Shunsuke Managi

1.1. Introduction

There has been an elusive quest to determine how we can go beyond gross domestic product (GDP) to attain a true indicator of social well-being. The well-known report by Stiglitz *et al.* (2009) suggested that GDP faces three challenges: conventional problems, quality of life aspects and sustainability issues. While some have argued that GDP is problematic on many fronts, it does have its uses. It is intended to measure the value added in an economy within a period and thus to act as a proxy for the magnitude of economic activity. Here, it is important to remember that one of the fathers of GDP, Simon Kuznets, originally intended to design an index that represents welfare rather than the value added in an economy (Coyle 2015).

In terms of the long-term well-being of an economy, the vast literature on green national accounting shows that net domestic product (NDP) – an adjusted index of GDP – provides a fairly good representation of human well-being (Weitzman 1976; Asheim and Weitzman 2001). NDP is computed from GDP and accounts for changes in capital assets, such as capital depreciation and natural capital depletion.

However, this adjustment is not sufficient for representing intergenerational well-being or the sustainability of an economy. In particular, NDP still includes the portion of the domestic product that is to be allocated to current consumption, which could potentially be excessive. Excluding the value of current consumption from NDP leaves us with investment in produced, human and natural capital – in other words, an Inclusive Wealth Index (IWI) (Dasgupta *et al.* 2015).

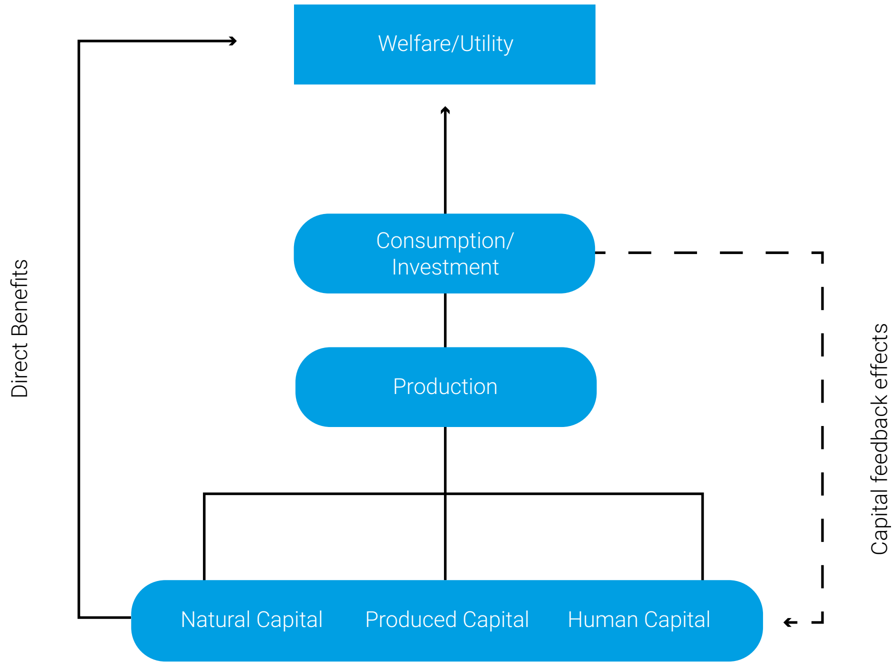
What makes our index and that of the World Bank's genuine savings indicator distinct from GDP is obvious.[10] It is calculated from stocks, rather than flows; it measures determinants, rather than constituents of well-being (Dasgupta 2001). For the latter, it is more a matter of subjective well-being – i.e. happiness and life satisfaction (Helliwell *et al.* 2017; Easterlin 2003; Kahneman *et al.* 2006; Layard 2005) – and objective outcomes of well-being, such as the Better Life Index (OECD 2014). The Human Development Index (UNDP 1990-2016) is a composite index of education and health, in addition to GDP. It is a commendable innovation in that it has shifted the focus towards human capital aspects of well-being.

Another strand of the literature arguing to abandon GDP for a true welfare or well-being indicator is also flourishing. Fleurbaey and Gaulier (2009) ranked OECD countries by accounting for international flows of income, labour, risk of unemployment, healthy life expectancy, household demography and inequalities, along with income. In a similar vein, Jones and Klenow (2016) constructed a welfare index that includes consumption, leisure, mortality and inequality fronts. They found that these data are highly correlated with GDP per capita, with some deviations. While the aspects that they address are, without doubt, important, our focus in more on the long-term sustainability of determinants of human well-being – which leads us to the construction of a capital-based indicator.

Of course, no single index can measure every aspect of human well-being, and the IWI is no exception in this regard. Note, in particular, that our IWI says little about the extent to which current well-being is achieved in practice, partly because the score of current capital stocks is not fully consumed by contemporaries and because the IWI is, by construction, a determinant- or opportunity-based indicator. It is not meant to be something that can explain the outcomes and constituents of well-being. In principle, the IWI should include a sufficiently broad, ideally exhaustive, but not redundant, score of capital assets that is relevant to current and future human well-being. While classical economics focused on (produced) capital, labour and land, neoclassical economics has treated capital and labour as part of the production function. Subsequently, the economics of exhaustible resources included capital and non-renewable resources (Dasgupta and Heal 1974; Solow 1974). In mainstream economics, human capital – the capitalized concept of labour – has also played an important role in how economic growth can be decomposed (Mankiw *et al.* 1992). For the sustainable development of well-being, we must include natural capital – a broader notion than natural resource stock alone. Thus, we have come full circle, to our ultimate set of capital stocks (or productive bases): produced, human and natural capital.

10 See UNU-IHDP and UNEP (2012) for what makes the Inclusive Wealth Index distinct from the World Bank's genuine savings. To be more precise, genuine savings are constructed from flow variables, complemented by stock calculations.

Fig 1.1: A three-capital model of wealth creation



Productive Base

Fig 1.1 shows how these three capitals lead to the ultimate purpose (if any) of an economy: social well-being. The three capitals are inputs into the production system; thus, they are called the *productive base* of the economy. Produced capital is the easiest to imagine and includes roads, ports, cables, buildings, machines, equipment and other physical infrastructures. Human capital consists of population (size and composition); knowledge and skills acquired by education; and health (enhancing quality of life, extending life and boosting productivity). For natural capital, the current accounting addresses subsoil non-renewable resources, forests and agricultural land; ideally, it should also include ecosystems in general.

Along with these three familiar capital assets, our first edition (UNU-IHDP and UNEP 2012) noted that knowledge, population, institutions and even time could be conceived as capital assets. Dasgupta (2015) called them *enabling assets*, in the sense that they enable the three capital assets to function well and, ultimately, improve social well-being. Formally, they could increase the shadow prices of capital assets.

Unconventional forms of capital include the following: institutions (property rights, firms, government, households); knowledge (natural laws, algorithms, theorems, cultural narratives); social capital (the law, social norms, habitual practices); and time (exogenous changes experienced by society over time). While including these capital assets would be commendable, they remain elusive as they currently stand. Changing institutions reveal themselves in how capital assets are employed to improve social well-being; thus, they could be a determinant of the shadow prices of capital assets. Time as an asset represents the value of waiting, including Solowian technological progress, resource price movements, population changes and other exogenous shocks to the economy in question. The IWR 2014 and our edition of this IWR 2018 address all of these terms in the adjustments to the IWI: namely, population change, total factor productivity (TFP), oil capital gains and carbon damage. As such, time as an asset is addressed in our framework. Once we establish relevant capital assets, then the output of this production process is either consumed or invested, as a result of national accounting identity. Current consumption directly improves current well-being, while investment increases the accumulation of the productive base, which in turn improves future well-being. This fundamental trade-off between consumption and investment has been a classic problem of optimal saving, dating back at least to Ramsey (1928). However, in the context of sustainable development, economies should strike a balance between consumption and investment, the latter including the degradation (negative investment) of natural capital.[11]

Some studies have suggested that capital stocks have a direct effect on utility, circumventing the consumption channel. For example, air pollution or climate change can cause disutility, for which increased consumption cannot be a substitute (Krautkraemer 1985; Xepapadeas 2005; d'Autume and Schubert 2008). It is not uncommon in climate change modelling to

11 Hartwick (1977) and Dixit *et al.* (1980) showed that investing exhaustible resource rents into produced capital, yields non-declining consumption, which is another way of defining sustainable development.

assume that climate directly affects utility (van der Ploeg and Withagen 2014). It is for these reasons that we present an alternative route from productive base to welfare in Fig 1.1.

It is important to note that the absolute value of wealth per se is of little interest to us. Only the comparison of wealth across time or space (nations) is significant in terms of welfare. Asheim (2010) showed that net national product (NNP) per capita is a useful index for the purpose of welfare comparisons across different countries. However, we must resist the temptation to compare the absolute value of inclusive wealth (IW) (per capita); our interest should lie in the change in IW per capita over time.

This year's report advances and expands on our first and second editions of the IWR. First, our rich sample continues to track the 140 countries sampled in IWR 2014, compared with only 20 countries in IWR 2012. The data set now represents a sizeable proportion of world GDP (US$56,835 billion) and of the global human population (6.885 billion). Second, the studied time period has also expanded by five years, to a quarter of a century (1990–2014), which provides us with a picture of the changes in capital assets over almost a generation. Third, our data set of natural capital now includes one of the most significant renewable but mobile resources: fisheries. This inclusion adds to our collection of renewable resource natural capital, which already included forest resources and agricultural land in IWR 2012 and 2014. IWR 2012 included some discussion of the fishery resources of four countries for the time period 1990–2006, based on the RAM Legacy Stock Assessment Database (Ricard *et al.* 2012) and shadow prices (SAUP 2011). Our edition boasts a much more refined calculation of fish stocks that includes many more countries (Sugiawan *et al,* 2017). Fourth, the methodologies for calculating components of human capital have been enriched and updated. In particular, we present alternative shadow prices of human capital (education and health), based on a non-parametric methodology called *frontier analysis*. Throughout the report, we refer to it as the *frontier approach*. This approach is contrasted with that adopted in IWR 2012 and 2014, following the literature on pricing human capital using a lifetime income approach.

The remainder of this introductory chapter is organized as follows. In Section 2, the basic idea and methodology behind the IWI are introduced. Further details regarding the architecture of the index are contained in the Methodological Annexes. Section 3 presents the central results and findings resulting from inclusive wealth calculations, based on non-parametric computation of shadow prices for human capital (education and health). Section 4 shows our parallel results, which employ agreed methods for human capital (education) calculation, consistent with the traditional interpretation of the rate of return on education and the IWR 2014 results. Section 5 summarizes our results, explains some limitations of the current methodology and addresses some concerns and potential criticisms of the IWI in general.

1.2. Methods

In this section, we outline our underlying framework, which is based on the literature on green accounting, particularly pertaining to imperfect economies (Arrow *et al.* 2012). We note that the economy's objective is sustainable development, in the sense that intertemporal well-being, V, at time, t, which is a function of consumption, C, is not declining:

$$V(t) = \int_t^\infty U(C_\tau)e^{-\delta(\tau-t)}d\tau$$

This expression is merely a discounted sum of instantaneous welfare depicted in Fig 1.1. A central assumption is that this intertemporal well-being is a function of capital assets in the economy. Thus, denoting produced, human and natural capital as *K*, *H* and *N* we have the following equivalence between IW and well-being:

$$W(K,H,N,t) = V(t) = \int_t^\infty U(C_\tau)e^{-\delta(\tau-t)}d\tau,$$

where *W* is inclusive wealth. Then, sustainable development is equivalent to non-declining inclusive wealth. Formally, we would like to ensure the sign of the temporal change of inclusive wealth:

$$\frac{dW(K,H,N,t)}{dt} = p_K\frac{dK}{dt} + p_H\frac{dH}{dt} + p_N\frac{dN}{dt} + \frac{\partial V}{\partial t},$$

where P_K, P_H and P_N are the marginal shadow prices of produced, human and natural capital, respectively. Note that aside from the three-capital channel, we have a direct channel through which only the passing of time directly affects well-being. The shadow prices are essentially marginal contributions to the intertemporal well-being of an additional unit of capital in question. They are formally defined by:

$$p_K \equiv \frac{\partial V}{\partial K}, p_H \equiv \frac{\partial V}{\partial H}, p_N \equiv \frac{\partial V}{\partial N},$$

given a forecast of how produced, human and natural capitals, as well as other flow variables, evolve in the future in the economy in question. In practice, shadow prices act as a weighting factor attached to each form of capital, resulting in the measure of wealth, or IWI:

$$IWI = p_K K + p_H H + p_N N.$$

In practice, *W* and IWI can be used interchangeably.[12] For sustainability analysis, what we need is the change in capital assets or what we can call inclusive investment,

$$\frac{dW(K,H,N,t)}{dt} = p_K\frac{dK}{dt} + p_H\frac{dH}{dt} + p_N\frac{dN}{dt} + \frac{\partial V}{\partial t}.$$

In our accounting – barring oil capital gains, which we elaborate on later – we omit the change in the shadow prices for both theoretical and practical reasons. Shadow prices are defined as the marginal changes when there is a hypothetical, small perturbation in capital assets. Thus, for tracking relatively short-term sustainability, it is sufficient to use fixed, average shadow prices within the studied period. It also makes practical sense in our report since fixing shadow prices will enable us to focus on the quantity changes in IW.

12 In theory, *W* is different from IWI, which is calculated based on constant shadow prices. When reckoning the real *W* , it is obvious that, for example, the last drop of oil should have a different marginal value than the regular drop when it is not scarce. We compute the IWI on the premise that the studied period is relatively short.

However, if there is a significant perturbation, such as the implementation of a large project, a natural disaster or a financial crisis, we must account for the change in shadow prices, even within a short time period. We should consider the price change – capital gains on any capital asset – seriously because we will accumulate our editions of the IWR in the years ahead.

One exception to this rule (constant shadow prices assumed over the studied period) is oil capital gains. Oil prices, or commodity prices, are notorious for fluctuations within relatively short time periods. Even if the quantity of oil within a nation does not change, a spike in the oil price means that the country can cash in its oil wealth and increase consumption and investment in IW. This is particularly pertinent to oil-rich nations in the Middle East, which are seeking to develop alternative economic bases and reduce their reliance on oil-related industries. Nurturing an industry from scratch takes a long time. Conversely, net oil-importing countries tend to experience a deterioration in social well-being as a result of rising oil prices. We account for this loss of opportunity by allocating global oil capital gains to oil-importing countries according to the current share of oil imports. Formally, if we allow the shadow price of natural capital *Pn* to change, we have

$$\frac{\partial V}{\partial t} = p_N N \frac{dp_N/dt}{p_N},$$

which represents our capital gain adjustment.

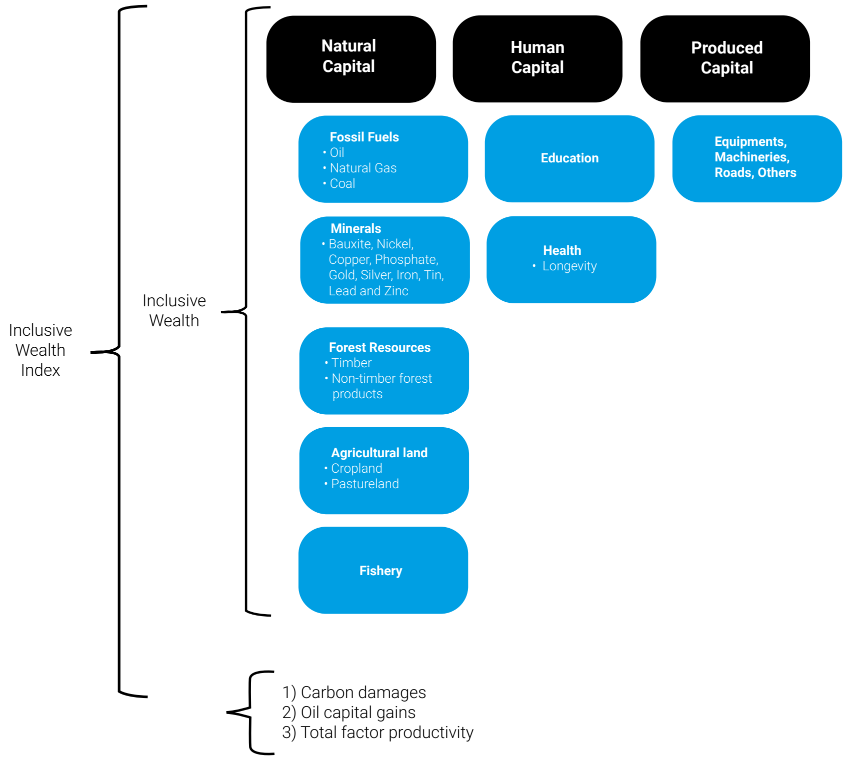
Aside from oil capital gains, there are other important adjustments that need to be taken into account. How capital assets are employed and utilized to yield social well-being can change over time – for example, through enhanced productivity, technological progress or improvement in trust and social capital. In practice, however, all of these factors can be captured by the change in TFP – insofar as social well-being improves (or deteriorates) more than the individual contributions of capital assets increase (or decrease). Arrow *et al.* (2012) showed that, in terms of accounting, all that we need to do is add the TFP growth rate to the inclusive wealth growth rate.

Finally, there is another aspect of the natural environment that needs to be considered in the coming centuries. Increasing carbon emissions are predicted to cause climate change, which will endanger many lives and lead to other forms of potentially devastating socio-economic damage. Current economic activity is reducing the carbon sink stock of our planet – which could conceivably count as another capital asset in IW. Alternatively, we can tap into the ongoing and increasing research on the social cost of carbon, which can be used to value the damage done to social well-being by additional emissions of carbon. In this report, we continue to adopt the latter approach. In particular, the total global emissions of carbon are evaluated using the social cost of carbon, which is then allocated to individual countries according to the share of the global damage done; this is then subtracted from the IW of nations.[13]

Fig 1.2 provides our schematic representation of how our three key capital assets, as well as adjustment factors, shape our final index of IW. Along with the familiar capital assets that we consider from previous reports (IWR 2012 and 2014), this report adds the fishery resource stock to the list of natural capital. In the ensuing sections, we report many aspects of the aggregated figures of the IWI, both before and after adjustments. To avoid confusion, in section 3, we focus on IW based on the frontier approach, which uses a non-parametric valuing of education- and health-induced human capital. Produced and natural capital are computed in a similar manner to the approach used in IWR 2012 and 2014. In section 4, we extend the conventional approach inherited from IWR 2012 and 2014. For human capital, we account only for the education-induced portion. For further notes on the different methodologies, readers are advised to examine the Methodological Annexes.

13 More specifically, the ratio of carbon damage to inclusive wealth can be deducted from the inclusive wealth growth rate to arrive at the adjusted inclusive wealth growth rate.

Fig 1.2: Schematic representation of the Inclusive Wealth Index and the Adjusted Inclusive Wealth Index.



1.3. The Inclusive Wealth of Nations

1.3.1. Measuring performances based on changes in wealth

In this subsection, we evaluate countries' sustainability conditions over the past 25 years by calculating human capital, including both education and health shadow prices, using the frontier approach. The sustainable growth of nations is evaluated by analysing changes in the IWI. We show the changes in IW, both in absolute and per capita terms, for 140 countries over the past few decades.

The results show that the growth of IW is positive for a considerable number of countries. However, for a significant number of countries, the growth of wealth is slower than the population growth, resulting in a negative per capita growth of wealth. In addition, some of the negative per capita growth of wealth occurred in countries that experienced absolute gains in wealth. The changes in countries' wealth are calculated using annual average growth rates over the past 25 years, with 1990 as the base-year.

Our estimation results show that 135 of the 140 countries assessed in the IWR 2018 experienced growth in inclusive wealth (before adjusted factors) (Fig 1.3 a). On a per capita basis, 89 of the 140 countries (64 percent) show positive rates of growth in the IWI (Fig 1.3 b).

Fig 1.3: Annual average growth rate in IWI and IWI per capita before adjustments for 140 countries, annual average for 1990-2014

Fig 1.3a: Annual average growth rate of Inclusive Wealth Index.

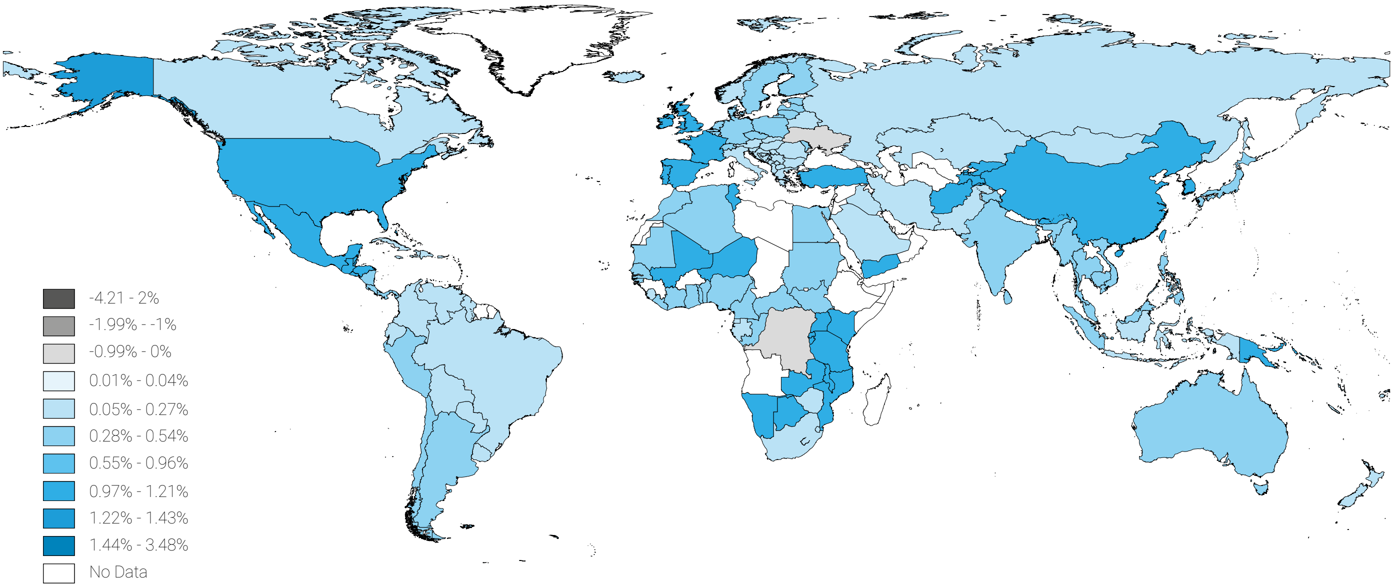
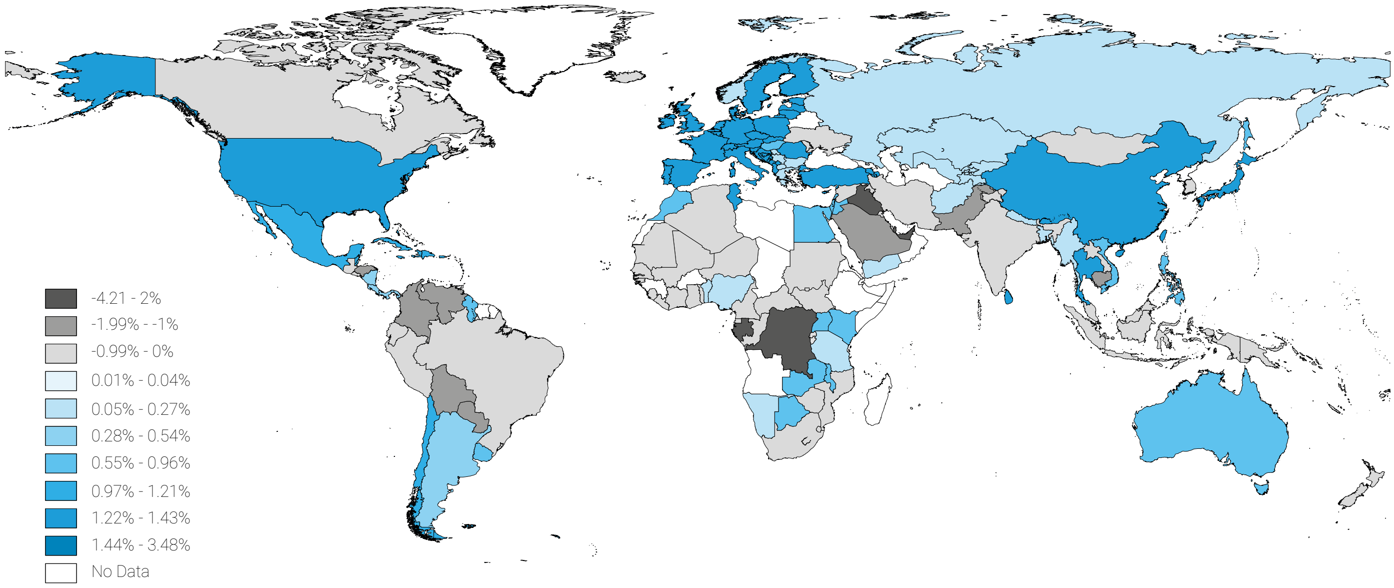


Fig 1.3b: Annual average growth rate of Inclusive Wealth Index per capita



When the IWI includes the adjustments for TFP, carbon damage and oil capital gains, 124 of the 140 countries showed a positive growth rate (Fig 1.4 a). In a per capita analysis, 96 of the 140 countries (69 percent) experienced positive IWI growth rates after adjustments (Fig 1.4 b).

Fig 1.4: Annual average growth rate in IWI and IWI per capita after adjustments for 140 countries assessed in the IWR 2018 from 1990 to 2014

Fig 1.4a: Growth in Inclusive Wealth Index (adjusted)

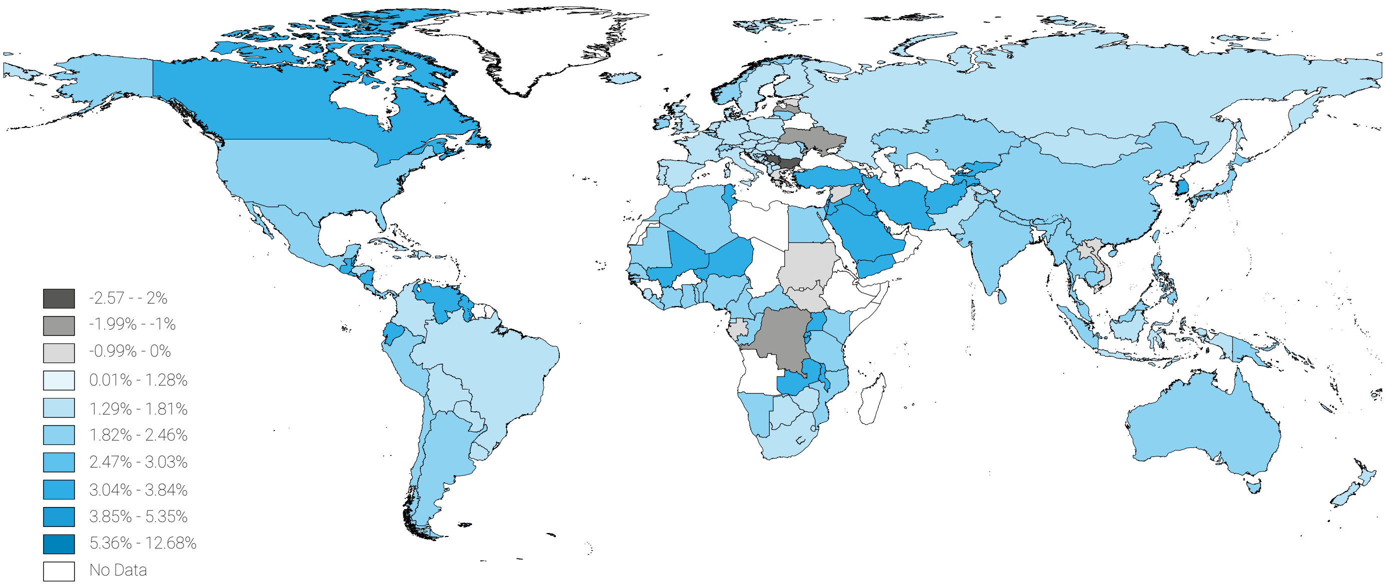
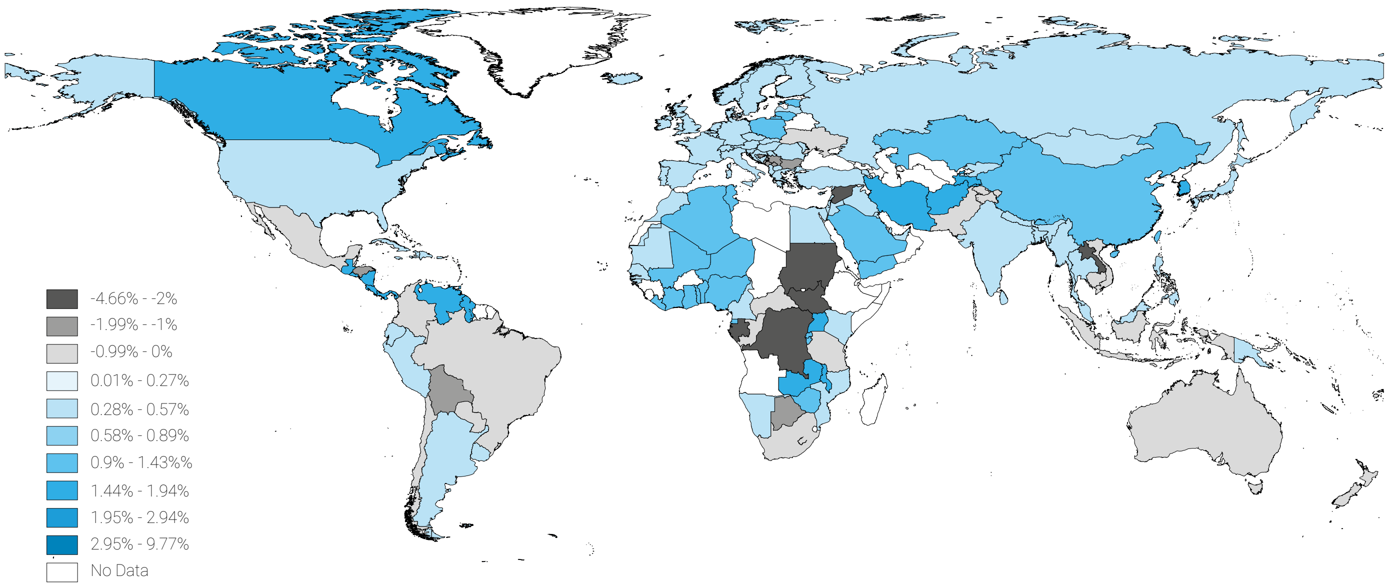


Fig 1.4b: Growth in Inclusive Wealth Index per capita (adjusted)



We investigate the inclusive wealth (IW) growth of countries and regions in Fig 1.5a. Three countries can be identified in Quadrant III: the Democratic Republic of Congo, Trinidad and Tobago, and Ukraine. All three experienced negative growth rates in both absolute and per capita terms. Two former Soviet-allied countries – Bulgaria and Moldova – *improved* their performance when population is considered in the index because both countries have had declining populations over time (Quadrant II of Fig 1.5a). The decrease in the population in these countries meant that more resources became available for each person compared to the base-year. Of the 135 countries with positive absolute growth in wealth (Quadrant I and IV), 87 also experienced per capita growth in wealth (Quadrant I). For the remaining 48 countries, the decrease in wealth per capita (Quadrant IV) could be interpreted as a result of underinvestment in light of their population growth.

We also identify the IW growth rates of countries after the three adjustments to the IWI in Fig 1.5b. Fifteen countries are assessed as unsustainable according to the adjusted IW per capita: Bulgaria, the Democratic Republic of Congo, Gabon, Gambia, Greece, Croatia, Haiti, Jamaica, Laos, Latvia, Sudan, Serbia, Syria, Ukraine and Viet Nam. Quadrant III of Fig 1.5 b shows countries with negative growth rates, both in absolute and per capita terms.

Estonia is the only country that improved when population is considered (Quadrant II). Of the 124 countries with positive absolute growth in adjusted IW (Quadrant I and IV), 95 also experienced growing wealth per capita (Quadrant I). The remaining 29 countries witnessed a decline in wealth per capita.

Fig 1.5: Annual average growth rate in IW and IW per capita

Fig 1.5a: Annual average growth rate in IW and IW per capita (unadjusted)

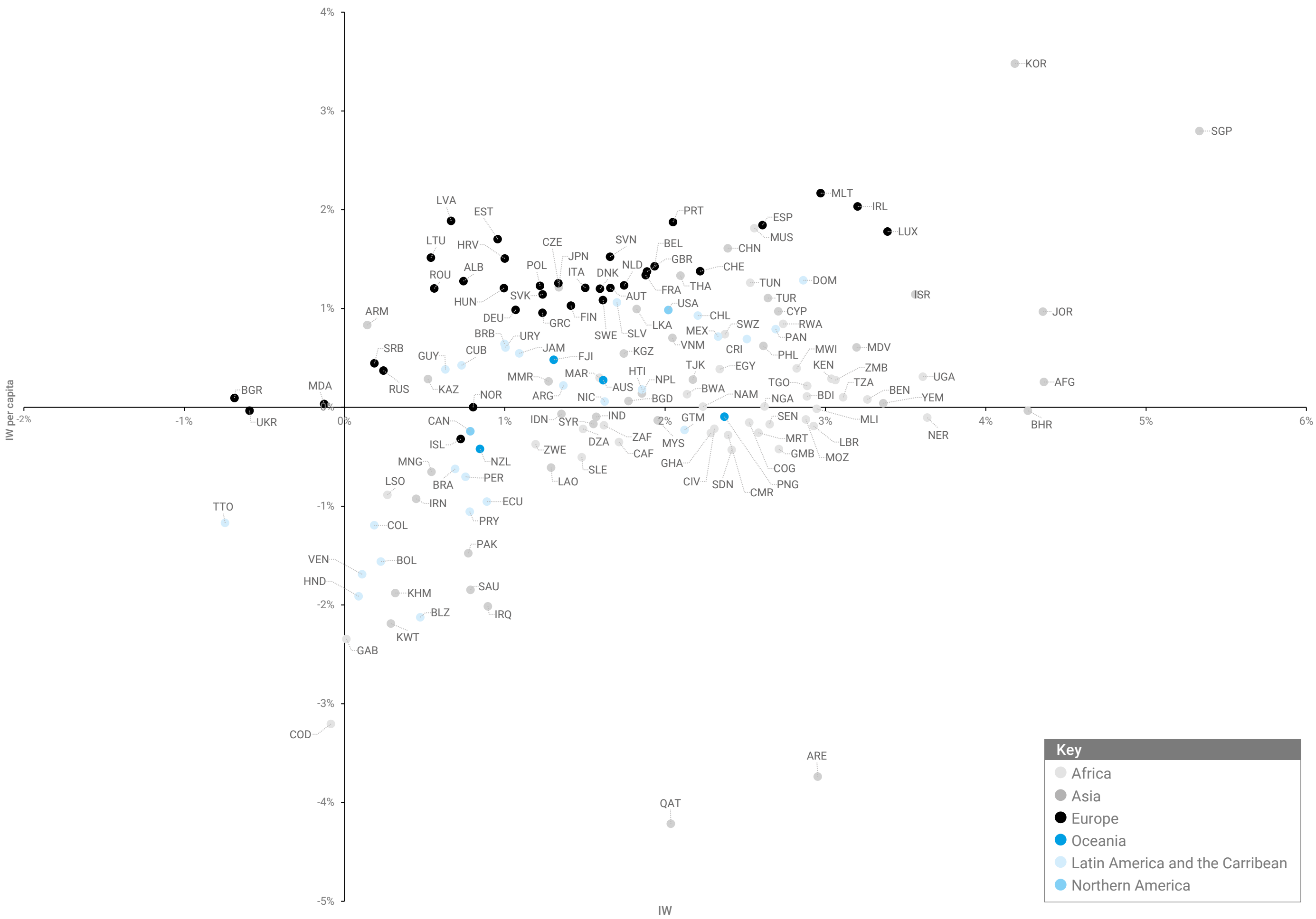
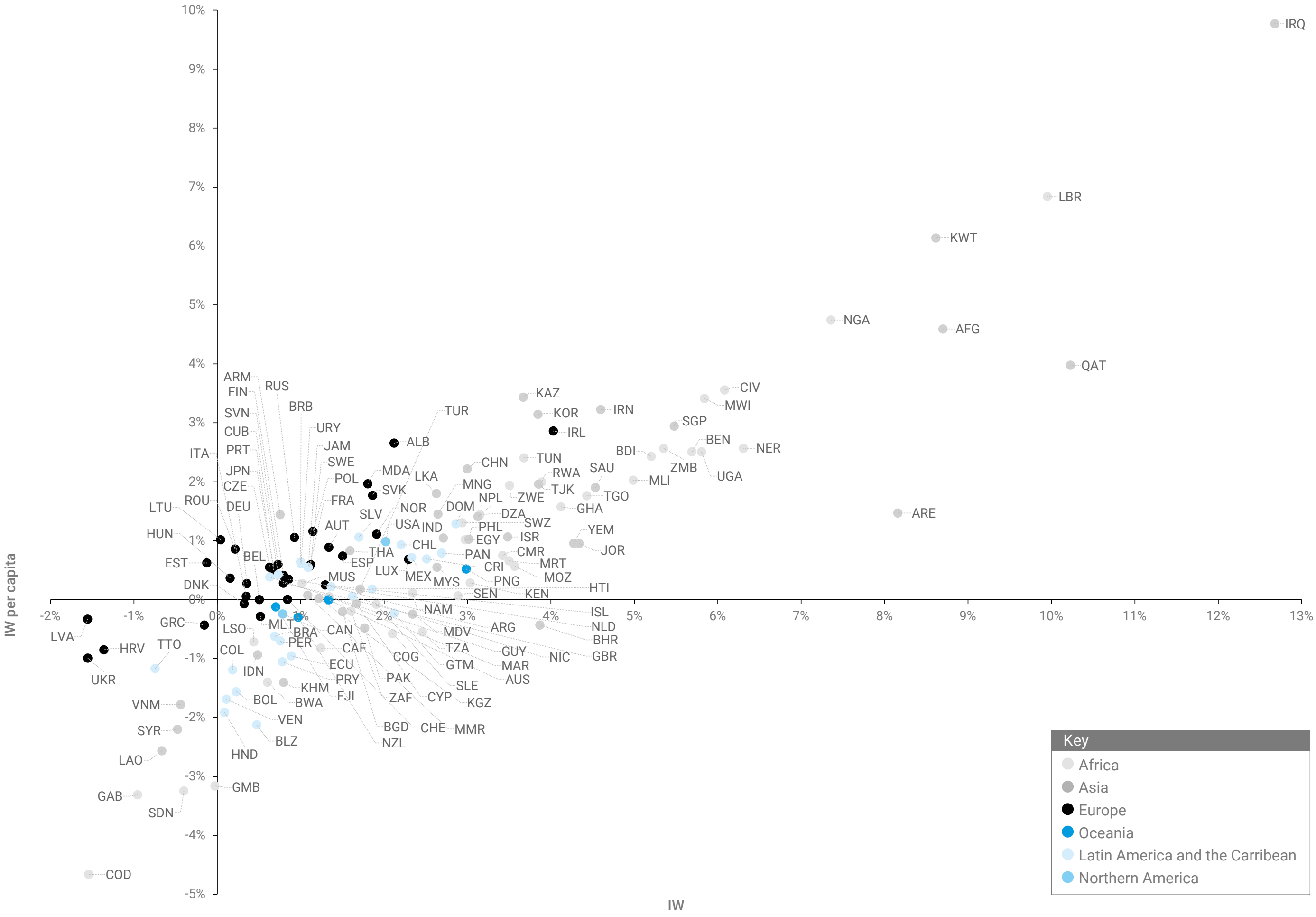


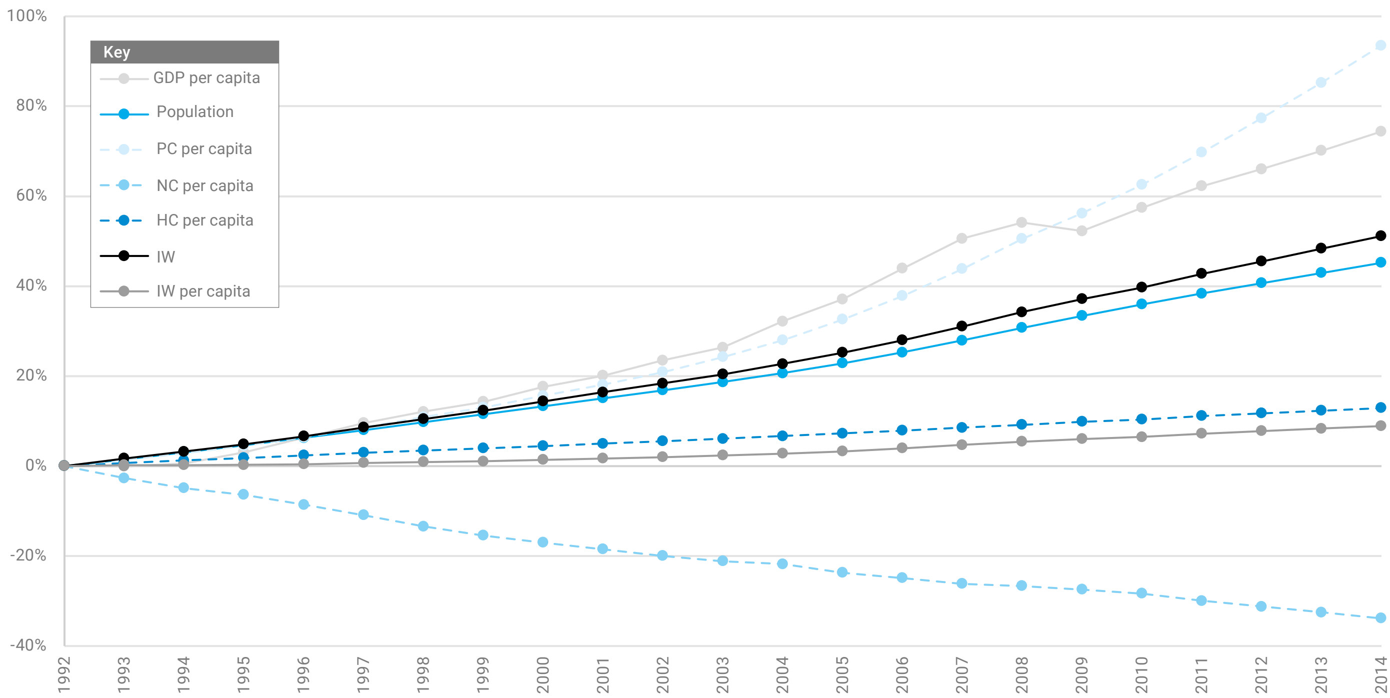
Fig 1.5b: Annual average growth rate in IW and IW per capita (adjusted)



1.3.2. Changes in the global composition of wealth

The global change in IW in absolute and per capita terms is critical for evaluating the performance of the global economy. We calculate the changes in IW and per capita IW in international dollars using purchasing power parity (PPP) exchange rates. These data are the aggregated wealth of all nations from 1992 to 2014. The results are illustrated in Fig 1.6. Changes in global wealth were largely positive from 1990 to 2014. The major positive changes were in produced capital, followed by human capital. In contrast, natural capital experienced a significant decline from 1992.

Fig 1.6: Changes in worldwide inclusive wealth per capita and other indicators for 1992–2014



1.3.3. Wealth composition

In this section, we discuss the composition of the wealth stock of nations. The composition of national assets are shown in Fig 1.7, which illustrates the relative importance of each type of capital. Human capital is the dominant form of capital for 93 of the 140 countries evaluated. Furthermore, for the majority (77) of these 93 countries, human capital made up 50 percent or more of the total capital assets.

Natural capital, on the other hand, is the most important source of wealth for 21 countries. Interestingly, 16 of the 21 natural capital-abundant nations are low-income or middle-income economies. Natural capital is an important source of wealth in South America, Central Africa and Western Asia.

For 19 countries, produced capital is the main source of capital. All of these are high-income countries and located in Europe, North America and East Asia.

Fig 1.7: Percentages of natural, produced and human capital in total wealth – annual average for 1990–2014

Fig 1.7a: Percentage of natural capital in total wealth

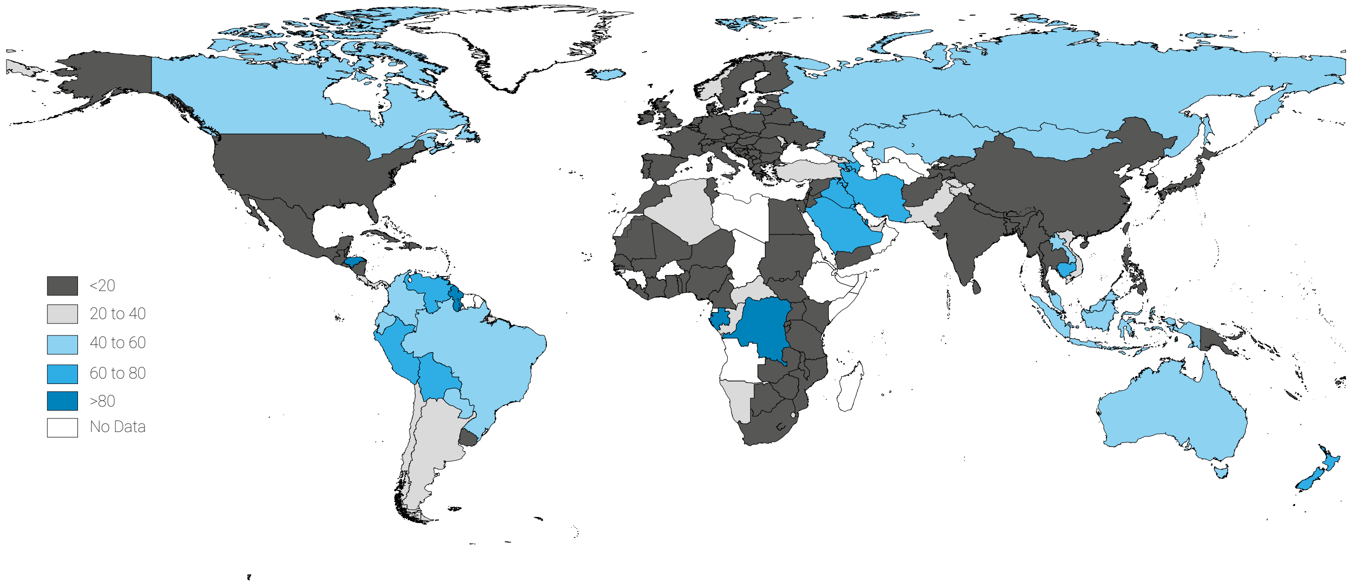


Fig 1.7b: Percentage of produced capital in total wealth

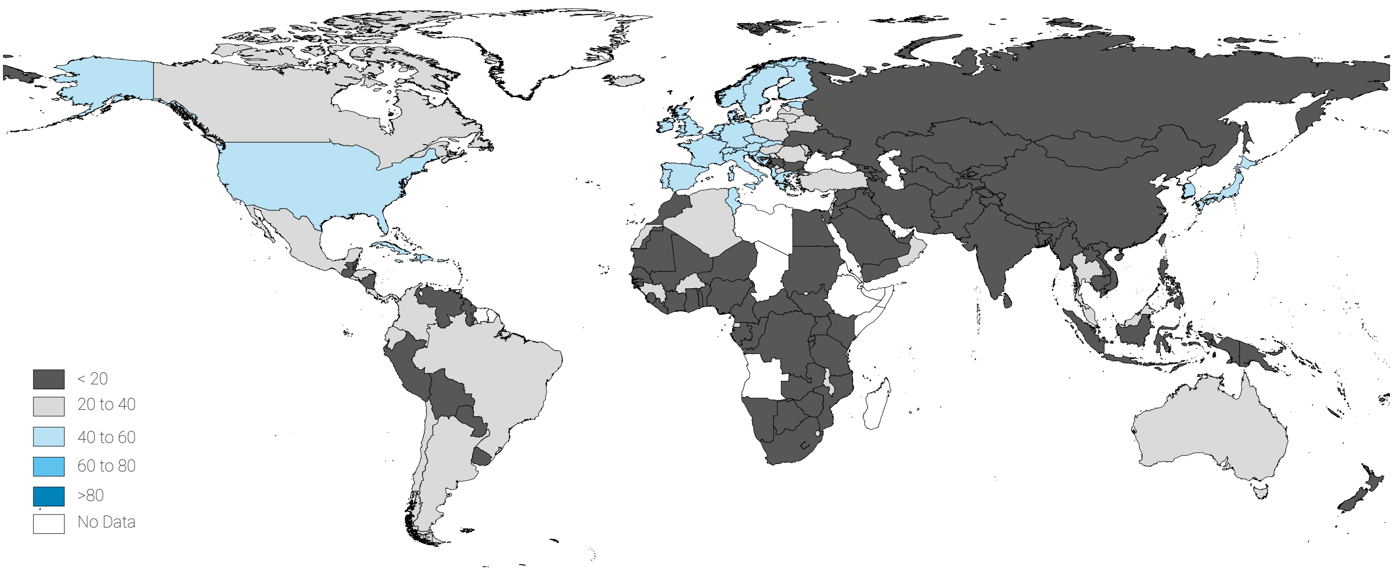
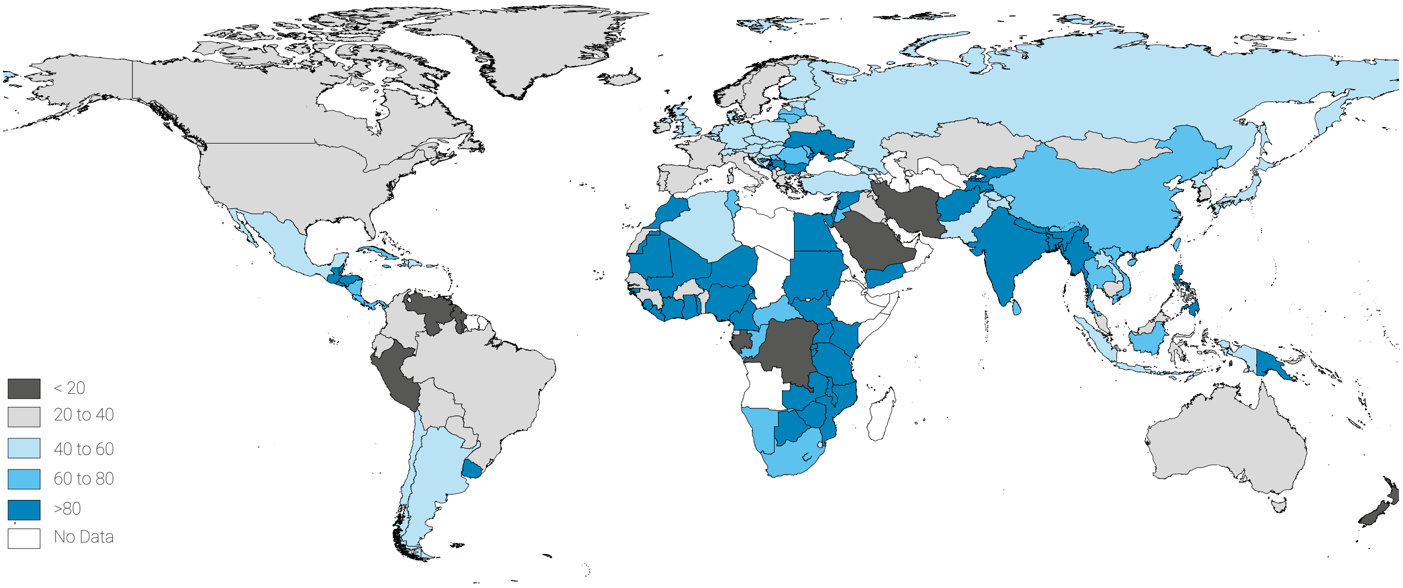


Fig 1.7c: Percentage of human capital in total wealth



We also explore the overall composition of capital on the global level. Fig 1.8a clearly demonstrates the importance of human capital, which represents 59 percent of total wealth.

Changes in the composition of the capitals over time show that, while the average contributions of human and produced capital to the total capital increased, the share of natural capital declined, as shown in the crossing line in Fig 1.8b.

Fig 1.8: Developments in the composition of wealth by capital from 1990 to 2014

Fig 1.8a: Average wealth compositions across countries (mean 1990–2014)

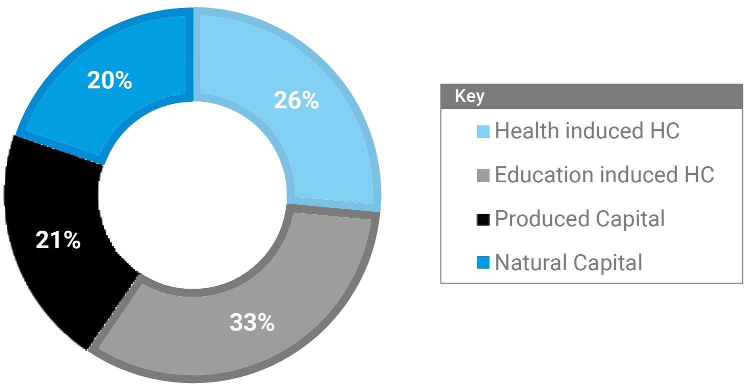
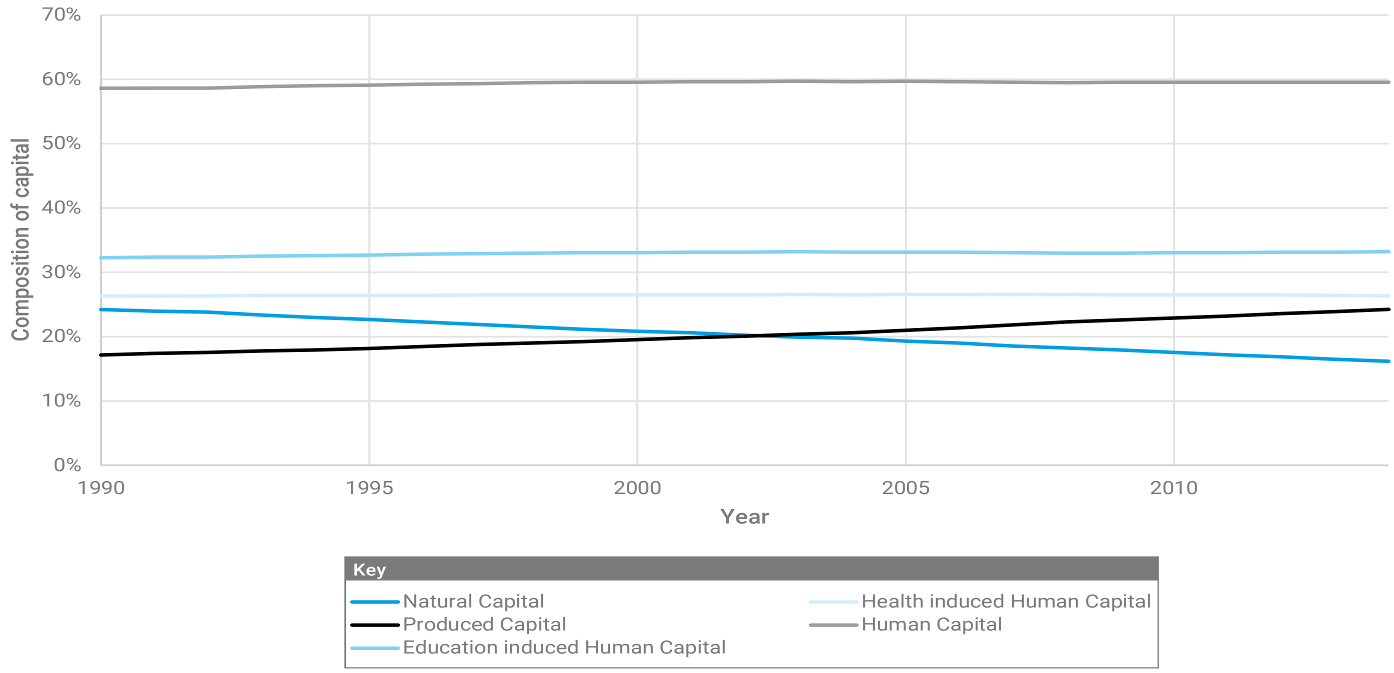


Fig 1.8b: Developments in the country average wealth composition



1.3.4. IWI adjusted

In this subsection, we investigate the performance of IW, after considering three factors.

1. Carbon damage: the damage from climate change, due to the increased impacts of carbon concentrations in the atmosphere
2. Total Factor Productivity (TFP): exogenous factors that impact economic growth
3. Oil capital gains: the changes in oil prices and the value of the productive base

The adjustment factors can affect the IW of nations either positively or negatively. If oil prices increase, oil-producing countries benefit, while oil-importing countries experience a loss. TFP can also impact either way; less efficient use of resources will cause negative productivity in the subsequent year (Managi, S. 2011, Kurniawan, R. and Managi, S. 2011).

We examine the contributions of specific adjustment factors. For carbon damage incurred by climate change, 134 of the 140 countries face negative economic impacts. Only six countries improved their productive base and avoided the adverse impacts of climate change. However, its impact is less than 0.5 percent of IW per capita adjusted, which can be said to be relatively low.

In terms of oil capital gains, 113 of the 140 countries suffered from increasing oil prices. The remaining 27 countries experienced positive impacts. Six oil-abundant countries, mainly in the Middle East, gained at least 4 percent from increasing oil prices: Venezuela, Iraq, Qatar, Kuwait, Saudi Arabia and the United Arab Emirates.

Finally, TFP growth rates were positive for 87 countries and negative for 53 countries. The average growth of TFP ranged from +7 percent to -3 percent and had significant impacts on several countries. Malaysia, for instance, moved to a positive per capita growth following IW adjustment, primarily due to positive TFP growth. In contrast, Serbia moved to negative IW per capita adjusted, mainly due to negative changes in TFP.

Fig 1.9: Annual average growth of the adjustment factors in 1990–2014

Fig 1.9a : Average growth rate of oil capital gains in 1990–2014

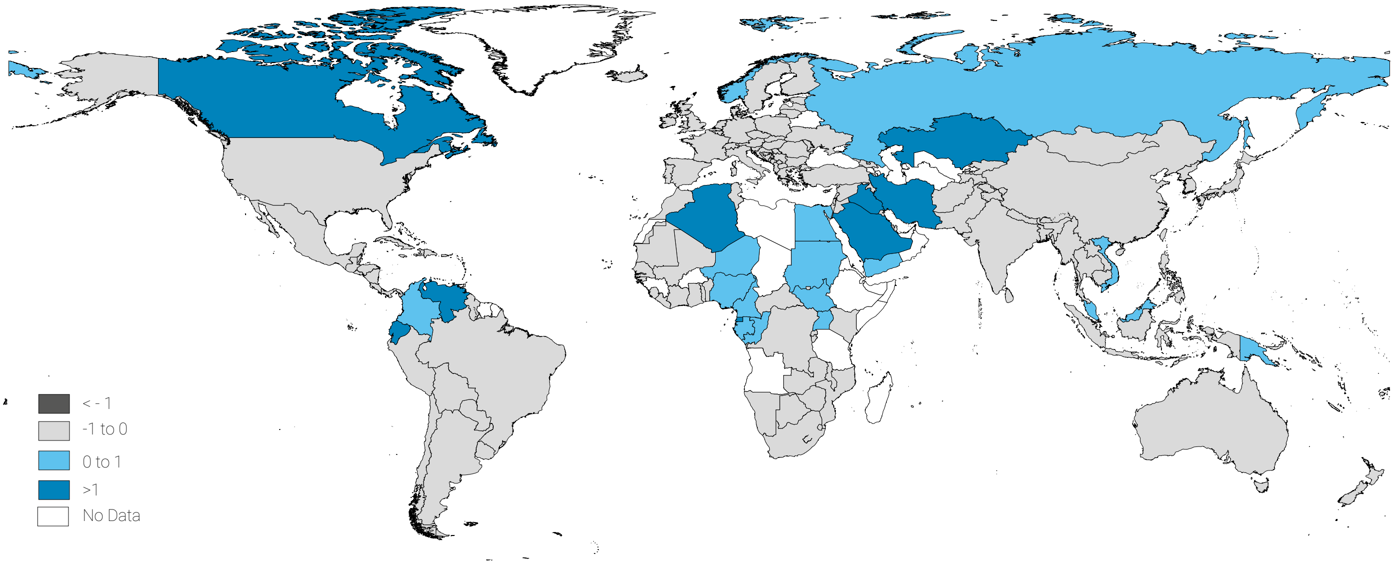


Fig 1.9b: Average growth rate of total factor productivity in 1990–2014

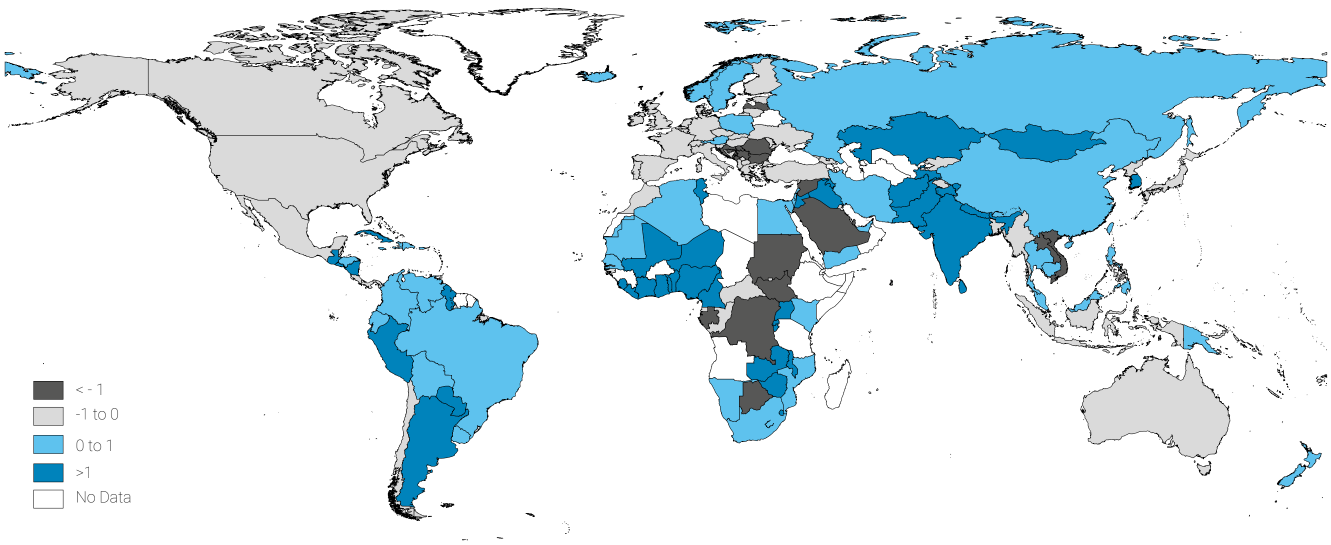
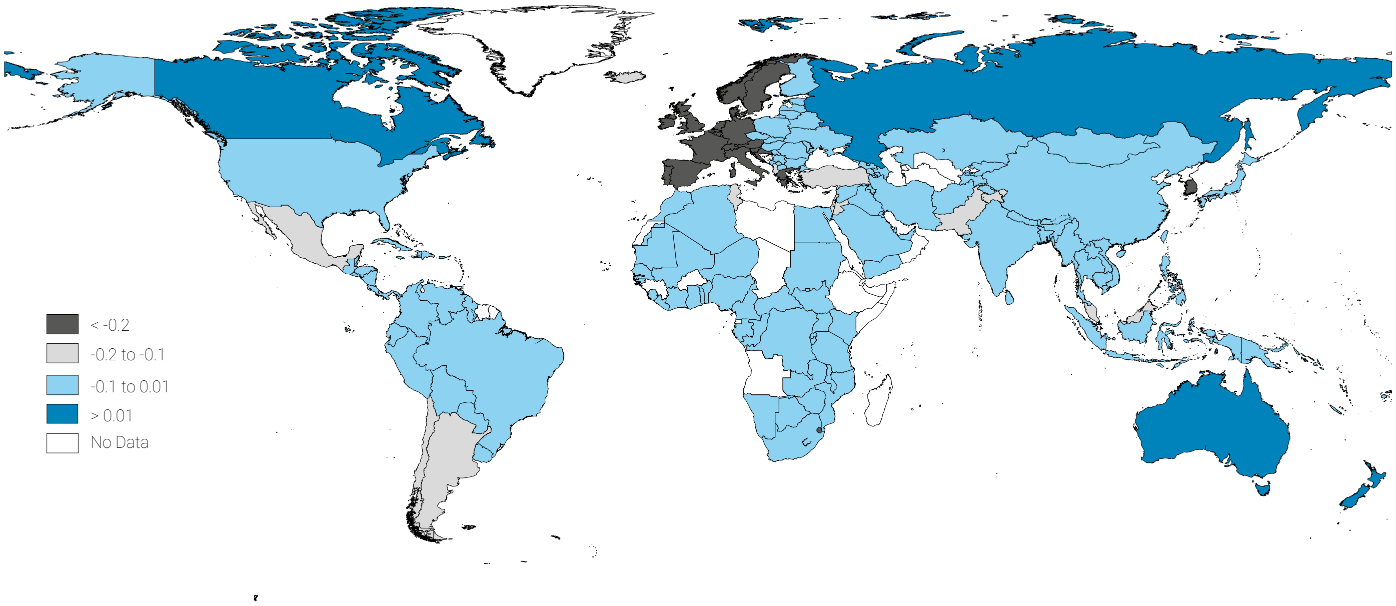


Fig 1.9c: Average growth rate of carbon damage in 1990–2014



1.3.5. Measuring economic performance: comparison of inclusive wealth, GDP, HDI and happiness

There are a number of indicators for evaluating nations' economic and social performance. Three of the commonly used indicators are GDP, the Human Development Index (HDI) and happiness. GDP measures the market value of final goods and services in an economy over a period. HDI measures the well-being of nations by considering education, life expectancy and income. Happiness, although measured in many ways, basically evaluates people's subjective satisfaction by considering factors such as freedom, social support, life expectancy and corruption, among others. Fig 1.10 provides an overview of countries' annual average growth rates of GDP per capita, HDI and IW per capita, over the period 1990 to 2014.

We find positive growth of IW per capita for 89 countries and negative growth for 51 countries. We identify positive IW growth for 97 countries, while for HDI, 139 of 140 countries show positive growth. Thus, the IW per capita paints a more a pessimistic picture of progress than the HDI. In terms of GDP, 128 of 140 countries indicate positive growth rates over the past 25 years. This is clearly different from the picture shown by the IWI or other indicators of sustainability.

Fig 1.10: Average annual growth rates of IW per capita, GDP per capita and HDI, 1990–2014

Fig 1.10a: IW per capita

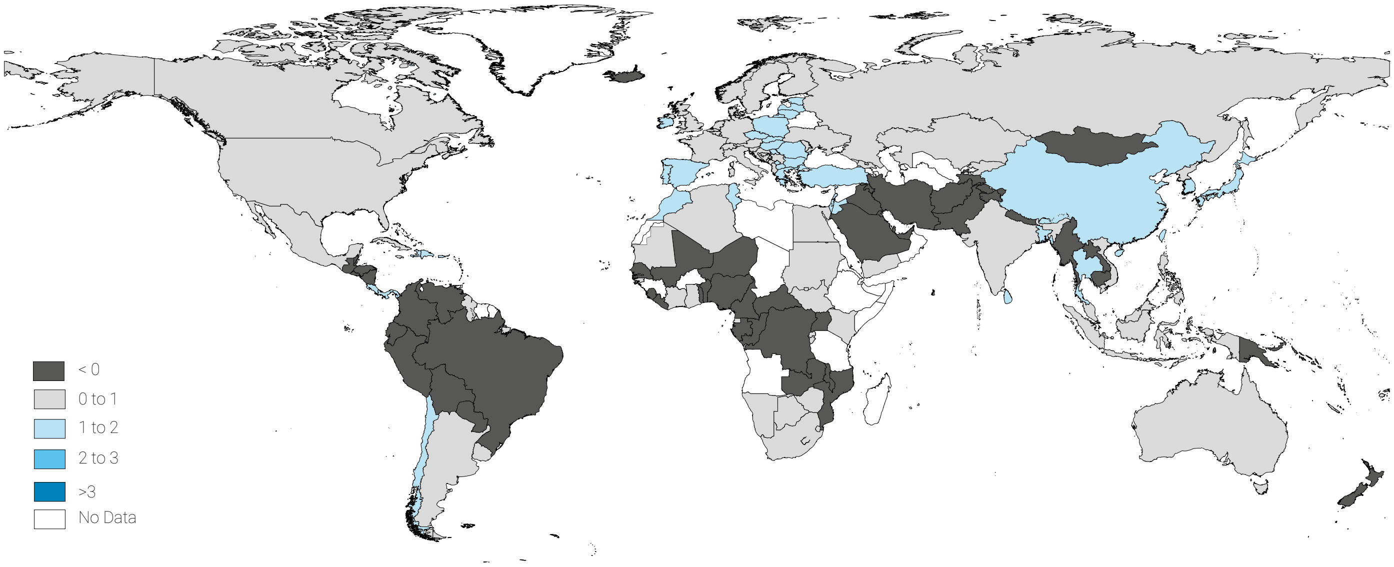


Fig 1.10b: GDP per capita

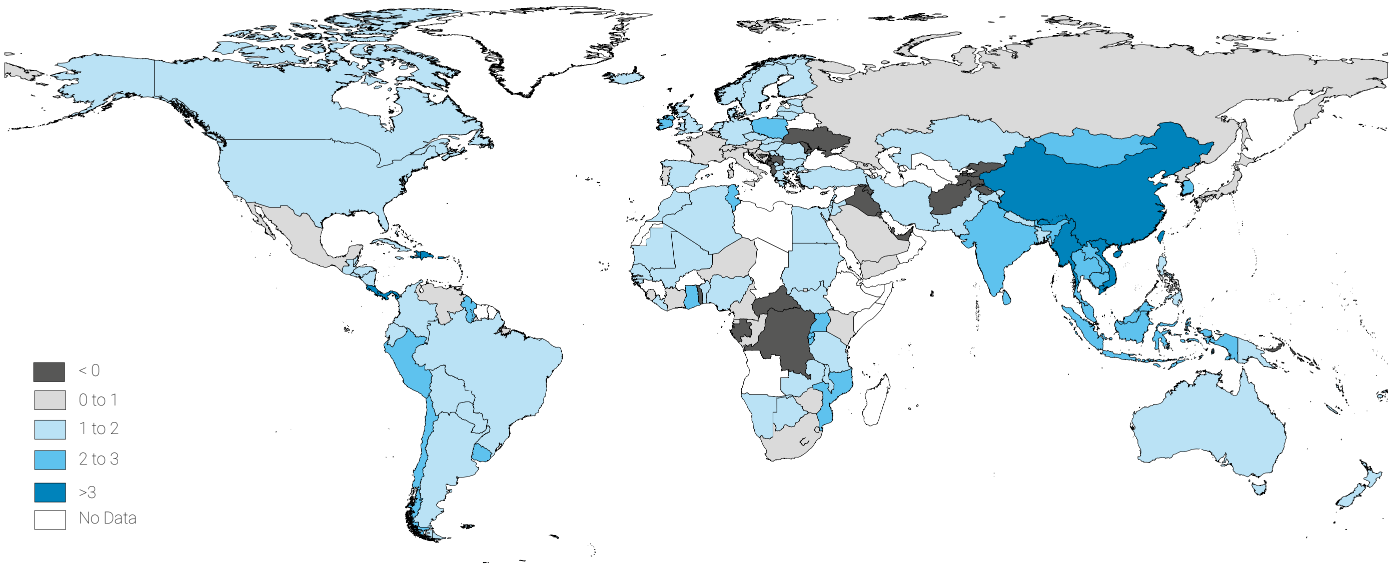
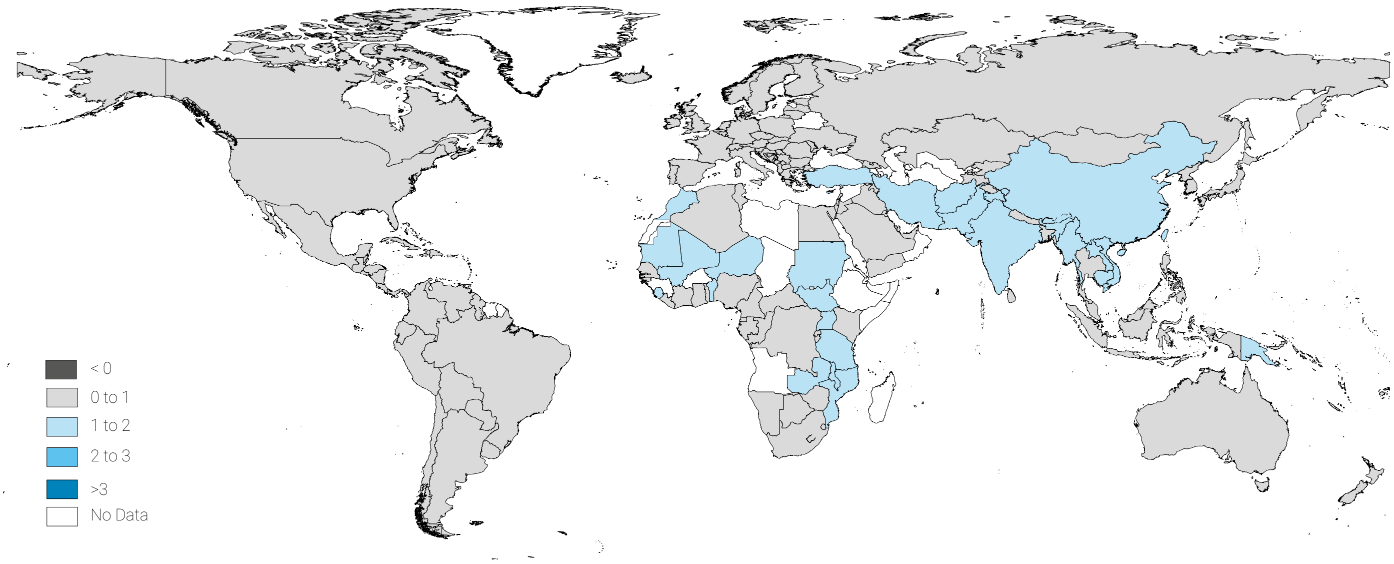


Fig 1.10c: HDI



1.4. The Inclusive Wealth of Nations: Education as Human Capital

1.4.1. Measuring performance based on changes in wealth

This section illustrates the inclusive wealth of nations following the approach used in IWR 2012 and 2014. This is based on the idea of education as human capital and shadow prices – which we henceforth call the *education approach*. The main difference from previous editions lies in the calculation of human capital: the rate of educational return is used as its shadow price. In line with IWR 2014, health capital is beyond the scope of this method, primarily because it would swamp other capital assets. Additionally, conventional TFP values are used for IW adjusted. Our results are based on both the education approach and the frontier approach in section 3. Because the methodology is in line with the long history of the economics of education, and is consistent with previous editions of the IWR, the reader can compare our results over time. Needless to say, the underlying question from the previous section remains the same: Have nations been maintaining their wealth for the past quarter century? We also use the same data set: 140 countries from 1990 to 2014.

As the methodology in this subsection is inherited from previous reports (IWR 2012 and IWR 2014), it is not surprising that the basic trends in inclusive wealth also continue to hold. In particular, the aggregated accumulation of wealth has been slower than population growth, leading to negative growth rates in IW per capita.

In terms of the total wealth of nations, 133 of the 140 countries (95 percent) enjoyed positive growth rates in IW over the past quarter century (see Fig 1.11a). While it is good news that global aggregate wealth has increased, there are still five countries that experienced a decline in their wealth.

Fig 1.11: Growth in Inclusive Wealth Index, using the education approach

Fig 1.11a : Growth in Inclusive Wealth Index (unadjusted), using the education approach

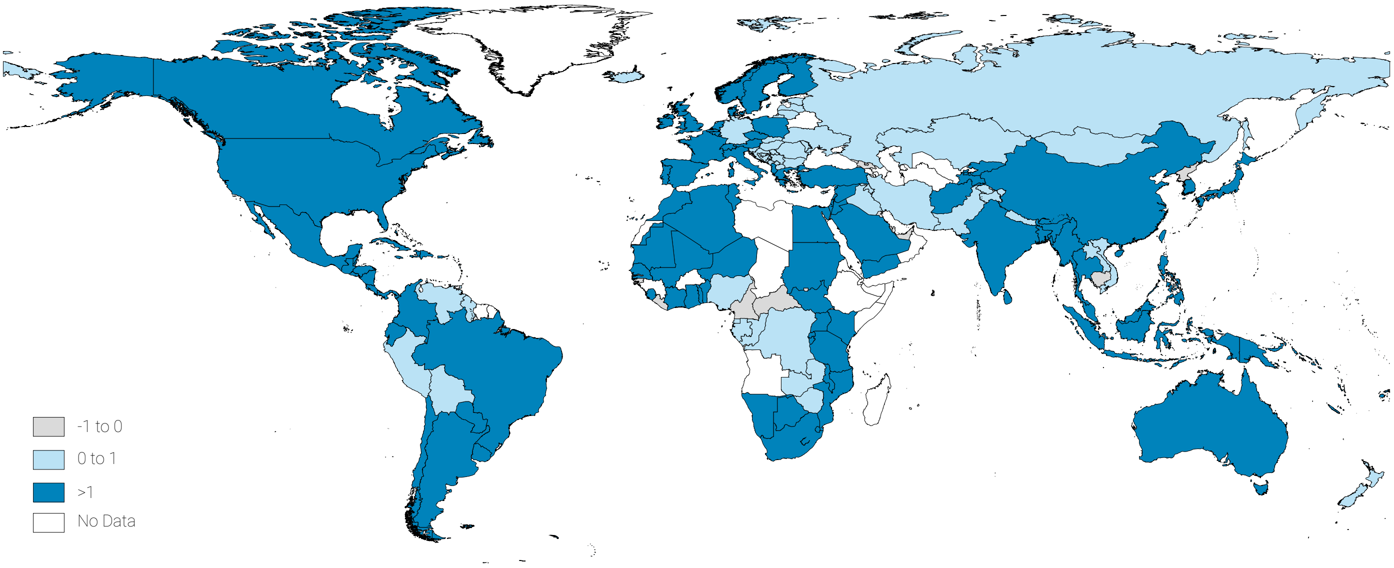


Fig 1.11b: Growth in Inclusive Wealth Index per capita (unadjusted), using the education approach

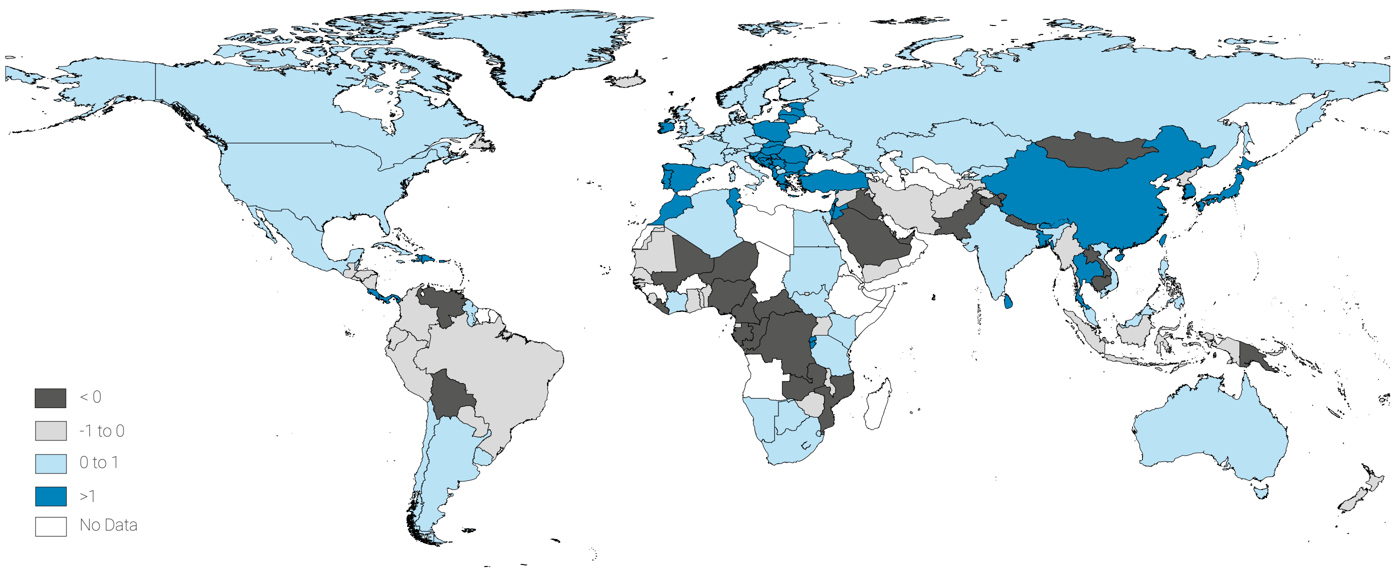
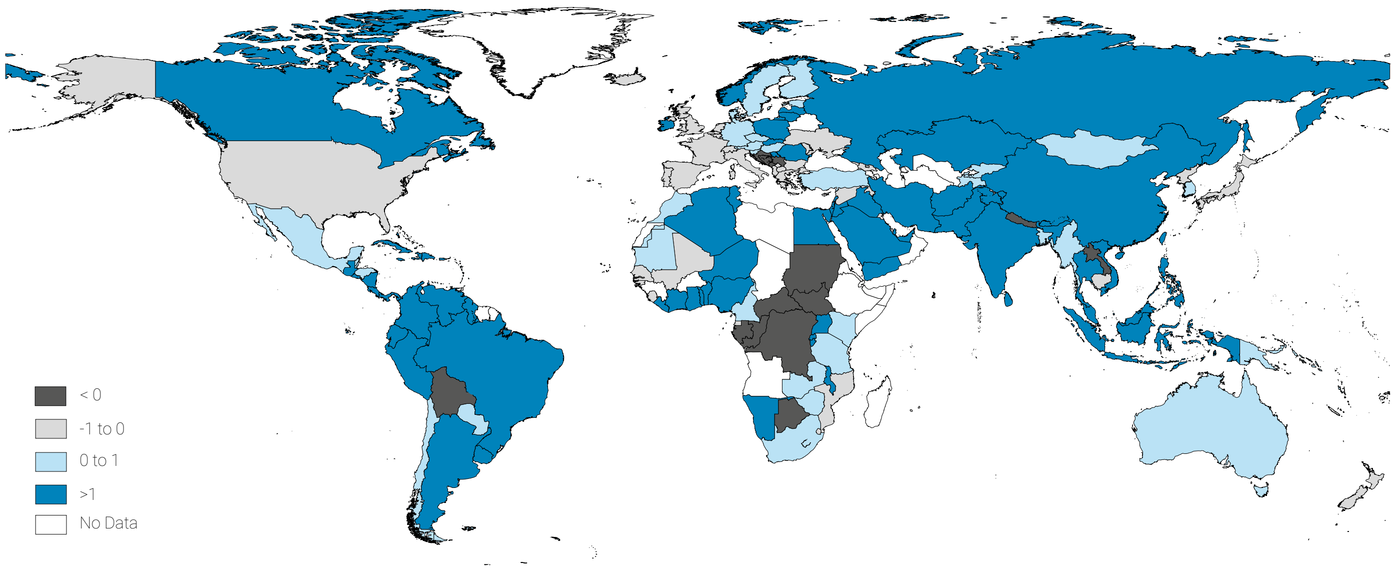


Fig 1.11c: Growth in Inclusive Wealth Index per capita adjusted, using the education approach



If we change the measure from total to per capita, 84 of the 140 countries (60 percent) experienced positive IW per capita (see Fig 1.11b). This decline in performance indicates the impact of the Malthusian effect – the adverse effects of population growth on resources – on sustainability worldwide, particularly in developing countries. Finally, growth in IW per capita with adjustments for TFP, carbon damage and oil capital gains (Fig 1.11c) indicates that 81 of the 140 countries (58 percent) are on a sustainable path.

These figures can be contrasted with the previous results of IWR 2014: for the period 1990-2010, only 128, 85 and 58 of the 140 countries (compared to 133, 84, and 81 in the current edition) experienced an increase in inclusive wealth in absolute terms, inclusive wealth per capita and inclusive wealth per capita adjusted, respectively (see Fig 1.12). Since the sample countries remain unchanged, and the methodology has not changed drastically, this improvement in performance could be down to either the extension of the study period by four years (2011-2014) or to the addition of fishery resources to natural capital.

Fig 1.12: Comparison of numbers of countries with positive IW growth, education approach

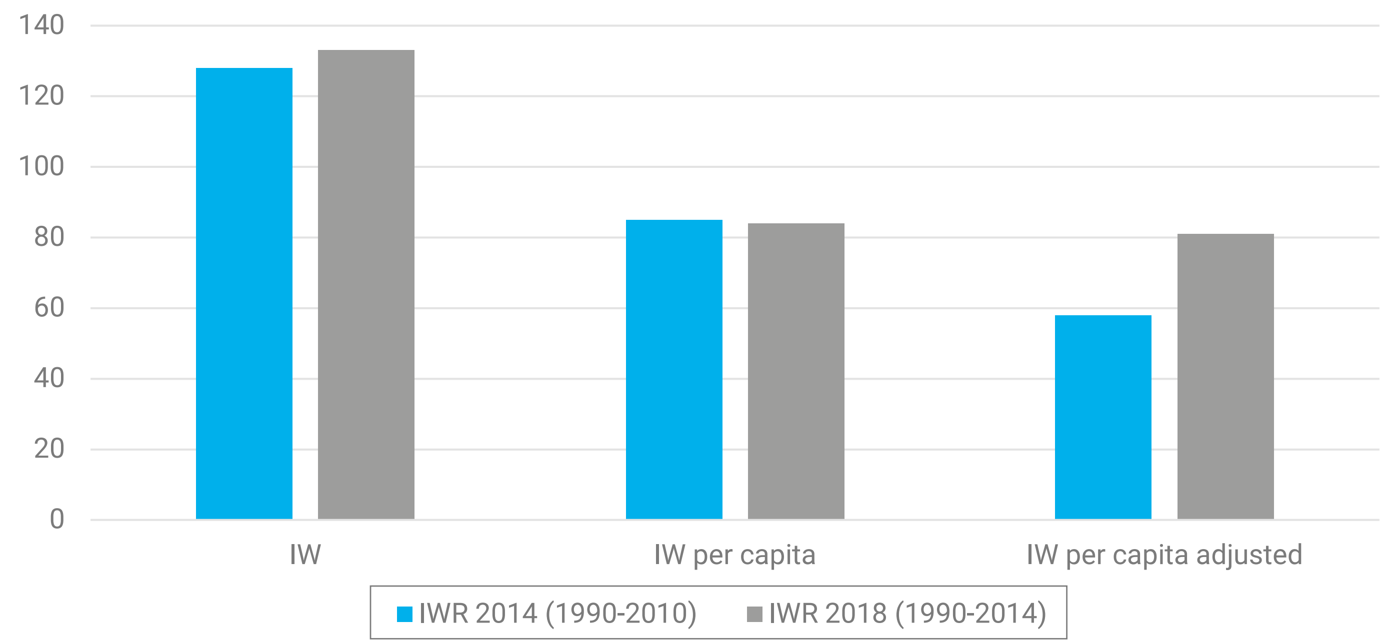
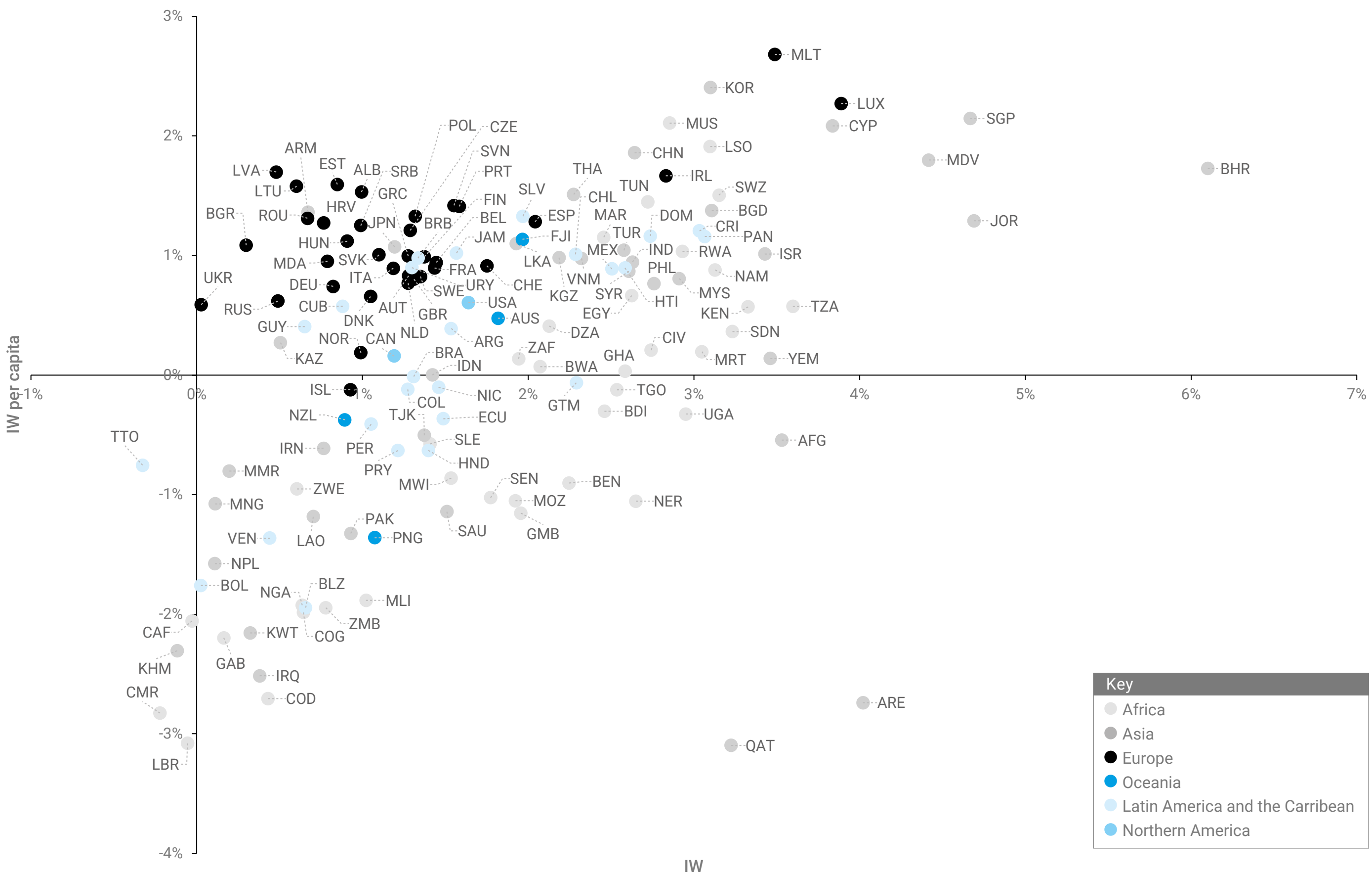


Fig 1.13 shows the relationship between absolute and per capita IW. Overall, we observe a positive relationship between the two: the larger the growth in IW, the larger the growth in IW per capita tends to be. Note also that almost all of the European and North American countries fall into Quadrant I: they have experienced increasing wealth in both absolute and per capita terms. For the other regions, the results are mixed. Bahrain, the United Arab Emirates and Qatar, all of which are sitting on enormous oil and gas capital, lie somewhat as outliers.

The seven countries with negative inclusive wealth growth include four African nations (Cameroon, the Central African Republic, Liberia and Sudan), Trinidad and Tobago, the Republic of Moldova and Cambodia. It is significant that, of these seven countries, only the oil-rich Caribbean nation, Trinidad and Tobago, falls into the high-income category. In absolute terms, Trinidad and Tobago's natural capital has declined by 3.9 percent per annum. It appears that the country has depleted its ample natural capital across the board, from agricultural land to oil and gas, but that the extent to which this has been converted into produced and human capital has not been sufficient to compensate for this loss.

Fig 1.13: Inclusive wealth and inclusive wealth per capita (education approach)



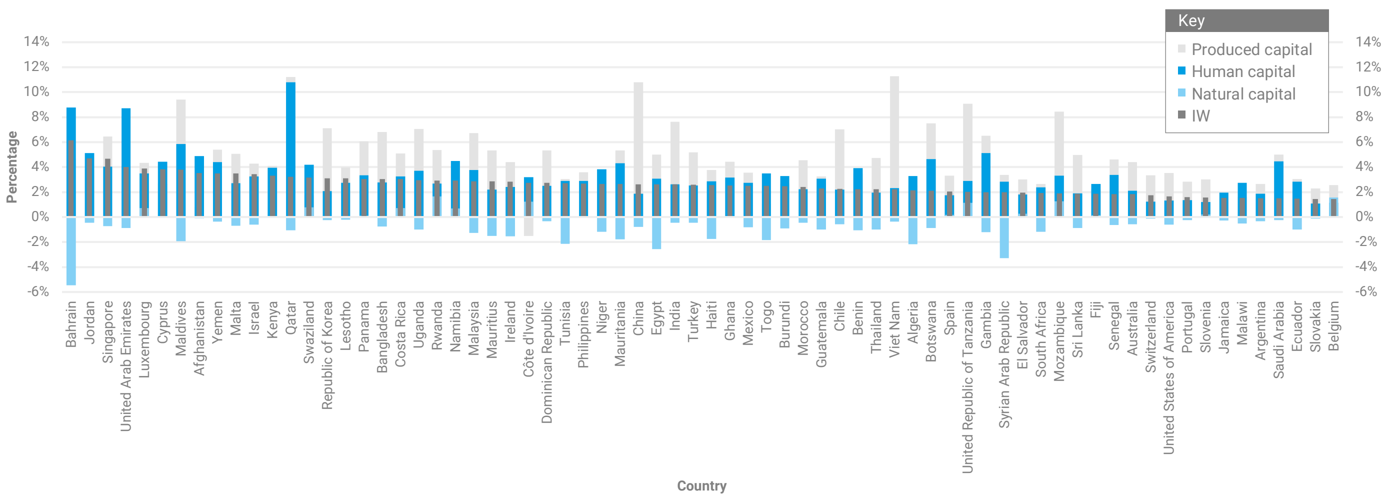
1.4.2. Changes in the composition of wealth

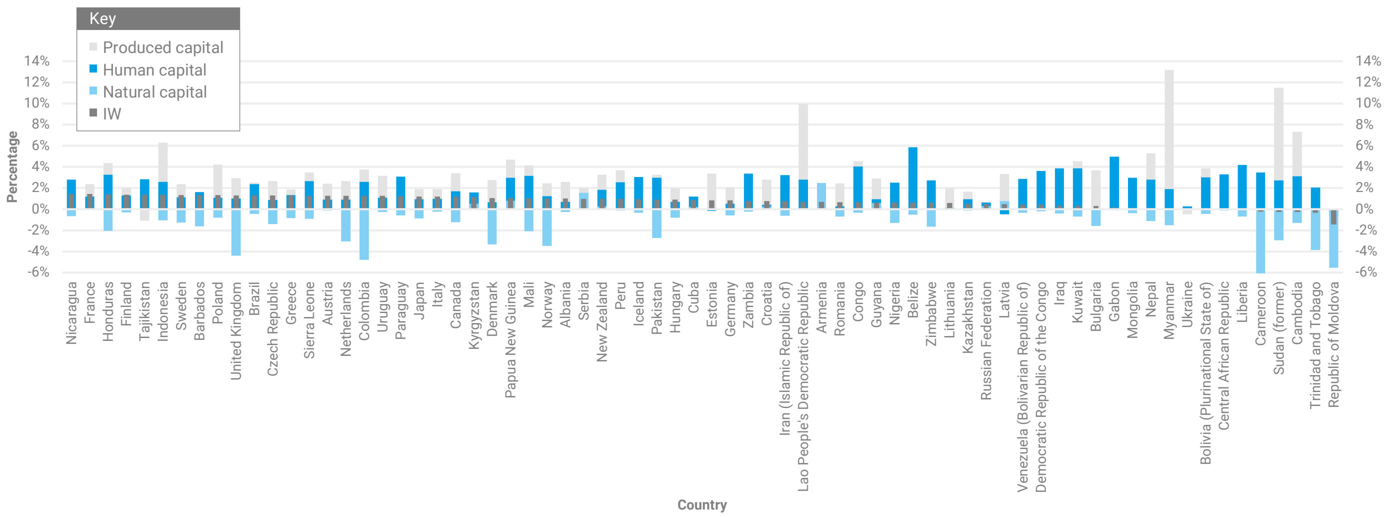
In this subsection, we take a closer look at the breakdown of the contributions of each capital asset group to total inclusive wealth average growth rates. Fig 1.14 shows the breakdown of (unadjusted) inclusive wealth growth into produced, natural and human capital groups. We observe that, even among countries with high inclusive wealth growth rates, the composition of capital assets varies significantly. For example, oil-rich gulf nations (Bahrain, the United Arab Emirates and Qatar) have converted massive amounts of natural capital into other capitals, especially human capital. Other nations, such as Singapore, Tanzania, Bangladesh, the Republic of Korea and the Philippines, have been on a sustainable path, primarily by either growing their produced capital, with very little rundown of their natural resources, or because they are poorly endowed with these resources in the first place.

Turning to unsustainable or barely sustainable countries in Fig 1.14, we note that, despite their sluggish growth in IW, human capital has grown by more than 2 percent (with some exceptions). Their disappointing inclusive wealth growth rates are therefore largely a result of the degradation of natural capital and the slow growth in produced capital. Notable exceptions include several former Soviet republics, such as Ukraine, Russia, Kazakhstan, Lithuania and the Republic of Moldova, where human capital has declined as a result of a decrease in population over the last quarter century. Furthermore, all of these countries have also experienced a decline in natural capital; the Republic of Moldova, in fact, has seen a reduction in all three forms of capital asset.

We note here that, since the growth rates are expressed in geometric terms, the growth rates of each component do not simply add up. Some ASEAN countries, such as Laos, Myanmar and Cambodia, have recently accumulated produced capital but this does not contribute to growth rates in IW for the studied period.

Fig 1.14: Breakdown of growth rates of inclusive wealth into three forms of capital asset before adjustments (education approach)

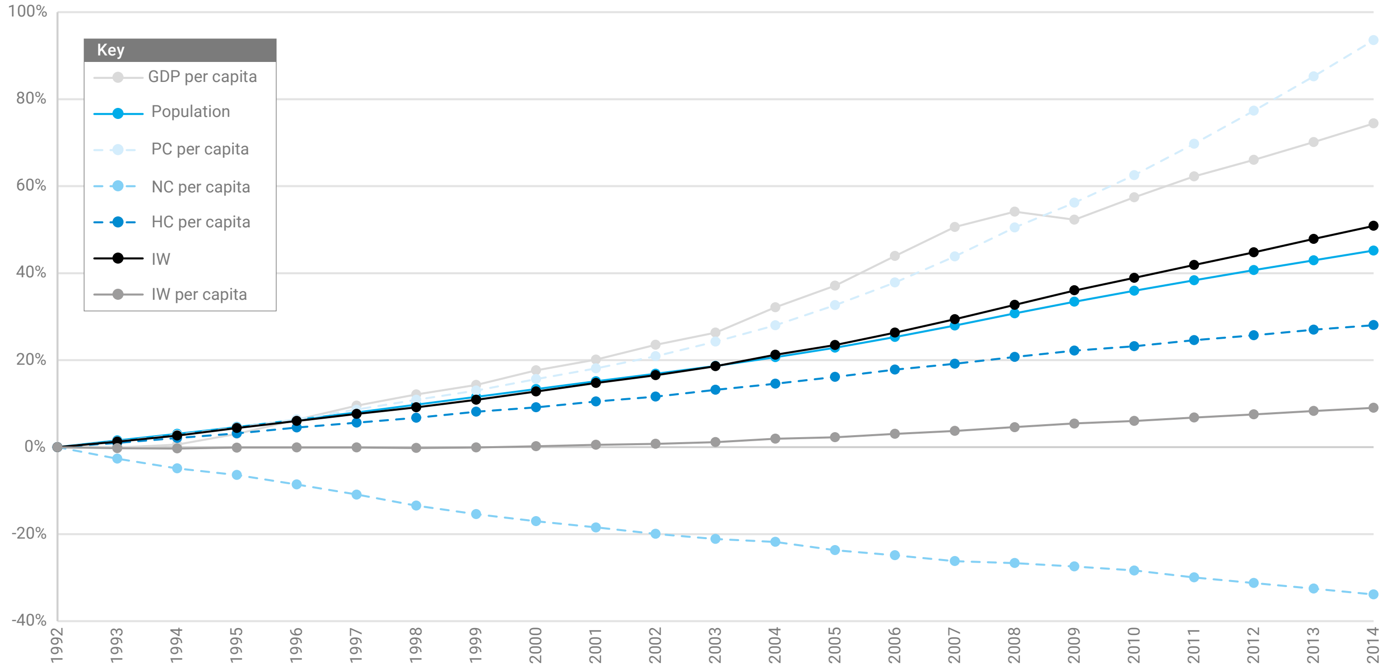




What if we aggregate the data for all the countries? In other words, has the world as a whole been preserving its wealth? Fig 1.15 shows the global change rates of IW and its components on a per capita basis, with 1992 as the reference year.[14] IW per capita has grown slightly, especially over the last decade. It is interesting to note the comparison with IW in absolute terms, which shows a cumulatively large decrease over the same period. Fig 1.15 also demonstrates vividly that natural capital degradation – which amounts to approximately 35 percent in cumulative terms – has been compensated for by investment in human capital and, to a much greater extent, in produced capital.

Another interesting observation from Fig 1.15 is that all of the aggregate global growth in capital assets has been linear, whether positive (produced and human) or negative (natural). In contrast, while GDP growth has been largely positive and linear, the enormous financial crisis caused a notable drop in 2008.

Fig 1.15: Global growth rates of inclusive wealth per capita and its components, relative to 1992 (education approach)



14 The years 1990 and 1991 have been omitted to avoid missing data in some former Soviet republics.

1.4.3. Wealth composition

As previously stated, what matters for the assessment of sustainability is the change in capital assets over the course of years. However, it is also of some interest to examine the composition of capital assets themselves. Fig. 1.16 shows the percentage of the three types of capitals in IW, averaged for the period between 1990 and 2014 (education approach). Fig 1.16a suggests that produced capital accounts for less than 20 percent of total wealth in many countries. It is relatively more important in some developed nations, such as the USA, the EU countries, the Republic of Korea and Japan. In contrast, the share of produced capital is alarmingly low in some developing countries; it accounted for less than 5 percent in some sub-Saharan African countries in 2014. It is difficult to draw normative implications only from this percentage, but history suggests that investing in produced capital would help some poor countries to take off.

Fig 1.16b shows the annual average share of human capital for 1990-2014. It demonstrates that human capital accounts for the lion's share of wealth in many countries. There are, however, several exceptions in the less developed world. As of 2014, human capital made up less than 20 percent of IW in Belize, Bolivia, Guyana, the Central African Republic, Laos, Liberia, Mongolia, Papua New Guinea and Tanzania.

Finally, Fig 1.16c represents the share of natural capital in IW. In contrast to other forms of capital, the share of natural capital largely depends on initial endowments, so it is often very small, both in low-income and high-income countries. For example, natural capital accounts for less than 5 percent of IW in both Belgium and Bangladesh. It is also worthwhile mentioning that some countries that were rich in natural capital are running down their reserves: in Bahrain and the United Kingdom, less than 1 percent of wealth was in the form of natural capital as of 2014, suggesting that they may have depleted their oil capital over the last few decades.

Fig 1.16: Percentages of produced, human and natural capital in total inclusive wealth, average for 1990–2014, education approach

Fig 1.16a: Percentage of produced capital in total inclusive wealth

Fig 1.16b: Percentage of human capital in total inclusive wealth

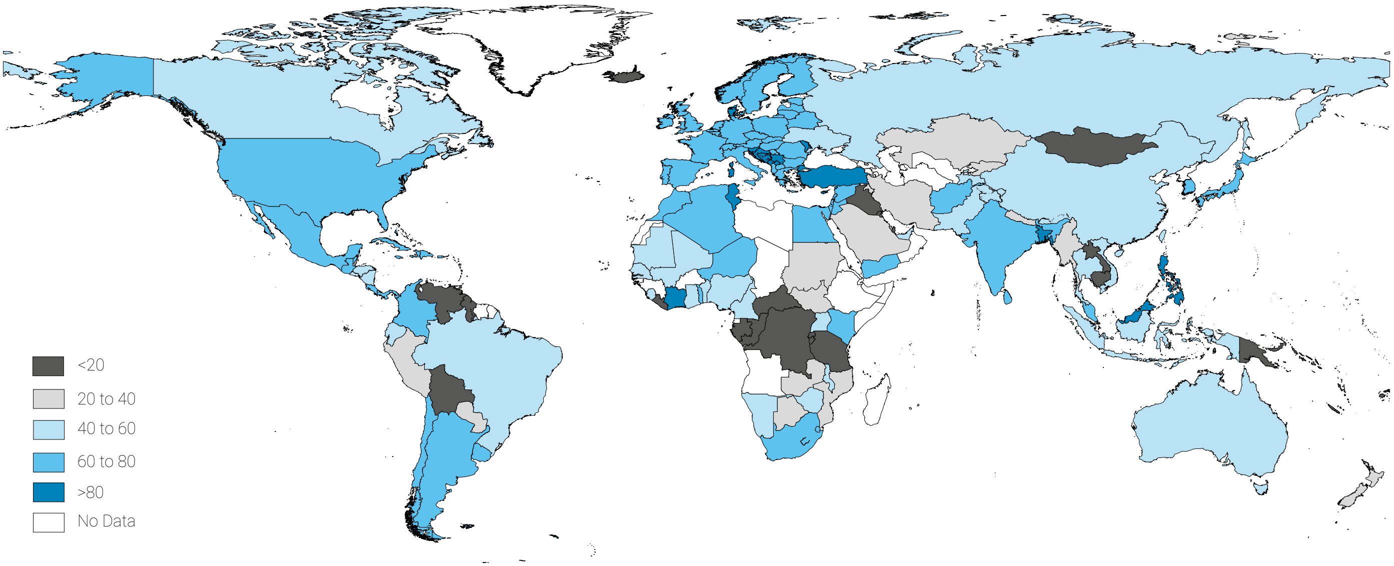
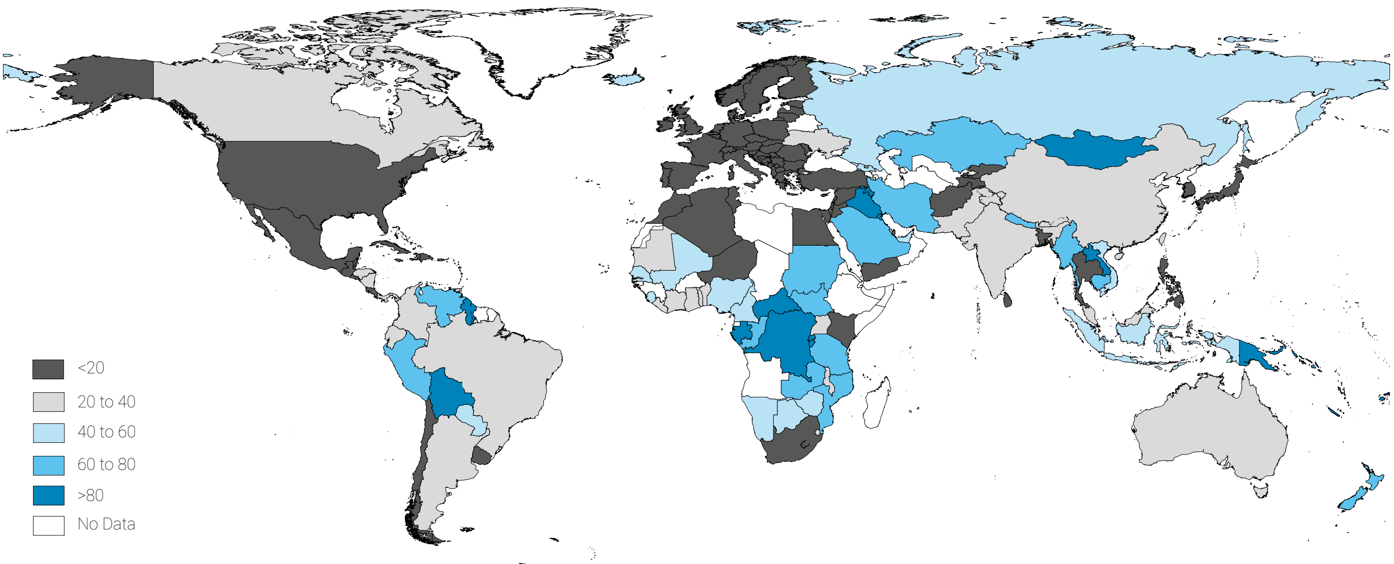


Fig 1.16c: Percentage of natural capital in total inclusive wealth



What about the composition of wealth across the whole world? Fig 1.17a shows that, on average, human capital is responsible for more than half of IW, followed by natural capital, which makes up just over a quarter of total wealth. Produced capital accounts for the smallest share: less than one fifth of total wealth worldwide. Note, however, that this figure is aggregated both over time and worldwide. The right-hand panel of Fig 1.17 shows the temporal changes in the composition of capital. It is clear that natural capital has been substituted primarily by produced capital. It is somewhat surprising to see that the shares of natural and produced capital converge at approximately 20 percent, while the share of human capital continues to account for more than half of total wealth.

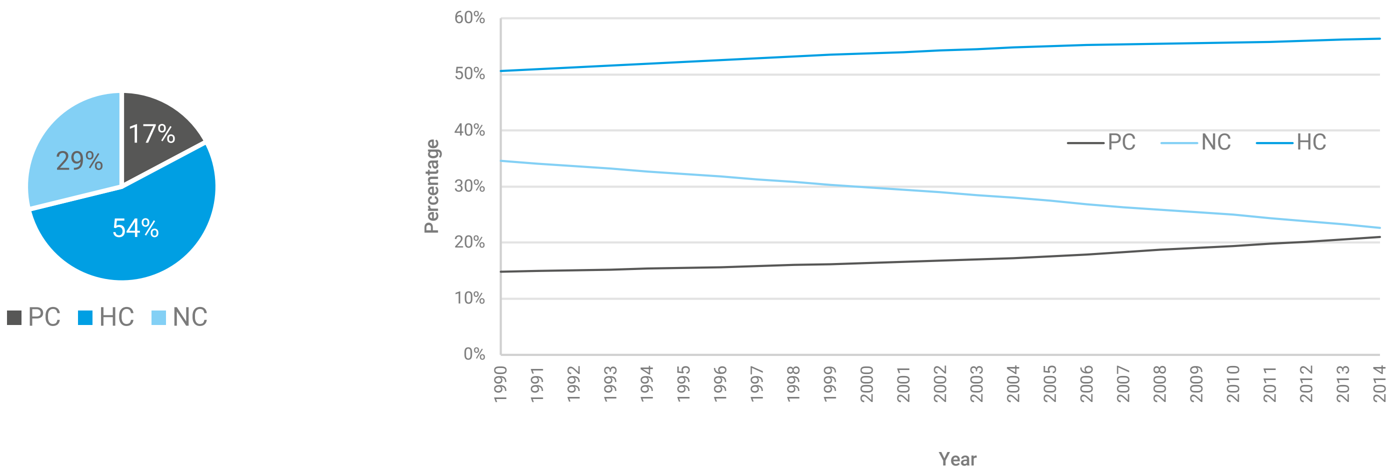
However, a different picture emerges when we use a different approach to aggregating the data. In Fig 1.17b, instead of calculating the average of the shares, we first aggregate each capital for a specific year for the whole world to compute each capital share in the right panel. According to this calculation, produced capital overtook natural capital in the mid-1990s. The pie chart shows the average for the whole period. Natural capital only accounts for 15 percent of total wealth – a somewhat sobering figure in light of the declining trend.

This replacement of natural capital by produced capital should be examined in further detail. The Inclusive Wealth Report (IWR) 2014 found that the share of produced capital tends to be slightly less than 20 percent in many countries, and – interestingly – natural and human capital shares tend to be inversely correlated. This tendency continues to hold for our updated data, as shown in Fig 1.17c. It is tempting to interpret this apparently linear relationship between produced and natural capital as an indication that natural capital is being depleted and converted into human capital. Our approximation suggests that, if one starts from a 'natural state' – with natural capital making up 100 percent of wealth – a 20 percent decrease in natural capital would translate into a 15 percent increase in human capital.

This would be reminiscent of the well-known Hartwick rule, which states that, to maintain future consumption and well-being, rents of depleted natural capital should be invested into other forms of capital (Hartwick 1977; Dixit *et al.* 1980). However, it is important to remember that Fig 1.17c only represents the apparent relationship across countries. In other words, the change in the share of capital assets will differ from country to country according to their historical paths. Moreover, it is important to remember that this correlation does not suggest any causation; it could be that, in theory, investment in natural capital results in a lower share of human capital.

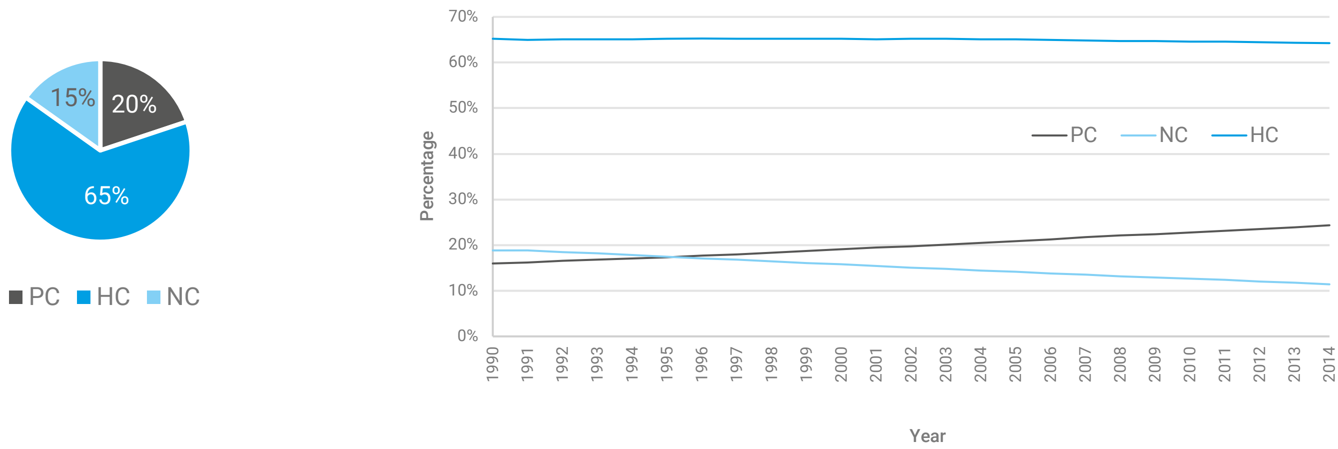
Fig 1.17: Global aggregate wealth composition, mean 1990–2014 and over time, and percentage shares of human and natural capital in total wealth (education approach)

Fig 1.17a: Global aggregate wealth composition, mean 1990–2014 and over time, education approach



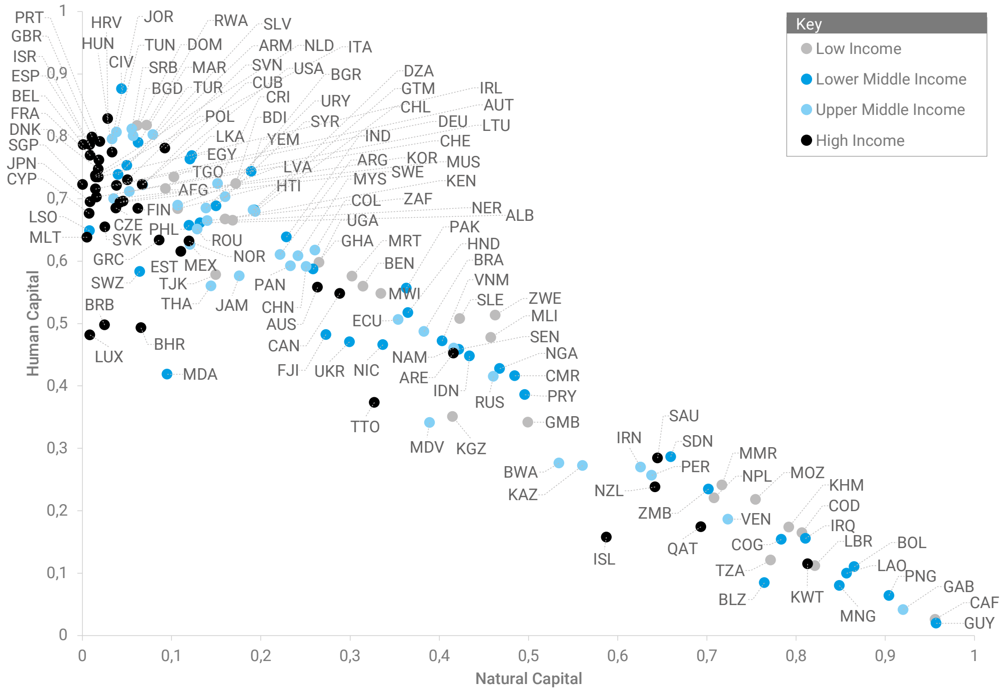
Note: Shares of each capital are computed for each country and year, and then aggregated across countries (the graph on the right). This is then averaged for the whole period, 1990–2014 (the pie chart on the left).

Fig 1.17b: Global aggregate wealth composition, mean 1990–2014 and over time, education approach



Note: Shares of each capital are first aggregated across countries for specific years (the graph on the right). These are then averaged for the whole period, 1990–2014 (pie chart on the left)

Fig 1.17c: Proportion of shares of human capital and natural capital in total wealth, average 1990–2014 (education approach)



In summary, the results show that natural capital has been used to increase produced and, to a lesser extent, human capital. The higher the share of natural capital, the lower the share of human capital tends to be. However, this amount is a global aggregate, and a closer look is warranted. In particular, the share of natural capital has little to do with the advancement of the economy in question. After all, it is the change in combined wealth that counts.

1.4.4. IWI adjusted

As we demonstrated in the methodology section, an increase in IW should result in an increase in social well-being. Aside from the Malthusian effect – an increase in the scarcity of resources as a result of rapid population growth – there are at least three factors, not accounted for in the conventional forms of capital, that affect social well-being: carbon damage, oil capital gains and TFP. Climate change – driven by increases in carbon emissions – is a global issue. The damage it does to a particular economy does not relate to the level of emissions of carbon dioxide from that economy or the changes in natural capital; it is caused by aggregate global carbon emissions. Oil capital gains boost total wealth through an exogenous increase in the price of natural capital. The economy can also enjoy improved social well-being through an increase in TFP, without any improvement in the quantity of IW. TFP represents technological progress in a broad sense, across the whole of society. In fact, TFP could even be considered as another form of capital asset (Arrow *et al.* 2012).

Fig 1.18 shows a breakdown of the changes in IW per capita following adjustments for the three terms: carbon damage, oil capital gains/losses and TFP.

Not surprisingly, carbon damage as a share of IW affects small countries more because their IW tends to be too small to absorb such exogenous shocks. In this regard, our measure proves useful because we express carbon damage as a share of IW. The annual adjustment for carbon damage does not exceed 1 percent of IW in any of the sample countries. In fact, of the three factors, it contributes the least to the adjustment of IW. Carbon damage has the largest effect on IW in Luxembourg (-0.6 percent), followed by Malta (-0.4 percent), the Maldives (-0.4 percent), Bahrain (-0.4 percent) and Barbados (-0.3 percent). It should be noted, however, that island nations are the most vulnerable to climate change and some are even on the verge of disappearing entirely as a result of rising sea levels; some of these are not included in our sample of 140 countries. In absolute terms, however, carbon damage is relatively large in high-income countries such as Germany, France, the United Kingdom and the United States, among others. In per capita terms, carbon damage exceeds $500 in Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, the United Kingdom, Ireland, Iceland, Italy, Luxembourg, the Netherlands, Norway and Sweden. It is also interesting to note that some countries have become better off due to climate change: Australia, Canada, Israel, New Zealand, Russia and Singapore actually gained as a result of global carbon emissions. In these countries, carbon damage is recorded in positive terms in our accounting.

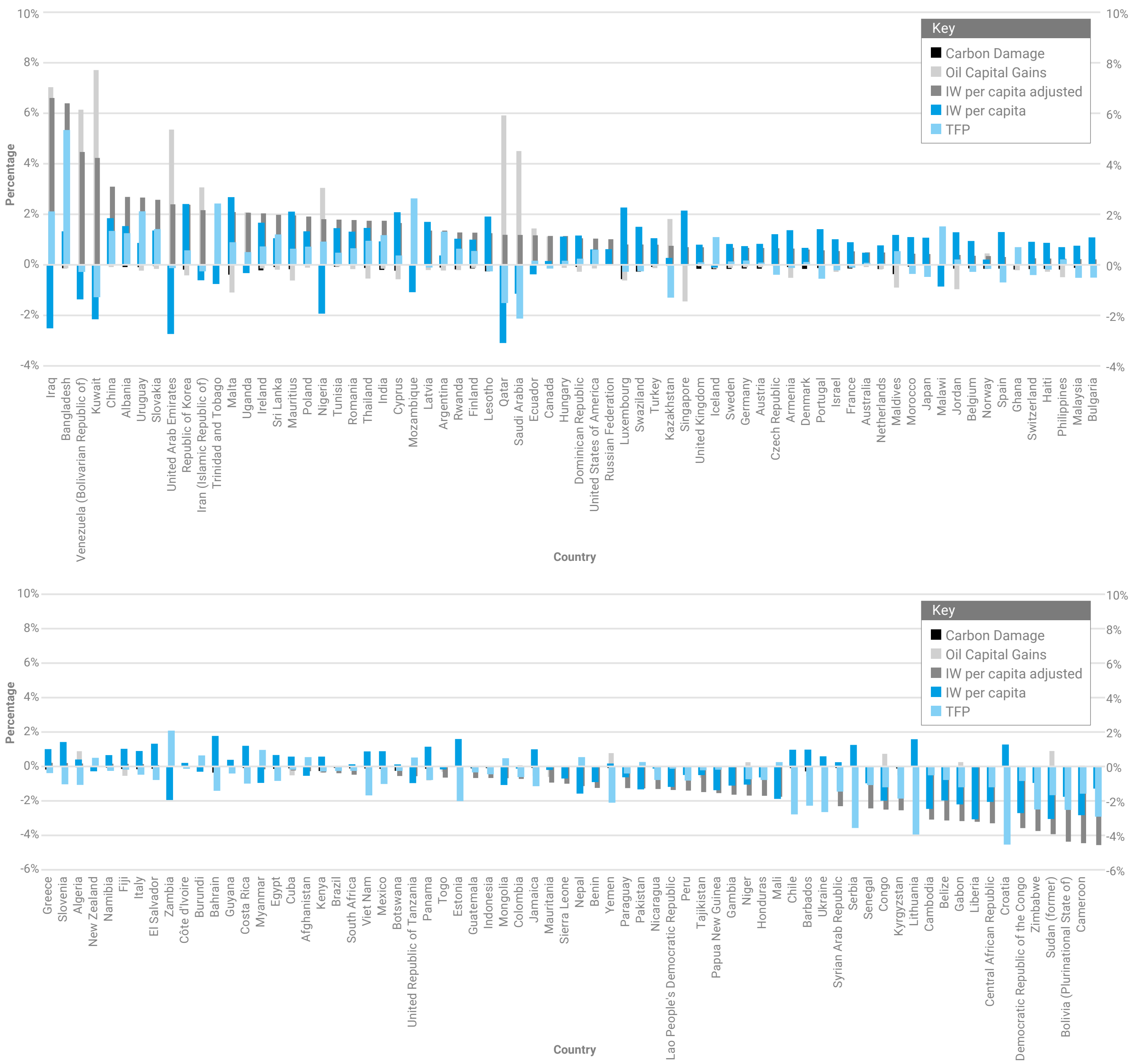
A much larger effect can be observed for oil capital gains and losses. In the current edition, an annual increase of 3 percent in the rental price of oil is assumed, corresponding to the average annual oil price increase during 1990-2014 (BP 2015). This means that even if no oil is withdrawn, oil-producing countries can enjoy a 3 percent growth in social well-being.[15,16] Over the last quarter century, oil capital gains count for more than 1 percent of annual IW in the following countries: Kuwait (7.7 percent), Iraq (7.0 percent), Venezuela (6.1 percent), Qatar (5.9 percent), the United Arab Emirates (5.4 percent), Saudi Arabia (4.5 percent), Iran (3.1 percent), Nigeria (3.0 percent), Uganda (2.1 percent), Kazakhstan (1.8 percent), Ecuador (1.4 percent) and Canada (1.1 percent). They are all countries with enormous reserves of either oil or natural gas, regardless of their income levels. Countries with reserves of unconventional fossil fuels such as shale oil and gas will also gain if oil prices continue to increase. Among those nations with large oil capital gains, the adjusted IW per capita of the United Arab Emirates ends up at a moderate 2.0 percent. In other words, had it extracted its oil wealth more moderately, its IW per capita would have been on a par with, for example, the United Kingdom.

Conversely, there are also 'losers' from these exogenous oil price movements. For completeness, we record negative numbers for those that were faced with higher import prices for oil. The majority (113 of 140) of our sample are importing countries with negative oil capital gains. The largest oil capital loss was in Singapore, equivalent to -1.5 percent per annum of its baseline wealth in 1990, followed by Malta (-1.1 percent), Jordan (-1.0 percent), the Maldives (-0.9 percent) and Panama (-0.8 percent), These smaller nations are more affected because of the relative size of their IW and their inability to absorb large oil price shocks. In comparison with oil capital gains, the magnitude of capital losses for individual countries is smaller, reflecting the fact that oil-importing countries are geographically more widespread than exporting ones.

15 In theory, the value of oil natural capital can remain intact if the decrease in the quantity of oil can be compensated for by the increase in oil price when the quantity is fixed.

16 If oil prices increase in the future (which they are likely to), the current list of capital assets could also be adjusted to reflect the gain in social well-being (Vincent *et al.* 1997; Hamilton and Bolt 2004; van der Ploeg 2010). We do not consider this possibility since future oil prices are too difficult to predict, as recent history demonstrates.

Fig 1.18: Breakdown of the growth in per capita inclusive wealth following the three adjustments (education approach)



Finally, TFP measures residual GDP growth that cannot be explained by the three types of capital assets. As Arrow et al. (2012) demonstrated, in terms of accounting, all we have to do is add the residual TFP growth to the change in inclusive wealth growth. In this section, we take a different tack from the frontier approach in section 3, and instead follow the education approach adopted in IWR 2012. We take the 25-year average of the TFP growth rates reported by the Conference Board (2017).[17] The only shortcoming of this data set is the lack of natural capital, which means that the TFP values might overestimate the true value of technical progress. However, this is not a serious concern because, for the purpose of the sustainability assessment, the final IW per capita adjustments for TFP would be relatively minor (compared to the other adjustments). The development paths of those countries with negative IW per capita and with somewhat optimistic TFP would not be judged as sustainable even if TFP data that took into account the input of natural capital were readily available. The top countries in terms of annual average TFP growth rates include Bangladesh, Mozambique, Trinidad and Tobago, Uruguay and Iraq, all surpassing 2 percent. Less than half of the sample (52 of 140) witnessed positive growth in TFP over the last 25 years

17 Of the 140 countries in the sample, 33 countries are missing TFP data for the Conference Board (2017); these are complemented by regional averages.

All things considered, the ultimate IW growth rate, which is adjusted for the three factors, along with population growth, can be calculated: the results are shown in Fig 1.18. Iraq, Venezuela, Kuwait and the United Arab Emirates have all experienced a decline in IW per capita because of the depletion of their oil capital. This demonstrates the importance of oil capital gains as a windfall benefit, particularly in terms of sustainable development. Bangladesh, China, Albania, Uruguay, Slovakia and the Republic of Korea experienced a moderate accumulation in IW and TFP.

At the opposite end of the scale, 59 countries have seen negative growth in adjusted IW per capita. It is remarkable that, aside from Croatia, all 10 of the worst performing countries have had both negative IW per capita and negative TFP. If they not only continue to lack investment in the usual set of capital assets but are also sluggish in improving the overall efficiency of their economies, their prospects of achieving sustainable well-being look slim.

1.4.5. Comparison with GDP and HDI

In this subsection, we compare our results, based on conventional calculations, with the past performances of other well-known indices. GDP per capita is the most popular index to date for monitoring the progress of nations. Since its launch in the early 1990s, the HDI has also been widely cited as an index for tracking the development of nations. The HDI is a composite index of human capital (health and education) and income levels (GDP). Happiness or, more generally, subjective well-being, has gained attention recently, shedding light on different aspects of social well-being – as opposed to our determinant-based indicator.

Finally, we compare our results with the World Bank's 'genuine savings' measure – the most similar to our index – which tracks formally adjusted net savings (and dissavings) in produced, human and natural capital. For our comparison, we use IWI per capita both before and after adjustments because they differ greatly.

1.4.5.1. GDP per capita

GDP has often been criticized for failing to represent the sustainability of social well-being. GDP growth can differ from that of IWI per capita, as shown in Fig 1.19a and b. Countries in Quadrant I, which make up the majority, have experienced both positive GDP and IWI in per capita terms. This finding is not surprising since portions of GDP are directed towards investment in capital assets. More importantly, many countries still fall into Quadrant II, with positive growth in GDP per capita but negative growth in IW per capita, both in non-adjusted and adjusted terms. Note, however, that the reverse is not true: positive growth in IW per capita is associated with negative growth in GDP per capita (Quadrant IV) for only five countries before adjustments and two countries with adjustments. This finding shows that it might be sufficient to monitor IW per capita growth, even for the purpose of tracking GDP growth.

There is a very weak correlation between growth in GDP per capita and IW per capita before adjustment, but there is a weak but positive correlation after adjusting for all of the income groups. The latter finding is not surprising since one of the adjustment terms, TFP, measures the unaccounted contribution of capital assets to GDP.

Fig 1.19: Growth rates in IW per capita versus GDP per capita

Fig 1.19a: Growth rates in IW per capita (education approach) versus GDP per capita

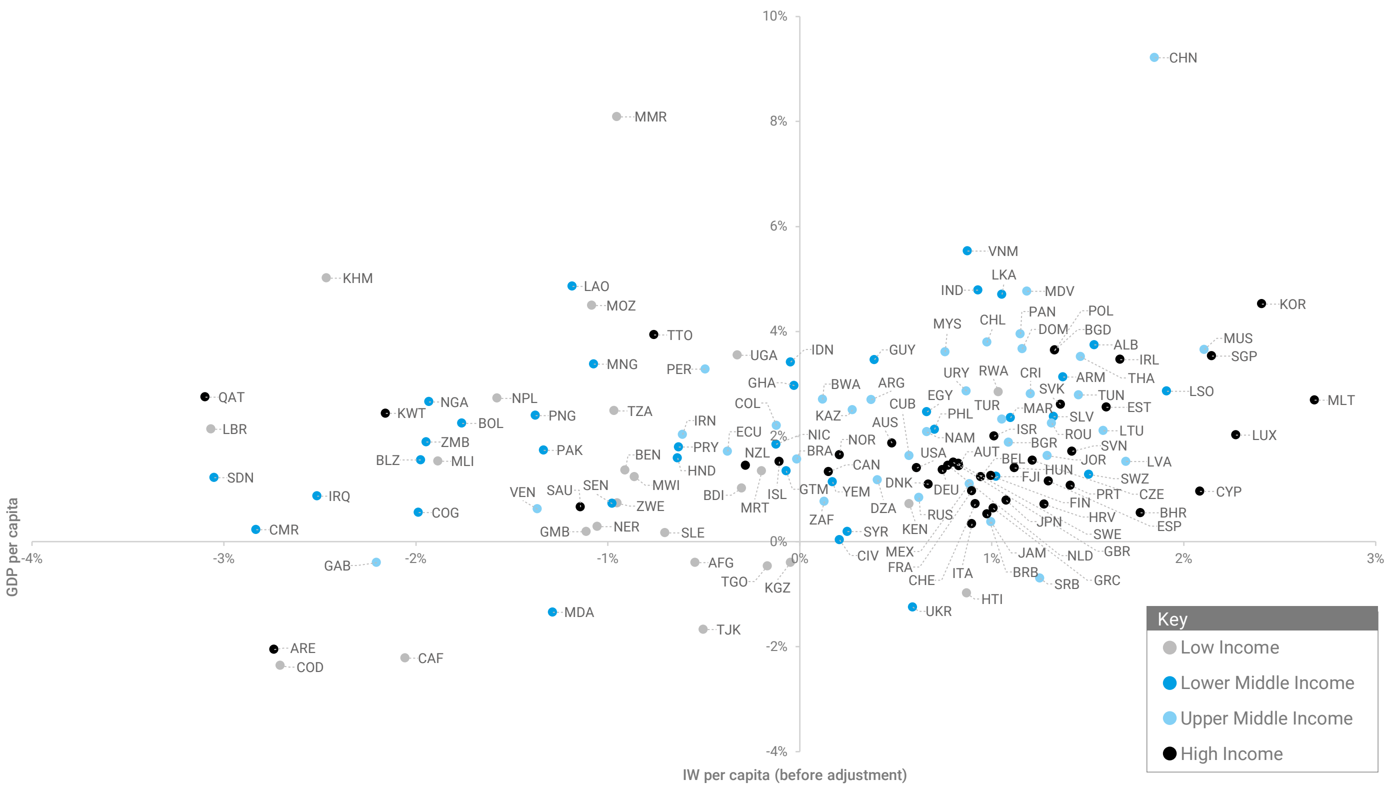
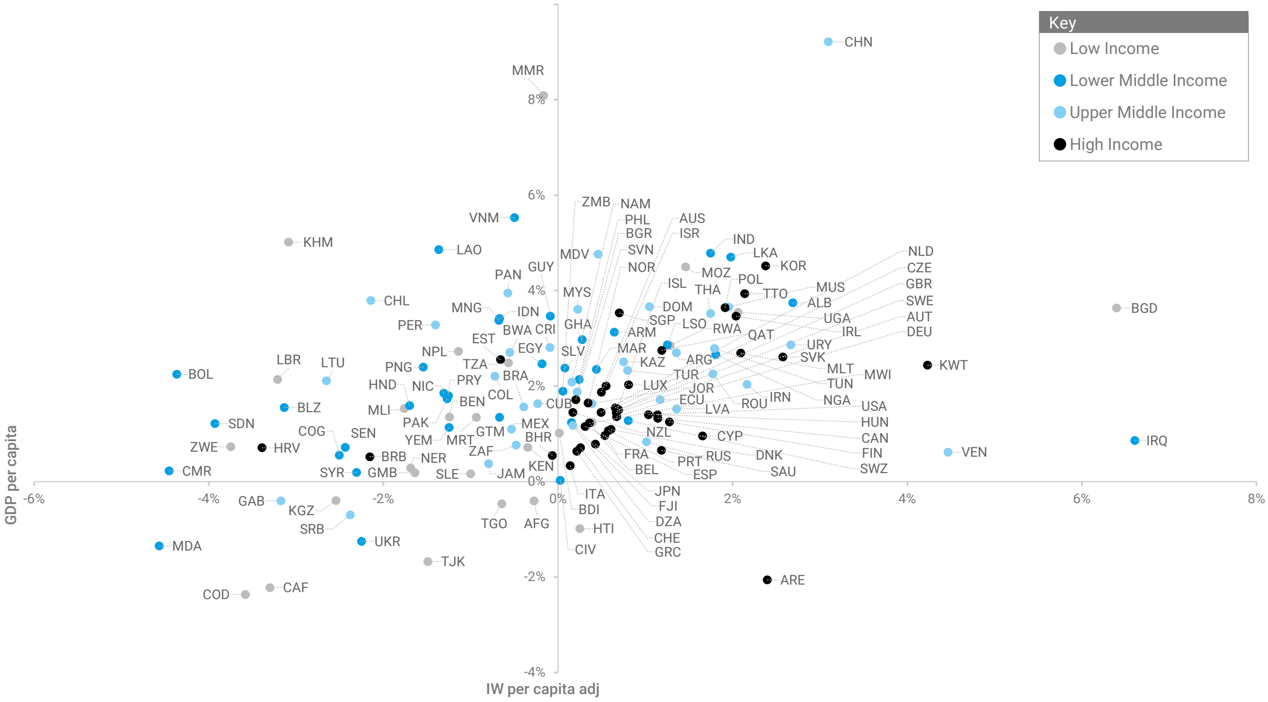


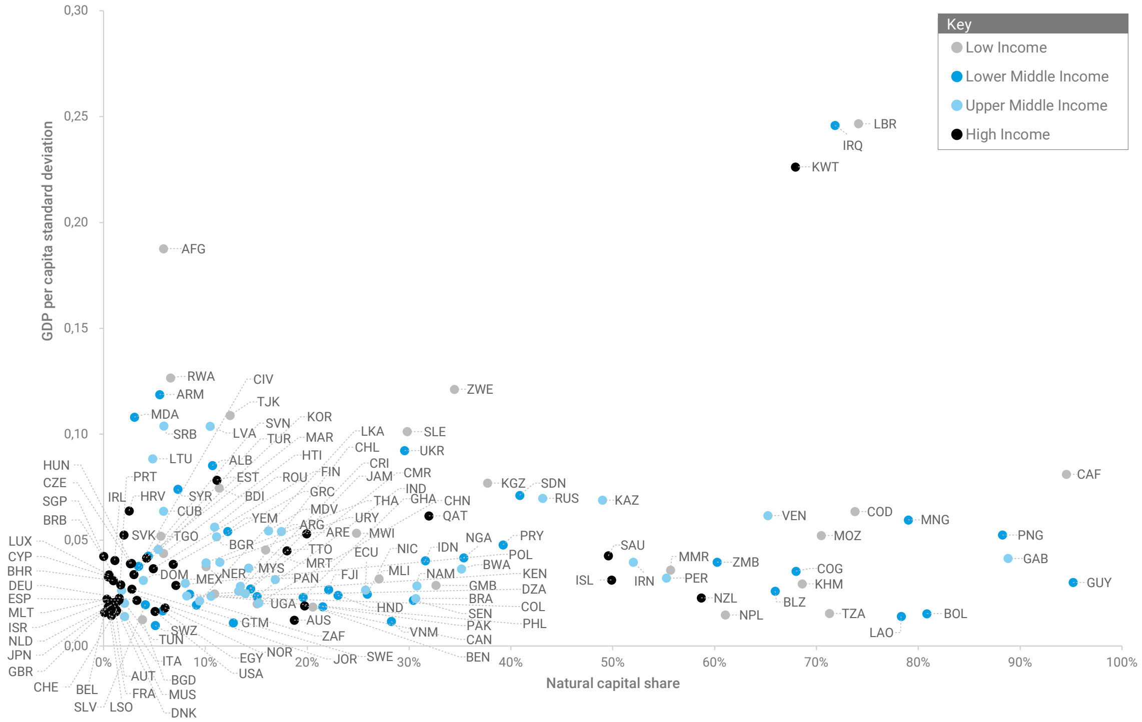
Fig 1.19b: Growth rates in IW per capita adjusted (conventional approach) versus GDP per capita



1.4.5.2. Growth volatility

Some authors have argued that the volatility of resource prices could damage economic performance (e.g. van der Ploeg and Poelhekke 2009). Although there is no formal theory to prove that volatility of output hampers sustainable development, it would be helpful to have a picture of how the two compare. Fig 1.20 plots GDP volatility, as measured by the standard deviation of the past 25-year output, against the share of natural capital. In contrast to our predictions, there is almost no relationship between volatility and dependence on natural capital. Although not reported, we do not see a clear correlation between volatility and IW per capita growth rate either. Countries that depend highly on natural capital are not necessarily experiencing volatile output growth, although Iraq, Kuwait and Liberia have seen bumpy growth rates.

Fig 1.20: Natural capital share in 2014 (education approach) versus 25-year average GDP per capita variation (standard deviation)



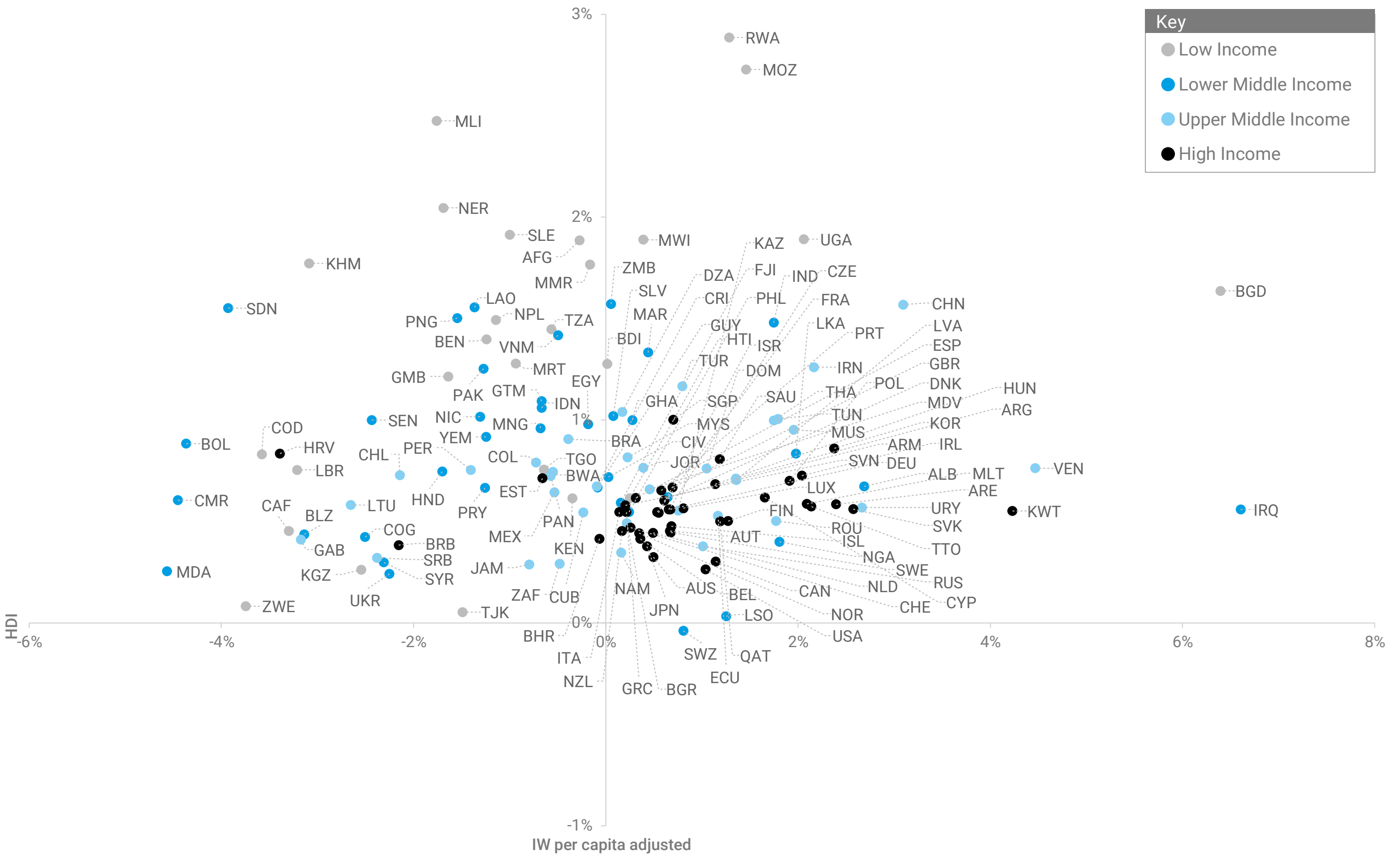
1.4.5.3. Human Development Index (HDI)

What about the correlation between the IWI and another oft-cited index of development, the HDI? Fig 1.21 shows that there is no apparent relationship between the two indices. For lower middle-income countries, it even shows a slightly negative relationship. Therefore, HDI could be sending the wrong message on sustainability. However, if we take a closer look at Fig 1.21b, we can see that, for a limited set of nations, the higher the growth in IWI per capita adjusted, the higher the HDI growth; with a slightly weaker correlation of R^2=0.17 for low-income nations and R^2= 0.21 for upper middle-income countries. No such relationship is evident for high- or lower middle-income nations. Again, there is a slightly better fit for IW per capita adjusted since the economic component of HDI is based on GDP per capita, which includes TFP, which in turn is one of the adjustment terms for IWI.

Fig 1.21: Growth rates in IW per capita (education approach) versus HDI

Fig 1.21a: Growth rates in IW per capita unadjusted (education approach) versus HDI

Fig 1.21b: Growth rates in IW per capita adjusted (education approach) versus HDI



1.4.5.4. Happiness

As we articulated earlier in this chapter, IW addresses the determinants of social well-being. Capital assets comprise the productive base of the economy, which, in turn, become the source of utility for further generations. IW is not intended, therefore, to address the constituents of well-being (Dasgupta 2001). It is not that these constituents should be ignored; rather, they can be used to complement our (determinant-based) approach to give a fuller picture of current and future social well-being.

As depicted in Fig 1.22a, there seems to be almost no correlation between these two aspects of well-being, at least for our studied sample. Note that the vertical axis represents the status of happiness rather than the growth of happiness. For some income categories, a slightly negative relationship can be detected. Although we may be tempted to infer that IW does not buy happiness, this may not necessarily be bad news. As we have argued, IW and happiness are totally different (but complementary) aspects of social well-being.

Fig 1.22: Growth rates in IW per capita (education approach) versus happiness

Fig 1.22a: Growth rates in IW per capita unadjusted (education approach) versus happiness

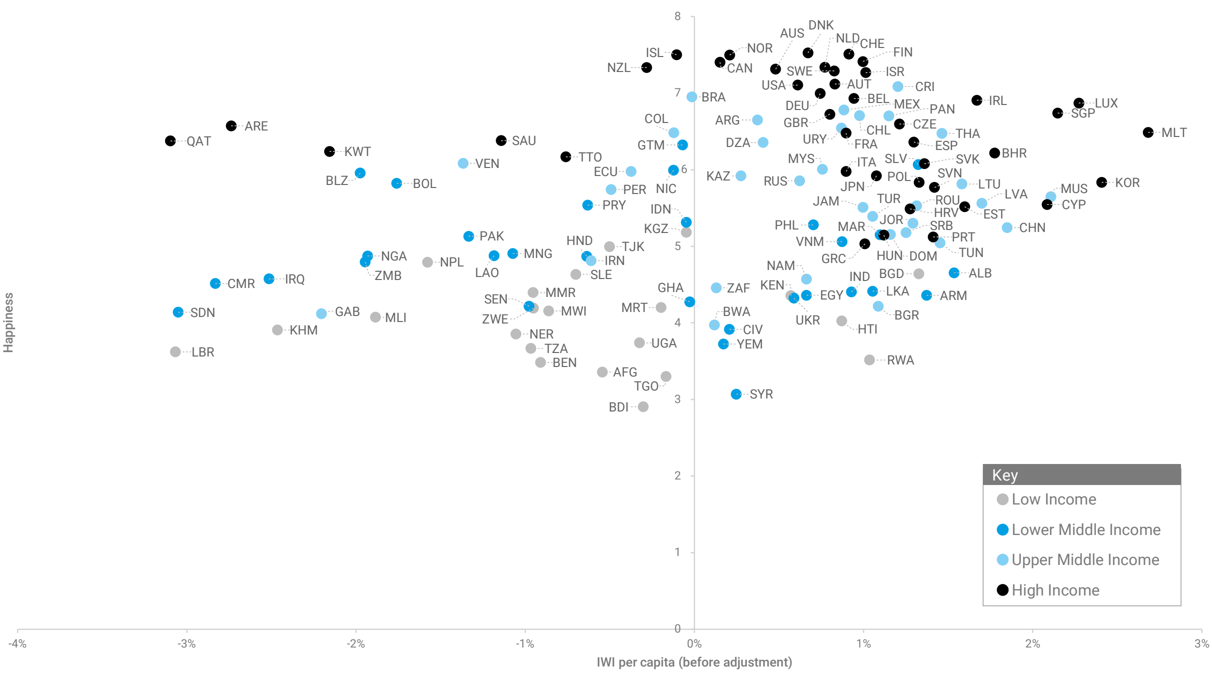
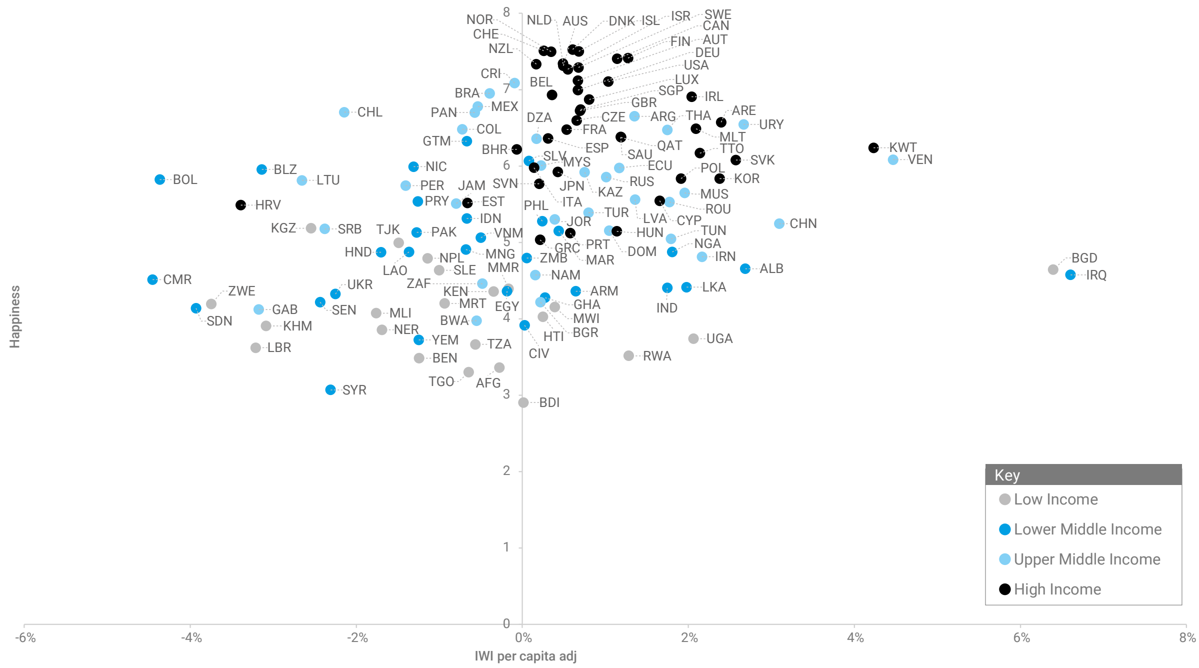


Fig 1.22b: Growth rates in IW per capita adjusted (education approach) versus happiness



1.4.5.5. Genuine savings

As part of their World Development Indicators database, the World Bank started to compute the genuine savings of nations as early as 1999. This composite index is similar to our IWI because they both measure the changes in produced, human and natural capital. However, we differ from the World Bank in many important details. Most notably, the World Bank does not compute annual capital assets per se; it accounts for the change in capital assets. For example, the change in produced capital corresponds to net national savings (NNS). Human capital is recorded as the change in inputs (i.e., education expenditure) instead of outputs (i.e., return on education).

For natural capital, the World Bank analyses fossil fuels, minerals, forests and carbon damage, but not agricultural land and fisheries. Additionally, its notion of intangible capital is based on the residual of the net present value of consumption, which cannot be explained by tangible capital assets. It is not our purpose to discuss in detail the theoretical difference here; for a more in-depth discussion of the comparison, see IWR 2012 (UNU-IHDP and UNEP 2012).[18]

18 The methodology of the World Bank's genuine savings is defined in World Bank (2011).

1.5. Conclusions

Assessing sustainability on the basis of capital stocks seems to be here to stay. However, it should be emphasized that the equivalence between wealth and well-being is the premise from which we all should start. On this premise, changes in well-being should mirror any changes in wealth. Following on from the Inclusive Wealth Report (IWR) 2012 and 2014, we continue our efforts towards identifying a truer measure of the wealth of nations. As we have stressed, it is the change in capital assets and wealth that counts; the value of wealth itself does not have any significance for welfare. Nonetheless, a description of wealth does provide some interesting insights.

In the current edition of the IWR, we show the inclusive wealth of nations, which consists of produced, human and natural capital. This is based on a non-parametric method, which we call the frontier approach. In this approach, shadow prices are determined so that GDP is the output and the three capitals are inputs. According to our results, 135, 89 and 96 of the 140 countries saw increases (compared to their levels in 1990) in IW, IW per capita and IW per capita adjusted, respectively. The global growth rate was 44 percent, which is an average growth rate of 1.8 percent per annum. However, this rate is slower than the annual average GDP growth rate (3.4 percent) during the same period.

If we look at the breakdown of growth, we find that produced capital increased at an annual average rate of 3.8 percent, while health- and education-induced human capital growth remained at 2.1 percent, and natural capital decreased by 0.7 percent. In short, there has been a notable investment in produced capital; however, health, education and natural capital, in which we see enormous potential for future well-being, either grew modestly or even decreased. On a global scale, the composition of capital is as follows: produced (21 percent), education (26 percent), health (33 percent) and natural (20 percent). It is remarkable that, of the different types of capital, only natural capital decreased in value. One way to interpret this outcome is that produced capital and, to a lesser extent, human capital have been enhanced at the cost of natural capital.

Some readers might want to examine education as human capital using the IWR 2014 approach, in which the shadow price of human capital is based on the rate of return on education, as well as conventional TFP (Arrow *et al.* 2012). We have, therefore, also shown the results of our computations for education as a capital asset, following IWR 2012 and 2014. According to this approach, between 1990 and 2014, 133, 84 and 81 countries experienced increases in IW in absolute terms, IW per capita and IW per capita adjusted, respectively. Since the number of countries and the methodology are comparable to previous editions of the IWR, we can compare our results with earlier reports: overall, the numbers have improved from 128, 85 and 58, reported in IWR 2014 (for the studied period 1990-2010). Because, for practical reasons, we do not include health capital in the education approach, the frontier and education approaches are not directly comparable because many variables would be double counted. With this caveat in mind, the averages of the shares of capital assets (which is further averaged for the 25-year period) are as follows: produced (17 percent), human (54 percent) and natural (29 percent), with little change from IWR 2014. However, using a different approach to aggregation, the averages are: produced (20 percent), human (65 percent) and natural (15 percent). The latter is an alarmingly low number, highlighting the rising scarcity of natural resources.

We conclude this chapter by alluding to some of the major challenges and potential discussions.

Completing the list of capital assets. In the construction of our index, we are asked to account for many capital assets, provided that they affect intertemporal well-being and do not overlap with existing capital assets. Otherwise, the very premise of an equivalent relationship between wealth and well-being would collapse.[19] We have included fish wealth as an important constituent of natural capital for virtually the first time. Another class of natural capital that comes to mind is water, which is vital to economies and people of all income categories. As was experimentally discussed in UNU-IHDP and UNEP (2012), water poses a challenge in terms of the tricky relationship between flow and stock variables.[20] In addition, natural resilience could also be added as another essential form of capital, at least conceptually (Mäler and Li 2010) and (in practice) locally (Walker *et al.* 2009). Accounting for resilience in a non-local manner would be difficult, if not impossible.

Institutions and social capital are even more challenging, partly because of their intangibility, and partly because, by their very nature, they enable other capital assets to function and yield well-being (Dasgupta 2015). Therefore, we should resist the temptation to add, for example, social capital as another capital asset in an ad hoc manner, such as the valuation of social capital through revealed preference. A more promising method would be to account for social capital in a two-stage set-up, in which we can examine how social capital raises the shadow prices of other capital assets.

Shadow prices. Even in imperfect economies, the relative weight of capital assets can be formalized as their marginal contribution to social well-being, given a range of economic growth rates in future scenarios (Arrow *et al.* 2012), as we demonstrated in section 2. The current volume of the IWR shows the results of the non-parametric frontier analysis used to compute the shadow prices of human capital. This capital comes with

19 If our list of capital assets is not complete, wealth could deviate from well-being. On an empirical level, there have been studies to test genuine savings and consumption changes (Ferreira et al. 2008; Greaseley et al. 2014), and we recommend similar studies be conducted for inclusive wealth as well.

20 Fenichel *et al.* (2016) attempted to account for local groundwater in an imperfect economy.

its costs: compared to the education approach to human capital shadow prices, GDP is used as the output, corresponding to the three capitals.[21] IW accounting for assessing sustainability is, by construction, founded on intertemporal well-being, so it would be best if we could use the latter (rather than GDP) as the output. Admittedly, the education approach is also not without its faults: the rate of return on education, as well as value of statistical life (VSL) year, is derived from market transactions and thus can deviate from the marginal impact on well-being. Perhaps of more concern to us, in the face of looming climate change, is the non-linearity of shadow prices. We will need to update our shadow prices, if necessary, once scientific evidence reveals the scarcity of the components of natural capital.

Coevolution and interdependence of capital assets. The shadow price of a given capital reflects marginal social value, but it can also be subject to other capital assets. In the language of ecological economists, capital assets co-evolve. Negative externality in health capital is a good example. We have already accounted for carbon damage by greenhouse gases in the adjustment terms, but it might also be a good idea to include local air pollution – in the same way that the World Bank (2016) includes particulate matter in its measurement of 'genuine savings'. Indeed, there is ample evidence that local air pollution, both indoor and outdoor, is hazardous to health and poses a threat to longevity. Local air pollution acts more like a flow variable than a stock, but it could be formalized as a persistent negative natural capital. Even so, care should be taken not to double count health capital: the VSL may already capture air pollution in shorter life years.

To provide another example, it is not clear to which capital urban land is allocated; in many cases, it is implicitly within produced capital. In its analysis of state-by-state wealth accounting, Chapter 5 of UNU-IHDP and UNEP (2012) explicitly treats urban land under produced capital. Improving the amenity value of the environment in cities, therefore, could potentially boost the shadow value of urban land. Conversely, natural capital shadow prices could be affected by produced capital investment. However, this question remains open to discussion, since it would involve consumer surplus, which might not exactly match the shadow value in IW accounting. This consideration brings us back, like it or not, to the matter of shadow prices.

21 One can defend the use of GDP as the output of the three capitals by claiming that the value of life expressed as health capital implicitly nests future generations. However, this interpretation of utility function would be very limited, so we do not push this thesis any further.

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CHAPTER 2: INCLUSIVE WEALTH: FROM THEORY TO PRACTICE


Pushpam Kumar, Rodney B. W. Smith

2.1. Introduction

One is unlikely to find a major publicly traded firm that does not conduct asset accounting and balance sheet analysis. The information embedded in such reports provides investors valuable insights into the composition of firm assets, and insights into its short- and long-run trends. Surprisingly, few nations have a history of preparing annual balance sheets, thus hamstringing the ability of policy analysts and policymakers to understand trends in the composition and status of national wealth, and use such information to inform policy design. Recently, however, the advent of wealth accounting by UN Environment and others is helping fill this information gap – how this information will be used remains to be seen.

Currently, UN Environment measures of wealth are calculated as weighted sums of human, natural and produced capital, with the weighted index called the Inclusive Wealth Index (IWI).[22] One can view a nation's wealth as an index of the productive base from which the flow of goods and services (i.e., gross national product or GDP) is generated. Roughly speaking, if the productive base (per capita) of a country has not fallen over time, and if projections suggest this pattern will continue into the future, we say the country's growth is sustainable. Note, that while sustainable growth can accommodate a pattern of increasing (or decreasing) GDP per capita over time, it is not wise to assume that a pattern of increasing GDP over time is consistent with sustainable growth. A simple example in the next section illustrates this point.

This chapter has four sections. The first section provides an overview of the rationale underlying the claim that – from an intergenerational welfare perspective – linking resource allocation policies to changes in wealth is more appropriate than linking resource allocation policies to changes in GDP. This second section provides an overview of the basis for wealth estimation and explores how various types of conservation and development policies recognizing the trade-off can be understood better with the help of inclusive wealth. The second section also brings the wealth concept closer to national level policies on selected conservation goals and targets, and shows its comparative advantage over others.

The third section illustrates some of the advantages of estimating wealth in the context of the United Nations Sustainable Development Goals (SDGs), which were endorsed in 2015. The chapter examines some of the global policy goals manifested in the 2030 Agenda and the SDGs. By selecting a few goals and targets, it has been shown how we can achieve greater results for the SDGs if the indicator is orchestrated through a wealth index. Finally, the chapter synthesizes the lessons learned, including caveats and limitations of wealth in formulating policies for conservation and development at various levels of decision-making units.

2.2. Gross Domestic Product, Wealth Measurement, Substitution and Sustainability

2.2.1. Gross domestic product and inclusive wealth

GDP was introduced at the Bretton Woods Conference in 1944, and was to serve as an index of the size of a country's economy – an accounting measure of all goods and services produced in a country over a given period of time. Since its inception, however, GDP gradually morphed from simply a measure of market activity, into a measure of a country's overall well-being – per capita GDP – a far cry from its original interpretation in the 1940s.

The shortcomings of GDP as a measure of social well-being are well known, with the two most germane to this discussion being: GDP ignores (i) the value of human capital and the non-market values of natural capital; and (ii) the economic value of externalities, both positive and negative. Few will argue that GDP was intended to serve as a measure of social inclusivity or environmental sustainability.[23] Perhaps this is why, as countries continue to advance economically, one questions the ability of GDP to adequately gauge human well-being and sustainability. This is especially the case when natural resource availability appears to present impediments to economic growth.

GDP is a measure of the value of service flows generated by an economy's produced (or physical), human and natural capital over a period of time. Wealth – in this case IW – is defined as the sum of the value of three types of capital stock: human capital, physical capital and natural capital. The value of each capital is defined as the unit stock value of that capital multiplied by the quantity of that capital. For example, if the unit stock price of physical capital is $1 and the economy is endowed with 5 million units of physical capital, the stock value of physical capital is $5 million. The IWI measures the wealth of a country by carrying out a comprehensive analysis of the country's productive base – the productive base includes

22 The long-run plan is to eventually define quantifiable measures of social and cultural capital, and introduce them into future wealth measures.
23 One might have an equally difficult time arguing inclusive wealth is a measure of social inclusivity.

three types of capital: manufactured or physical, human and natural. Its objective is that of measuring a nation's capacity to create and maintain human well-being over time. A country's IW is the social value (as contrasted with the market value) of all its capital assets, including natural capital, human capital and produced capital. If a country's IWI is non-decreasing over time, we say its growth is sustainable. The implication being that the average household in the future will be no worse off than households today.

Manufactured capital is the physical capital produced by humans – automobiles, roads, buildings, etc. Human capital is often defined as the stock of knowledge and skills possessed by a population, and the health status of that population. Investments in education, training and health are called investments in human capital.[24] Natural capital can be viewed as the stocks of natural assets, ranging from soil, water and air, to all living things.

The wide range of services natural capital provides are called ecosystem services, some of which are provisioning services like fuel from wood, cooking water from streams and lakes, and food from agricultural production. In developing countries, the poor and other economically vulnerable groups are highly dependent on ecosystem services for their livelihoods, with natural capital accounting for 36 percent of wealth in low-income countries (WAVES, 2012).

In addition to the provisioning service flows that directly support human life, there are less visible ecosystem services that come within the purview of regulating, habitat and supporting, and cultural functions. Although these services can be just as important – in some cases, essential – for human well-being, their contributions typically fall outside the domain of market valuation. Examples of regulating services include a forest's contribution to flood control and climate regulation, or its carbon storage services – each of which may be intangible from an economic standpoint, but undeniably valuable to humans, animals and other life forms. Despite the importance of the regulating and sustaining services to human well-being, the value of the services or the natural capital that produce them are seldom measured.

One could argue that, traditionally, economic policymakers focused on efficient production (e.g. eliminating subsidies, curtailing trade barriers) and increasing per capita GDP growth. The thinking was that efficiency and growth would increase the size of the economy, and the larger the economy, the more goods and services available for social consumption. Such productive activities, however, were often accompanied by negative externalities like air and water pollution. As the negative impact of the environmental externalities became more apparent, and were documented with verifiable statistics, many countries adjusted their industrial policies to lessen the levels and impact of the externalities. Still, in spite of these efforts, air pollution levels in cities across the globe provide evidence of the continued negative side effects of modern economic production.[25] Furthermore, the impacts of environmental degradation on health and recreational quality have not yet made their way into any well-known economic indices.

We have come to a similar point with natural resource and ecosystem management: a more clear understanding – and acceptance – of the potential problems associated with natural resource and ecosystem degradation has led to efforts to collect data that eventually should help better manage ecosystems and increasingly scarce natural resources. Data such as water stocks and qualities, soil depth, forested area and carbon sequestration are beginning to enter national account tables via the United Nations System of Environmental-Economic Accounting (SEEA).[26] The hope is to eventually use the natural resource stock levels to calculate natural resources, and possibly ecosystem services, stocks and flow value indices.

2.2.2. Why a wealth-based index of sustainability?

Typically, if per capita GDP growth is non-negative, decision makers assume the economy is doing well. The following example, however, illustrates this assumption could be misleading. Table 2.1 presents hypothetical levels of physical, human and natural capital for an (closed) economy, along with unit flow and unit stock prices. For simplicity, assume the economy produces a single final good, and that producing a unit of the final good takes one year, and requires one unit of natural capital, 40 units of physical capital and 0.006 units of labour.[27] The reader can verify that, given the factor endowments in Table 2.1, the maximum amount of the final good the economy can produce over the year is 250,000 units. In such a case, given the unit rental rates of capital and labour, and assuming the unit cost of the unit price of timber is $20; the economy's GDP is $9 million. The initial value of IW is equal to the sum of the stock values of physical, human and natural capital: $1x10,000,000 + $400,000x150 + $20x1,000,000 = $90,000,000.

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24 See http://www.econlib.org/library/Enc/HumanCapital.html for a short discussion by Becker on human capital.
25 For example, see http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/ for historical data on air pollution, and https://waqi.info/ for real-time (current) air quality data.
26 For more information, see https://unstats.un.org/unsd/envaccounting/seea.asp.
27 This production structure – one unit of natural capital, 40 units of physical capital and 0.006 units of labour – is often referred to as a fixed coefficient or Leon tief production function.

Table 2.1: Productive base – capital quantities, unit flow and stock values, GDP and inclusive wealth

Factor	Quantity	Unit Cost	Unit Value Stock	Flow Value	Initial Value Stock
Physical capital	10,000,000	$0.10	$1.00	$1,000,000	$10,000,000
Human Capital	150	$20,000	$400,000	$3,000,000	$60,000,000
Natural Capital	1,000,000	$20	$20	$5,000,000	$20,000,000
GDP	-	-	-	$9,000,000	-
Inclusive Wealth	-	-	-	-	$90,000,000

To keep calculations simple, assume physical and human capital does not depreciate, and the economy never replaces the natural capital used over the year. Then GDP in the subsequent year would also be equal to $9 million. However, since the economy used 250,000 units of natural capital, its capital stock would be equal to 750,000 and its IW equal to $85 million. In this simple example, the economy could generate $9 million in GDP for four years. On the other hand, IW per capita is falling over time – hence, the economy's growth pattern is not sustainable.

In this example, GDP does not change and provides no indication the economy is approaching a cliff. The inclusive wealth measure, however, provides a warning, as IW falls over the period. As a sustainability index, it appears the Inclusive Wealth Index (IWI) is superior to GDP (and any current measure of income changes). As such, the example illustrates why we might want to focus on wealth-based measures of sustainability. For an elegant mathematical argument underlying the superiority of wealth-based sustainability measures, see Dasgupta, (2009).

Of course, with no trade, and given the fixed coefficient production structure, the economy would be unable to produce any of the final good in the fifth year. This example, of course is highly stylized, but does show what can happen to a region in a country if an essential natural resource is improperly managed and if one ignores sustainability concerns. An extremely relevant example is the Aral Sea debacle, where water diversions for cotton and rice production caused the surface area of the Aral Sea to shrink to the extent that ships could no longer reach the cities on its shores – transforming a once economically vibrant water body into one with virtually no economic value.

2.2.3. Substitution and sustainability indices

The GDP and inclusive wealth pattern in the above example occurs because the assumed production technology did not allow input substitution – for example, it did not allow the economy to use more human capital and less natural capital and get the same level of output. If it was possible to produce income without natural capital, or produce the same level of output with less natural capital and more human or physical capital, the economy or region could continue generating income as natural capital levels fell. This issue of substitution possibilities for natural capital is central to an ongoing discourse on policy formulation for sustainable development.

Many economists assume technological advances will offset the potential fall in productivity due to natural capital losses. This view implicitly assumes human and physical capital can serve as substitutes for natural capital. On the other hand, many ecological scientists assume the substitution possibilities among human, physical and natural capital are limited, and that natural capital stocks impose a limit on productivity: this notion borrows from the concept of carrying capacity (Ehrlich and Pringle, 2008). The ecologists implicitly assume a shrinking natural capital base implies a decreasing level of potential productivity – maintaining the life support system of the earth is required to ensure sustainability.

Concerns with the substitutability of natural, human and physical capital influence the way we define and measure sustainability indices. Two broad classes of sustainability indices exist. One class assumes human and physical capital is unable to serve as a substitute for natural capital. Strong sustainability goals are linked to such restrictions. A sustainability index designed to satisfy strong sustainability goals would likely require the level of natural capital stocks per capita to not fall over time, and a separate index of human and physical capital per capita to not fall over time.

The other class of sustainability indices accommodates substitution between natural, human and physical capital. Weak sustainability goals are linked to these requirements. The IWI is a single index composed of the values of human, physical and natural capital and yields a weak sustainability index. By construction, it allows for an increase in IW (per capita) in the face of natural capital depreciation – it can increase as long as the decrease in natural capital stocks is offset by enough of an increase in human and physical capital stocks.

Combining, or reconciling, the economists' and ecologists' perspectives should be possible if the context and character of resources are known. The ecologists' notions of substitution and sustainability are captured in the Aral Sea debacle, where there are no substitution possibilities across human, physical and natural capital. An island tourism economy, on the other hand, is an example of how substitution could lead to an opposite outcome. Say an island's growth is linked to water recreation activities and, over time, loses natural capital through the degradation of its coral reef system. If the island invests in casinos and associated activities, it is possible the increase in physical and human capital could lead to an outcome where IW per capita increases over time.

Some types of natural capital have little or no human or physical capital alternatives. In poor nations the ability of climate conditions to control vector borne diseases may be limited. The regulative services inherent in nutrient cycling, soil formation and bioremediation also likely have few human and physical capital alternatives. The capital underlying these services is referred to as critical capital. If one could identify and measure critical capital, and monitor the levels and growth of that capital, it might be possible to develop a sustainability index of critical capital, but it is unlikely a market value of the capital would enter GDP measures anytime soon.

The Aral Sea, island tourism and critical capital examples suggest that the degree of ease with which an economy can substitute human or physical capital for natural capital will determine whether a strong or weak sustainability criteria is appropriate. Initial empirical studies suggest substitution possibilities exist for a wide range of production scenarios (Markandya and Pedroso-Galinato, 2007).

The IWR also suggests that, over the past 20 years, for over 100 countries, the negative wealth effects of a decline in natural capital have been offset by growth in human and physical capital. However, the emergence of concepts like critical natural capital and regulating services of ecosystems, and their role in sustaining the extremely impoverished, suggests there remains significant deficiencies in our current crop of sustainability indices. For instance, like GDP, the IWI has very little to say about income distribution and its impact on social welfare.

The IWI has the potential to measure a nation's wealth in terms of economic progress and long-term sustainability. It measures the wealth of nations via implementing an analysis of a country's productive base. The value of the productive base provides an index of an economy's production potential: if the IWI increases over time, it signals the economy is making economic progress much the same way that per capita GDP does. If the health and human capital component of the IWI increases, it provides a signal that human well-being is improving as well. An increasing IWI also suggests past and current consumption does not come at the cost of future generations' consumption potential.

Using the IWI can scale up resource efficiency – by providing policymakers with an overview of changes in the productive base of a country. It provides insights into trends within the capital asset groups, particularly human and natural capital – the central pillars of IW that remain underserved by current statistical collection efforts, and economic and policymaking analysis. The IWI can provide insights into whether current growth is sustainable or is based on overexploiting natural capital. This information can help develop policy better suited to sustaining growth while better managing human and natural capital. For example, results from the 2014 IWR demonstrate that investing in human capital would be the most beneficial for countries with the highest rates of population growth. It also demonstrates the multiple benefits of investments in natural capital, in particular agricultural land and forests.

2.3. Wealth, Income, Growth and Sustainability

2.3.1. Inclusive wealth and growth accounting

Section 2.2 provides an overview of the rationale for preferring changes in wealth per capita over GDP per capita as an index of sustainability – although this does not mean we should assume GDP is devoid of policy relevance. We compared the per capital growth rates of IW and GDP for 121 countries, and found 47 averaged negative rates of growth in per capita IW over the years 1990 through 2010.

Table 2.2 reports the growth rates of the 47 countries, and reveals almost all of them are either developing or middle-income countries; 10 of the countries also experienced negative per capita GDP growth over the 20-year period. Almost half of the countries in Table 2.2 are in sub-Saharan Africa. The remaining 74 countries experienced positive rates of growth in both per capita IW and per capita GDP (for a list of these countries, see Table 2A in the appendix to this chapter).

Table 2.2: Countries with negative (average) per capita growth rates* in inclusive wealth: 1990–2015

Country	Per Capita Growth in %		Country	Per Capita Growth in %		Country	Per Capita Growth in %	
	IWI	GDP		IWI	GDP		IWI	GDP
Burundi	-0.6	-8.0	Ecuador	-4.6	6.0	Nicaragua	-3.0	7.8
Cameroon	-8.4	-1.0	Ghana	-3.6	12.5	Nigeria	-8.6	15.9
Central African Rep.	-9.8	-1.0	Guyana	-0.5	20.4	Papua New Guinea	-12.8	9.2
Congo	-12.5	-13.9	Honduras	-3.0	5.8	Paraguay	-5.5	5.3
Côte d'Ivoire	-2.6	-4.1	Indonesia	-0.1	16.9	Peru	-2.8	17.4
Gabon	-8.1	-5.7	Iran	-3.5	14.7	Saudi Arabia	-6.5	1.7
Niger	-5.1	-2.1	Iraq	-13.7	12.2	Senegal	-5.0	4.5
Tajikistan*	-4.9	-1.0	Lao	-7.2	25.5	Sierra Leone	-4.2	0.7
UA Emirates	-13.9	-13.8	Liberia	-14.7	38.9	Sudan	-7.5	18.0
Zimbabwe	-5.4	-12.0	Malawi	-6.2	8.9	Tanzania	-10.9	9.7
Algeria	-3.6	6.4	Mali	-7.7	10.3	Trinidad & Tobago	-1.0	27.5
Belize	-6.6	11.4	Mongolia	-5.8	12.5	Uganda	-1.5	18.5
Benin	-6.0	5.6	Mozambique	-11.5	26.2	Venezuela	-5.3	3.6
Bolivia	-9.8	9.9	Myanmar	-6.3	50.9	Yemen	-1.9	7.7
Botswana	-0.9	13.3	Namibia	-3.8	10.5	Zambia	-11.1	10.1
Colombia	-0.5	9.9	Nepal	-7.5	13.5			

** Note: reported averages are 5-year averages, e.g. (GDP_{1995} – GDP_{1990})/GDP_{1990}.*
Sources: This report and the World Bank Development Indicators.

Often, macroeconomists use an analytical tool called growth accounting to gain insight into economic growth dynamics. This tool can also be used to understand inclusive wealth dynamics; albeit growth accounting only provides a clearer understanding of what contributes to growth – it does not imply causality. Before writing the growth accounting expression, consider the following definitions: Let *At* denote the value of IW at time t – a proxy for the aggregate value of physical capital, human capital and natural capital. Let *Kt* , *Ht* and *Nt* denote the levels of physical capital, human capital and natural capital (respectively) at time t. Let *Pk* , *Ph* and *Pn* denote the (respective) unit prices of physical, human and natural capital – to keep subsequent notation simply, these prices are assumed constant over time. Given this notation, we write IW as:

$$A_t = P_K K_t + P_H H_t + P_N N_t$$

Given our IWI is defined in per capita terms, divide both sides of this equation by population, which we denote by *Lt*. Reasonably straightforward algebraic manipulations yield the following inclusive wealth growth accounting expression:[28]

$$\frac{\dot{a}_t}{a_t} = \alpha_{K,t}\left(\frac{\dot{K}_t}{K_t} - \frac{\dot{L}_t}{L_t}\right) + \alpha_{H,t}\left(\frac{\dot{H}_t}{H_t} - \frac{\dot{L}_t}{L_t}\right) + \alpha_{N,t}\left(\frac{\dot{N}_t}{N_t} - \frac{\dot{L}_t}{L_t}\right)$$

(1)

Here is the (instantaneous) change in the level of IW per capita. The remaining "dotted" variables represent the change in that variable given a change in time— e.g. *Kt* is the instantaneous change in the physical capital. The following variables are inclusive wealth value shares at time t; $\alpha_{K,t} = P_K K_t / A_t$ is physical capital's share of IW; $\alpha_{H,t} = P_H H_t / A_t$ is human capital's share of IW; $\alpha_{N,t} = P_N N_t / A_t$ and is natural capital's share of IW. The three shares sum to unity. Finally, the term $\dot{a}_t / a_t$ is the (instantaneous) rate of growth in IW per capita – analogous definitions extend to the remaining variables, e.g. $\dot{L}_t / l_t$ is the rate of growth in population.

Equation (1) reveals seven sources of IWI growth. One source is population growth, which puts downward pressure on the IWI. Between 1990 and 2015, the average annual rate of population growth in sub-Saharan Africa was 2.7 percent, as compared to less than 1 percent annual growth in the OECD countries. Hence, even if a country did not overexploit its natural resource base, high population growth rates could explain a large part of a pattern of unsustainable growth.

Changes in physical, human and natural capital account for three more sources of IWI growth. An increase in the stock of physical and human capital occurs when a nation invests enough of its income (GDP) to yield a net increase in physical or human capital.

For example, when investment in physical capital is greater than the amount lost through depreciation, then physical capital growth contributes positively to IWI growth. Investments in agricultural extension training can lead to soil conservation and lower levels of natural resource degradation, as could training in forest management – both forms of human capital investment. What we hope is clear is that, even if an economy is experiencing a decline in natural resource stocks, the IWI index can increase if the economy reinvests enough of its income to increase its physical and human capital stocks.

The remaining three potential influences on IWI growth are the inclusive wealth asset shares. Consider two countries, both of whom are depleting their natural resource base. All else equal, the country with the larger natural capital share will have the larger fall in its IWI. An implication for development is, arguably, the inclusive wealth share of natural resources in most developing countries will be higher than that for a typical developed country. If this is the case, to support sustainable development a developing country will likely need larger rates of growth in physical (and human) capital stocks than the typical developed country. If the natural resource share in one country is 5 percent and the physical capital share is 50 percent, a 10 percent fall in natural capital stocks can be offset by a 1 percent increase in physical capital. On the other hand, if the natural resource share in the country is 20 percent and the physical capital share is 50 percent, the country would need a 4 percent increase in the capital stock to offset a 10 percent fall in natural capital.

Table 2.3: Malawi inclusive wealth growth accounting

Asset Type	2005 US $ per capita					5-year Growth			
	1990	1995	2000	2005	2010	1995	2000	2005	2010
Human	1,505	1,488	1,504	1,571	1,576	-0.011	0.011	0.045	0.003
Physical	889	871	749	671	789	-0.020	-0.140	-0.104	0.176
Natural	2,499	2,287	1,983	1,690	1,414	-0.085	-0.133	-0.148	-0.163
Inclusive Wealth	4,893	4,646	4,236	3,932	3,779	-0.050	-0.088	-0.072	-0.039
	Inclusive Wealth Shares					Contributions to IWI growth			
Human	0.308	0.320	0.355	0.400	0.417	-0.003	0.003	0.016	0.001
Physical	0.182	0.187	0.177	0.171	0.209	-0.004	-0.026	-0.018	0.030
Natural	0.511	0.492	0.468	0.430	0.374	-0.043	-0.065	-0.069	-0.070

28 For the empirical exercises conducted in prior chapters, the change in time is a year, not instantaneous as depicted in this section. A rough approximation of equation (1) using discrete time is

$$\Delta a_t = \alpha_{K,t}\left(\frac{\Delta K_t}{K_t} - \frac{\Delta L_t}{L_t}\right) + \alpha_{H,t}\left(\frac{\Delta H_t}{H_t} - \frac{\Delta L_t}{L_t}\right) + \alpha_{N,t}\left(\frac{\Delta N_t}{N_t} - \frac{\Delta L_t}{L_t}\right)$$

Returning to Table 2.2, for almost all 47 countries, natural resources serve as an important source of GDP, and one can safely assume that the fall in per capita IW is linked directly to natural resource extraction (e.g. minerals and oil) or harvesting (e.g. forests). Also, population growth is high in most of the countries, which further serves to hamper sustainable growth. Finally, at least for the developing countries in the list, natural resource shares are likely quite high. Hence, in spite of the relatively high rates of GDP growth experienced by some of the countries, these factors combine to make sustainable growth a difficult objective to achieve. Table 2.3 provides an example of inclusive wealth growth accounting for Malawi. Note, natural capital accounts for over 50 percent of Malawi's IW in 1990, and falls to 37 percent by 2010. The rates of growth in human capital is very low relative to the rates of decline in natural capital, as are the rates of growth in physical capital. These factors all contribute to the unsustainable wealth trajectory for the country.

As for the 74 countries in the appendix (Table 2A), even if a county's natural capital stocks are falling, its reinvestment in physical and human capital more than offsets the wealth lost through depleted natural assets. The result being an increase in IW, and hence, what appears to be a sustainable growth trajectory. Table 2.4 reports inclusive growth accounting figures for China. China begins with a natural capital share of 42 percent in 1990, which falls to 21 percent by 2010. Note, however, the rates of growth in human and physical capital stocks (relative to the decline in natural capital stocks). This reinvestment in human and physical capital is one of the reasons China's IWI has outperformed all other countries.

Table 2.4: China inclusive wealth growth accounting

Asset Type	2005 US $ per capita					5-year Growth			
	1990	1995	2000	2005	2010	1995	2000	2005	2010
Human	8,043	8,620	9,138	9,504	10,025	0.072	0.060	0.040	0.055
Physical	1,369	1,995	3,123	5,044	8,748	0.457	0.565	0.615	0.734
Natural	6,805	6,355	5,882	5,429	5,061	-0.066	-0.074	-0.077	-0.068
Inclusive Wealth	16,217	16,970	18,143	19,977	23,834	0.046	0.069	0.101	0.193
	Inclusive Wealth Shares					Contributions to IWI growth			
Human	0.496	0.508	0.504	0.476	0.421	0.036	0.031	0.020	0.026
Physical	0.084	0.118	0.172	0.252	0.367	0.039	0.066	0.106	0.185
Natural	0.420	0.374	0.324	0.272	0.212	-0.028	-0.028	-0.025	-0.018

2.4. Wealth and the Sustainable Development Goals (SDGs)

Unlike the Millennium Development Goals, which were more focused on achieving specific development targets for developing nations, the proposed SDGs[29] are truly global in nature. Applicable to all nations, developing or developed, the SDGs emerged from an evolving and collaborative process, representing collective aspirations, while taking into account different national realities, capacities and levels of development. Rooted in the outcome document, *The Future We Want*, from the Rio+20 summit in 2012, the SDGs were promulgated to reflect the pursuit of all three dimensions of sustainable development - social, economic and environmental. Through Rio+20, the Open Working Group was formed with representatives from 70 countries, which by July 2014 had published a draft with a set of 17 goals and 169 targets. Assessing and valuing natural capital and the change in per capita inclusive/comprehensive wealth over time has the potential to keep track of progress on most SDGs.

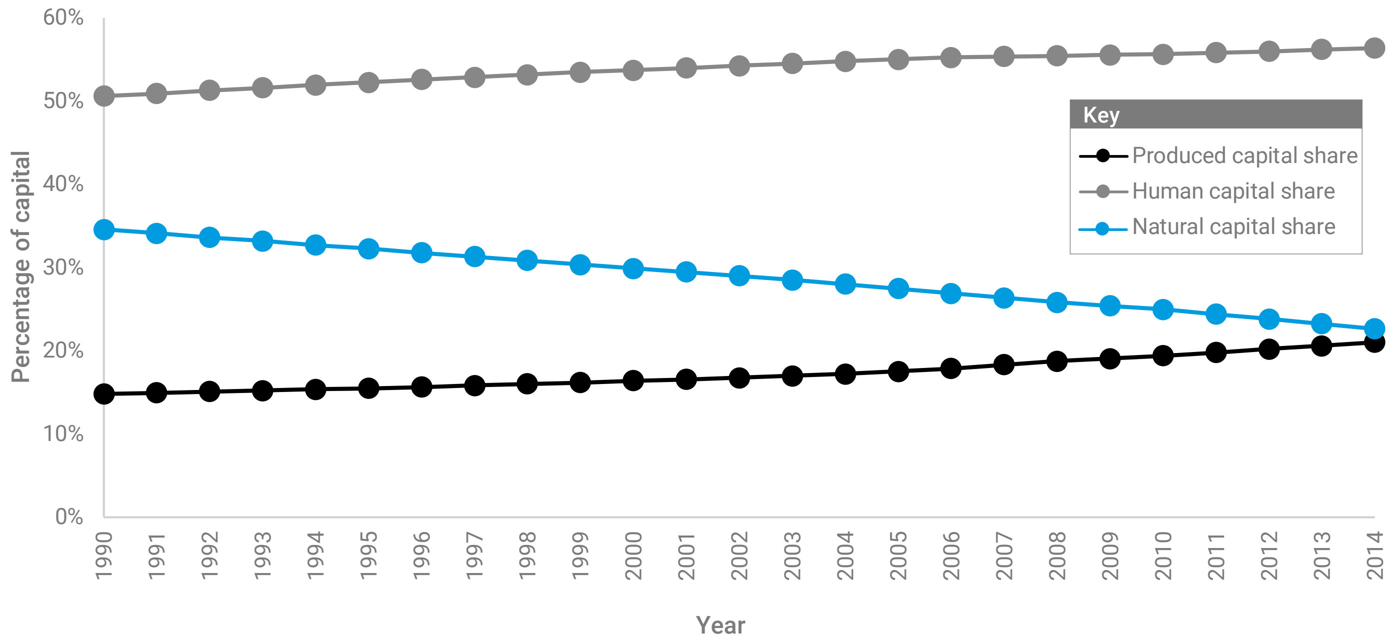
The IWI is a multi-purpose, multi-target measure of sustainable development. An increase in the IWI will suggest poverty eradication (SDG, 1) and an improvement in food security, while promoting sustainable agriculture (SDG 2) and healthy lives and well-being (SDG 3). An increase in the IWI will also indicate sustained, but not necessarily inclusive economic growth (SDG 8), and sustainable consumption and production patterns (SDG 12). A decrease in the IWI will indicate degradation of natural capital and failure to take steps to combat climate change and its impacts (SGD 13), conserve and sustainably use the oceans, seas and marine resources (SDG 14), protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, reverse land degradation and halt biodiversity loss (SDG 15). The IWI can measure the strength of the means of implementation for sustainable development (SDG 17).

The IWI has a specific role to play in complementing SDG Target 8.1, which is currently measured by GDP growth, with a target of 7 percent per year (a measure of growth in the level of transactions). The IWI complements this by emphasizing the growth of wealth – something that is much better aligned with the SDGs as the indicators and targets clearly link sustainability with the productive base of the economy: water, air, soil and other natural assets.

The environmental dimension of the SDGs is very explicit. Most of the targets are directly or indirectly related to the status of natural capital. The overarching message from the 2030 Agenda is for nations to keep their natural capital stocks intact. Since GDP does not track natural capital levels, it will most certainly be inadequate for managing these resources. Fig 2.1 highlights one conclusion we can draw from the chapters in this volume: that natural capital's share in IW has fallen since 1990, while the share of human capital and physical capital have steadily increased. Under a weak substitutability criteria, the world has been experiencing sustainable growth. Our guess, however, is the world likely would not satisfy sustainability under a strong substitutability criteria.

29 See Appendix for a full list of Sustainable Development Goals and targets. See further at: https://sustainabledevelopment.un.org/sdgsproposal

Fig 2.1: Global trend in human (HC), natural (NC) and physical (PC) capital shares



One of the core strengths of the SDGs is its recognition of the complex interlinkages that prevail among human well-being, economic prosperity and a healthy natural habitat. Thus, as we move towards exploring more sustainable ways of developing, we need forms of measure that reflect such objectives. In this regard, an indicator or a bundle of indicators that can reflect such interlinkages, connectivity and causality by recognizing impact on sustainability and inclusivity, are key to measuring long-term progress.

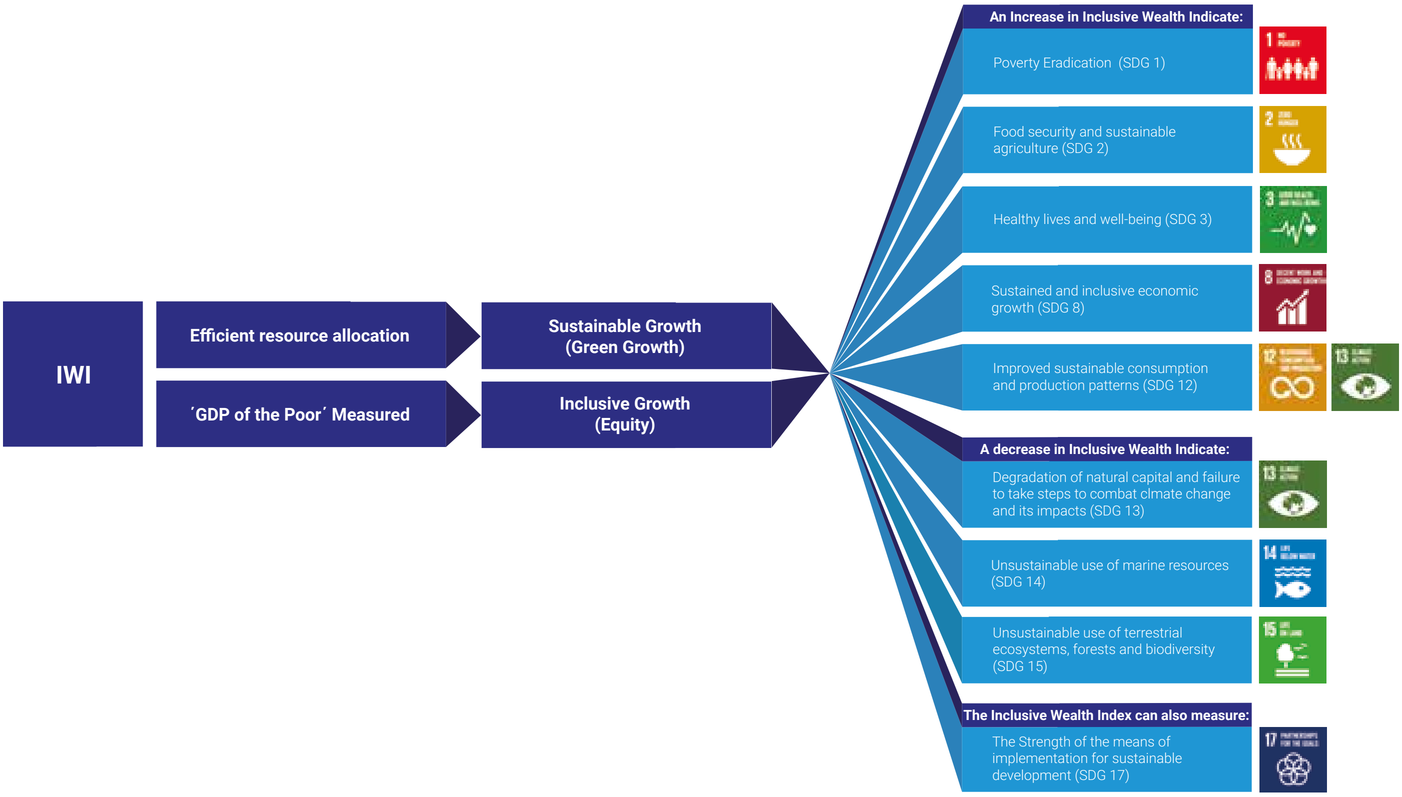
2.4.1. Inclusive Wealth Index – sustainability and inclusivity

By incorporating changes in human and natural capital alongside the existing measures of produced capital, namely GDP, the IWI provides a balance sheet for nations that offers them a more comprehensive view of their asset endowments. Fundamentally, the approach aims to address the major policy gaps that exist on growth and development that fail to address issues of sustainability, natural resource depletion and human well-being.

The 2014 IWR assessed data from 140 countries over a span of 20 years and observed changes in produced capital, human capital and natural capital. The aggregate data suggests that while GDP and the HDI made significant strides over the period, natural capital declined in 127 of the 140 countries. Such analysis through the IWI enables countries to monitor their comprehensive capital pool and push for greater action and accountability and the pursuit of more sustainable pathways.

Assessing and valuing natural capital and the change in per capita inclusive/comprehensive wealth over time has the potential to keep track of progress on several SDGs. Fig 2.2 illustrates.

Fig 2.2: Institutional Framework for IWI and Sustainable Development Goals (SDGs)



The IWI has a specific role to play in tracking SDGs and related targets 1, 2, 3 and 8.1. The IWI complements the current target provided by technical work of the SDGs, of 7 percent per year in GDP (a measure of growth in the level of transactions) as the wealth estimates would keep track of the base from which income is generated. The wealth estimate is much better aligned with the SDGs as they are more reliable about information on the productive base of the economy.

The IWI's key strength lies in its potential to serve as an indicator for guiding sustainable development policy. The Inclusive Wealth can inform planning and investment decisions that promote a low-carbon, resource efficient and socially inclusive economy. Wealth estimates organize information on various types of wealth and the trade-offs between them. As the estimates in this volume suggest, a number of countries are recording growth in human capital at the cost of natural capital (unsustainable agriculture and industrialization leading to better ports, roads and infrastructure, at least in the short run). Unlike GDP, information on wealth can also be used as an instrument for designing more efficient and effective policy reforms and regulation changes that act as a catalyst for sustainable investment and development pathways.

Recognizing the importance of natural capital – for poorer members of society and for the broader economy – can inform planning and policy decisions that prioritize investing in natural capital as a way of reinvesting in wealth. Inter alia, fighting poverty is conditional on the sustainable management of land. Without managing our natural resources, such as agricultural land, forests and fish stocks, we will not be able to ensure sustainable economic growth and an inclusive green economy (UNEP, 2015).

However, in order to monitor progress towards the SDGs, we must be equipped with appropriate benchmark data, be capable of assessing progress from one year to the next, and have a meaningful way to compare progress across countries. Such analysis, through universally accepted indicators and statistical frameworks, is key to understanding how the globe is faring. Significant data gaps exist, however, specifically with regards to natural capital measurement. As data is a key building block in the development framework, we must explore: 1) how innovation in information technology and existing data infrastructures can be aligned to produce improved development data; 2) how participatory mechanisms, and qualitative methods and knowledge can strengthen quantitative information to enhance our understanding; and 3) disaggregating data to enable more nuanced insights into the inequalities and challenges faced by particular groups within a given economy.

Moreover, the new sustainability indicators that emerged over the past decade – including the IWI – have pushed the envelope and called for a re-imagination of how we define and measure progress. Although these indicators are the results of efforts to capture the three domains of sustainable development – economic, social and political – it is important to more clearly identify and understand the links, inter-dynamics and causality between these domains. Indeed, this is an area of work not limited to economists or statisticians, but entails the involvement of policy analysts, academics and development practitioners from diverse fields. In order to support all these initiatives, indices and measurement of SDG performance, there is a fundamental need for policy coherence. Building capacities for integrated policy and data assessment, as well as coherence and coordination among strategies to achieve the SDGs, can allow for mutual co-benefits and avoid any counterproductive results.

Nonetheless, it is important to acknowledge and appreciate the political processes thus far that have led to the culmination of the SDGs. Fundamentally, the SDGs and their widespread acceptance will not only represent the aspirations of both the developed and developing worlds but will reflect their mutual meeting ground. It is imperative that we continue to work past the challenges that may arise, and strive to make the three common foundational principles of the SDGs – leave no one behind; ensure equity and dignity for all; and achieve prosperity within earth's safe and restored operating space (UNEP, 2015) – a reality.

2.5. Inclusive Wealth and Conservation Policies

A large literature exists that argues the current System of National Accounts (SNA) undervalues natural capital and its contributions to human well-being. In such cases, policies aimed at protecting natural capital will, at best be fraught with inefficiencies, and likely lead to sub-optimal resource allocations. The inclusive wealth account can serve as a key tool in designing more efficient and effective environmentally sustainable policies that underpin economic and social progress, and overall sustainable development imperatives. This section discusses how the IWR can be used to inform policy decisions related to the conservation of natural capital, with a specific focus on forests, air pollution and fisheries.

2.5.1. Inclusive wealth and forestry policy

As demonstrated in Chapter 6, in many countries, forests comprise a major share of their capital stocks, and are a source of a range of vital ecosystem services: provisioning services (e.g. food, fuel and fibre); regulating services (e.g. carbon regulation); supporting services (e.g. biodiversity conservation); and cultural services (e.g. recreation and tourism) (MA, 2005). Yet in many countries, the current SNA does not adequately account for the contributions of forest capital to watershed protection, carbon storage and biodiversity conservation, as well as a factor of production in other sectors of the economy.

Under the IWR, the value of forest capital is calculated as the present value of the future net benefits expected over the life of a forest resource. It integrates the contributions of a wide range of forest services, although current data limitations preclude a full accounting of all contributions. The forest capital component of the IWR can serve as an indicator of whether forest resources are being used sustainably for present and future generations. This information could be used to move resource managers and country authorities towards policy options aimed at: (i) managing trade-offs among competing forest uses; (ii) designing effective and efficient economic policy instruments (e.g. property rights, taxes and subsidies, creating markets for non-market forest services) and (iii) providing the basis for monitoring policy implementation and effectiveness (Lange, 2004).

Lange (2004, 2003) outlines six key policy questions related to managing forest resources or developing cross-sectoral policies that facilitate forest management. These policy questions underlie World Bank initiatives like WAVES (Wealth Accounting for Ecosystem Services). Given that policy uses and management options likely vary from country to country, we do not attempt to provide an exhaustive list of relevant questions and policy options. The remaining section outlines how the IWR and, in particular, the forest account component of the IWR could be used to inform some of these policy questions.

2.5.2. What is the total economic contribution of forests and forest ecosystems, and what are the potential benefits from sustainable management?

The forest capital component of the IWI takes into account a wide range of forest contributions and, therefore, reflects a more accurate approximation of the value of forest resources. Consequently, the value of forest capital is likely to be higher than that typically embedded in GDP calculations. This higher valuation should help forest resources gain wider recognition in macroeconomic policy deliberations: a higher value of forest contributions to GDP could potentially increase the forestry sector's bargaining power for a larger share of the national budget for forest management and investment.

2.5.1.1. How are benefits of forest resources distributed across society?

Presently, inclusive wealth measures provide country-level aggregate measures of forestry assets. However, it has been argued that a more robust accounting needs to distinguish the spatial productivity of different forest assets. For instance, it is important to distinguish between forest benefits that accrue to commercial users (e.g. hydroelectric power, municipalities, fisheries) and those that accrue to subsistence users (charcoal for heating and cooking), and between benefits that accrue to direct and indirect beneficiaries. It would also be useful to distinguish between forest benefits to local communities, downstream users, non-local communities and the global community (e.g. biodiversity and carbon storage).

The United Nations Framework for the SEEA highlights the importance of this information – particularly regarding optimal forest management aimed at meeting both economic and social objectives (e.g. local community preservation versus increased equity). Policy response may include designing economic instruments like property rights – ensuring that beneficiaries pay for the benefits (e.g. in the form of environmental fees) to compensate those who might be sacrificing the benefits. At watershed levels, the value of forest capital can be useful in designing Payment for Ecosystem Services schemes.

2.1.5.2. Is economic growth sustainable or is it based on the depletion of forests?

IW can be used for evaluating trade-offs between economic (GDP) growth and forest wealth. This information is a key indicator of whether economic growth across a range of countries for which data is available is sustainable, or if economic growth comes at the expense of declining forest wealth triggered by deforestation and land use change. This information would be useful for re-evaluating existing forestry and economy-wide policy options; for example:

1. Which sectors are the key contributors to economic growth?
2. How are these sectors linked to forestry resources and what are the potential impacts?
3. What are the costs of forest asset depletion?
4. Can available resources be re-allocated across sectors to achieve at least the same level of economic growth with minimal or no damage to the forestry sector?

2.1.5.3. What are the economic trade-offs among competing users and how can we optimize forest resource utilization?

Forest accounts from IW could help assess the trade-offs among competing users: for example, forestry versus agricultural land use, and commercial logging versus catchment protection. Assessing the level of economic trade-offs could help in the design of appropriate economic instruments to minimize losses tied to these trade-offs – instruments like user fees, compensating payments and property rights.

2.1.5.4. What are the impacts of other sectors' policies on forests?

Linking forestry values to other sectors and the wider economy would provide a convenient way of integrating forestry policy with national development, and monitoring interactions and feedback across different sectors. This would make it possible to measure the winners and losers, and measure pressures on forest capital coming from alternative macroeconomic or development policies. Potential conflicts – for example, between forestry versus agriculture – are relatively easy to identify (e.g. deforestation and cattle grazing). Policy response would include creating optimal forest management strategies aimed at addressing these conflicts. One set of strategies includes developing economic instruments like fees and compensating payments schemes to influence forest use. Another is to build social capital – for example, facilitate strategic alliances with stakeholders across sectors who are dependent on the forestry sector (agriculture, tourism, electric power and water). Table 2.5 further illustrates how information from forest accounts can be used to inform these questions and their corresponding policy linkages.

Table 2.5: Selected policy applications of forest accounts

Indicator/measure	Use for policy analysis	Examples of policies and actions taken from policy analysis
1. What is the total economic contribution of forests and what are the benefits from sustainable management		
Total value of forests including non-market forest goods and services.	More comprehensive, accurate value of forests' contribution to GDP.	Showing a higher value for forest contribution to GDP may increase the forestry sector's ability to request a larger share of national budget for forest management and investment.
Value of forest services to non forestry sectors.	Measure of the economic importance of forest services to agriculture, electricity, fisheries, tourism, municipal water supply, etc.	Design economic instruments to promote sustainable forest use, for example: • Institute conservation fee on water and hydroelectricity tariffs for downstream beneficiaries that can be used for forest management or to compensate local communities • Institute tourism fees for biodiversity conservation for forest management/ compensation of local communities • Negotiate international payments for carbon storage services of forests • Build multi-sectorial stakeholder alliances based on mutual benefits. • Identify institutional weaknesses in forest management, e.g. where one sector benefits but does not pay, or does not have a say in forest management.
Value of forest goods and services used by local communities.	Share of forest goods in rural livelihoods provides measure of dependence on forests of local communities.	Useful for design and implementation of PRSPs.
2. What is the distribution of forest benefits among different groups in society		
Share of forest benefits accruing to commercial, artisanal and subsistence users of forests Or Share accruing to local, downstream and global beneficiaries.	Identify social benefits from preservation of local communities and increased equity	• Identify potential conflicts, e.g. benefits to subsistence users/local communities are low because commercial / downstream users obtain benefits. • Design economic instruments so that beneficiaries pay for the benefits, compensating those who may sacrifice benefits. For example, property rights – some say over how a forest is managed – and fees for environmental services received. • Optimize investment in forests and forest infrastructure that balances social objectives for equity and regional development as well as economic objectives of maximizing national income.
3. Is economic growth sustainable or is it based on the depletion of forests?		
Value of forest assets and the cost of deforestation and forest degradation.	Macroeconomic indicators of sustainability (such as NDP, national wealth, asset depletion).	Reassess forest management if deforestation is occurring.

Indicator/measure	Use for policy analysis	Examples of policies and actions taken from policy analysis
4. What are the trade-offs among competing users of forests?		
Value of forest goods and services under alternative forest management options.	• Measure economic linkages between forestry and other sectors of the economy, upstream and downstream. • Identify the economic trade-offs among competing sectors.	• Optimize forest use and investment in forests and forest infrastructure by considering total economic value of forests, market and non market, including linkages to non-forestry sectors and impacts on all stakeholders, economy-wide. • Identify winners and losers. • Design appropriate economic instruments to achieve that strategy (fees, compensating payments, property rights, etc.).
5. What are the impacts of non-forestry policies on forest use?		
Analyze economic development scenarios that trace the full chain of causation from macroeconomic policy and/or non-forestry sector policies to their impact on forestry and land use.	• Assess the winners and losers, pressures on forests and forest users from alternative development strategies. • Identify potential conflicts between development objectives of forestry and those of other sectors, e.g. commercial logging vs. catchment protection (Ministry of Agriculture, Ministry of Energy, etc.). • Identify conflicts among divisions of the same ministry (Ministry of Agriculture), e.g. pastoralists' use of forest vs. downstream crop farmers.	• Identify winners and losers. • Identify optimal forest management strategy, based on addressing conflicts among ministries and within a single ministry. • Design appropriate economic instruments to achieve that strategy (fees, compensating payments, property rights, etc.).

Source: FAO. Policy Uses of Forest Accounts

2.6. Conclusions

National income, usually referred to as GDP, correlates strongly with national wealth. GDP provides information on levels of economic activities in the economy. However, a lot of critical information is missing in national accounts. Wealth accounting fills that gap. Wealth information (which includes all types of capital) also provides a better guide for measuring progress, trade-offs and sustainability.

One of the key aspects of wealth estimates is that they provide a robust methodology for valuing natural capital. This goes beyond mere transaction or exchange value, to capture externality aspects. The pricing for capital in inclusive wealth schemes uses a shadow pricing method, which is more reliable and scientifically credible.

The share of natural capital in the total wealth of a nation also depends on how well these assets are maintained, as the value of natural capital is directly related to institutions and the technological advancement of nations, which is reflected through rents from natural assets. The shadow pricing method is well equipped to capture these aspects.

There should be a regular estimate of wealth on a national scale to track the sustainability of the economy. Natural capital must take priority as it is likely to be pushed to the margins as there is no well-functioning market, especially in developing countries, to capture its contribution. The scale, unit and dimension of natural capital must be explicitly spelled out and conservation policies should be clearly linked with wealth and natural capital. At the institutional level, there should be a natural capital committee in every country to monitor and assess the trends. The committees should work closely with ministries of finance and development.

In order to examine the impact of trade reform and agricultural policies (such as subsidies), the ease with which one capital can substitute another should be estimated. This is known as the substitutability of capital – for example, produced capital for natural capital. In the case of critical natural capital, assessment and monitoring at the national scale is a must. Countries are in the process of designing the means to achieve the SDGs; a detailed mapping of the goals and targets should be done vis-à-vis natural capital.

Policies on protected areas (marine/terrestrial), forests, land degradation, climate change and biodiversity have a better prospect of being embraced by the public at large if their link with natural capital is properly delineated and understood.

Finally, wealth information can supplement the information in Systems of National Accounts, but eventually all macroeconomic policies and the allocation of resources should take cognizance of changes in net per capita wealth. This should serve as the key guide for sustainability and equity, including for various SDG targets.

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APPENDIX

** Note, reported averages are 5-year averages, e.g., (GDP_{1995} – GDP_{1990})/ GDP_{1990}.*

Sources: This report and the World Bank Development Indicators.

Table 2A: Countries with positive (average) per capita growth rates (percent)* in inclusive wealth: 1990–2015

Country	Per Capita Growth		Country	Per Capita Growth		Country	Per Capita Growth	
	IWI	GDP		IWI	GDP		IWI	GDP
Albania	3.9	23.1	Gambia	0.2	2.4	Norway	1.5	10.0
Argentina	1.6	15.1	Germany	7.6	6.6	Pakistan	3.2	8.9
Armenia	5.3	25.2	Greece	5.0	9.0	Panama	3.1	18.7
Australia	1.6	9.8	Guatemala	1.3	7.1	Philippines	2.5	8.9
Austria	5.8	8.5	Iceland	0.1	8.0	Poland	5.7	20.9
Bahrain	4.1	4.2	India	3.8	26.1	Portugal	5.2	8.0
Bangladesh	7.2	17.5	Ireland	7.9	21.6	Romania	5.3	13.1
Barbados	3.2	4.0	Israel	4.4	10.8	Russia	0.7	7.2
Belgium	5.3	7.6	Italy	4.1	4.0	Rwanda	3.3	14.2
Brazil	0.6	9.0	Jamaica	3.4	2.7	Singapore	9.7	20.5
Bulgaria	4.9	14.7	Japan	4.6	4.1	South Africa	0.5	5.3
Canada	1.4	6.9	Jordan	3.5	11.0	Spain	9.9	8.4
Chile	5.7	21.5	Kazakhstan	1.6	17.5	Sri Lanka	6.0	23.7
China	10.2	58.4	Kenya	1.0	1.2	Swaziland	1.6	8.0
Costa Rica	4.0	13.7	Kyrgyzstan	0.8	0.8	Sweden	3.2	8.8
Cuba	0.6	11.3	Lesotho	4.5	14.6	Switzerland	2.2	4.0
Cyprus	5.0	10.0	Luxembourg	7.7	12.6	Thailand	6.4	20.4
Czech Republic	5.8	9.5	Malaysia	2.2	19.4	Tunisia	5.7	16.9
Denmark	2.5	7.0	Malta	8.5	15.4	Turkey	4.6	12.1
Dom Republic	5.1	20.8	Mauritania	1.4	4.4	Ukraine	1.9	0.5
Egypt	3.3	13.8	Mauritius	6.6	21.3	UK	4.3	8.0
El Salvador	8.1	12.9	Mexico	4.6	5.7	Uruguay	3.8	15.3
Fiji	3.5	5.8	Morocco	5.6	13.6	USA	3.0	7.6
Finland	3.5	9.0	Netherlands	4.7	9.3	Vietnam	10.0	31.5
France	5.5	5.8	New Zealand	2.4	7.6			

Construction project, London, United Kingdom, Jamie Street on Unsplash.com

CHAPTER 3: MORE ON NATURAL WEALTH OF NATIONS AND REGIONS

Shunsuke Managi

3.1. Introduction

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

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

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

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

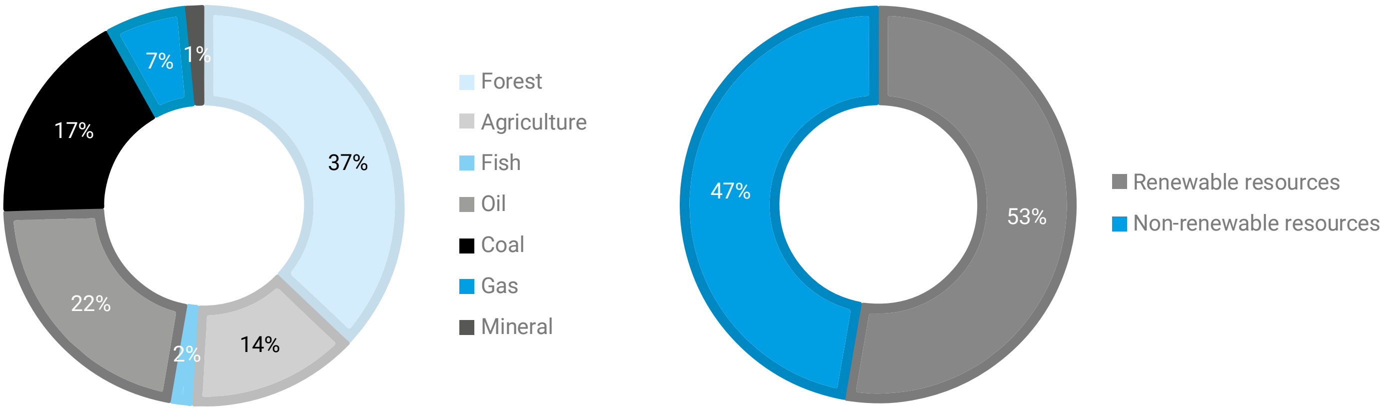
Natural capital also deserves special attention because it can collapse in a non-linear manner, with no advanced warning. This relates to the idea of thresholds and tipping points. Climate change is a prime example of this, which is why negotiations to set the 2-degree target in the Paris Agreement have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

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

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

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

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



3.2. The Natural Capital of Nations

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

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

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

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

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

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

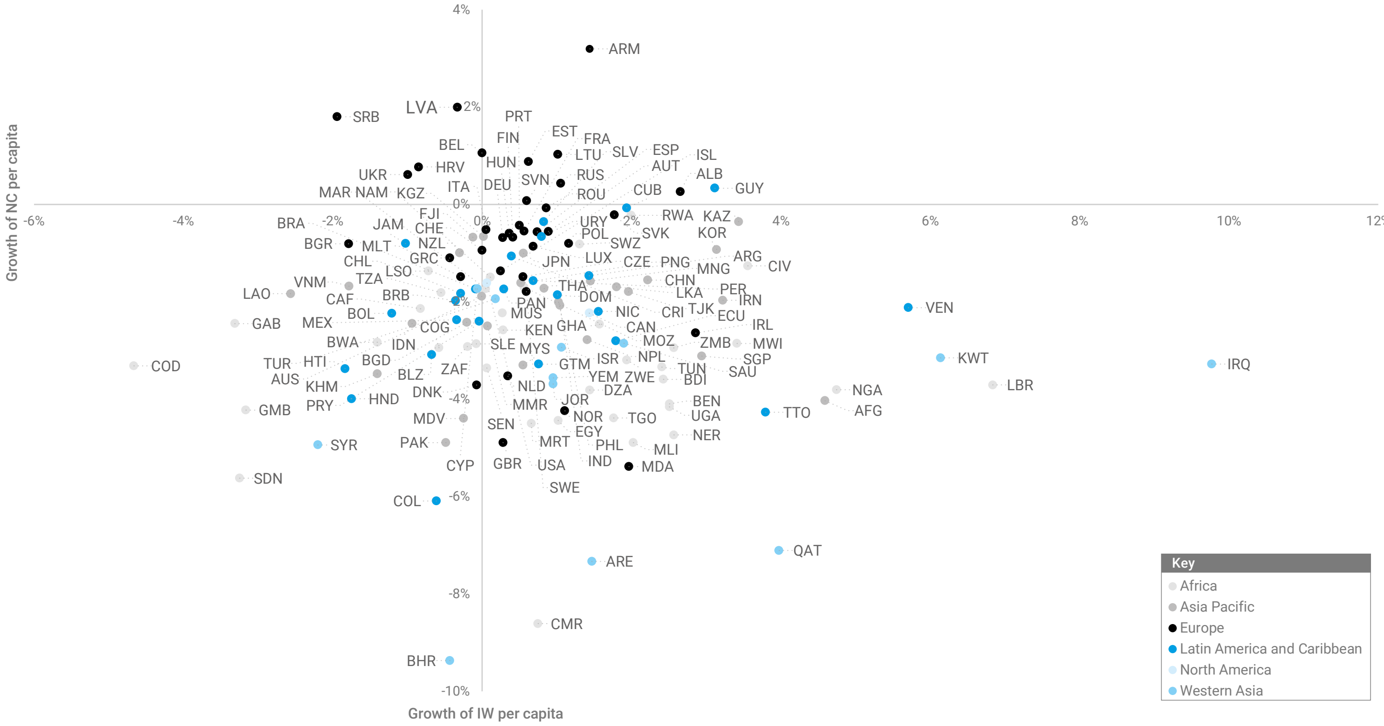
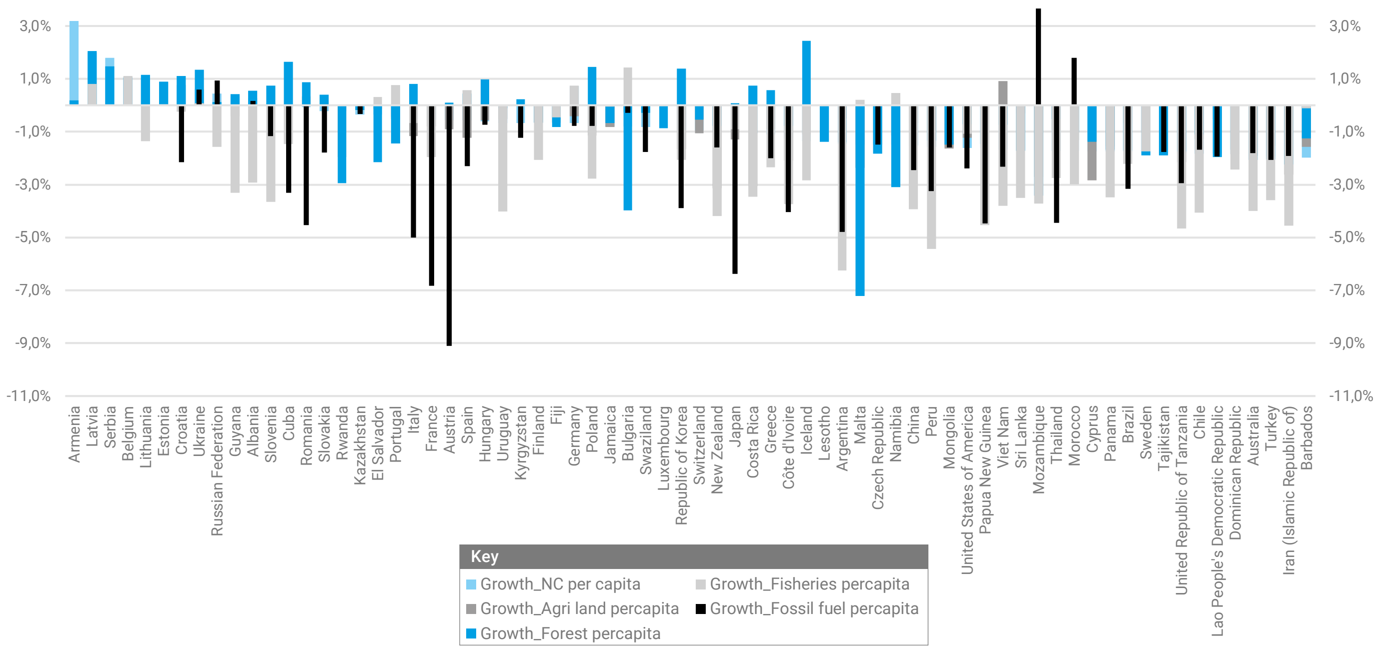
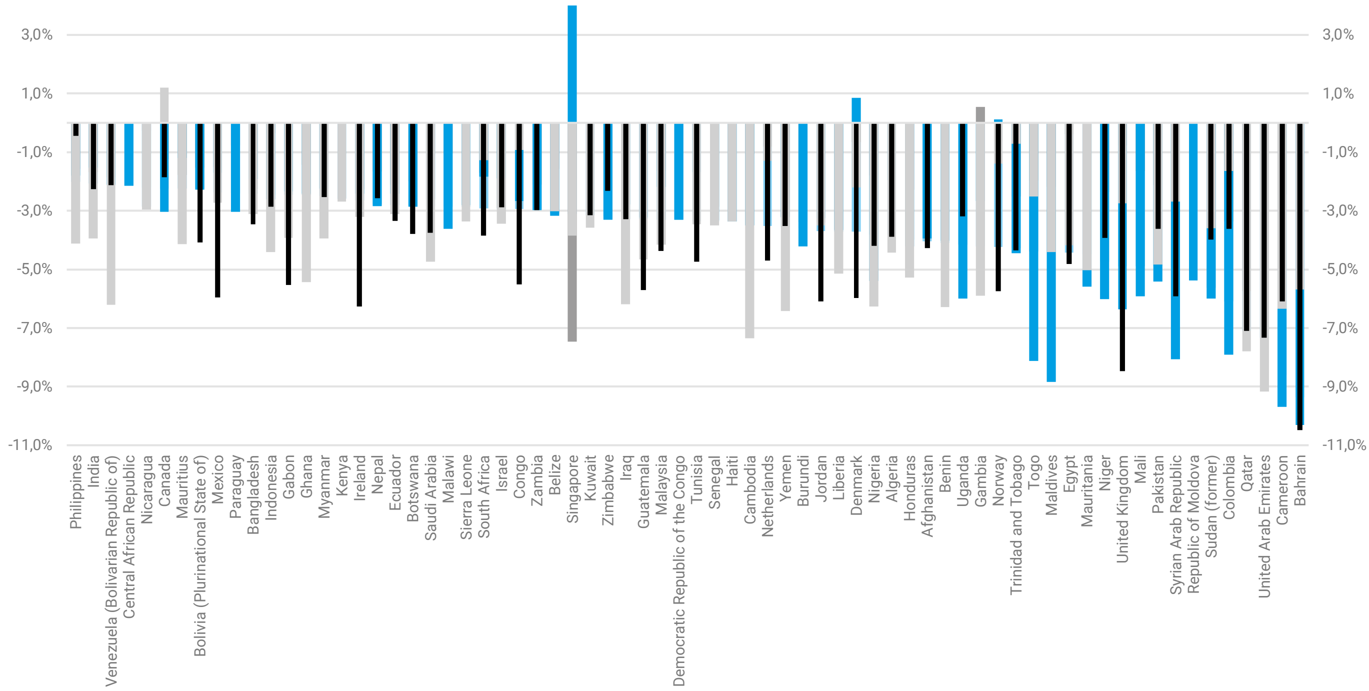


Fig 3.3 shows the trends for individual countries, providing a better understanding of the contribution of natural capital to sustainability. We disaggregated the annual average per capita growth rate of natural capitals, to identify the contribution of agricultural land, forests, fisheries and fossil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

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

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

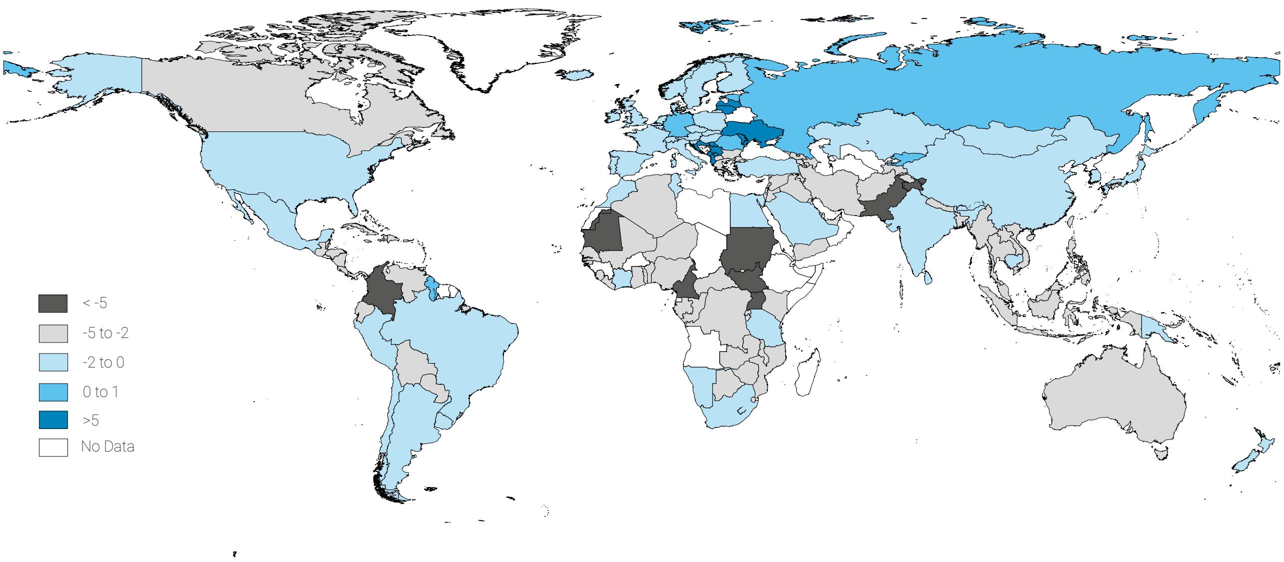




3.2.1. Renewable resources

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

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



3.2.1.1. Agricultural land

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

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

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

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

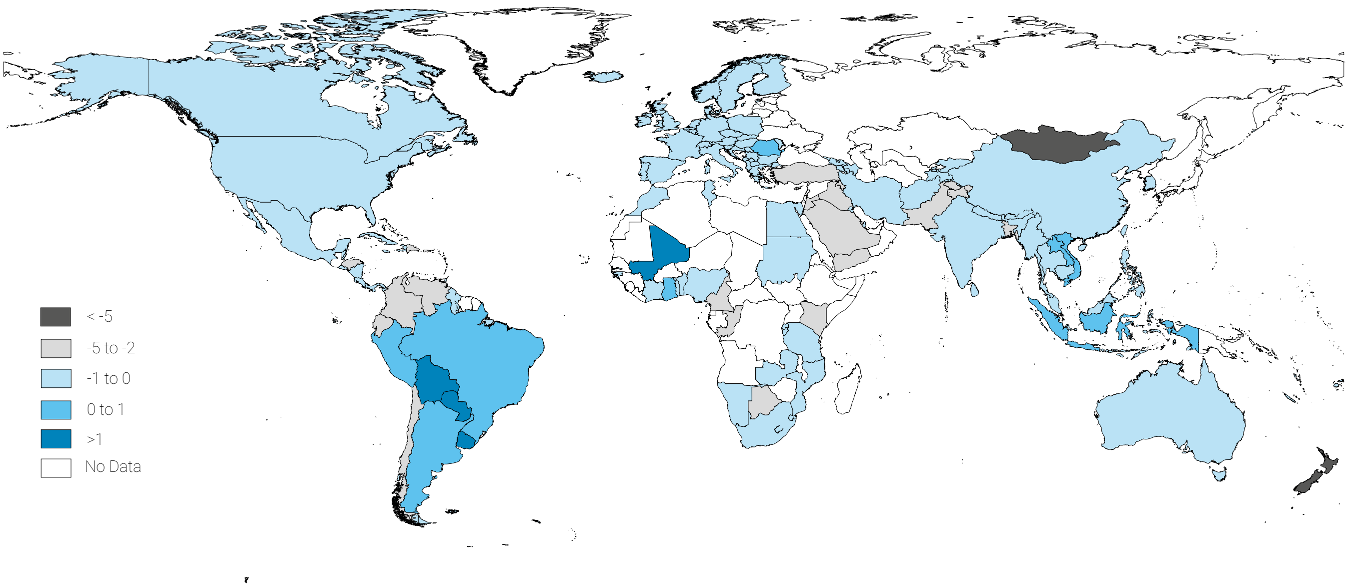
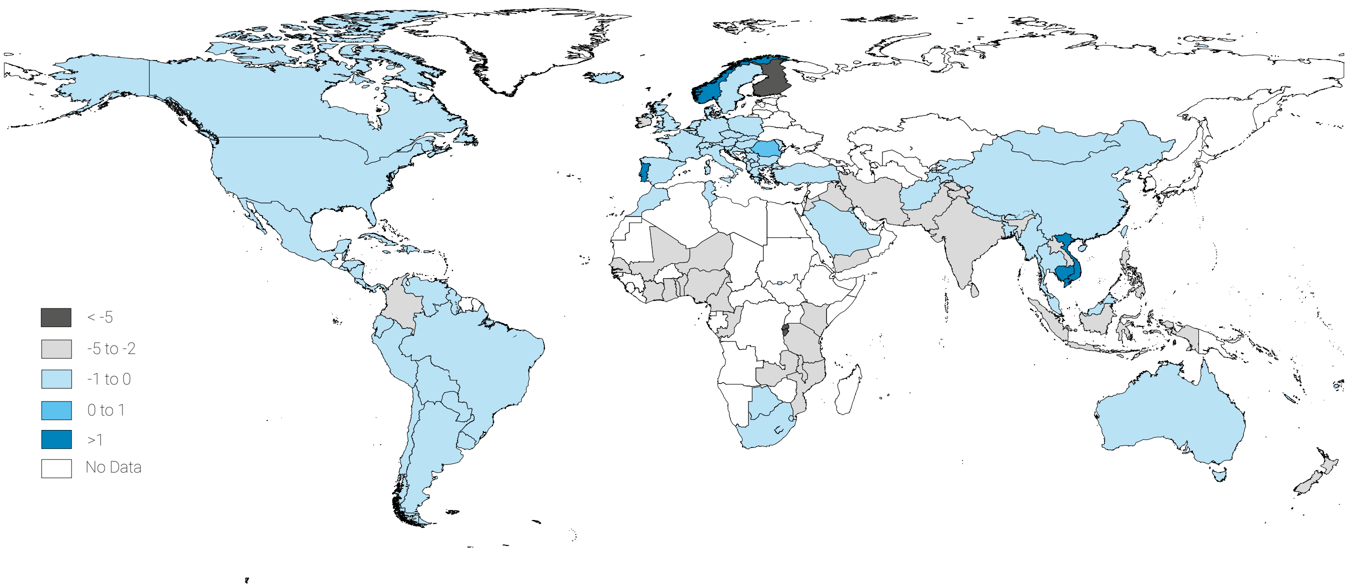


Fig 3.6: Average annual growth rate of pastureland per capita from 1990 to 2014



3.2.1.2. Forest and fishery resources

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

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

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

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

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

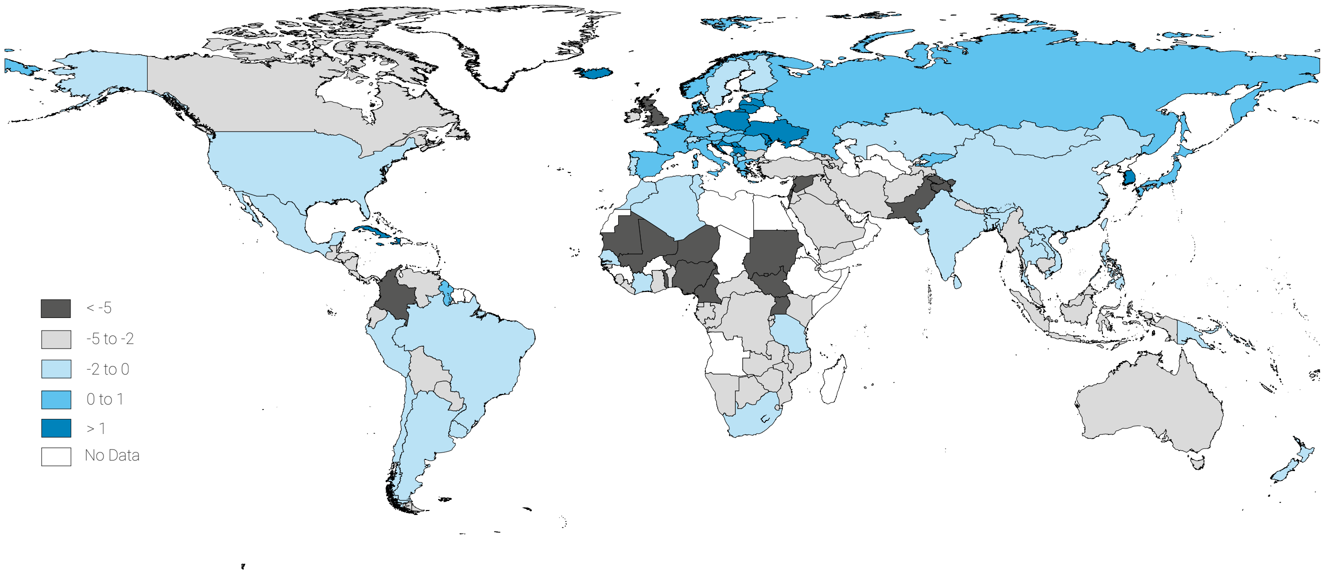
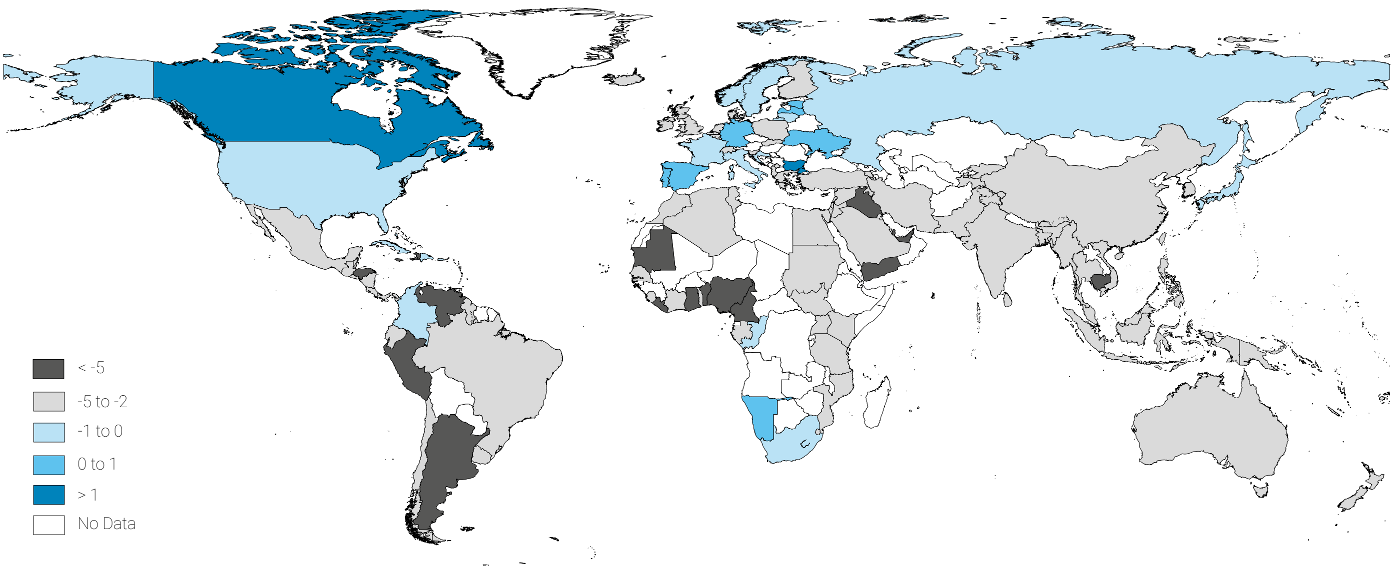


Fig 3.8: Average annual growth rate of fisheries per capita from 1990 to 2014



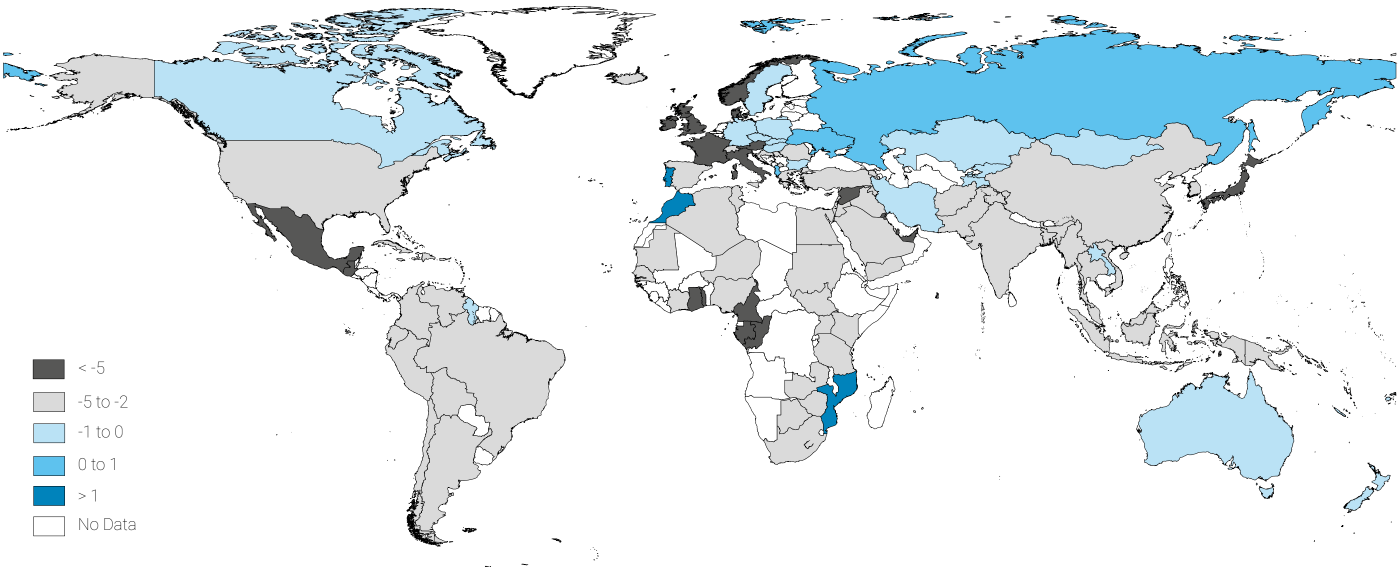
3.2.2. Non-renewable resources

3.2.2.1. Fossil Fuels

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

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

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



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

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

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

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

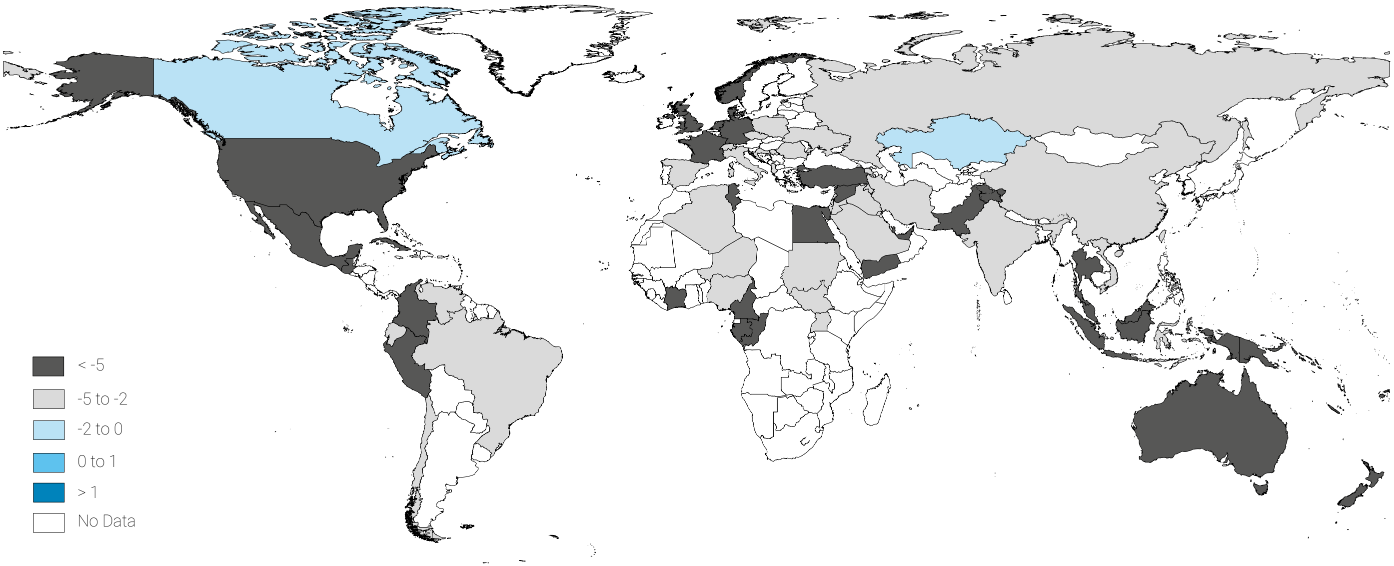


Fig 3.11: Average annual growth rate of natural gas per capita from 1990 to 2014

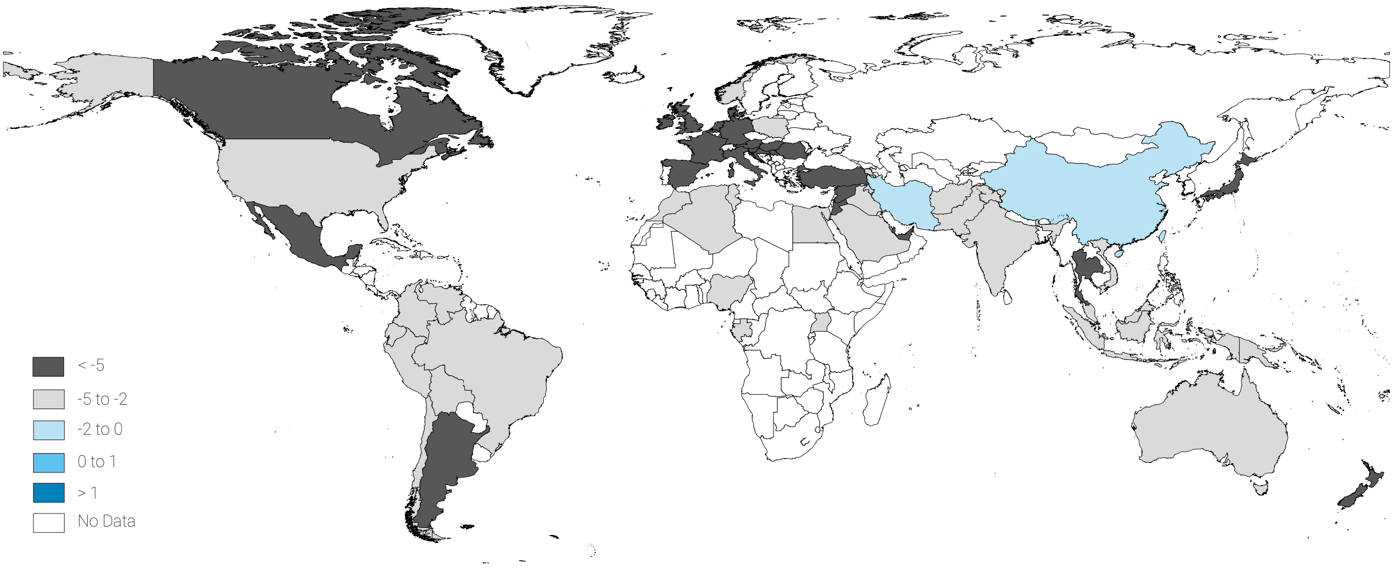
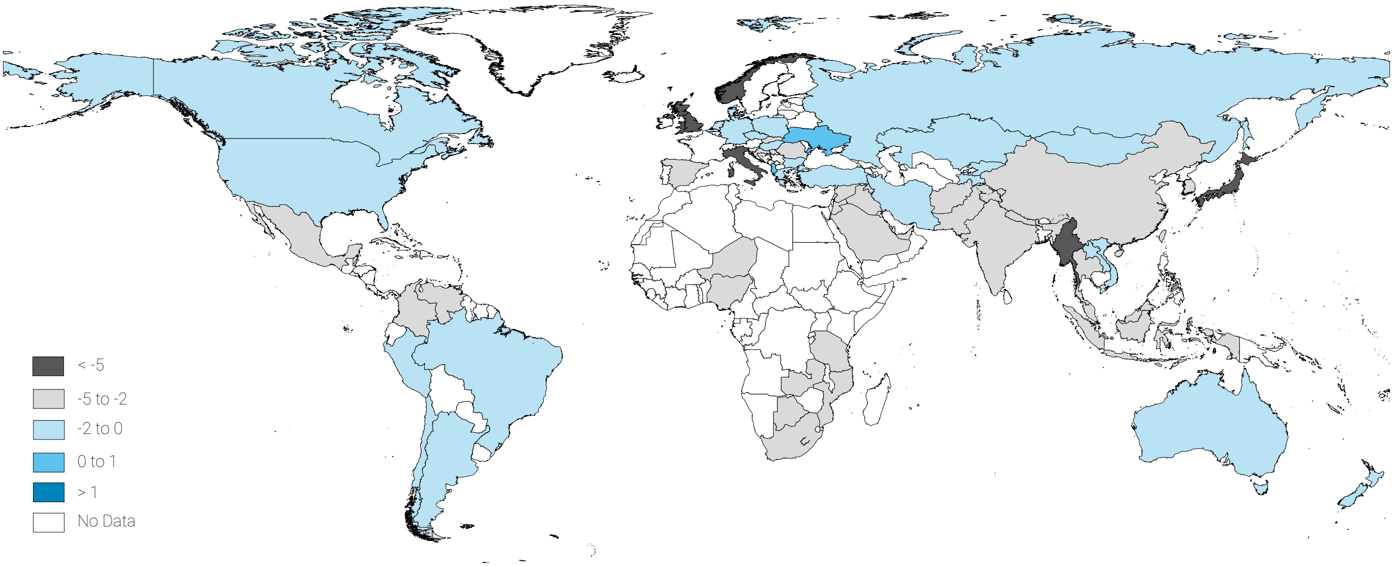


Fig 3.12: Average annual growth rate of coal per capita from 1990 to 2014

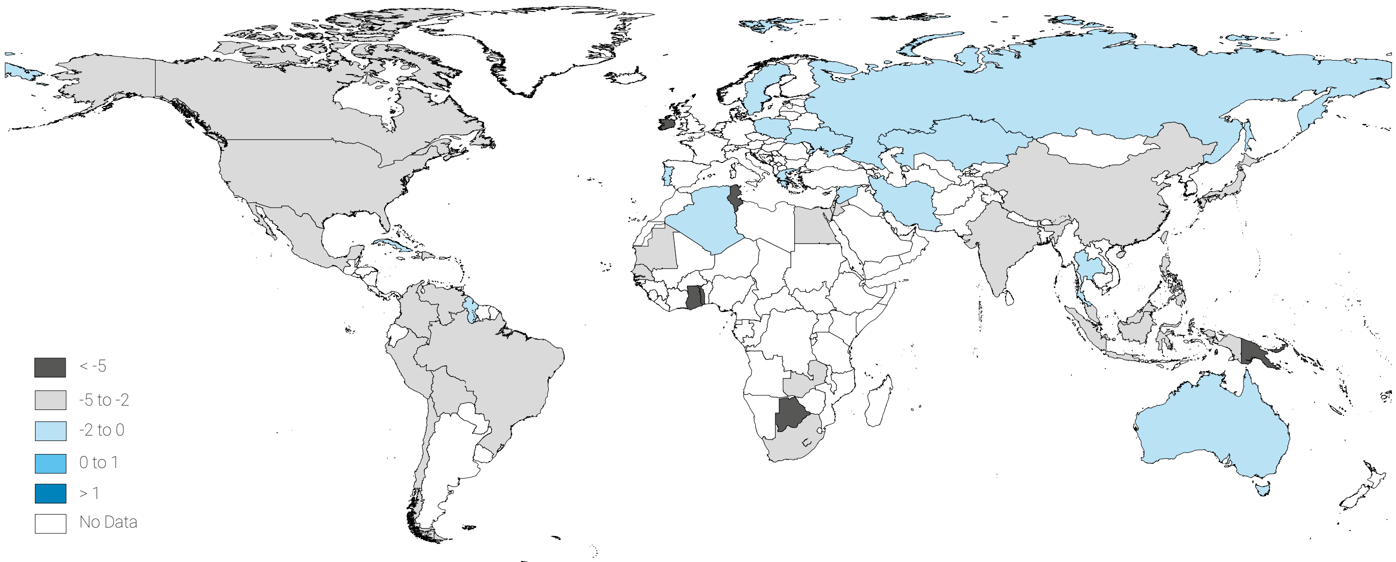


3.2.2.2. Minerals

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

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

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



3.3. Regional Natural Capital Growth and Sustainability

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

3.3.1. Asia and the Pacific

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

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

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

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

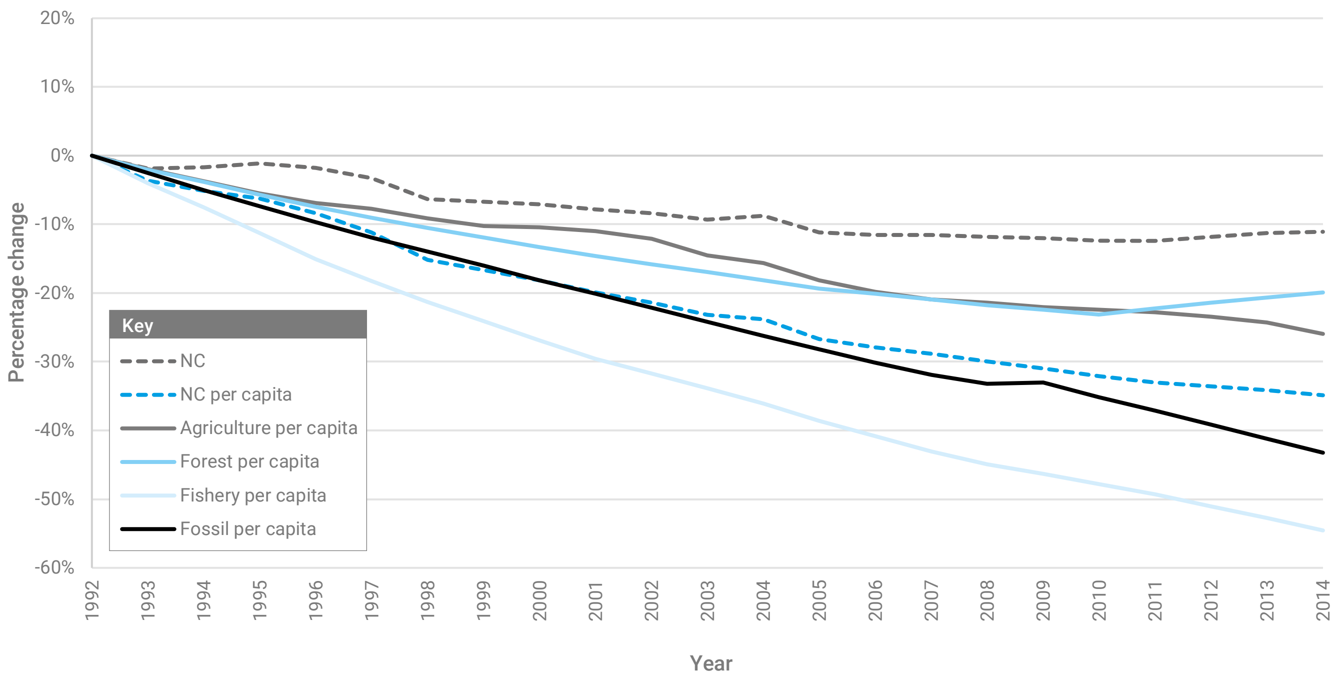


Table 3.1: Changes in natural capital in Asia Pacific countries: average annual growth rates from 1990–2014

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

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

3.3.2. Africa

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

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

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

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

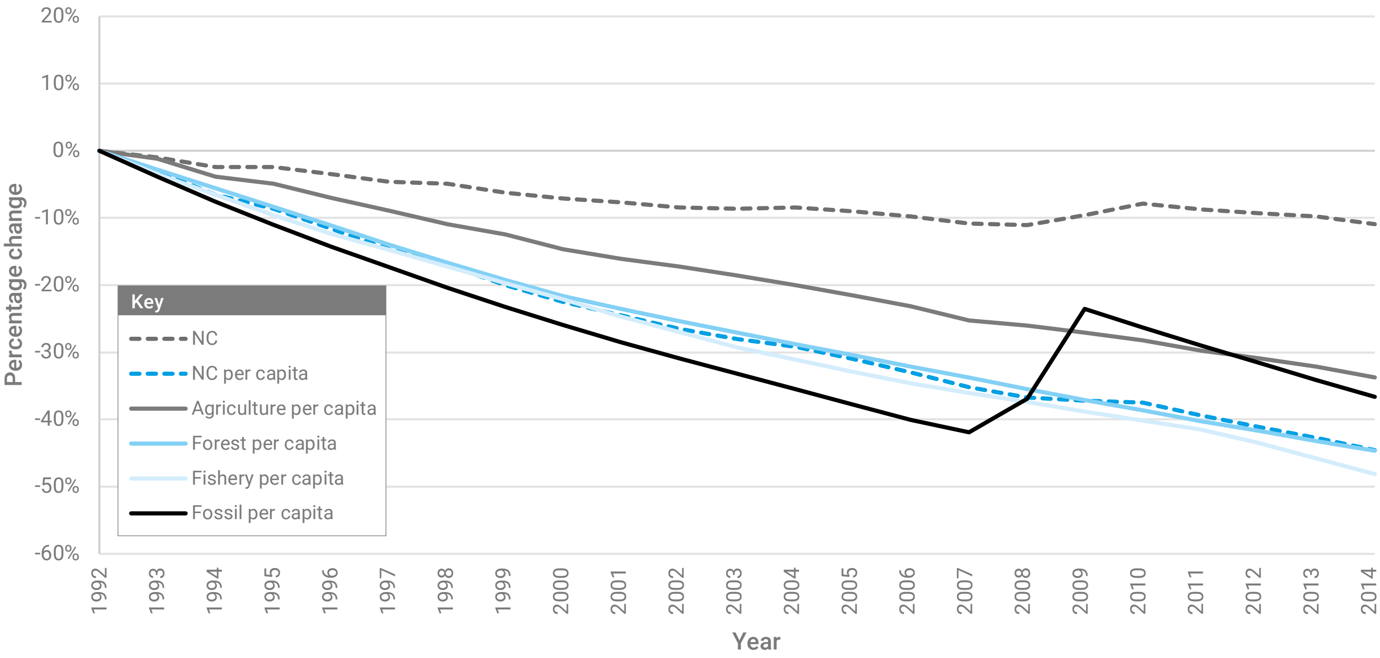


Table 3.2 shows a high population growth rate in the region, which has the potential to increase human capital. As a result, the impact on the growth of wealth from the decline in natural capital has not been as significant, and many African countries have experienced growth in IW.

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

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

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

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

3.3.3. Latin America and the Caribbean

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

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

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

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

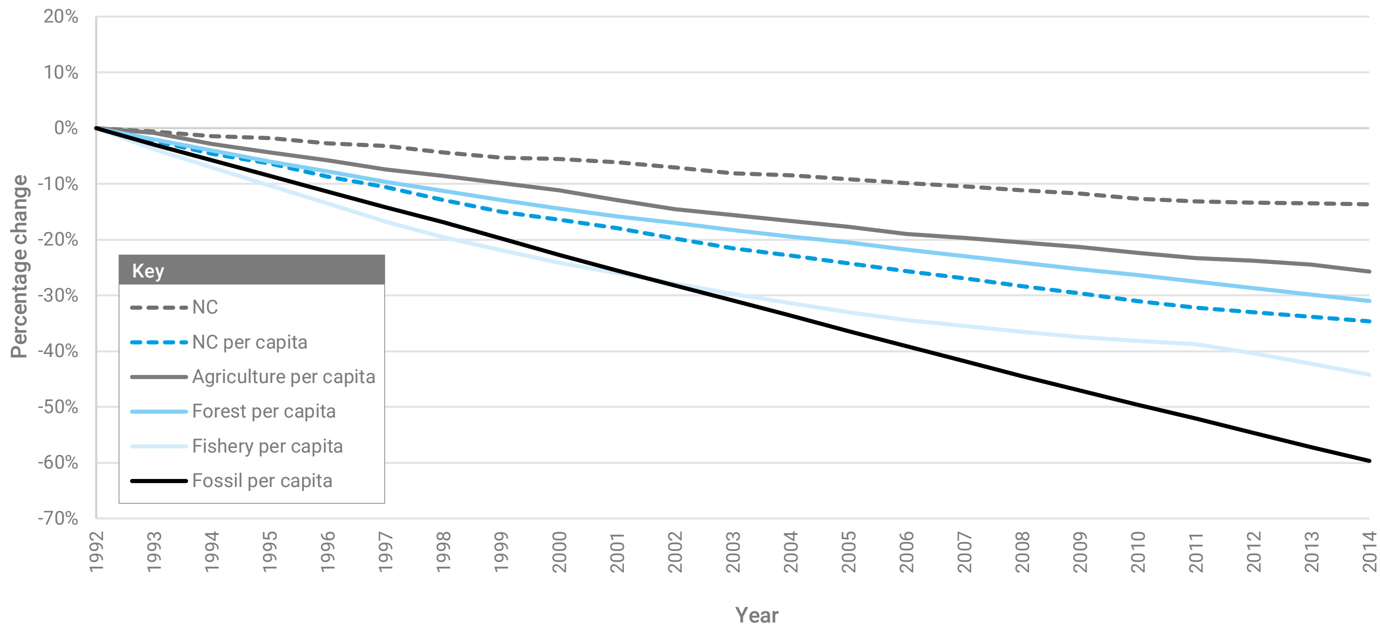


Table 3.3: Changes in natural capital in Latin America and the Caribbean countries: average annual growth rates from 1990 - 2014

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

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

3.3.4. West Asia

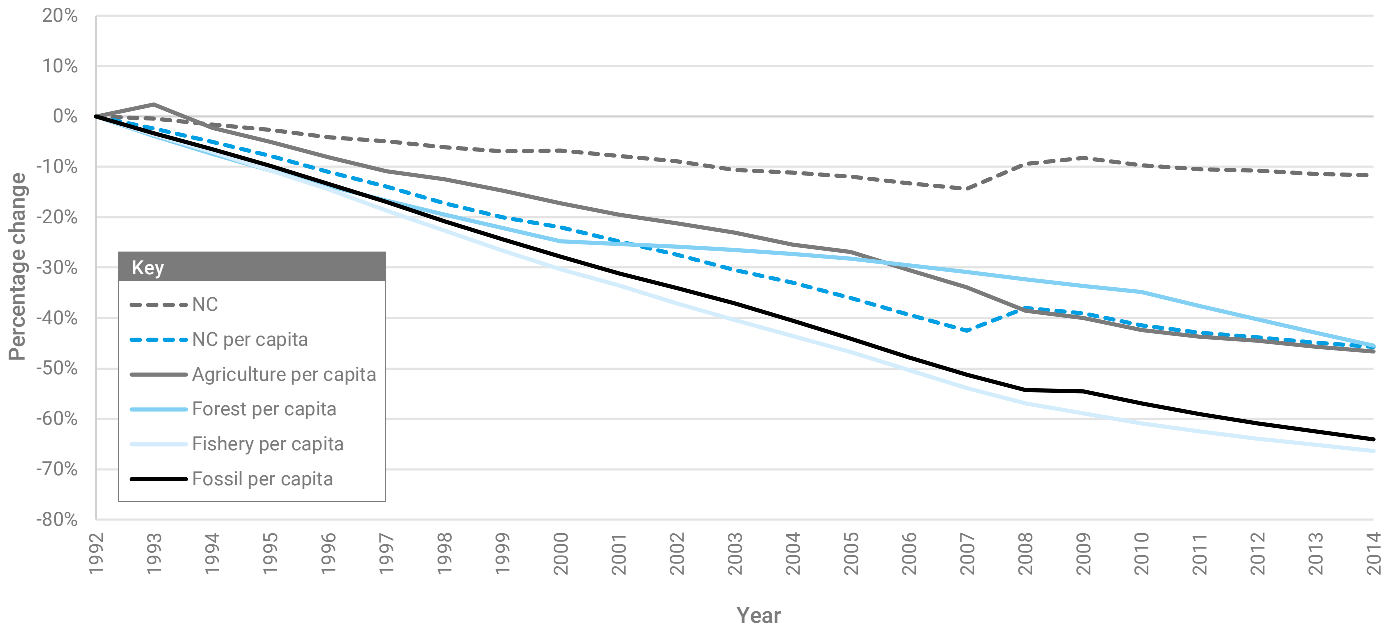
West Asia has experienced extensive deforestation and land degradation. High population growth is placing significant pressure on arable land, fresh water and food supplies. Urbanization, soil salinization, soil erosion and the conversion of wetland to dryland are some reasons for the degradation of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

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

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

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

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



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

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

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

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

3.3.5. North America

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

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

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

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

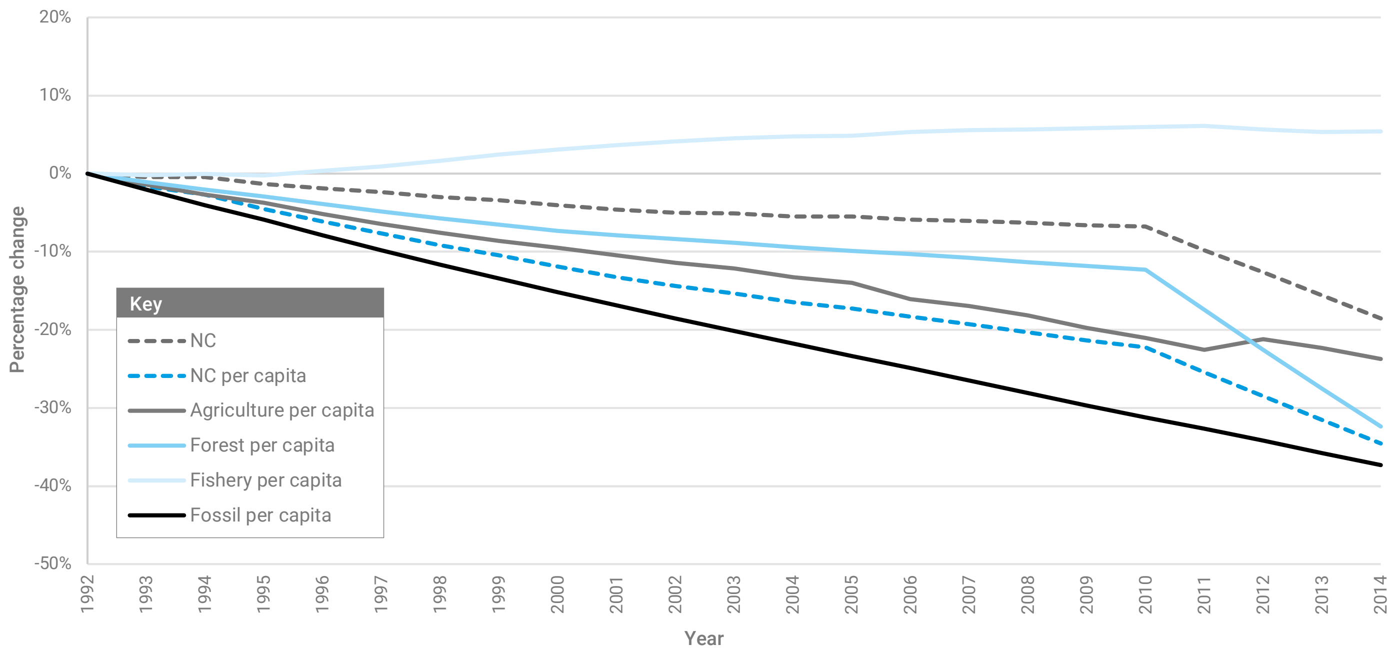


Table 3.5: Changes in natural capital in North America: average annual growth rates from 1990–2014

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.5. Renewable Energy as Capital Stocks

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

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

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

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

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

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

3.5.1. Solar energy

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

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

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

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

3.5.2. Wind energy

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

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

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

3.6. Fish Wealth of Nations

3.6.1. Background

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

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

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

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

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

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

3.6.2. Methodology

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

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

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

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

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

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

$$H_t = qE_tS_t,$$

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

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

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

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

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

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

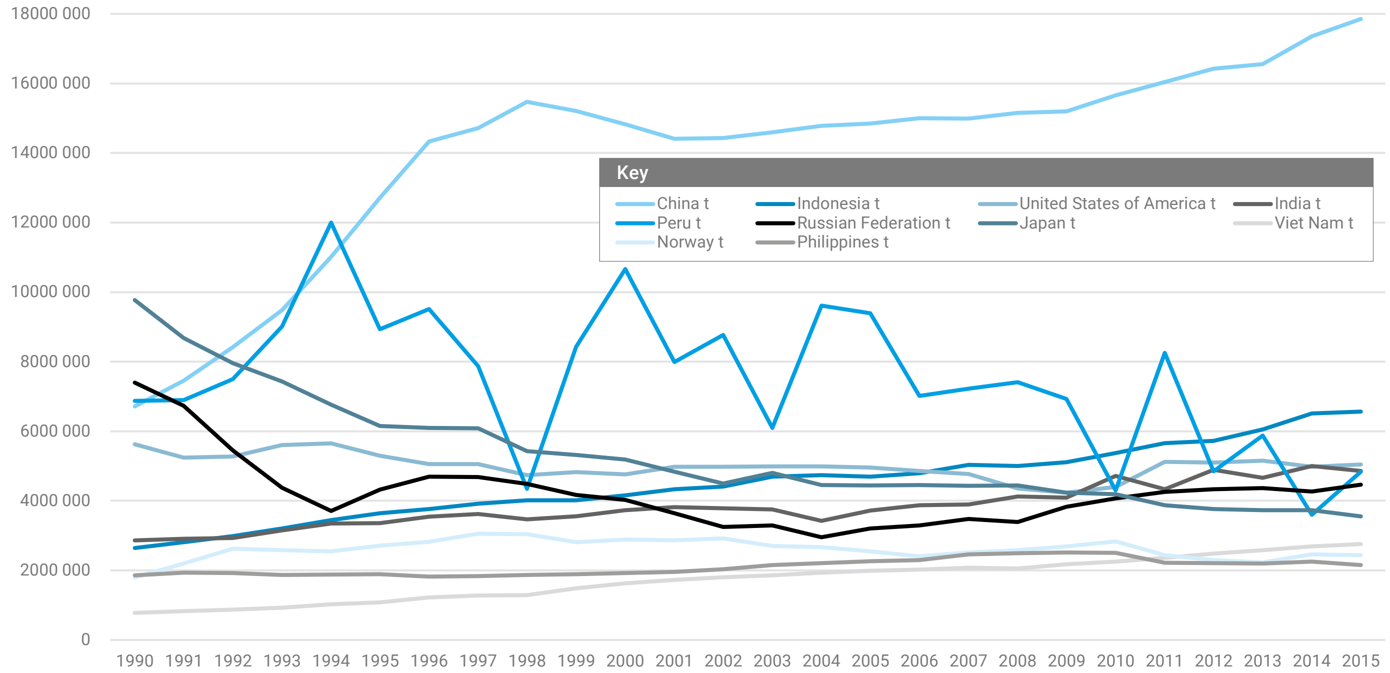
The time-series data of the catch (tonnage and value) of each country's economic exclusive zone (EEZ), either by domestic or foreign fleets, for the period 1950-2010, are obtained from the Sea Around Us Project (SAUP 2016). We only evaluate the stock with a catch record of at least 20 years and which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

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

3.6.3. Results and discussion

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

Fig 3.19: Top 10 countries in fishery capture production



Source: FAO – Fishery and Aquaculture Information and Statistics Branch

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

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

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

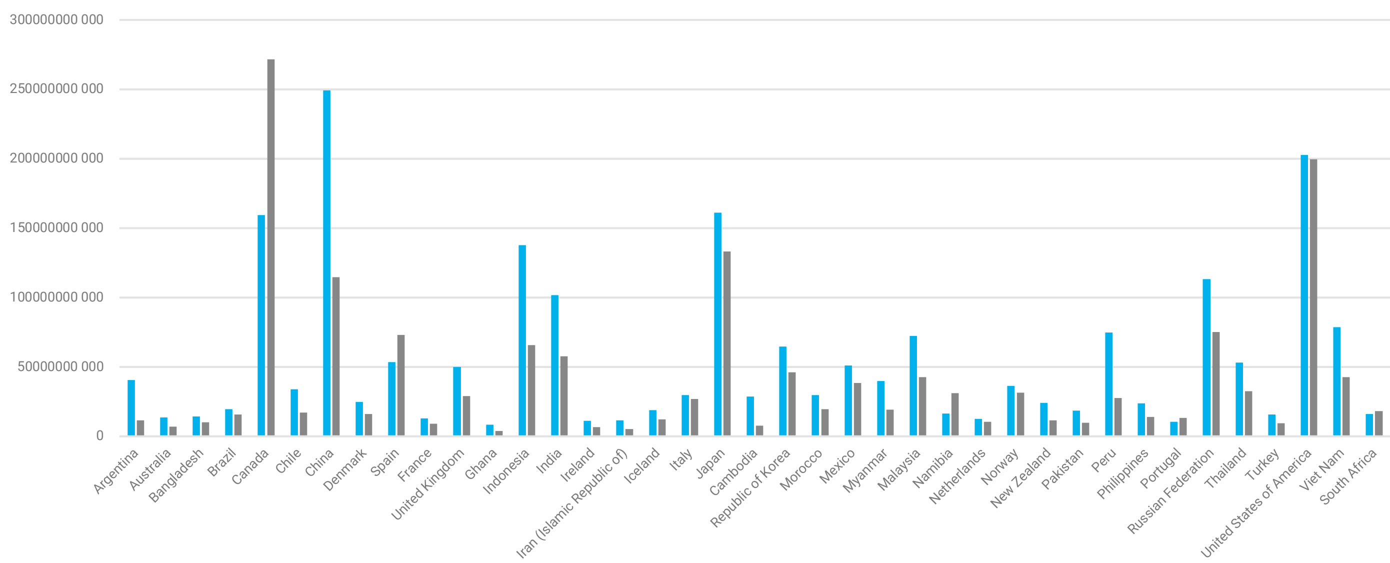
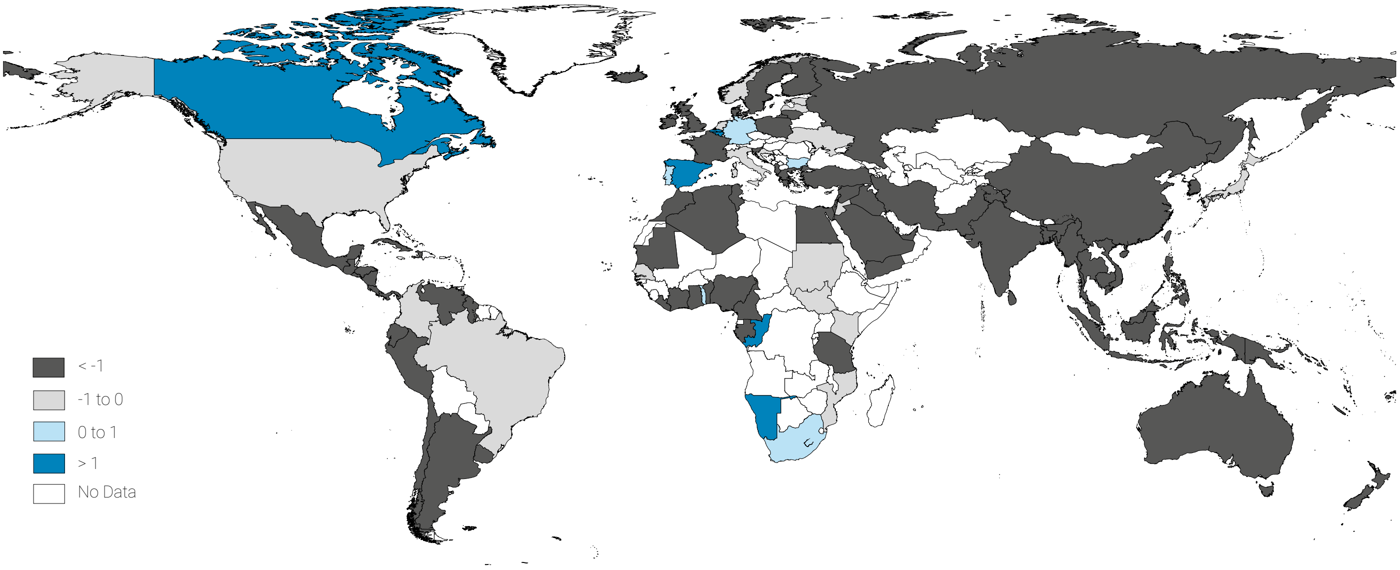


Fig 3.21: Average annual growth rate of fishery stocks from 1990 to 2014



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

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

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

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

3.7. Conclusions

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

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

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

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

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

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

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

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

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

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

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

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

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PART II: NATURAL CAPITAL
CHAPTER 4: RECONCILING INCLUSIVE WEALTH AND PIKETTY: NATURAL CAPITAL AND WEALTH INTHE 21ST CENTURY

Edward Barbier

4.1. Introduction

In his book *Capital in the Twenty-First Century*, Piketty (2014) documents the rise in the wealth-income ratios from 1970 to 2010 for eight high-income economies – the United States, Japan, Germany, France, the United Kingdom, Italy, Canada and Australia. For each of these countries, the wealth-income ratio increased from 200–400 percent in 1970 to 400–600 percent in 2010. In addition, the rise in this ratio was accompanied by another important trend. Over the past four decades, much of the accumulated capital in rich countries has been predominantly private wealth, including largely financial and industrial capital and urban real estate. The effect of these trends has contributed to what Piketty (2014, pp. 193-194) refers to as the “financialization” of the global economy, and as a result, increasing wealth and income inequality:

“Broadly speaking, the 1970s and 1980s witnessed an extensive “financialization” of the global economy, which altered the structure of wealth in the sense that the total amount of financial assets and liabilities held by various sectors (household, corporations, government agencies) increased more rapidly than net wealth. In most countries, the total amount of financial assets and liabilities in the early 1970s did not exceed four to five years of national income. By 2010, this amount had increased to ten to fifteen years of national income (in the United States, Japan, Germany, and France in particular) and to twenty years of national income in Britain, which set an absolute historical record.”

To construct these measures of wealth and income for 1970 to 2010, Piketty (2014) uses official national accounts for each country, following the UN System of National Accounts (SNA). Wealth is defined conventionally as market-value “national wealth”, which can be decomposed into domestic capital, including land and real estate, and net foreign assets.[34] Income is “net-of-depreciation national income”, which means the sum of GDP and net foreign income, less any domestic capital depreciation. Similarly, the national saving flow that adds to wealth is measured net of capital depreciation.

As pointed out by Barbier (2015 and 2016), the SNA approach used by Piketty (2014) to estimate wealth, net income and net savings does not include the depreciation in natural resources essential to production and income, such as fossil fuels, minerals and forests. These resources are important sources of “natural” capital, and the value of their net depletion should also be deducted from annual income and savings (Arrow *et al.* 2012; Hamilton and Clemens 1999; Hartwick 1977 and 1990; Solow 1986; Weitzman 1976; World Bank 2011). If we use up more energy, mineral and forest resources to produce additional economic output today, then we have less natural capital for production tomorrow. Thus, net national income and savings today should also account for any natural capital depreciation.

Accounting for natural capital depletion in wealth accounts is a key and familiar contribution of the inclusive wealth approach, as highlighted in previous IWRs (UNU-IHDP-UNEP 2012 and 2014). Barbier (2016) has shown it is possible to reconcile this approach of accounting for natural capital depreciation with Piketty’s method of estimating net national income and savings.

Specifically, this leads to two key indicators: the net national saving rate adjusted for natural capital depreciation, and the ratio of this saving rate with respect to the long-run average annual growth in adjusted net national income per capita. Using World Bank data, Barbier (2016) applies these two indicators to examine the impacts of depreciation of key natural resources, such as fossil fuels, minerals and forests, on the accumulation of adjusted net wealth over 1970 to 2013. The analysis used the same eight rich countries analysed by Piketty (2014) and Piketty and Zucman (2014), and for comparison, over 1979 to 2013 for 95 low- and middle-income economies.

In developing economies capital accumulation has largely kept pace with rising natural capital depletion, but in the rich countries, adjusted net savings have fallen to converge with the rate of natural capital depreciation. This suggests less compensation by net increases in other capital.

Natural capital depreciation clearly matters for wealth accumulation and long-run wealth-income ratios in all economies, including rich countries. Moreover, missing out natural capital depreciation has important implications for Piketty’s explanation for growing global inequality. If overall wealth accumulation net of natural capital depreciation is slowing in rich countries, then the “financialization” of economies observed by Piketty (2014) will continue to worsen wealth and income inequality.

34 See also Piketty and Zucman (2014) for a more detailed modeling approach and investigation of the 1970-2010 wealth trends analysed by Piketty (2014). Note that both Piketty and Zucman (2014) and Piketty (2014) use the terms “national wealth” and “national capital” interchangeably.

The purpose of this chapter is to adjust Piketty's method of estimating long-run trends in wealth-income ratios with net income and savings taking into account natural capital depreciation. In addition, the analysis is extended from Piketty's original group of eight rich countries to 30 high-income economies that are members of the Organization for Economic Cooperation and Development (OECD) over 1970 to 2014. Evidence suggests that growing income and wealth inequality has been pervasive in all OECD economies (OECD 2011), and thus determining whether natural capital depreciation impacts long-run wealth accumulation in these economies may be an important factor underlying this trend.

This chapter also extends the analysis by Barbier (2016) to 113 low- and middle-income, developing, economies from 1970 to 2014. For comparison, the subgroup of 26 low-income countries is analysed separately, and turns out to display different trends over 1970–2014 than either all developing or the rich OECD economies.

Over the past four decades the rate of natural capital depreciation has been on average five times larger in developing countries than in the rich OECD economies. However, in low- and middle-income economies other forms of capital investments have largely compensated for the rising natural capital depletion that has occurred since the late 1990s. In contrast, in rich countries, the rate of adjusted net savings has converged to the rate of natural capital depreciation. For low-income economies, adjusted net wealth accumulation fell on average each year at a rate four times greater than long-run growth, although since 2000 this trend may have been reversing. If this rising trend continues, low-income countries could experience accumulation in net adjusted wealth at a faster pace than long-run per capita income growth.

Over the past 40 years there may have been substantial accumulation of wealth relative to income in rich economies. However, natural capital depreciation is being compensated less and less each year by net increases in other forms of capital, so a measure of national wealth that excludes natural capital depreciation likely exaggerates the actual increase in an economy's wealth over time. This is especially true in countries where accumulation of other forms of wealth is failing to compensate for diminishing natural capital, like rich countries. This means income and wealth inequality may be worsening in rich countries particularly, and in the global economy generally, as emphasized by Piketty (2014).

4.2. Conventional versus Adjusted Net Income Accounting

Because official national account statistics do not routinely account for changes in stocks of natural capital – even fossil fuels, minerals, forests and similar natural resources that can be bought and sold on markets – it is difficult to measure directly long-run trends in the natural capital/national income ratio for an economy. However, it is possible to indicate how natural resource depreciation affects wealth accumulation, through extending the approach to measuring national wealth developed by Piketty (2014) and Piketty and Zucman (2014).[35]

The appendix to this chapter outlines how this can be done, and the approach is summarized here. Let W_t denote the market value of national wealth at time t, and Y_t be conventionally defined net national income (NNI), which is gross national income less any depreciation in domestic capital assets, like factories, machines, equipment, and buildings, each year. Similarly, S_t is conventional net national savings (NNS) at time t;; this means gross savings adjusted for domestic capital depreciation. Consequently, Piketty (2014) and Piketty and Zucman (2014) focus on three important relationships among these conventional indicators:

Net wealth accumulation: $W_{t+1} - W_t = S_t$

Net national saving rate: $W_t / Y_t = \beta_t$

Wealth-income ratio: . $W_t / Y_t = \beta_t$

However, as argued by Barbier (2016), an economy contains a stock of available natural resources for production, with market value at time t of.

$$\tilde{N}_t \geq 0$$

This suggests that the adjusted net wealth of the economy is $W_t^* = W_t + \tilde{N}_t$. As wealth now includes an endowment of natural capital, net national income Y_t and net national savings S_t need to be adjusted for natural capital depreciated through its use in production over t and t+1. Let Y_t^* and S_t^* represent the adjustments to net national income (ANNI) and savings (ANNS) for any natural capital depreciation, respectively. This leads to three additional indicators:

Adjusted net wealth accumulation: $W_{t+1}^* - W_t^* = S_t^*$

Adjusted net national saving rate: $S_t^* / Y_t^* = s_t^*$

Natural capital depreciation rate: . $\left(\tilde{N}_{t+1} - \tilde{N}_t\right) / Y_t^* = n_t^*$

Fig 4.1 outlines how the conventional economic indicators of gross and net national income can be adjusted for natural capital depreciation to derive ANNI. Similarly, Fig 4. 2 shows how conventional gross and net savings can be adjusted to determine adjusted net national savings (ANNS).

Barbier (2016) also suggests that the savings rate S_t^* can be expressed as a ratio with respect to the long-run average growth in ANNI per capita, $\bar{g}^*$. This leads to another indicator:

- Saving-ANNI growth ratio: s_t^*

35 See the appendix of Barbier (2016), which shows analytically how the one-good wealth accumulation model of Piketty and Zucman (2014) can be modified to allow for natural capital depreciation in the context of inter-temporal optimizing behaviour.

Trends in this ratio indicate how the rate of wealth accumulation over time, $W^*_{t+1} - W^*_t / Y^*_t$, compares with the long-run growth rate of an economy.

The rest of this chapter explores long-run trends in S_t^*, n_t^* and $s_t^* / \bar{g}^*$ for high-income OECD, developing and low-income economies along with the implications of these trends for the wealth and income inequality arguments of Piketty (2014). However, first we show the key trends that lead Piketty to conclude that inequality has been worsening in the major rich countries and the global economy.

Fig 4.1: Net national income (NNI) adjusted for natural capital depreciation

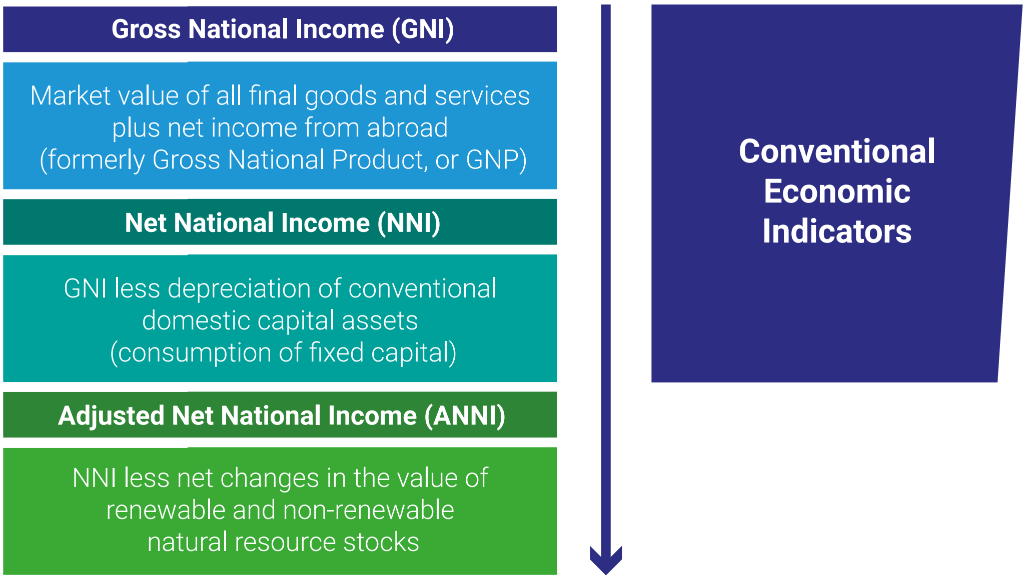
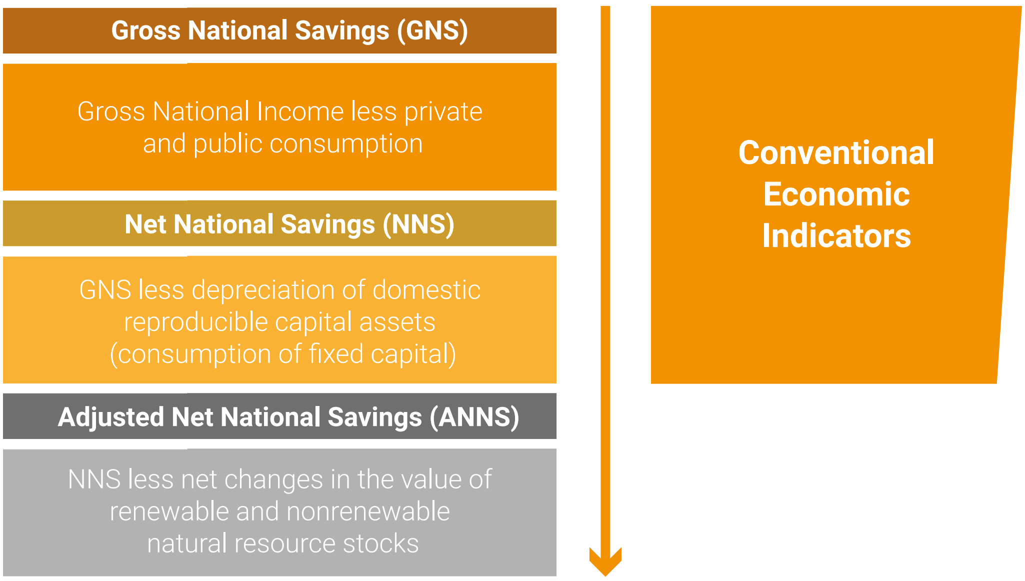


Fig 4.2: Net national savings (NNS) adjusted for natural capital depreciation

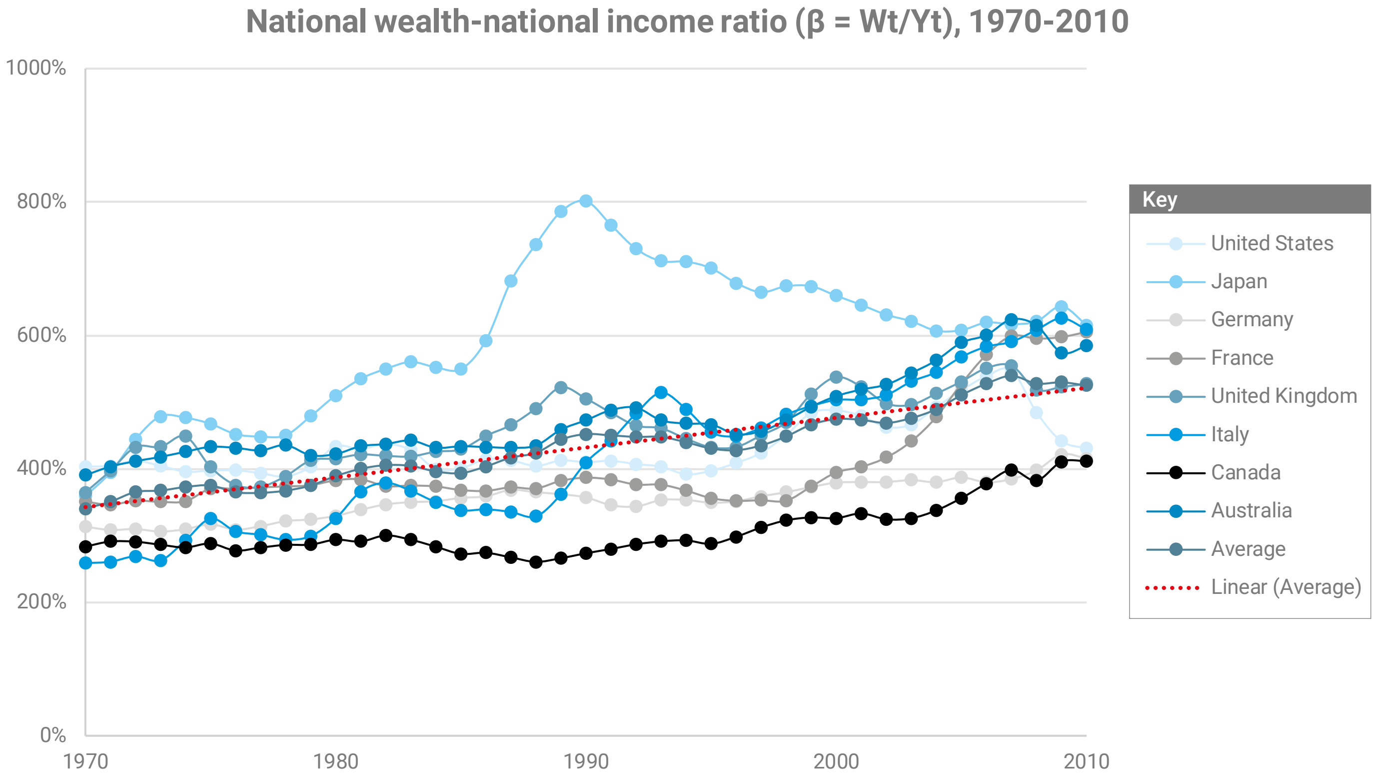


4.3 Financialization and Inequality

Piketty (2014) argues rising wealth and income inequality is attributed to several important features of wealth accumulation in the world economy. First, the ratio of conventionally measured national wealth to income has increased steadily over 1970 to 2010 for the eight richest economies; Fig 4. 3 recreates these trends in the wealth-income ratio for these countries.

For the past four decades the average trend in the wealth-income ratio for this group of wealthy economies has been rising. In 1970, wealth ranged from two to four years (200–400 percent) of national income for these countries, and by 2010 wealth was four to six years (400–600 percent) of income.

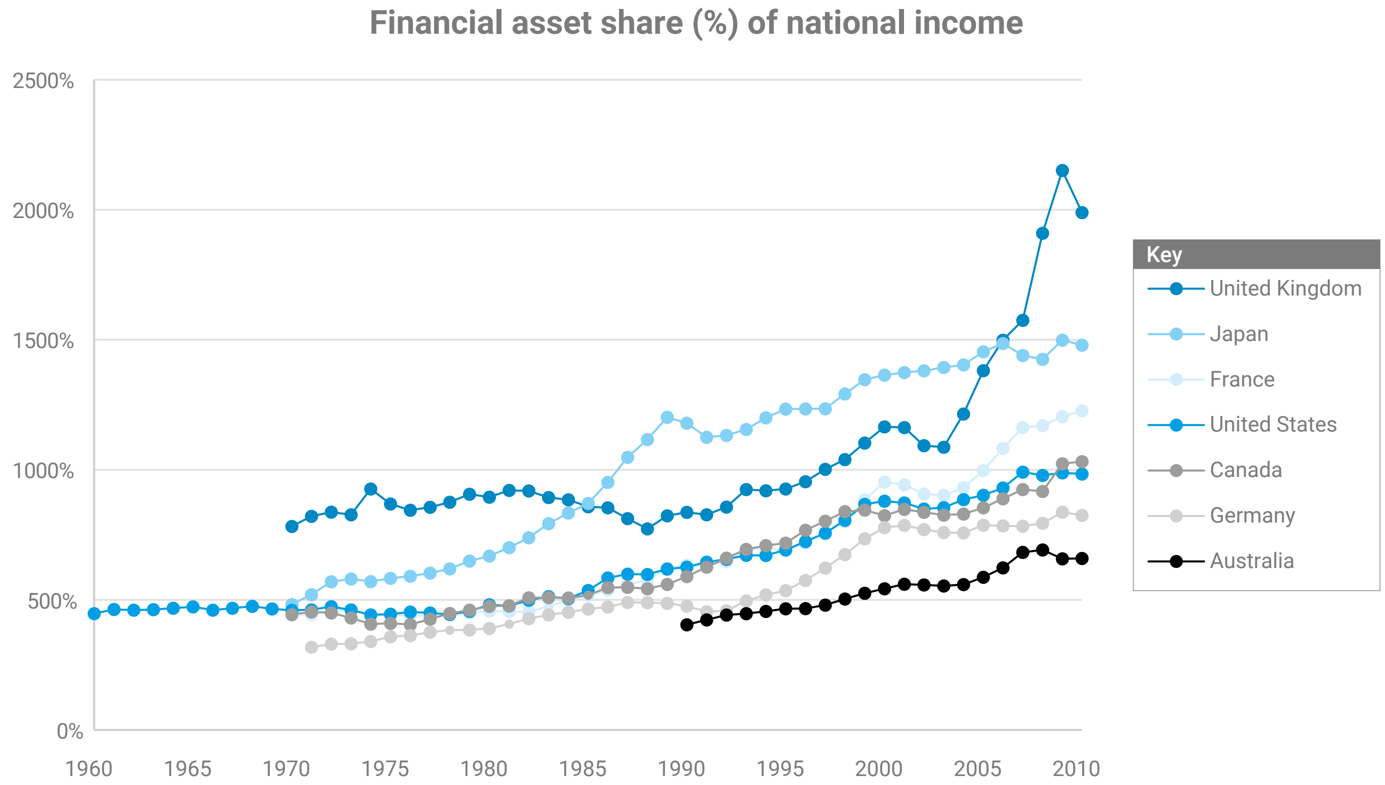
Fig 4.3: Wealth-Income ratios in rich countries, 1970–2010



Source: Piketty and Zucman (2014), Appendix Table A1: National wealth-national income ratio 1870-2010 (annual series), available at http://piketty.pse.ens.fr/fr/capitalisback

Financial assets are the total amount of financial assets and liabilities held by various sectors (household, corporations, government agencies) of an economy.

Fig 4.4: Financial asset-income ratio in rich countries, 1960–2010



Source: Piketty and Zucman (2014), Appendix Table A30: Gross financial assets of all domestic sectors 1960–2010 (percentage of national income), available at http://piketty.pse.ens.fr/fr/capitalisback

Piketty (2014) notes that national wealth in rich countries is predominantly private wealth, comprised of largely financial and industrial capital as well as urban real estate, for example housing. In contrast, agricultural land is no longer a significant share of wealth in these economies. In particular, the ratio of financial assets to national income has risen markedly, which Piketty calls the extensive "financialization" of rich countries, and thus the global economy. Fig 4. 4 replicates Piketty's trends in the financial asset-income ratio in rich economies from 1960 to 2010.[36]

Especially since the 1980s, the financial asset share of national income in all wealthy economies has risen sharply (see Fig 4. 4). In 1980, this share amounted to four to nine years (400–900 percent) of income in these countries. By 2010, financial assets accounted for seven years (700 percent) of national income in Australia, 10–15 years of income in the United States, Japan and Germany, and 20 years in the United Kingdom. As can be seen from comparing Fig 4.3 with Fig 4.4, the financial asset share of national income has risen much more quickly than the overall wealth-income ratio in rich countries. Piketty (2014) argues this extensive and rapid "financialization" is the main cause of the jump in the growing income and wealth inequality in recent decades. In particular, the widening gap between rich and poor is due to the increasing wealth of the world's rich, who benefited most from the financialization of the world economy.

For example, based on estimates by Piketty (2014) complied from data on billionaires' wealth in Forbes magazine, Table 4. 1 indicates how the wealth of the very rich increased from 1987 to 2013 compared to average world wealth per adult.

The wealth of the global rich appears to be growing much faster than that of the average individual. Out of 3 billion people in the 1980s, the richest billionaires in the world consisted of 30 adults, and their average wealth was US$3.4 billion in 1980. This group's accumulated assets grew by 6.8 percent each year to 2013, when it totalled US$32.3 billion. There were 150 billionaires globally in the 1980s, and their average wealth grew at 6.4 percent per year between 1987 and 2013, from US$1.6 billion to US$14.0 billion. In comparison, average world wealth per adult increased by only 2.1 percent annually from 1987 to 2013, and average income per person by just 1.4 percent.

36 Piketty (2014) and Piketty and Zucman (2014) estimate financial assets as the total amount of financial assets and liabilities held by various sectors (house hold, corporations, government agencies) of an economy. Thus, this estimate of financial assets can exceed their measure of national wealth for some coun tries in some years.

Table 4.1: Increase in wealth of the world's rich, 1987-2013

	Wealth or Income in:		Average annual growth (%) 1987-2013
	1980	2013	
The richest billionaires[a]	$3.4 billion	$32.3 billion	6.8
Billionaires[b]	$1.6 billion	$14.0 billion	6.4
Average world wealth per adult	$26,065	$76,628	2.1
Average world income per adult	$7,759	$19,187	1.4
World adult population	2.85 billion	4.68 billion	1.9
World gross domestic product (GDP)	$22,119 billion	$89,719 billion	3.3

All values are in US dollars, and adjusted net of inflation (2.3 percent per year from 1987 to 2013).

[a] About 30 adults out of 3 billion in the 1980s, and 45 adults out of 4.5 billion in 2010.

[b] About 150 adults out of 3 billion in the 1980s, and 225 adults out of 4.5 billion in 2010.

Source: Thomas Piketty. 2014. Capital in the Twenty-First Century. Harvard University Press, Cambridge, MA, Table 12.1 and Supplementary Table S12.3 http://piketty.pse.ens.fr/capital21c

Most analysts agree that, although data on long-run trends are available for only a handful of countries, the wealth of the super-rich, the wealthiest 1 percent of all adults, has been increasing since the early 1970s for some economies and since 1980 for others.[37] More importantly, worldwide:

- the top 1 percent today account for almost half of the all the wealth in the world,
- the richest 10 percent own 87 percent of all assets, and
- the lower half of the global population possess less than 1 percent of global wealth.[38]

Wealth inequality is not only continuing to rise but also spreading throughout the world economy. Table 4. 2 depicts the level of inequality in 46 major economies, and also indicates whether the level has been rising or falling from 2000 to 2014. Wealth inequality is high or very high in 30 of these countries.

Moreover, since 2000, nine countries have experienced a rapid rise in inequality, five have seen a rise, and three a slight rise. Of particular concern is that nine of these countries that have seen some form of rise in inequality are members of the Group of 20, which comprises the largest and most populous economies. Wealth inequality also appears to be a problem for a number of developing economies, although for most of these it appears to be unchanged or falling.

37 See, for example, Alvaredo *et al.* (2013) and Stierli *et al.* (2014). The ten countries with long-term wealth inequality data that are the focus of Stierli *et al.* (2014) are Australia, Denmark, Finland, France, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and the United States. Alvaredo *et al.* (2013) also analyse long-term trends for Canada and Japan, but not Denmark, Finland, the Netherlands, Norway and Switzerland.

38 Stierli *et al.* (2014, p. 13).

Table 4.2: Trends in wealth inequality across countries, 2000-2014

	Change in wealth share of the top decile, 2000-2014						
Top decile wealth share, 2014	**Rapid fall**	**Fall**	**Slight fall**	**Flat**	**Slight rise**	**Rise**	**Rapid rise**
> 70% **Very high inequality** **(US ca. 1910)**		Malaysia Philippines	Switzerland	Peru *South Africa* Thailand *United States*		*Brazil* *Indonesia*	*Argentina* Egypt Hong Kong *India* *Russia* *Turkey*
> 60% **High inequality** **(US ca. 1950)**	Poland Saudi Arabia	Colombia *Mexico*	Denmark *Germany*	Austria Norway Sweden	Chile	Czech Republic Israel	China *South Korea* Taiwan
> 50% **Medium inequality** **(Europe ca. 1980)**		*Canada* *France* New Zealand Singapore		*Australia* Finland Greece Ireland *Italy* Netherlands Portugal	United Arab Emirates	*United Kingdom*	Spain;
< 50% **Low inequality**			*Japan*	Belgium			

The top decile is the wealthiest 10% of all adults. 46 countries, with the Group of 20 (G20) countries indicated in italics. The members of the G20 include 19 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the UK and the US), plus the European Union.

Source: Markus Stierli, Anthony Shorrocks, Jim Davies, Rodrigo Lluberas and Antonios Koutsoukis. 2014. Global Wealth Report 2014. Credit Suisse Research Institute, Zurich, Table 1, p. 30 and Table 2, p. 33.

If natural capital depreciation does matter for long-run wealth accumulation in all economies, including rich countries, then there may be further implications for Piketty's explanation of growing global inequality. Current measures of national wealth, income and saving that exclude natural capital depreciation likely exaggerate the actual increase in an economy's wealth over time, especially in those countries where accumulation of other forms of wealth is failing to compensate for diminishing natural capital.

This suggests income and wealth inequality may be even worse than in the global economy generally, as emphasized by Piketty (2014) and other scholars. To examine whether this is the case, the next section explores long-run trends in s_t^*, n_t^* and $s_t^*/\bar{g}^*$ for high-income OECD, developing and low-income economies.

4.4. Measuring Adjusted Net National Income, Saving and Growth

The World Bank's World Development Indicators contain values for net natural resource depletion, net national saving rates, and ANNI from 1970 to 2014 for most countries of the world (World Bank 2017). Using these data, it is possible to construct long-run trends in the natural capital depreciation rate n_t*, the adjusted net savings rate S_t*, and the saving-ANNI growth ratio $s_t^* / \overline{g}^*$ for high-income OECD, developing and low-income economies.

The World Bank defines the value of net natural resource depletion as the sum of net forest, fossil fuel and mineral depletion.[39] 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, also capped at 25 years. It includes tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.

The World Development Indicators (WDI) provide annual estimates from 1970 to 2014 of the World Bank's aggregate value of net natural resource depletion, as a percentage of gross national income (GNI) for the eight high-income countries. Converting this estimate to natural resource depletion as a share of ANNI (constant 2010 $), which is the natural capital depreciation rate n_t*, involves multiplying the WDI's annual measure of net natural resource depletion as a percentage of GNI by its measure of GNI (constant 2010 $), and then dividing the result by the WDI's annual estimates of ANNI (constant 2010 $).

Annual NNS, which are gross national savings less the value of consumption of fixed capital, are also calculated as a percentage of GNI in the WDI. Estimating the adjusted net savings rate S_t* requires first adjusting the annual NNS rate for natural capital depreciation as a share of GNI, multiplying by GNI (constant 2010 $), and then dividing by ANNI (constant 2010 $). Finally, the average annual growth of ANNI per capita over 1970 to 2014, which is already estimated in the WDI, serves as the measure of $\overline{g}^*$.

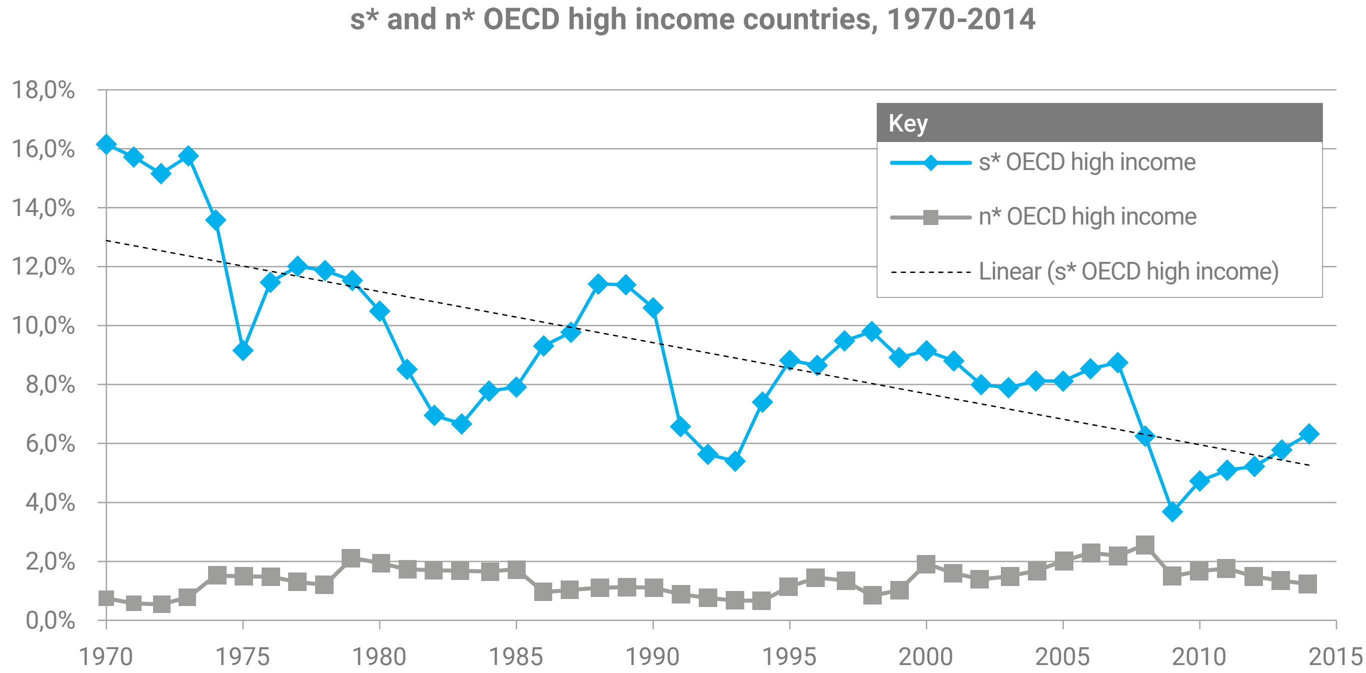
4.4.1 OECD high-income countries

Fig 4. 5 depicts the estimates over 1970-2014 of n_t* and S_t* averaged across 30 high-income countries that are also members of the OECD. They include the eight countries originally analysed by Piketty (2014) – the United States, Japan, Germany, France, the United Kingdom, Italy, Canada and Australia.

The adjusted net savings rate for these countries declined considerably during these four decades. It was around 15–16 percent in the early 1970s but from the mid-1990s to mid-2000s hovered around 8–10 percent. The savings rate fell to below 4 percent during the Great Recession, but has recovered since to above 6 percent. On average from 1970 to 2014, S_t* was 9.1 percent (see Fig 4. 5). In contrast, natural capital depreciation has remained between 1–2 percent of ANNI for most of the past 40 years. Thus, it appears that for the rich economies of the world S_t* and n_t* have been converging. In these economies there is less accumulation of other forms of capital each year to compensate for ongoing natural capital depreciation. The result is the overall annual accumulation in adjusted net wealth relative to income has been trending downward since the 1970s.

39 Further details on this methodology can be found in World Bank (2011) and in the notes accompanying World Bank (2017). Although the depreciation of key natural resources, such as fisheries and freshwater supplies, are missing from this measure, the net depletion of sub-soil assets and forests by economies accounts for much of their natural capital used up in current production and wealth accumulation.

Fig 4.5: Adjusted net savings and natural capital depreciation in OECD high-income countries, 1970–2014



The 30 OECD high-income countries are Australia, Austria, Belgium Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, the Republic of Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom and United States. High-income economies are those in which 2015 GNI per capita was $12,476 or more.

The data are based on the WDI (World Bank 2017). The measure of s is gross national savings less the value of consumption of fixed capital and the value of net natural resource depletion as a percentage of ANNI (constant 2010 US$); the measure of n* is annual value of net natural resource depletion as a percentage of ANNI (constant 2010 US$).*

From 1970 to 2014, the average s for these eight countries was 9.1 percent, and average n* was 1.4 percent. The margin of error (95 percent confidence level) associated with the sample mean for s* and n* was 1.7 and 1.2, respectively.*

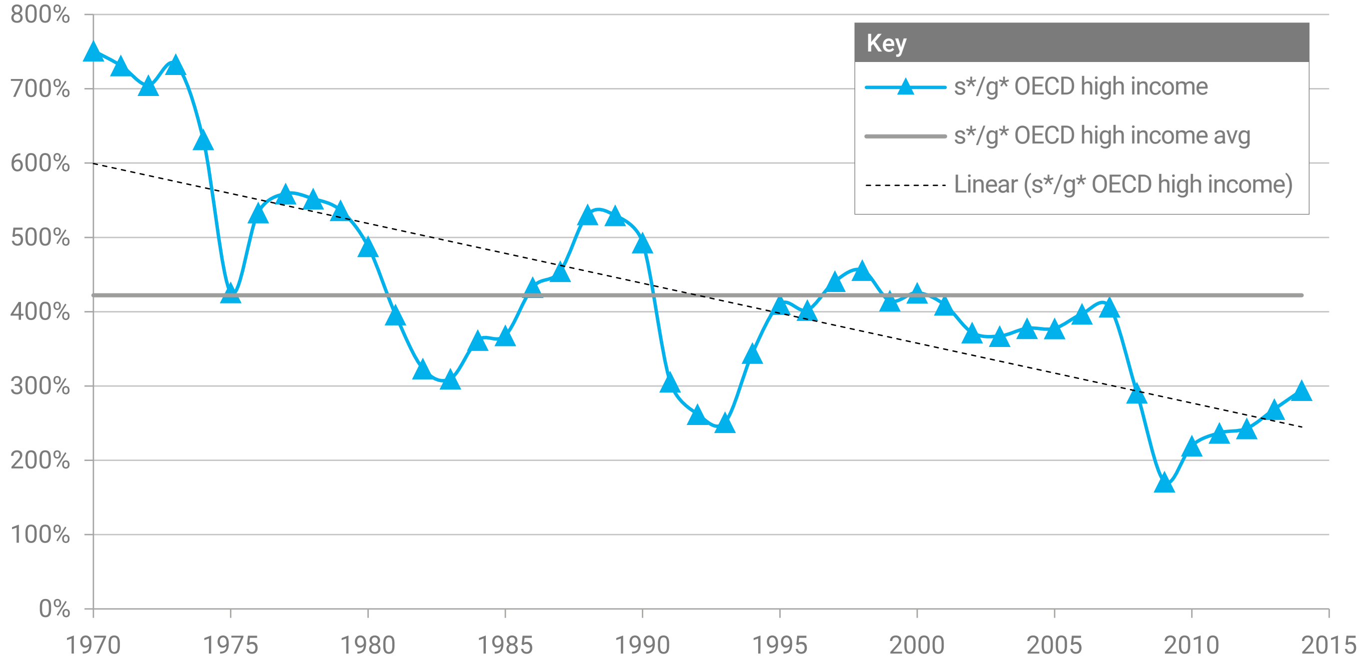
Fig 4.6 shows the estimate in the saving-ANNI growth ratio $s_t^*/\bar{g}^*$ averaged for the 30 OECD high-income economies over 1970-2014. For illustrative purposes, the figure also includes the trend in the conventional capital-income ratio $b_t = W_t \; Y_t$ averaged for the eight rich countries over 1970 to 2010, estimated by Piketty and Zucman (2014). Finally, Fig 4. 6 also includes the average ratio over the four decades.

The trend in β_t depicted in Fig 4.6 confirms Piketty's finding that the capital-income ratio for the eight wealthiest countries has increased steadily over 1970 to 2010. In 1970, their average capital-income ratio was around 340 percent (i.e. more than three years) of national income, and has risen to 525 percent (more than five years) of national income in 2010.[40] In contrast, the saving-ANNI growth ratio for all 30 OECD high-income countries displays a distinctly downward trend.

In the early 1970s, this ratio was around 700 percent, which suggests that the annual rate of adjusted net wealth accumulation was more than seven times the long-run average growth rate for the 30 countries from 1970 to 2014. But since the mid-2000s, the $s_t^*/\bar{g}^*$ ratio has fallen below 300 percent, which indicates the rate of adjusted net wealth accumulation each year has been less than three times the growth rate. On average, from 1970 to 2014, the saving-ANNI growth ratio was 422 percent, i.e. the rate of adjusted net wealth accumulation each year was four times long-run growth.

40 However, Jones (2015) shows that, when the value of the capital stock for the United States, France and the United Kingdom calculated by Piketty and Zucman (2014) and Piketty [2014] excludes land and housing, the rise in the capital-output ratios for each of these three countries in recent decades is more gradual. For example, in France, "the rise in the capital-output ratio since 1950 is to a great extent due to housing, which rises from 85% of national income in 1950 to 371% in 2010" (Jones 2015, p. 41).

Fig 4.6: Wealth-income accumulation relative to growth in OECD high-income countries, 1970–2014



High-income economies are those in which 2015 GNI per capita was $12,476 or more. The 30 OECD high-income countries are Australia, Austria, Belgium Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, the Republic of Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom and United States.

β is the capital/income ratio averaged for eight countries over 1970 to 2010, based on the national income-national wealth annual data series in Table A1 of the online technical appendix accompanying Piketty and Zucman (2014), available at http://piketty.pse.ens.fr/en/capitalisback (Accessed 12 June 2014). The eight countries are the United States, Japan, Germany, France, United Kingdom, Italy, Canada and Australia.

The data for constructing the s/g* ratio are based on the WDI (World Bank 2017). The measure of s* is gross national savings less the value of consumption of fixed capital and the value of net natural resource depletion as a percentage of ANNI (constant 2010 US$); the measure of g* is average annual growth of NNI per capita adjusted for the value of net natural resource depletion (constant 2010 US$).*

From 1970 to 2014, the average s for these eight countries was 9.1 percent, and g* was 2.1 percent; consequently, the average s*/g* ratio for this period was 422 percent. The margin of error (95 percent confidence level) associated with the sample mean for s* and g* was 1.7 and 0.5, respectively.*

The falling trends in s_t^* and $s_t^*/\overline{g}^*$ depicted in Fig 4.5 and Fig 4.6 indicate that the rate of net national saving adjusted for natural capital depreciation has declined even faster than any slowdown in long-run growth in rich economies from 1970 to 2014. This could have implications for long-run adjusted net wealth relative to income in these countries. For example, it is possible that the decline in saving-ANNI growth ratio over the past four decades in OECD high-income countries will continue into future years. If so, the rate of net wealth accumulation relative to growth will continue to fall well below the average rate of 422 percent from 1970 to 2014. To verify this possible long-run trend will require more analysis of these trends in the coming years.

4.4.2 Developing countries

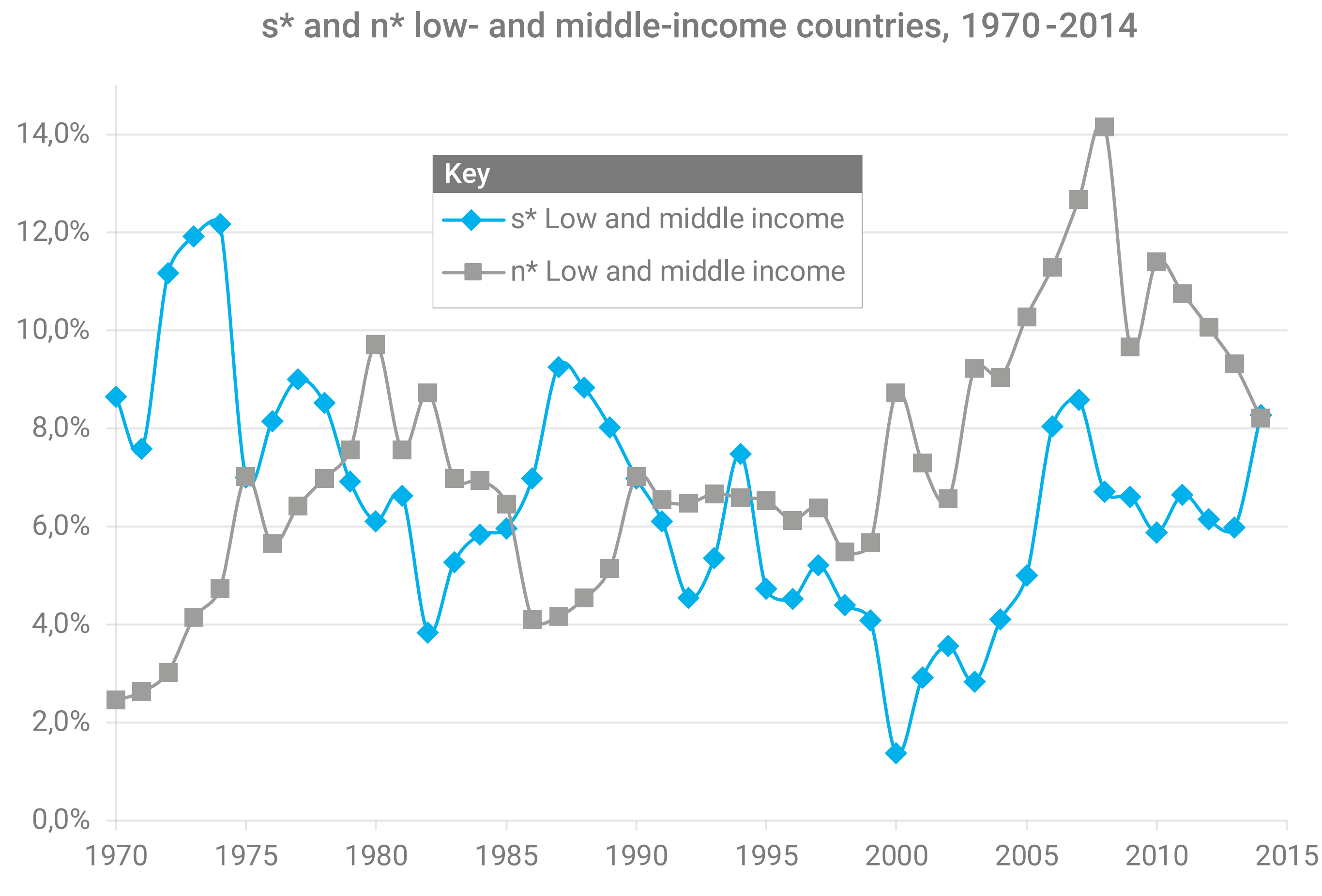
In comparison, very different trends in s_t^* , n_t^* and $s_t^*/\overline{g}^*$ have occurred for low- and middle-income countries over the past few decades. Fig 4. 7 indicates the average annual rates of adjusted net saving s_t^* and natural capital depreciation n_t^* for 113 developing economies from 1970 to 2014.

Both rates have varied considerably; there were distinct periods when the adjusted net saving rate has been above then fallen below the rate of natural capital depreciation. For example, in the 1970s the rate of natural capital deprecation was generally below the rate of savings, whereas from the mid-1990s onward the rate of natural capital depreciation has largely exceeded the adjusted net savings rate. One reason is the natural capital depreciation rate began rising from around 6 percent in the 1990s to peak at 14 percent in 2008, before declining to 8 percent by 2014. However, since its low point in 2000, the adjusted net savings rate has also increased, and in more recent years has been hovering around 6–7 percent. On average, from 1970 to 2014, both the rates of natural capital deprecation and adjusted net saving in developing countries were around 6–7 percent.

These long-run averages, plus the possibly converging trends in the two rates since 2005, indicate that, by and large, increases in other forms of capital may be keeping pace with the large natural capital depreciation occurring in these economies.

Overall, the saving-ANNI growth ratio $s_t^* / \bar{g}^*$ has declined for low- and middle-income countries from 1970 to 2014 (Fig 4. 8). The ratio has been rising since 2000, although in more recent years it has tended to fluctuate around the long-run average of 371 percent. This is still slightly lower than the average ratio of 422 percent over the 1970–2014 period for the OECD high-income economies (see Fig 4. 6). It is unclear whether the long-run average $s_t^* / \bar{g}^*$ ratio for developing countries will rise, as that will require the current trend of accumulating more net wealth relative to increasing income to continue into the future.

Fig 4.7: Adjusted net saving and natural capital depreciation in developing countries, 1970–2014

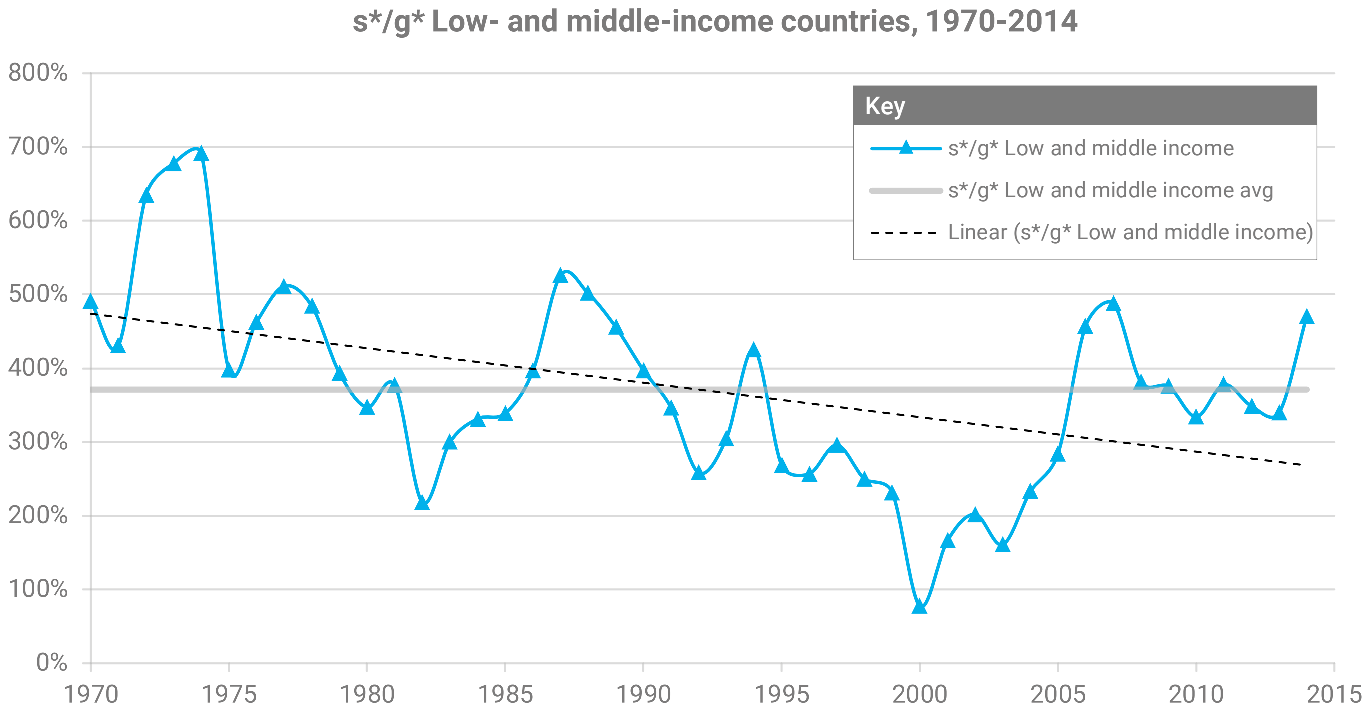


Based on a sample of 113 low- and middle-income (or developing) countries, which are economies with 2015 per capita income of $12,475 or less.

The data are based on the WDI (World Bank 2017). The measure of s is gross national savings less the value of consumption of fixed capital and the value of net natural resource depletion as a percentage of ANNI (constant 2010 US$); the measure of n* is annual value of net natural resource depletion as a percentage of ANNI (constant 2010 US$).*

From 1970 to 2014, the average s for these developing countries was 6.5 percent, and average n* was 7.3 percent. The margin of error (95 percent confidence level) associated with the sample mean for s* and n* was 2.1 and 2.8, respectively.*

Fig 4.8: Wealth-income accumulation relative to growth in developing countries, 1970–2014



Based on a sample of 113 low- and middle-income (or developing) countries, which are economies with 2015 per capita income of $12,475 or less.

The data for constructing the s/g* ratio are based on the WDI (World Bank 2017). The measure of s* is gross national savings less the value of consumption of fixed capital and the value of net natural resource depletion as a percentage of ANNI (constant 2010 US$); the measure of g* is average annual growth of NNI per capita adjusted for the value of net natural resource depletion (constant 2010 US$).*

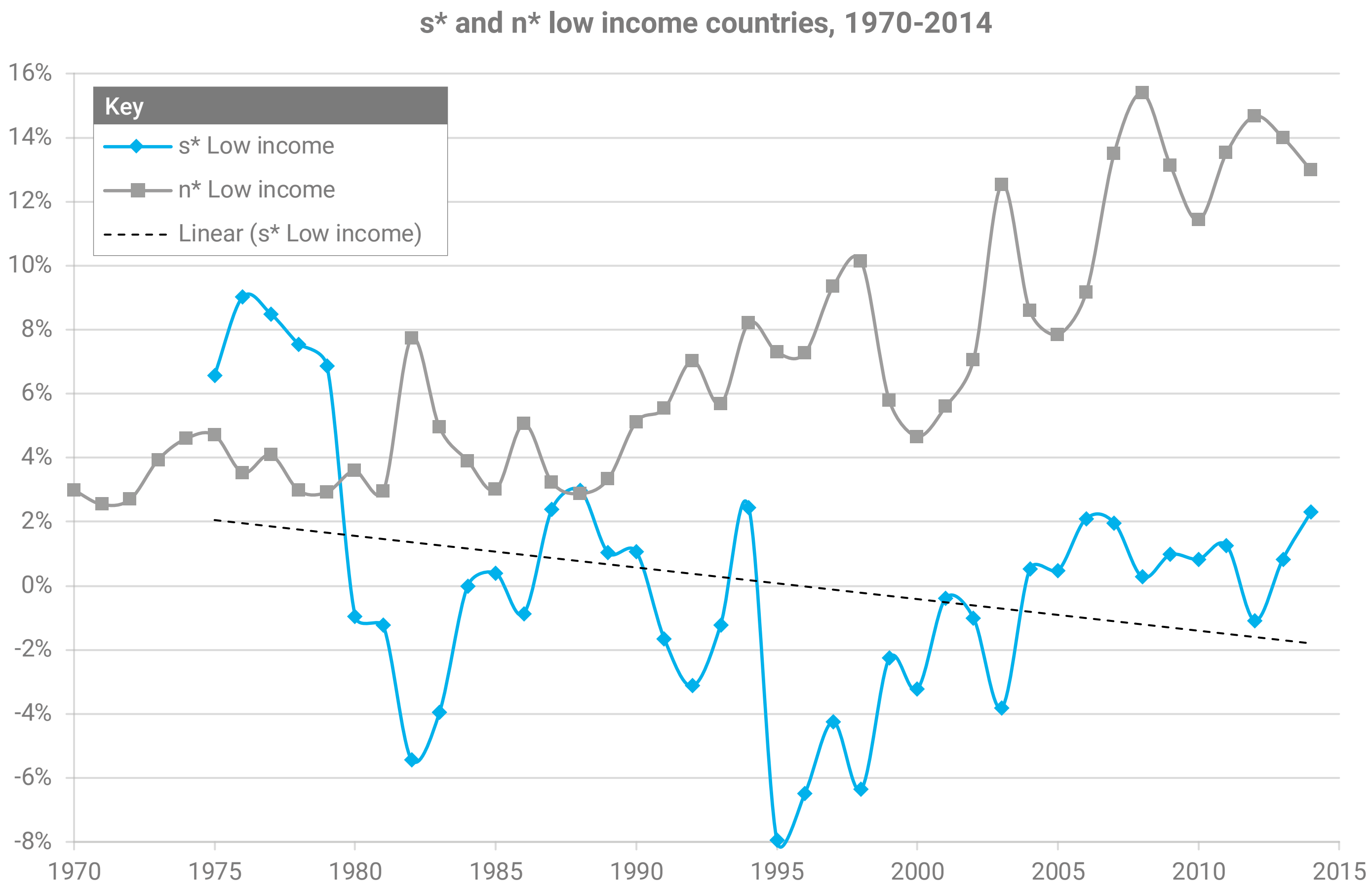
From 1970 to 2014, the average s for the sample of developing countries was 6.5 percent, and g* was 1.8 percent; consequently, the average s*/g* ratio for this period was 371 percent. The margin of error (95 percent confidence level) associated with the sample mean for s* and g* was 2.1 and 1.4, respectively.*

4.4.3 Low-income countries

As shown in Fig 4. 9, the adjusted net saving rate across 28 low-income economies has averaged 0.1 percent from 1975 to 2014, which is much lower than the average rate of 6.5 percent for the 1970–2014 period for all 113 developing countries (see Fig 4. 7). Moreover, for low-income countries, there is still a considerable gap between the long-run adjusted net saving rate and the natural capital depreciation rate of 6.9 percent. Although s_t^* has been rising since 1995 for poor economies, so has n_t^*.

The result is that the gap between these two rates is still considerable, and may even be growing. Since the mid-2000s, the adjusted net saving rate for low-income countries has fluctuated between 0 percent and 2 percent, whereas the rate of natural capital depreciation has risen from 8–9 percent to around 13–15 percent.

Fig 4.9: Adjusted net saving and natural capital depreciation in low-income countries, 1970–2014



Based on a sample of 28 low- and middle-income (or developing) countries, which are economies with 2015 per capita income of $1,025 or less.

The data are based on the WDI (World Bank 2017). The measure of s is gross national savings less the value of consumption of fixed capital and the value of net natural resource depletion as a percentage of ANNI (constant 2010 US$); the measure of n* is annual value of net natural resource depletion as a percentage of ANNI (constant 2010 US$).*

From 1970 to 2014, the average s for these developing countries was 0.1 percent, and average n* was 6.9 percent. The margin of error (95 percent confidence level) associated with the sample mean for s* and n* was 4.7 and 4.3, respectively.*

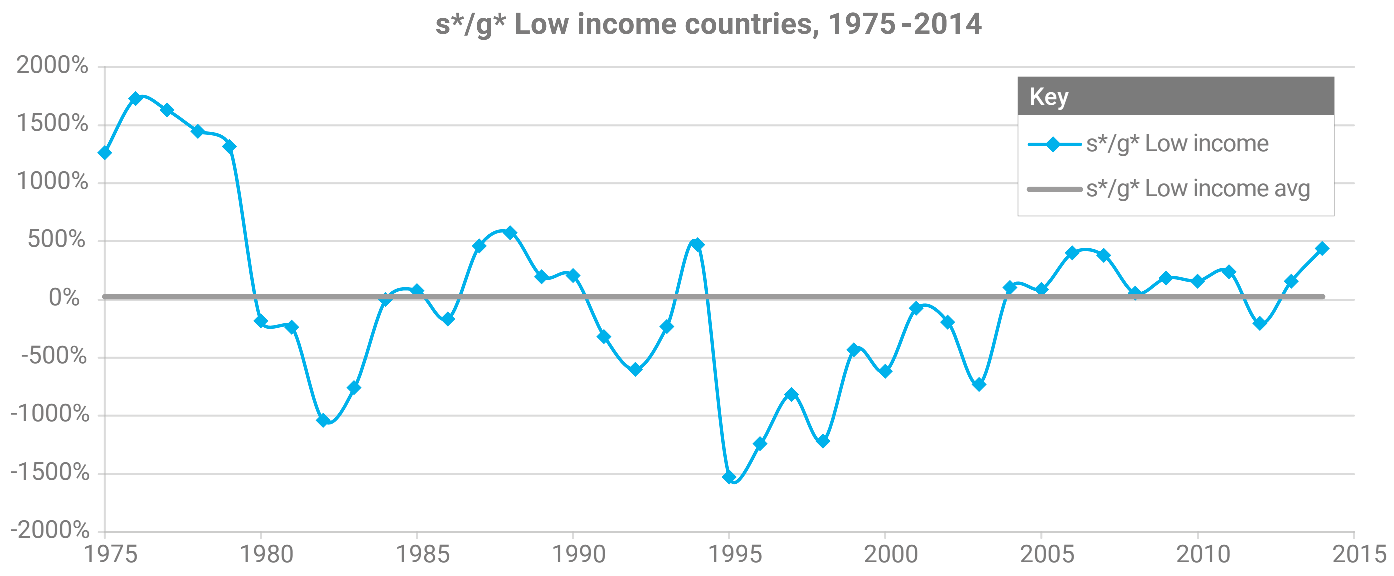
These trends in n_t^* and n_t^* have important implications for long-run wealth-income accumulation relative to growth in poor economies (Fig 4. 10). First, the long-run average growth in ANNI per capita $\bar{g}^*$ was only 0.5 percent for low-income countries from 1975 to 2014.

This was much lower than the equivalent rate for all developing countries, 1.8 percent (see Fig 4. 8).

Consequently, the average ratio of adjusted net saving to this growth rate over this period was only 24 percent, and there have been long stretches over the past four decades when this ratio has been significantly negative (see Fig 4.10). However, since 2000 the $s_t^*/\bar{g}^*$ ratio for the 28 low-income economies has been rising, and from 2005 to 2014, has averaged 190 percent.

If this positive trend continues, low-income countries will continue to experience accumulation in net-adjusted wealth at a faster pace than long-run per capita income grow

Fig 4.10: Wealth-income accumulation relative to growth in low-income countries, 1975–2014



Based on a sample of 28 low- and middle-income (or developing) countries, which are economies with 2015 per capita income of $1,025 or less.

The data for constructing the s/g* ratio are based on the WDI (World Bank 2017). The measure of s* is gross national savings less the value of consumption of fixed capital and the value of net natural resource depletion as a percentage of ANNI (constant 2010 US$); the measure of g* is average annual growth of NNI per capita adjusted for the value of net natural resource depletion (constant 2010 US$).*

From 1975 to 2014, the average s for the sample of developing countries was 0.1 percent, and g* was 0.5 percent; consequently, the average s*/g* ratio for this period was 24 percent. The margin of error (95 percent confidence level) associated with the sample mean for s* and g* was 4.7 and 1.0, respectively.*

To summarize, the high and rising rate of natural capital depreciation in low-income countries remains a concern. Although the rate of adjusted net saving has been rising since 1995, it remains very low, at less than 2 percent. This implies that in poor countries, accumulation of other forms of wealth is not keeping pace with ongoing natural capital depreciation.

The increase in wealth-income accumulation relative to growth in poor economies is encouraging, but this is in large part due to the very low growth in ANNI per capita over the long run (0.1 percent) in these countries. Reducing natural capital depreciation and increasing accumulation of other forms of capital is essential to improving long-run net wealth accumulation in poor economies in the long term.

4.4.4 Implications for wealth-income ratios and inequality

As the above analysis indicates, the wealth-income ratios for OECD high-income economies over the past four decades are clearly influenced by the depreciation of key natural resources, such as fossil fuels, minerals and forests. Although there may have been substantial accumulation of wealth relative to income, natural capital depreciation in these rich economies is being compensated less and less each year by net increases in other forms of capital. This implies that wealth accumulation, net of natural capital depreciation, has declined as a share of national income. As depicted in Fig 4. 5, this trend has been steadily falling over the past four decades.

If overall wealth accumulation net of natural capital depreciation as a share of national income is falling while private financial wealth is rising, the gap between rich and poor will continue to widen in all economies (see Table 4.1 and Table 4.2). If these trends for rich countries continue into the future, there will be even less net wealth creation relative to growth in these economies. If this is accompanied by increased financialization as observed by Piketty (2014), the result will be worsening wealth and income inequality. Piketty finds national wealth in rich countries is predominantly private wealth, and it comprises largely financial and industrial capital as well as urban real estate. This concentration of wealth is the source of much of the inequality in these countries, and the global economy. Unsurprisingly, studies of inequality in OECD countries already suggest that the problem is a serious one for these economies (OECD 2011).

For developing countries, although net wealth accumulation appears to have increased relative to income in recent years (see Fig 4. 7), the high rate of natural capital depreciation remains a concern. In the long run, the current rate of more than 7 percent across all low- and middle-income countries may adversely affect their net wealth accumulation. The overall trend of saving to ANNI growth has also been negative over the past four decades (see Fig 4. 8). Finally, as indicated in Table 4. 2, wealth inequality appears to be a problem for some developing economies. High rates of natural capital depreciation that reduce net wealth accumulation in low- and middle-income countries will only exacerbate this problem.

The high and rising rate of natural capital depreciation in low-income countries is a major concern (see Fig 4. 9). The long-run average rate is around 7 percent, but in recent years it has climbed from 8–9 percent to 13–15 percent. The gap with the current adjusted net saving rate, which is 0–2 percent, is therefore considerable, and indicates that investment in other forms of wealth is failing to compensate for the high rate of natural capital loss in poor economies. Unsurprisingly, the long-run average growth in ANNI per capita (0.5 percent) and net saving relative to this growth (24 percent) is extremely low for these countries. Although it is difficult to determine the implications for wealth inequality in low-income economies, the lack of progress in net wealth accumulation does not bode well for either fostering sustainable development or reducing any inequality.

4.5 Conclusions

It is possible to reconcile the inclusive wealth approach with Piketty's efforts to analyse long-run trends in wealth-income ratios and the composition of wealth for major economies. Given improved data sources, it is feasible to extend such an analysis to a wider set of economies. Here, the approach of adjusting to net national saving, income and growth for natural capital depreciation has been extended to 30 high-income economies, all members of the OECD, from 1970 to 2014. We have also examined the resulting implications for net wealth accumulation and inequality that have been observed by Piketty (2014) and other studies.

These trends have several important implications. For the OECD high-income countries, the long-run convergence of adjusted net savings rates with natural capital depreciation rates should raise concerns about overall wealth creation and growing inequality in these economies. For these countries, policies to encourage more economy-wide investment in other forms of capital to raise adjusted net saving rates, especially the long-run rate of net wealth accumulation relative to growth, are urgently needed. Although human capital accumulation is not included in the analysis of this chapter, there is also concern that investments in skills, training and education in these economies are lagging in these economies, both absolutely and relative to natural resource use (Barbier 2015; Goldin and Katz 2008; OECD 2011).

For developing countries, although net wealth accumulation appears to have kept pace with income growth in recent years, the high rate of natural capital depreciation is worrisome. This is especially true in low-income economies where the problem appears to be worsening. Over the long run, these high rates of depreciation are bound to affect the sustainability of development efforts adversely, and to worsen inequality. A key focus of policies should be to improve the efficiency and sustainability of natural resource use so that natural capital depreciation in developing countries is diminished substantially. This could be especially important for low-income countries, where reducing natural capital depreciation may prove instrumental to improving the adjusted net wealth-income ratio of these poorer economies over the long run.

To verify the long-run trends in net national saving, income and income growth adjusted for natural capital depreciation will require long-term data on natural capital stocks as well as depreciation rates. As we develop better measures of natural capital stocks and depreciation for 70 to 100 years or even longer, other considerations need to be taken into account. These include the role of demographic transitions, TFP changes, appropriate accounting for long-run natural capital asset and price appreciation, and the economic contributions of ecosystems and other environmental assets beyond fossil fuels, minerals and forests (Arrow *et al*. 2012; Fenichel and Abbott 2014; Greasley *et al.* 2014).

Finally, the long-run trends identified here confirm a bigger issue, which is explored by Barbier (2015). Namely, the world economy faces two major threats: increasing natural resource degradation and the growing gap between rich and poor. These two threats are symptomatic of a growing structural imbalance in all economies, how nature is exploited to create wealth and how it is shared among the population. As argued by Barbier (2015), the root of this imbalance is that natural capital is underpriced, and hence overly-exploited, and the resulting proceeds are insufficiently invested in accumulating other forms of wealth, especially human capital. The long-run trends in net national saving, income and income growth analysed for rich and poor economies in this chapter gives some indication of this structural imbalance. We need further development of such indicators – and perhaps others too – to shed further light on the possible links between growing environmental and natural resource scarcity and inequality in all economies.

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APPENDIX

Adjusting Conventional National Income and Savings for Natural Capital Depreciation

Following the approach developed by Barbier (2016), it is possible to modify the conventional income and savings measures used by Piketty (2014) and Piketty and Zucman (2014) to allow for natural capital depreciation.

Following their approach and notation, let *Wt* denote the market value of national wealth at time *t*, and *St* is the net national savings flow between time *t* and *t*+1. In the absence of any capital gains or losses between *t* and *t*+1, then wealth accumulation is simply $W_{t+1} - W_t = S_t$. If *Yt* is net national income (i.e. national income less domestic capital depreciation) at time *t*, then the corresponding net national saving rate in the economy is $s_t = S_t / Y_t$ and the ratio of wealth (or capital) to income is $\beta_t = W_t / Y_t$.

Suppose that, in addition to *Wt*, an economy also contains a stock of available natural resources for production, with market value at time *t* of $\tilde{N}_t \geq 0$.

The total wealth of the economy at time *t* is therefore $W_t^* = W_t + \tilde{N}_t$. As wealth now includes an endowment of natural capital, both net national income and net national savings in time *t* should be adjusted for any depreciation of natural capital depletion through its use in production over *t* and *t*+1, net of any changes in the endowment due to new discoveries over the year and also renewable resource growth. Barbier (2016) refers to this modification of Piketty's definition of wealth W_t^* as adjusted net wealth.

Let Y_t^* and S_t^* represent the adjustments to net national income and savings for any natural capital depreciation, respectively. It follows that the accumulation in adjusted net wealth between *t* and *t*+1 is

$$W_{t+1}^* - W_t^* = S_t^*$$

Dividing both sides by adjusted net national income Y_t^* yields

$$\frac{W_{t+1}^* - W_t^*}{Y_t^*} = \frac{\Delta W^*}{Y_t^*} = s_t^* \qquad (1)$$

where $s_t^* = S_t^* / Y_t^*$ is the net national saving rate adjusted for natural capital depreciation, or the adjusted net saving rate. As equation (1) states, s_t^* is an indicator of the annual change in wealth (inclusive of natural capital) relative to net national income (adjusted for natural capital depreciation).[41]

The saving rate s_t^* can also be expressed as a ratio with respect to the long-run average annual growth in ANNI per capita. For any period of *T* years, the latter growth rate is.

$$\bar{g}^* = \frac{1}{T}\sum_{t=0}^{T-1}\frac{\Delta Y_t^*}{Y_t^*}$$

Consequently,

$$\frac{s_t^*}{\bar{g}^*} = \frac{\Delta W^* / Y_t^*}{\bar{g}^*} \qquad (2)$$

The ratio indicates how annual changes in adjusted net wealth relative to income compare with the average annual income growth per capita over some defined time period of *T* years. For example, if this growth rate is 2 percent per year, and adjusted net saving is 10 percent, then the rate of adjusted net wealth accumulation each year is 500 percent of long-run growth. However, if the adjusted net saving rate falls to 4 percent, then the rate of annual wealth accumulation relative to income is only 200 percent of $\bar{g}^*$. Thus, this ratio is an important indicator as it depicts, over a defined period of *T* years, how the annual rate of net wealth accumulation compares to long-run growth over that period. Consequently, if there is a discernible trend in the $s_t^* / \bar{g}^*$ ratio, it indicates whether or not adjusted net wealth is accumulating relative to increases in income over the long term.

41 As shown in the appendix to Barbier (2017), the adjusted net savings rate is also an indicator of the annual change in adjusted net wealth per capita relative to adjusted net national income per capita $s_t^* = \frac{\Delta \hat{W}^*}{\hat{Y}_t^*}$, where η_t represents population growth and a "hat" (^) indicates a per capita variable.

CHAPTER 5: CHALLENGES TO ECOSYSTEM SERVICE VALUATION FOR WEALTH ACCOUNTING

Kristine Grimsrud, Henrik Lindhjem, David N. Barton, Ståle Navrud

5.1. Introduction

The Inclusive Wealth Framework is a tool to analyse "society's sustainability" (Dasgupta and Duraiappah 2012), a property which may be defined as non-declining human well-being over time. Dasgupta argues that the best index to track human well-being over time is society's wealth, where "wealth is the social worth of an economy's capital assets" (Dasgupta and Duraiappah 2012: p22). Further, the Inclusive Wealth Framework defines the aggregate wealth as the shadow value (or price) of the stocks of all assets of an economy. It also suggests "natural capital", resources like fossil fuels, should be included in this wealth.

Shadow values are a key measure to IW. Dasgupta and Duraiappah (2012) define the shadow price or value of a capital asset as the monetary measure of the contribution a marginal unit of that asset is forecast to make to human well-being. The shadow value is thus a more comprehensive measure of value than, for example, unadjusted market prices. Shadow prices capture the substitutability of the capital assets not just in the present period, but also in the future. The Inclusive Wealth Framework can accommodate non-linear processes of natural systems and provide early warnings in the process, to avert such thresholds from being reached if the shadow prices are estimated using certain valuation methods.

The major challenge, however, is to estimate the shadow prices of the natural and ecosystem capital assets. For example, we do not have full knowledge of the production functions of life-supporting systems. Dasgupta and Duraiappah (2012) recognize that we may never get the shadow prices "right", instead we can simply try to estimate the range in which they lie. The next best solution, they argue, is to use shadow prices based on willingness to pay measures, while recognizing these shadow prices may not capture threshold effects of an ecosystem (Farley 2012). The Inclusive Wealth Accounting Framework proposes to expand the net domestic product (NDP), which equals the GDP adjusted for appreciation/depreciation of capital, as is currently measured in most national economies, in two ways:

(1) The depreciation or appreciation of human and natural capital should be included (i.e. natural resources and ecosystems).

(2) The basis for valuing the capital stocks should be shadow prices. Exchange values as is currently used in statistical offices may be used if the exchange values are a good approximation to the shadow prices.

In the SNA, goods are valued using exchange values when such values are available. The reason is, national accounts aim to provide a measure of production, not welfare as such, and therefore exclude consumer surplus. While the exchange value often is the market price, it is important to be aware of some slight nuances between the concept of a market price and an exchange value. Market prices depend on level of scarcity and on market conditions. The following definition has been used for market price: "the amounts of money that willing purchasers pay to acquire goods, services or assets from willing sellers" (EC *et al*. 2009, para3. p119). In national accounting one refers to "exchange values" and not to "market prices" where an exchange value is "the value at which goods, services and assets are exchanged regardless of the prevailing market conditions" (Obst *et al*. 2015).

The Inclusive Wealth Accounting Framework and the SEEA (United Nations *et al*., 2014a) of the United Nations have several challenges in common in terms of valuing natural resources and ecosystems. Both have a goal to better account for the importance of ecosystem and natural capital stocks to society. SEEA aims to better account for the relationships between the economy and the environment and the stock of environmental assets and how environmental assets, benefit humanity. The Inclusive Wealth Framework considers the impact of changes in capital stocks on human welfare. However, as noted above, there is a major difference between the two accounting frameworks; the Inclusive Wealth Framework requires shadow prices for valuing capital stocks while SEEA requires exchange values in valuing capital stocks. Exchange values is required by the latter to be consistent with the accounting framework of the SNA, which countries use to estimate the asset value of produced capital stocks.

This chapter will largely focus on the SEEA system for ecosystem accounting: the SEEA Experimental Ecosystem Accounting (SEEA EEA) (United Nations *et al*. 2014b). SEEA EEA has a goal to account for the contribution of ecosystems to production and consumption of economic units including households, where the concept of production and consumption is broader than the standard SNA to include all types of ES (pers. comm., Carl Obst, 2017). Both the Inclusive Wealth Framework and the SEEA EEA framework rely on non-market valuation methods for ecosystem assets. SEEA EEA requires that the non-market valuation methods are consistent with the methods used in the field of accounting.

The Inclusive Wealth Framework has, in past reports, drawn more generally on the non-market valuation methods used in environmental economics; thus far, a large number of such studies have been performed in environmental economics. Thus, there is a need to clarify and bridge the gap between the disciplines of accounting and environmental economics when it comes to non-market valuation.

At the same time, there are challenges with the non-market valuation methods accepted within both the accounting and the environmental economics communities. Many of the challenges with using the valuation methods are the same for both accounting frameworks, so we will discuss some of the progress to date that has been made on meeting these challenges in the last version of the SEEA EEA (United Nations 2014b) and the associated Technical Recommendations (United Nations 2017) developed by the United Nations. As development and practical implementation and testing of SEEA EEA progress, many of the measurement challenges associated with valuation of ecosystem services will become better understood, and potential solutions are already being discussed. This progress should also be of great relevance for addressing many of the measurement challenges within the Inclusive Wealth Framework. SEEA and its developments is an important step on the road to wealth accounting (Perrings 2012). The accounting community has criticized the various forms of "green accounting" and different indicators proposed to measure macroeconomic welfare in the economic literature (where IW is one of several such indicators). One particular criticism has been that they are situated at a very "high level of abstraction without searching any longer for any relationship to actual national accounting measurements" (Vanoli 2005, Obst *et al.* 2016).-

In this chapter we first provide an overview of recent progress on the SEEA, and specifically look at the inclusions of spatially explicit physical and monetary accounts for ecosystems (SEEA EEA) in section 3. In section 4 we discuss some key challenges and ways forward for monetary valuation of ecosystem services, benefits and assets within this accounting framework. We use examples from Norway as illustrations. We end the chapter by discussing some limitations of the SEEA accounting framework and future directions.

5.2. System of Environmental-Economic Accounting (SEEA)

The main goal of the SEEA is to better monitor the interactions between the economy and the state of the environment, in order to inform decision-making, typically at the national level. The SEEA framework is consistent with the SNA to allow the integration of environmental and economic statistics and make it simple for national statistical offices to adopt the SEEA system. Compared to SNA, the SEEA framework expands the production boundary, with the aim to include the whole biophysical environment and a broader set of ecosystem services. SEEA 2012 (United Nations et al. 2014a) builds upon revisions of SEEA 2003 (discussed in the IWR 2012 by Perrings (2012)), and SEEA 1993. SEEA contains the internationally agreed upon concepts for producing internationally comparable statistics on the environment and its relationship with the economy. By 2014, 18 percent of United Nations member countries had initiated a programme to enhance environmental-economic accounting, and 27 percent of developing countries and 8 percent of developed countries had a programme for environmental-economic accounting. Thus, the United Nations Statistical Commission's current initiatives to revise and improve the SEEA system appear to be welcomed by member countries. As of September 2017, SEEA consists of three parts:

- The SEEA Central Framework (SEEA CF).
- The SEEA Experimental Ecosystem Accounting (SEEA EEA).
- The SEEA Subsystems for Energy, Water, Fisheries, and Agriculture. The 'subsystems' are consistent with SEEA, but provide further details on specific topics.

The central framework of SEEA, SEEA CF, accounts for individual resources such as timber resources, land, energy and minerals resources; physical environmental flows, such as water, energy, emissions and waste; and environmentally related transactions within the economy, such as environmental protection expenditure and environmental taxes. The SEEA CF was adopted by the United Nations Security Council (UNSC) in 2012 as the first international standard for environmental-economic accounting. The official version of SEEA CF was published in 2014.

Since the publication of the previous IWRs, rapid progress has been made in the effort to develop an accounting system for ecosystem flows and assets both in physical and monetary terms through the work on the SEEA Experimental Ecosystem Accounting (SEEA EEA). In 2013, the UNSC endorsed SEEA EEA for further development and testing, and the accounting framework was published in 2014. The SEEA EEA: Technical Recommendations (SEEA EEA TR) presents information that supports the testing and research on SEEA EEA; it is motivated by the practical experiences with the accounting framework and advances in thinking on specific topics since the first SEEA EEA (United Nations 2017). The SEEA EEA TR was published in fall 2017 and work has been initiated to revise the SEEA EEA by 2020.

Monetary valuation of ecosystem services in SEEA EEA is motivated by several perspectives: input for wealth accounting, demonstration of the contribution of ecosystems to human welfare, and evaluation of policy alternatives. SEEA EEA provides insight into how ecosystems can be considered a form of capital that can appreciate and depreciate, in the same way as other forms of capital such as human, social and economic capital.

The development of the necessary accounting-compatible concepts for a spatially explicit accounting system for ecosystem services and assets is a challenging task, and currently one that is a work in progress. The concepts and thinking developed and implemented in SEEA EEA to date should be helpful in contributing to improve inclusive wealth accounting of natural capital.

5.2.1. SEEA Experimental Ecosystem Accounting

SEEA EEA contains spatially explicit physical and monetary accounts for ecosystems. Compiling these kind of accounts requires a multidisciplinary approach. To determine rates of asset appreciation or depreciation, one also needs these accounts to be compiled regularly over time. SEEA EEA is termed experimental because many concepts for such spatially explicit and repeated accounts for ecosystem services and assets are still under testing and development (see e.g. Remme *et al.* 2015).

As noted above, the work on developing the SEEA EEA accounts is progressing fast. In the experimental phase the focus is generally on policy relevant case studies, where concepts are being developed and tested. In this phase, numbers may not be as accurate as one would desire. However, it has been argued that having approximate numbers to map ecosystems that can demonstrate their importance to the general economy may be better than the current practice; implicitly valuing ecosystems through decisions regarding the maintaining or transforming of ecosystems. Bateman *et al.* (2013; 2011) show, for example, in the context of the UK National Ecosystem Assessment (UK NEA), a systematic environmental and economic analysis of the benefits and costs of land use options, that taking account of multiple environmental objectives fundamentally alters decisions regarding optimal land use.

Fig 5.1 provides an overview of the conceptual thinking for the ecosystem accounting in SEEA EEA. Ecosystems are at the basis for the accounting system. In the accounting terminology, individual contiguous ecosystems are considered ecosystem assets (element 1 in Fig 5.1).[42] Ecosystems are characterized by their extent, biotic and abiotic components and their processes. Ecosystem assets may be aggregated into the ecosystem types, ecosystems with similar ecology and use that are typically not contiguous, for example forests or agricultural ecosystems within the accounting area under study.

The relevant characteristics and processes describe the ecosystem functioning (element 2). An ecosystem asset delivers ecosystem services, and the focus in SEEA EEA is on final ecosystem services (United Nations et al. 2014b). Final ecosystem services are either benefits to users (economic units) directly in themselves, or they can be thought of as an input to production of benefits, along with other inputs such as labour and produced assets. Both for accounting purposes and for monetary valuation, it is important to clarify this distinction between ecosystem services and ecosystem benefits (United Nations *et al.* 2014b; Banzhaf and Boyd 2012). This distinction helps to avoid double counting.

The SEEA EEA uses the classification of final ecosystem services into: provisioning services, like those relating to the supply of food, fibre, fuel and water; regulating services like those relating to actions of filtration, purification, regulation and maintenance of air, water, soil, habitat and climate; and cultural services, like those relating to the activities of individuals in, or associated with, nature.

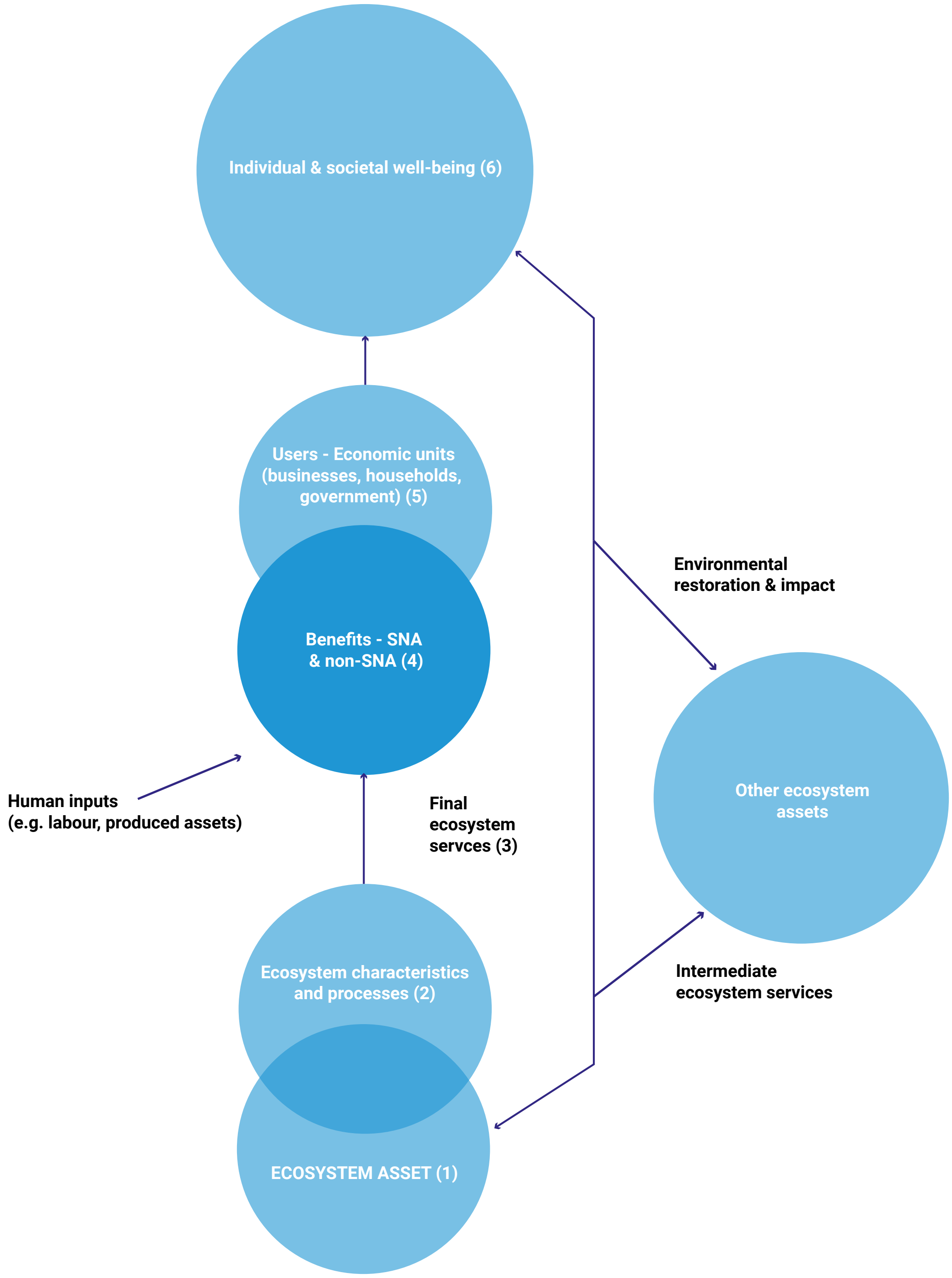
The benefits produced by ecosystem services may either be so-called SNA-benefits, meaning they are already accounted for in SNA (e.g. timber products) or they may be non-SNA benefits, which means they are outside the accounting boundary of SNA (e.g. flood protection). It is important to be clear about whether an ecosystem service already may have been accounted for in SNA, to prevent potential double counting. It is generally still important to make the role of the ecosystem services explicit, even for those ecosystem svices that presently are within the accounting boundary of SNA.

The supply of ecosystem benefits is matched with the economic units that use the benefits, like businesses, households and the government. To be consistent with the accounting framework, supply of ecosystem benefits must equal the use or demand ("use" is more in line with the terminology of SEEA). The benefits contribute to "individual and societal well-being", the measure of which is the ultimate purpose of the accounting framework (Fig 5.1). The accounting system is designed to account for benefits both in terms of physical production and in monetary units where possible.

It should be noted that intermediate ecosystem services, those that are inputs to the supply of other ecosystem services, are also identified in the framework. In ecosystem accounting, if one ecosystem produces services that contribute to produce ecosystem services in another ecosystem, like pollination and flood control, these are also considered intermediate (SEEA EEA TR, paragraph 5.40)

42 Note that in the ecosystem accounting framework biodiversity is treated as a component of the ecosystem asset rather than as an ecosystem service in its own right (United Nations 2017). In addition, biodiversity is also included in standalone thematic accounts.

Fig 5.1: Ecosystem Accounting Framework for SEEA EEA



Source: United Nations (2017)

Further, the SEEA EEA has five core accounts:

1. Ecosystem extent account – physical terms
2. Ecosystem condition account – physical terms
3. Ecosystem services supply and use account– physical terms
4. Ecosystem services supply and use account – monetary terms
5. Ecosystem monetary asset account – monetary terms

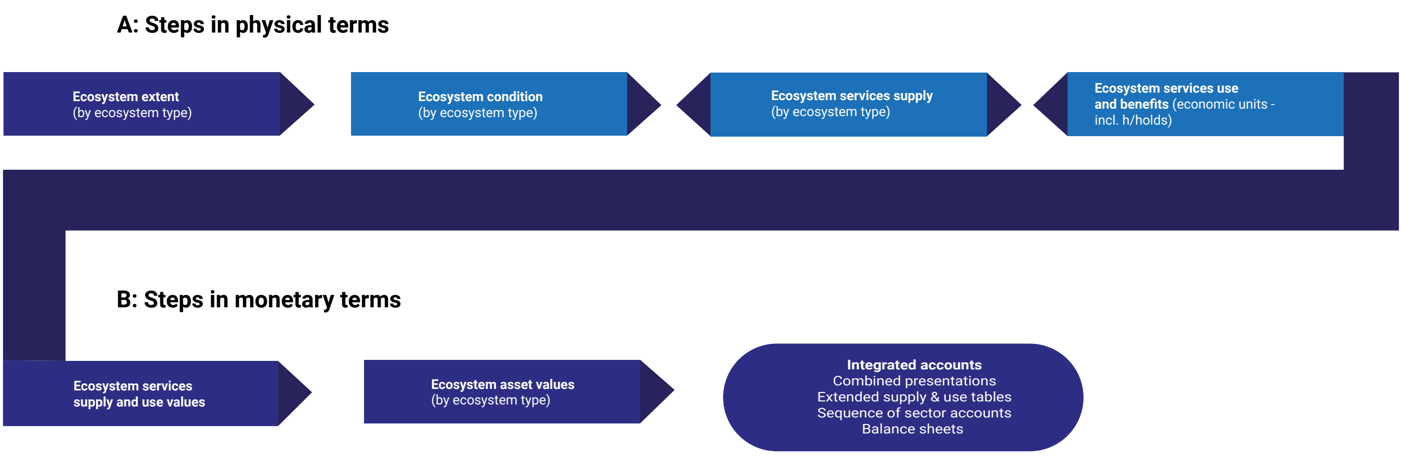
Fig 5.2 describes the relationship between these accounts as a series of (a) physical and (b) monetary steps, arriving at a set of integrated accounts. Even if one may describe this as a sequence of accounts, it should be emphasized that the development of these accounts most often will be iterative; permitting one to go back to adjust and make improvements. Hence, an arrow could be drawn from the final step back to the first. Each of the accounts is intendent to provide useful information in itself, while also being an input into other accounts. In Fig 5.2, ecosystem services supply and use accounts are included as two separate boxes to reflect the iterative process in generating ecosystem services supply and use accounts in physical terms.

SEEA EEA TR includes example tables for all the accounts. These tables are useful illustrations of the accounts, but too extensive to include here. The ecosystem extent account maps the area of land in each land use and ecosystem type. Examples of ecosystems include forests, agriculture, wetlands, and urban, although subcategories of these ecosystem types may be deemed necessary depending on the circumstances. For example, natural forest and planted forests for timber production will have quite different characteristics. For each of the ecosystem types, the condition account includes the available and appropriate indicators of the "overall quality of an ecosystem asset in terms of its characteristics" (United Nations et al. 2014b, paragraph 2.35). The condition of the ecosystem is the basis for the capacity of the ecosystem to provide ecosystem services in the future, which in turn affects the ecosystem asset value.

The ecosystem condition may be evaluated by comparing ecological indicator values now, with the ecological indicator values in the reference condition for the ecosystem.

What the reference condition should be is discussed in the Technical Recommendations (United Nations 2017). It is part of an ongoing debate, since ecosystems in some countries have been affected by human beings for such a long time that the ecosystems have evolved to be dependent on human management. One suggestion for a choice of reference condition is to consider the condition that existed when data collection began (United Nations 2017).[43] Depending on the condition of an ecosystem, the ecosystem supplies a basket of ecosystem services. Then the ecosystem services use and benefits are further attributed to economic units, including households, agriculture, the government, and other economic sectors. Again, the subcategories one chooses for the economic units depends on the circumstances; the measurements necessary for the ecosystem condition account, the ecosystem services supply and ecosystem services use may be completed concurrently. This is indicated by the dotted line.

Fig 5.2: Broad steps in ecosystem accounting



Source: United Nations (2017)

43 Data collection started in many countries when ecosystems were already at a highly modified, depleted state. Hence, this view of the references condition has its problems.

While the first row in Fig 5.2 are all physical accounts, the second row in Fig 5.2 are monetary accounts; the ones with which we are primarily concerned. The first box in the second row is the account for the ecosystem services use and supply values.

In the SEEA EEA TR, the ecosystem monetary asset account is defined as accounts that "record the monetary value of opening and closing stocks of all ecosystem assets within an ecosystem accounting area and addition and reductions in those stocks" (United Nations 2017, paragraph 7.5). The reason for using monetary valuation of ecosystem assets in SEEA EEA is twofold. One motivation is that monetary valuation gives a common measurement unit which is helpful when comparing alternative uses of ecosystem assets. A second motivation is that monetary valuation allows the ecosystem asset account to be integrated with other accounts, for the other capital assets discussed in Chapter 1 of this report. In that sense, compiling the SEEA EEA ecosystem asset accounts and integrating them with the NDP could give a more complete assessment of a nation's net wealth. As in the Inclusive Wealth Framework, the SEEA EEA framework considers a depreciation of aggregate ecosystem assets a potential sign of unsustainable ecosystem use, but there are some important differences in the view on the meaning and treatment of depreciation in the two frameworks (Obst pers. comm., 2017).

The thinking regarding the construction of ecosystem asset accounts in SEEA EEA is related but slightly different to the ecosystem capital thinking in the Inclusive Wealth Framework. SEEA EEA is an expansion of the accounting framework in the SNA. The SNA defines the GDP as a measure of economic performance, and states explicitly that GDP is not a measure of human welfare (United Nations 2008). SEEA EEA TR recognizes there are several perspectives that may be taken when it comes to estimating a nation's wealth in terms of natural and ecosystem capital (United Nations 2017, paragraph 7.1). In the perspective of the Inclusive Wealth Framework, the goal is to maximize intergenerational human welfare derived from all capital stocks. When operationalizing this, the Inclusive Wealth Framework proposes to expand the NDP (the depreciation adjusted GDP) to include all types of capital.

SEEA EEA holds that one may account for ecosystem assets, as for any other asset, using a capital theoretic framework. If there is no market for an asset, such as for ecosystem assets, then the monetary value of the asset may be estimated in terms of the present value of the future flow of income attributable to an asset. For an ecosystem asset, estimation of the monetary asset value requires information on:

- the appropriate prices now and in the future;
- the expected future ecosystem service supply;
- the appropriate discount rate to calculate the net present value (NPV);
- the expected life of the asset.

The expected ecosystem service supply should be as close as possible to what one actually expects to be used and the prices should be as close as possible to the exchange values one expects for the future.

The final box in Fig 5.2 refers to the integration of ecosystem accounts with the standard national accounts, one of the purposes of EEA. This may be done in several ways depending on how closely one wants to integrate the accounts. The methods range from combined presentation of only physical data on ecosystem condition and services alongside presentations of standard national accounts numbers to complete integration where the value of ecosystem assets is incorporated with the values of other capital assets in order to extend the measure of national wealth.

The SEEA EEA offers useful concepts and accounting structures ultimately leading to ecosystem asset accounts. Furthermore, the SEEA EEA provides a framework that is compatible with national accounts and therefore with statistical offices' definitions used in the NDP. However, SEEA EEA differs from the theoretical framework of the Inclusive Wealth model since the latter requires that all the economy's capital assets should be valued at their shadow value.

5.3. Valuation Challenges for Ecosystem Services, Benefits and Assets

As noted above, the meaning of an exchange value is quite different from the meaning of a shadow value, in terms of its implications for human welfare. Yet, there are some commonalities in terms of the challenges that one may run into when attempting to determine these values. We now discuss some of these challenges.

5.3.1. Ecosystem service delineation and some fundamental challenges

The definition of an ecosystem service has been widely discussed in the literature in recent years, and the definition in MEA (2005), for example, has been deemed inappropriate for valuation and accounting purposes both in IWR and in SEEA EEA (Pearson *et al.* 2012, United Nations 2017, paragraph 5.35). Instead, the need to focus on final ecosystem services and to separate between ecosystem services and ecosystem goods or benefits, to avoid double counting has been recognized in both previous IWRs and in the SEEA EEA (see also discussion in section 3 above). By making the distinction between benefits, also called goods in the UK NEA, and services it is possible to include several ecosystem services that are inputs in the production function of an ecosystem benefit. For example, harvested fish is an ecosystem benefit, but one must subtract the cost of harvesting to find the contribution of the ecosystem — that is the ecosystem service — to the benefit.

Several definitions of ecosystem services and goods exist. For example, Barbier (2012) adopts the definition that "ecosystem services are the direct or indirect contributions that ecosystem make to the well-being of human populations (EPA, 2009, p.12)". Whichever definition one adopts, the literature has reached the conclusion that one should avoid double counting, and this is possible by focusing on final ecosystem benefits (goods) (indirect) and services (direct).

Before we take a practical and pragmatic approach to estimating monetary values for ecosystem services, benefits and assets, it is necessary to recall that many ecosystems are complex and poorly understood both by scientists and the general population (see e.g. the recently discovered cold water corals in Norway discussed in Aanesen *et al.* 2015). Barbier (2012, p. 163), for example, states that: "There is inadequate knowledge to link changes in ecosystem structure and function to the production of valuable goods and services". Though knowledge of ecosystem processes is never going to be complete or perfect, it is important to attempt to value them using current knowledge in order to help demonstrate the importance of ecosystem health and function to human well-being.. Implicit valuation by a limited number of decision makers, which is generally the norm when it comes to ecosystem management, is unlikely to reach efficient or welfare optimal choices (as noted above in the context of the UK NEA). This is also the argument made by the international project and process of The Economics and Ecosystems and Biodiversity (TEEB) (Kumar 2010).

In the following sections, we discuss some important challenges with valuation of ecosystem services and benefits that are market (section 4.3) and non-market (section 4.4), respectively, and the valuation of ecosystem assets (section 4.5). We relate the discussion to the framework of experimental ecosystem accounting (cf. back to Fig 5.1 and Fig 5.2 above) and especially the use of methods for non-market services.

5.3.2. Market ecosystem services and benefits

Many ecosystem services and benefits such as fish, grains, timber and products derived from these have market prices which are relevant exchange values and therefore compatible with national accounting and SEEA EEA. When estimating the contribution of the ecosystem to harvested fish, one estimates the surplus remaining after all costs related to harvesting have been subtracted from the total revenue. In an accounting framework, it is important to be aware of the impact the institutional arrangement has on the value of the resource rent of many of the provisioning goods. The institutional arrangement may affect both the prices received by fishers and the costs of harvesting, and it is the prices and costs along with the quantity produced that in turn determine the size of the resource rent. For fisheries, examples of institutional arrangements may be open access, quotas or individually tradable quotas, among others. In an open access management regime, the value of the resource rents tends to zero and it is an open question how to value the resource under such circumstances (Hein *et al.* 2015). However, other management regimes can contribute to conceal the resource rent in national accounts, even if access to the fishery is limited. Policies that make fishing artificially expensive, for example, may cause the resource rent to be masked in national accounts. In such cases, there are likely to be other indicators than resource rents that are of policy importance and which can be monitored, such as employment. In cases where exchange value principles do not provide any additional information, parallel accounts and complementary indicators must be relied upon.

5.3.3. Non-market ecosystem services and benefits

The most significant challenge for valuation of ecosystem services is that many of them are non-marketed (Barbier 2014). To tackle this issue, the field of environmental economics has developed a number of methods to value non-market ecosystem services. Barbier (2012) provides an overview of the progress that has been made in environmental economics on developing methodologies for valuation of non-market ecosystem services, and presents the non-market valuation methods that are currently available along with the ecosystem services for which each of the methods is appropriate. These valuation methods are summarized in Box 4.

Box 4 - Categories of non-market valuation methods

Stated preference methods: Willingness to pay/or to accept compensation for changes in provision of ecosystem services/benefits are elicited from respondents in surveys using structured questionnaires. Stated preference methods are the only methods that can cover non-use/existence values. Well-known methods include contingent valuation and choice experiments.

Revealed preference methods: Values are "revealed" through studying consumers' choices and the resulting price changes in actual markets, that can then be associated with changes in provision of ecosystem services. A well-known method is hedonic pricing of property characteristics, i.e. where the impact of environmental quality attributes on prices of properties is distinguished from other factors that affect prices. Travel cost methods used to value recreational benefits of ecosystems are often also included in this category.

Production/damage function approaches: A group of methods used to value an ecosystem service, where intermediate ecosystem services are one of several "inputs" to the final service or good enjoyed by people. Ecosystems' marginal contribution to the final service is valued.

Cost-based methods: Assume that expenditures involved in preventing, avoiding ("averting"), mitigating or replacing losses of ecosystem services represent a minimum value estimate of what people are willing to pay for the ecosystem service. In ecosystem accounting a distinction is made between replacement cost (of a particular ecosystem service) and restoration cost (of an ecosystem asset and its bundle of ecosystem services).

Benefits/value transfer methods: Refer to the use of secondary, existing study valuation estimates, from any of the valuation methods mentioned above, transferred to the "policy context" in need of value information. Values can either be transferred using unit value transfer methods or more advanced function-based transfers (e.g. based on meta-analysis of the literature).

Sources: Champ et al. (2017), Barton and Harrison (2017), Johnston et al. (2015), Barbier (2012), Koetse et al. (2015).

Even if the coverage of environmental valuation studies may be considered patchy across ecosystem goods (ecosystem goods are referred to as ecosystem benefits in SEEA EEA) and services (Barbier 2014), a large number of valuation studies for ecosystem services and benefits have been carried out in the past few years, using environmental economic methods (e.g. Kumar 2010). The ideal situation would be to have specifically designed valuation studies for accounting purposes; yet this is rarely the case. Consequently, accountants and economists typically use value or benefit transfer methods (see Box 4) based on suitable, existing studies to estimate, if possible, exchange values (see e.g. Johnston and Wainger 2015).[44]

National accountants have their set of accounting-compatible valuation methods for non-market environmental goods (Vincent 2015). Unfortunately, only a subset of the non-market valuation methods developed in environmental economics are accounting compatible, meaning they are directly appropriate in an accounting framework. This is because environmental economics is focused on finding estimates of welfare, and as a consequence, most non-market valuation methods produce value estimates that include consumer surplus. SNA-compatible accounting requires exchange values, so values used here should exclude the consumer surplus. At the same time, finding accounting-compatible monetary values for all ecosystem services is a significant challenge for SEEA EEA (United Nations 2014b). The SEEA EEA TR therefore offers several suggestions to bridge the gap between accounting and economics when it comes to valuation.

A subset of methods developed in environmental economics does not include consumer surplus and has therefore been deemed appropriate for SEEA EEA. SEEA EEA TR (United Nations 2017, Table 6.1) provides a list of valuation techniques used in economics for non-market ecosystem services that are accounting compatible. There is, broadly speaking, three types of accounting compatible non-market valuation methods:

44 It is worth noting that the international database of valuation studies, Environmental Valuation Reference Inventory (EVRI), has just recently been opened for the public: www.evri.ca

- Production, cost and profit function techniques for provisioning, regulating and cultural ecosystem services.
- Hedonic techniques, which can estimate the marginal contribution of ecosystem services/attributes on house prices.
- Methods that provide information about expenditures such as defensive expenditures and travel cost may be used to estimate the demand for the specific ecosystem service.

Environmental economics also contribute to the valuation methods used in accounting in cases where these methods are used for ecosystem services. While national accountants typically use cost-based techniques like replacement cost, such techniques are only supported within the field of environmental economics if "the alternative considered provides the same services; the alternative is the least cost alternative and if there is substantial evidence that the service would be demanded by society if it were provided by the least-cost alternative" (Barbier 2012, p. 180). These are relatively strict conditions.

Further research is needed to develop and test valuation techniques that reflect exchange values and hence exclude consumer surplus for non-market ecosystem services (Hein *et al.* 2015). The challenges of how to value ecosystem services without a market price while still being consistent with SNA, and while providing complementary information to support policy assessment, is one of the topics that is under testing and development in SEEA EEA.

Specifically, SEEA EEA TR proposes to develop methods where non-market valuation studies, originally meant to derive values including consumer surplus, may later be used to derive the demand curve that would have existed if there was a market for the good in question. Through combining such a demand function with the supply function for the ecosystem service or benefits one may be able to derive the exchange value. In this step, one would also have to make assumptions about the institutional arrangement for the exchange. Here one might have to try to evaluate, as realistically as possible, what the institutional arrangement would have been had a market existed. Developing such credible provision scenarios is one of the strengths of stated preference methods, when they are conducted to state-of-the art standards. This information combined with a supply curve for the ecosystem service could yield information about the exchange value of the ecosystem service or benefit. Caparros et al. (2017) provide an example of how this method may be put into practice.

Box 5 - Use of restoration costs for replacing city trees

Restoration cost refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition. The SEEA-EEA Technical recommendations suggest that the methods are likely to be inappropriate since they do not determine a price for an individual ecosystem service, but may serve to inform valuation of a basket of services. Accounting incompatibility in this case is due to an increased risk of double counting when ecosystem services cannot be identified separately, and instead are valued as a bundle associated with a specific ecosystem site or green structure. The valuation method is nevertheless useful in municipal policy, and can meet accounting requirements under special conditions. For example, in the city of Oslo, restoration costs of city trees are calculated as a basis for a compensation fee to be paid by parties responsible for damaging trees on public land. The replacement cost is adjusted for the age, health and physical qualities of the tree. The compensation cost is in many cases absorbed as a transaction cost of property development when destroying a tree is unavoidable. As such this is an exchange value, although it has been set through regulation rather than the market. Regarding the risk of double counting, this may be avoided by not including municipal trees in other valuation models (e.g. hedonic pricing models).

Source: Barton et al. (2015)

In Boxes 4 and 5 we show how one could use restoration cost and contingent valuation methods, normally considered inappropriate or incompatible with accounting standards. This involves thinking above to arrive at estimates of exchange values that could be decision-relevant and fit for accounting. The first example discusses the restoration costs of city trees as the basis of exchange value and how to avoid double counting (Box 5).

The second example shows how a contingent valuation survey of people's willingness to pay to maintain or increase the density of street trees can be combined with the costs of supply, to arrive at an exchange price that may be deemed acceptable for accounting purposes (Box 6).

The SEEA EEA TR further proposes a way to determine the most suitable valuation method to use for accounting purposes, to identify so-called "channels" through which an underlying ecosystem asset provide benefits to the users or economic units (see Box 2). The next step is to identify ecosystem services, benefits and respective valuation methods for each service channel and user. Some of the methods will be accounting compatible and some will require adjustments along the lines noted above, to arrive at exchange values.

Box 6 - Valuation methods and links to accounting via channels to users

In order to see the relevance of the non-market valuation methods from environmental economics for accounting purposes, it is useful to view the "channels" through which an underlying ecosystem asset ultimately provide benefits to, or affect the well-being of, the users or economic units. SEEA EEA TR (United Nations 2017) summarize three such channels:

- Ecosystem services used as inputs for production (such as pollination for agricultural production).
- Ecosystem services that act as joint inputs to household final consumption (such as nature recreation that requires time and travel expenditures on the part of the household).
- Ecosystem services that provide household well-being directly. This is an abstract channel that includes non-use values.

These channels have parallels in accounting, in the way GDP is affected either through inputs to existing (economic) production (channel 1) or to final household consumption (channels 2 and 3). The idea is to identify each buyer (producer or household) and seller (ecosystem), and identify valuation methods that can be used to estimate exchange values, under prevailing institutional conditions. Valuation methods can be grouped according to channels in a supply and use context (Freeman et al. 2014). For industry users, for example, provisioning, regulating and cultural services, would provide value through channel 1. For households, provisioning services work through channel 1, regulating through channel 2, and cultural through both channels 2 and 3. Once suitable services, channels, users and methods have been identified, the next step is to use the methods to construct an exchange value estimate for the non-market service. There are different ways this can be done, e.g. as illustrated in Boxes 5 and 6 above.

Sources: Freeman et al. (2014), United Nations (2017).

Even for non-market valuation techniques from environmental economics that are considered accounting compatible, there are still other challenges related to using them for valuation. As spatially explicit accounting frameworks both SEEA EEA and inclusive wealth accounting need spatially explicit valuation of ES. There is a lack of studies in general, though numbers have increased in recent years. Many valuation studies are not motivated by policy questions (Laurens et al. 2013). In those cases where valuation addresses policy, some questions tend to come up more often, and some services appear to be more frequently valued than others. Recreation benefits, for example, may be valued more often than some regulating services. This is also due to the complexity of modelling the ecosystems and some services and benefits, as discussed above.

Adopting landscape, or land area, as the basic accounting unit, makes characterizing the ecosystem as a natural asset relatively straightforward. To match the accounting units, non-market valuation studies should also be spatially explicit. With increased availability, use of satellite data maps and geographical information systems, and spatially explicit data analysis techniques, the number of spatially explicit valuation studies is expected to rise. But at present, SEEA EEA accounting efforts will rely on benefit transfer based on studies that are rarely spatially explicit. For those valuation results that are available and site specific (on some level of spatial resolution), a main challenge, pointed out by Hein *et al.* (2015) is to transfer values to other sites and scale the estimates to larger areas required for accounting purposes.

To transfer to other sites there must be sufficient ecological and economic correspondence between the study and the policy sites (Johnston et al. 2015; Barbier 2014). The benefit transfer literature offers simple and more advanced, and sometimes more precise, methods for benefit transfer; these sometimes use GIS and scaling-up procedures (see e.g. Brander *et al.* 2012). Meta-analysis requires knowledge of the values of the independent variables for the policy site of interest and assumes the statistical relationship between the dependent and independent variables is the same between the study and the policy sites. It is not always guaranteed that more advanced methods perform better (Lindhjem and Navrud 2008). It is also important to delineate different ecosystems and services, to avoid double counting (Barbier 2012).

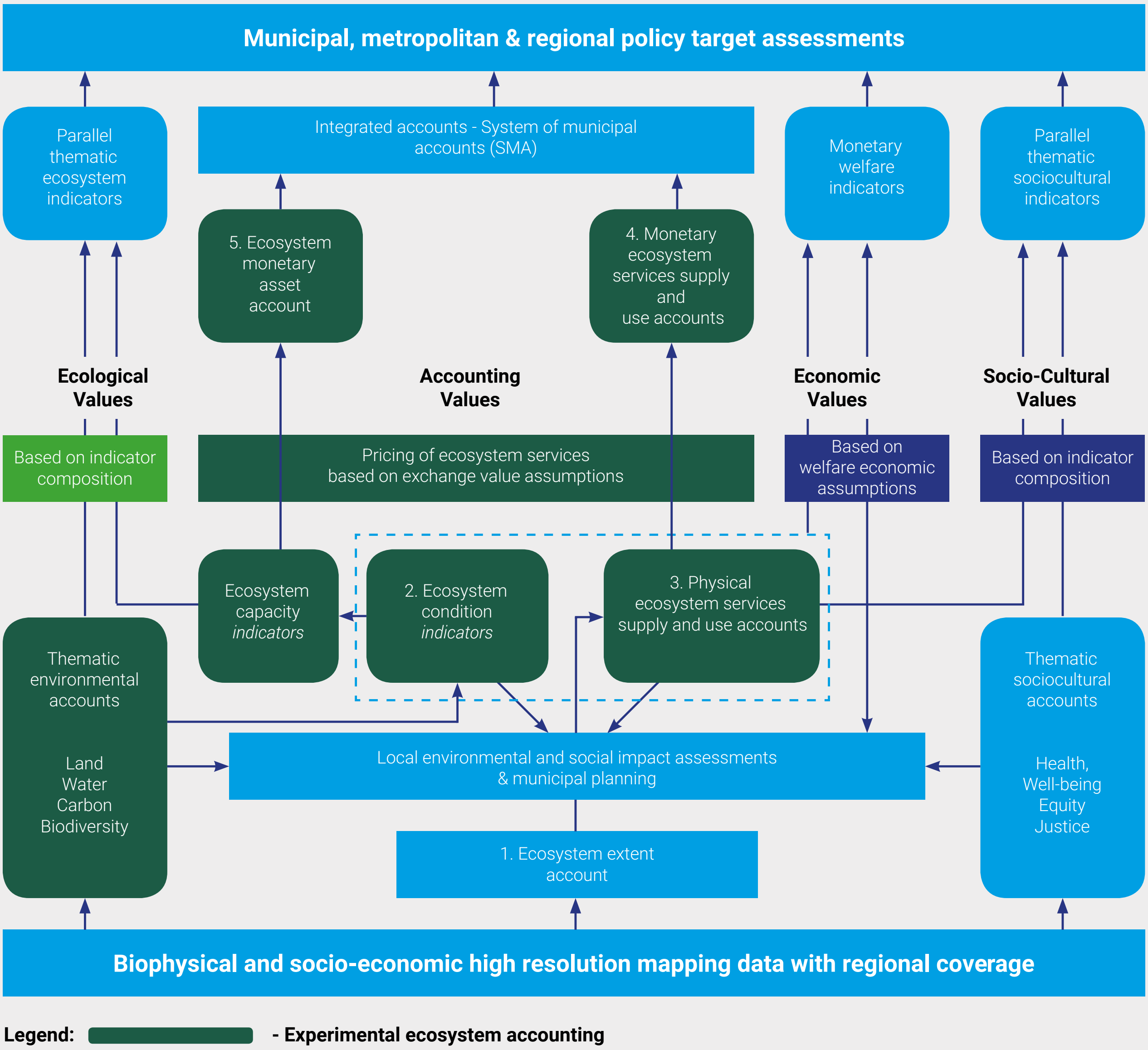
For wealth accounting purposes it is often ideal to have aggregate values of ecosystem services at the regional or national level. If ecosystem service values have been estimated based on case studies at specific sites, one may question whether the target population of such studies will be appropriate for wealth accounting. That is, can the numbers based on a case study in one location be scaled up to a national level? It is not uncommon that local land use preferences differ from the national preferences for land use (e.g. Lindhjem 2007 on forest services). Differences in preferences for a policy is not unexpected when a policy has a different impact locally than nationally. Local communities which are more affected by a policy may have per capita net benefits that are much greater than the average per capita net benefits nationally, and vice-versa. But the aggregate net benefits at the national level may be much greater than the local net benefits.

Using a simple physical index of an area, such as hectares, to expand value estimates to another scale may violate basic economic principles such as diminishing marginal utility, changing relative scarcity and substitutability. However, using average per hectare values is often the way in which scaling-up is done in practice because of a lack of information regarding these factors. However, in some cases average per hectare values for some degree of scaling may work as approximations that in any case are better than no such information.

To track the wealth of a nation, the aggregate values of ecosystem services at the regional or national level should ideally be replicated and updated annually. An important use of such information is to track trends over time. But with the scarcity of non-market valuation studies one may risk using outdated values. Preferences or demand may change over time, for example as incomes increase, people on average tend to prefer to use more cultural ecosystem services. Preferences are shown in some valuation studies to be stable for periods of up to five years, but that for periods beyond 20 years this is not the case (Skourtos et al. 2010). Non-market valuation methods have also improved and can hopefully provide more reliable estimates than some older studies.

Box 7 - Ecosystem accounting at municipal level

5.3.3. Non-market ecosystem services and benefits



Source: Based on Barton et al. (2017)

Fig 5.3 shows the recommended system of accounts in the SEEA-EEA (in green), placed in the context of different municipal uses of information compiled for accounting. The framework emphasizes the need at municipal level to base decisions on available information on value of ecosystems. The valuation methods used – whether exchange-based or consumer surplus based — depend on the type of policy question at hand. Information stemming from different valuation and indicator methods is complementary and can be triangulated. This approach has been called integrated or plural valuation (Jacobs *et al.* 2017), exploring the role of SEEA-EEA as a contribution to 'considering ecosystems through multiple analytical lenses'. Ecosystem accounting within such a plural valuation approach is being tested at the municipal level within the metropolitan area of Greater Oslo, Norway. Local and city governments already make use of land use mapping and thematic environmental and sociocultural indicators to inform impact assessments, municipal planning and zoning. The Urban EEA project is testing SEEA-EEA recommendation on how to identify the economic contributions that urban ecosystems make to the municipal, household and commercial sectors in Greater Oslo. Ecosystem accounting offers a complementary set of indicators to municipal government aimed at making fragmented urban nature and blue-green infrastructure more visible in city planning. The project has found that characteristics of urban landscapes may limit the scope of monetary ecosystem accounts in the assessment of municipal policy targets. Urban green structures can be small, hard to identify in GIS, but still be locally valuable. Remnant and constructed urban nature is highly spatially fragmented, mixed-use density is high and highly localized. This makes it challenging to identify marginal values of particular green space qualities and ecosystem services from transactions in the property market. Municipal utilities such as water supply, rainwater management, sewage treatment and solid waste management operate according to cost-recovery, meaning that the residual resource rent attributable to ecosystems is zero. Recreational time use in neighbourhood public spaces is very high relative to travel expenses to use the areas, leaving little trace in market transactions. Given these and other challenges of valuation urban ecosystem services (Gomez-Baggethun and Barton 2013), Urban EEA aims to provide municipal government with a suite of spatially explicit indicators of accounting value, as well as indicators of ecological, welfare economic and sociocultural values that are at stake across a cityscape.

The current SEEA EEA process is geared towards testing the operationalization of the Technical Recommendations in practical cases and through increased practice gather experiences that may help solve some of the challenges in deriving exchange values for accounting. One relatively large-scale implementation of SEEA EEA principles is currently being undertaken in the Greater Oslo area in Norway (see Box 7). The aim is to test how the SEEA-EEA framework can identify the economic contributions that urban ecosystems make to the municipal, household and commercial sectors in Greater Oslo. This project is under way and has already identified specific challenges of implementing the framework in an urban setting.

5.4. Accounting for the Value of Ecosystem Assets in SEEA EEA

In estimating the expected ecosystem services supply it is important to assess possible trade-offs between different ecosystem services. For example, there may be a trade-off between forest recreation and production of timber. When valuing ecosystem assets, it requires aggregation of many ecosystem services under the assumption that the prices of them are independent (Hein *et al.* 2015). As discussed in the Technical Recommendations, while the link between physical flows and provisioning services is quite tangible, the same many not be the case for regulating and cultural services. The supply of these services depends on factors that often are not stable over time such as vegetation, management regimes and pollution levels. Moreover, one may have limited information about the capacity of the ecosystem to supply the service over time. Finally, for cultural services such as enjoying biodiversity and aesthetic aspects of nature for example, it may be difficult to identify and describe in general terms the specific link between the condition of the ecosystem in physical terms and the supply of cultural services. Hence, indicators for cultural services require the most development at this stage, according to the Technical Recommendations (United Nations, 2017, paragraph 7.16).

For integration of ecosystem asset accounts with national accounts, the SEEA EEA TR states that consistency with the exchange value concept in SNA, one also should use the market based discount rates. However, estimating for a variety of discount rates to demonstrate the sensitivity of the estimates is recommended. For a more thorough discussion on the application of net present value (NPV) for natural resources, see SEEA CF (United Nations 2014a, section 5.4).

The life, or duration, of the ecosystem asset depends on the way it is being used. If use is sustainable then one can assume an infinite asset life. However, some ecosystem asset uses can be unsustainable and this will limit the asset life. Even in cases where the asset life is assumed to be infinite, discounting incomes at a high rate may cause the present value of incomes to be negligible after two or three decades. Thus, the decision about discount rate and asset life are not independent. Since there is no a priori preferred asset life, the SEEA EEA TR highlights the need for sensitivity analyses on the asset life and the discount rate.

In finding NPV values, one must recognize the expected future flows of ecosystem services for an ecosystem asset is affected by the ecosystem condition, which again is affected by the use of ecosystem services. The nexus between use and condition of an ecosystem leads us to the concept of ecosystem capacity. Hein *et al.* (2016) define the concept of ecosystem capacity for accounting purposes as "the ability of an ecosystem to generate an ecosystem service under current conditions and uses at the maximum yield or use level that does not negatively affect the future supply of the same or other ecosystem services". Thus, capacity may be thought of as the sustainable use of an ecosystem service for which there is demand, preferably at aggregate scales such as at the landscape level.

The ecosystem capacity was briefly mentioned in the SEEA EEA but there was no discussion of how to measure it. The SEEA EEA TR (United Nations 2017) states that "Ecosystem capacity is considered a topic of ongoing research but with a very high priority" (paragraph 7.68), and that the "concept of ecosystem capacity is a central one for explaining the ecosystem accounting model and applying the model in practice. This is especially the case in relation to developing information sets that can support the discussion of sustainability" (paragraph 7.33).

One of the reasons why the concept of ecosystem capacity is still under development is that it involves ecologically complex effects such as threshold effects, resilience, ecosystem dynamics and other non-linear effects. These effects also create challenges for standard valuation (exchange or welfare-based valuations, see e.g. discussion in Farley 2012). In addition, one needs to resolve how to measure capacity in practice.

The SEEA EEA TR discusses issues of the measurement of ecosystem capacity. Ecosystem capacity may be monetized in terms of the NPV of estimates for the future basket of services. To obtain an estimate of ecosystem capacity, one needs to estimate the future ecosystem service use that is as close as possible to the actual or revealed patterns of use under the expected legal and institutional arrangements. This implies the estimated future use does not necessarily reflect sustainable uses. One may then compare the NPV of ecosystem use at capacity to the NPV of the actual use, and determine whether the ecosystem is being used above, below, or at capacity.

Sustainable ecosystem management, ultimately requires managing ecosystems at or below capacity. If the ecosystem is used above capacity, it reduces the opportunity for this and future generations to manage the ecosystem sustainably. A decline in condition of an ecosystem asset as a result of economic and other human activity would in SEEA EEA be considered ecosystem degradation. How to include ecosystem degradation has also yet not been determined. While ecosystem degradation is clearly related to declining condition, it can be defined more specifically as reflecting either a decline in the ecosystem asset value as measured in relation to the change in the NPV of an ecosystem asset based on the expected flow of services, or in relation to the change in the NPV of an ecosystem asset based on its capacity. For both the concept of ecosystem degradation and for the concept of ecosystem capacity one needs to resolve some practical measurement issues, that will also have bearings on how to value ecosystem assets within the SEEA EEA framework.

5.5. Conclusions and Future Directions

SEEA and its developments is seen as an important step on the road to wealth accounting (Perrings 2012). We have discussed how the accounting framework SEEA EEA currently is moving towards developing operational solutions to important challenges related to monetary valuation as discussed in the SEEA EEA TR (United Nations 2017).

The requirement only to permit exchange values in SEEA EEA is motivated by the goal of compatibility with national accounting. This would later make it possible to consistently estimate the asset value of a nation's total capital stock. However, accounting that only includes exchange values will not fully reflect the importance of ecosystem services to society (Remme *et al.* 2015). For example, risks will be accounted for in the exchange values (Hein *et al.* 2015), and there may be unpriced, unaccounted for externalities. Moreover, capturing the value of many regulating and cultural services with exchange value methods will remain a challenge. Further research and testing, such as the Urban EEA project in Greater Oslo (Box 5 above), is necessary in order to integrate values into an ecosystem accounting framework that is useful for policy assessment (e.g. Remme *et al.* 2015; Hein *et al.* 2015).

Another challenge with using exchange values for ecosystem services is that a large share of existing estimates of non-market ecosystem services are in the form of willingness to pay, which includes consumer surplus, and not in the form of exchange values. However, research on how to derive the exchange value from welfare-based studies is ongoing (see e.g. Caparras *et al.* 2017; Day 2013; United Nations 2017).

Like SEEA EEA, inclusive wealth accounting is mainly constrained by the lack of shadow prices for ecosystem assets, and "there is insufficient experience with the calculation of these shadow prices at the scale required for accounting" (Hein *et al.* 2015, p. 90; Barbier 2013). Dasgupta and Duraiappah (2012) recognize that we can never get the shadow prices "right". Instead, we can simply try to estimate the range in which they lie. Given these challenges, empirical studies in the Inclusive Wealth Framework have also resorted to using market prices (exchange value) for those ecosystem services and benefits that have market prices. However, research is also ongoing to find better estimates of shadow prices (Fenichel and Abbott 2014). The next best solution, suggested by Dasgupta and Duraiappah (2012: p. 26) is to use "willingness to pay shadow prices", while recognizing that these prices may not capture threshold effects of an ecosystem.

Both for SEEA EEA and the Inclusive Wealth Framework, there is increasing interest among researchers to tailor valuation studies for natural and ecosystem capital accounting, as recommended by Tallis *et al.* (2014). This would be the ideal situation, since the need for and challenges of benefit transfer and scaling-up would be reduced. For both wealth accounting frameworks, it may be difficult to account for non-use values such as existence values and other subtler cultural services and benefits, even though we know from many studies that such benefits can be important for people's welfare (Lindhjem et al. 2015). If the goal is to demonstrate the importance of an ecosystem service, one may have to use other indicators of value (see Box 7 and Barbier 2014) when direct valuation of the ecosystem service fails. This could be due to lack of data, difficulty in defining institutional arrangements that mimic exchange values, or because accounting compatible values capture only a very small part of welfare.

Inclusive wealth accounting is a developing accounting framework for both human, natural and ecosystem capital with the goal of demonstrating the importance of these types of capital to human well-being. Since the focus is welfare-based, one needs shadow values of the capital stocks, yet estimates of shadow values are hard to come by. SEEA EEA specializes in ecosystem accounting using a national accounting framework. While the national accounting framework implies some restrictions, such as the use of exchange values, developing ecosystem accounts based on an existing accounting framework may be quite helpful. The SEEA EEA has developed concrete solutions to several accounting challenges and contributed to operationalize measurement. Furthermore, the need to complement the SEEA EEA framework with ecosystem capacity accounts to better track sustainability of ecosystem use has been recognized.

On the other hand, inclusive wealth accounting emphasizes intergenerational welfare and is not restricted by national accounting standards. However, calculating the total value of natural capital for inclusive wealth calculations is also quite difficult and may go beyond what can currently be achieved. A more achievable goal might be to evaluate the marginal value of natural capital, which is how a small change will alter the present value of the flow of services. Moreover, in order to find the present value of future flows of ecosystem services, one may need models to estimate the impact of changes in natural capital on the provision of ecosystem services. One also needs to predict the future prices and determine the appropriate discount rate. Other related challenges include issues related to resilience and thresholds of ecosystems.

Finally, equity is also a crucial part of sustainability. Solely focusing on aggregated numbers at the national level may not be the best way to evaluate sustainability, because numbers at the national level might mask the impacts at the local level as well as inequalities among income groups in the current generation, and across generations. Thus, inclusive wealth accounting should also address the spatial and temporal distribution of wealth.

This chapter discussed the progress that has been made in SEEA EEA which at present is the most developed and comprehensive accounting system for ecosystem assets. We have also discussed the assumptions behind this accounting framework and the associated limitations. In the end, if attempting to account such complex assets as ecosystem assets, no matter which accounting system one applies, it is important one is aware of the assumptions and the limitations of the accounting framework. Moreover, it is crucial to be aware of the benefits of an accounting framework that can be applied consistently over time.

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PART III: NEW INSIGHTS
CHAPTER 6: HUMAN CAPITAL: EDUCATIONAL ATTAINMENT PROGRESS

Barbara Fraumani and Gang Liu

6.1. Introduction

Human capital is an essential component of individual well-being and vital for a country's sustainability (e.g. OECD, 2013; UNU-IHDP and UNEP, 2014). Arguably more worldwide attention has been paid to GDP than any other indicators, including human capital. Although GDP is an important macroeconomic construct, it fails to consider environmental and inequality impacts, and the future viability of a country (e.g. Stiglitz et al., 2010).

Human capital and other wealth measures as presented in this report will help to fill the gaps left by only studying GDP. This chapter focuses on human capital, particularly on those that are captured in levels and trends in country's educational attainment, with reference to the United Nations' Millennium Project and Sustainable Development education goals.

The United Nations Millennium Project, an international effort which operated from 2002 through 2006, established eight goals and 18 technical indicators with 48 associated targets to measure progress towards the Millennium Development Goals (MDGs). Two goals relate to education: Goal 2 - Achieve Universal Primary Education; and Goal 3 - Promote Gender Equality and Empower Women. The stated objective of Target 3 of Goal 2 is to have all boys and girls complete a full course of primary schooling by 2015. The stated objective of Target 4 of Goal 3 is to eliminate gender disparity in primary and secondary education in the short run (2005) and in all levels of education in the intermediate run (2015).

However, as stated in the report of the United Nations Secretary-General, despite progress, the world failed to meet the MDGs of achieving universal primary education by 2015. For instance, in 2013, 59 million children of primary-school age were out of school. Estimates show that, among those 59 million children, 1 in 5 of had dropped out. In addition, recent trends suggest that 2 in 5 of out-of-school children will never set foot in a classroom (UN, 2016).

In 2015, the United Nations Member States reached agreement on 17 SDGs with 169 associated targets. SDG 4 and SDG 5 are similar to MDG 2 and MDG 3, respectively. SDG 4 calls for inclusive and quality education for all and the promotion of lifelong learning by 2030. SDG 5 calls for gender equality by 2030, noting the importance of education and the elimination of discrimination in jobs, unpaid work, and political office in achieving the goal.

Following an indicators-based approach to measuring human capital,[45] human capital developed due to education is frequently proxied by educational attainment, such as average years of schooling. A famous example in this field is the Barro-Lee data set that has been established through many years' research (see Barro and Lee, 2001, 2013). The previous IWRs also used the Barro-Lee data set as one of the primary data sources for calculating monetary estimates of human capital (e.g. IWR 2014, 2016).

This chapter, by using numerical estimates based mainly on the latest Barro-Lee data set (Barro and Lee, 2016), tries to investigate educational attainment progress across major regions in the world, and over the time period of 1950 to 2010. We also investigate what has been achieved during this period, with reference to the educational attainment gender gaps, and age differences in different regions. As the quality of education matters as well as the average years of schooling, discussions are also provided about how the quality side of educational attainment is practically taken into account.

The next section summarizes the methodology for compiling the Barro-Lee data set. This is followed by a section presenting and discussing several numerical results. A subsequent section focuses on the quality of education. By using the implicit quality-adjustment method, the findings drawn from the progress of primary, secondary and tertiary education are presented and discussed.

6.2. Barro-Lee methodology

Barro-Lee average years of schooling estimates enter into the IWR human capital (due to education) calculations in two ways. The IWR uses a country representative adult approach. The representative adult's educational attainment by gender (*Edu*) comes from the Barro-Lee average years of schooling. The minimum age of an adult in a country by gender is determined by *Edu*+5. The total number of adults by gender is equal to the number of individuals in the country who are at least the minimum age. All adult individuals are counted whether or not they perform paid work. A complete description of the IWR human capital measuring methodology can be found in the Methodological Annexes

45 For discussions on other approaches to measuring human capital, as well as the strengths and weaknesses associated with each measuring approach, please refer to Liu and Fraumeni (2014).

The Barro-Lee data set (2016) is available by gender in five calendar year increments from 1950 to 2010, for five year age groups from age 15 to 74, and for age 75 and over, for 146 countries. The data used in this chapter by age groups and gender include population, the no school percentage, and the average years of total schooling, as well as the average years of primary, secondary, and tertiary schooling, respectively.

The Barro-Lee benchmark data is collected from various census and/or survey information and compiled by UNESCO, Eurostat, national statistic agencies, and other sources.[46] The Barro-Lee data set uses a variety of techniques to fill in gaps in observations and educational attainment subcategories, with the purpose to avoid misestimating of average years of schooling.

To fill in missing observations (as benchmarks are not available for all five-year periods), they begin by calculating the distribution of educational attainment among four broad categories: no formal education (h_u), primary (h_p), secondary (h_s), and tertiary education (h_h). Primary and tertiary are further divided into complete and incomplete; secondary is further divided into lower secondary and upper secondary.

Most missing observations are filled in with backward or forward extrapolation with an appropriate time lag. The 13 five-year age groups are referred to by ag = 1 (15-19 years old) through to ag = 13 (75 years and over). The forward extrapolation method assumes that the educational attainment distribution of the age group ag at time t is identical to that of the age group that was five years younger at time t - 5.

EQUATION 1 $$h_{j,t}^{ag} = h_{j,t-5}^{ag-1}$$

where j = u, p, s, h, and ag = 3 (25-29 years old), through to ag = 11 (65-69 years old).

This forward extrapolation applies to individuals who have completed their schooling by time t – 5. As those younger than 25 are potentially still in school, a different methodology is employed. Similarly, the backward extrapolation assumes that the educational attainment distribution of the age group ag at time t is the same as that of the age group that is five years older at time t +5.

EQUATION 2 $$h_{j,t}^{ag} = h_{j,t+5}^{ag+1}$$

This forward extrapolation applies to individuals who have completed their schooling by time t – 5. As those younger than 25 are potentially still in school, a different methodology is employed. Similarly, the backward extrapolation assumes that the educational attainment distribution of the age group ag at time t is the same as that of the age group that is five years older at time t +5.

As a result, the net effect of this methodology is to hold an individual's educational attainment constant from age 25 through to 64. For older individuals, the probability of dying is observed to differ by educational attainment level. Accordingly, for the three oldest age groups; ag = 11 (65-69 years old), ag = 12 (70-74 years old), and ag = 13 (75 years and over), survival probabilities are estimated by educational attainment level. Highly educated individuals live, on average, longer than their less educated peers; this correction is necessary to ensure accurate estimations of average educational attainment for older age groups. For all younger age groups (ag = 10 (60-64 years old) and below), it is assumed that survival rates do not differ by educational attainment.

The process for creating subcategories of educational attainment (complete and incomplete for primary and higher education; lower and upper for secondary school) depends upon the age level. For primary school, the Barro-Lee data set uses country and age-specific completion ratio profiles to estimate the subcategories for ag = 1 (15-19 years old) and ag = 2 (20-24 years old). For ag = 3 (25-29 years old), the primary school completion rate is set equal to the ratio of the number of individuals who completed primary school, but did not enter secondary school, to the number of individuals who entered primary school.

Backward and forward extrapolation and other methods are used to fill in any missing observations for ag = 3 (25-29 years old) and above.

When there are missing observations, secondary-school enrollees for ag = 1 (15-19 years old) are assumed to be incompletely educated at the secondary level, and higher-school enrollees for ag = 2 (20-24 years old) are assumed to be incompletely educated at the higher level.

Other estimation problems arise because some countries do not report the proportion of the population with formal education, but do report on the proportion of the educated population who have achieved primary, secondary, or tertiary level of education. Alternatively, the proportion of the population with no formal education, or those who have achieved at most some level of primary education, is often reported as a single number. The Barro-Lee data set uses illiteracy rate, primary enrolment ratio, and/or data from other census years to resolve such inconsistencies.

Finally, estimations are made for the average number of years of schooling for the population aged 15 and above, and separately for each of the 13 five-year age groups. For those aged 15 and above, the average years of total schooling at time t, S_t, is measured as:

EQUATION 3 $$S_t = \sum_{ag} l_t^{ag} s_t^{ag}$$

where the summation is over all age groups (i.e. ag = 1 (15-19 years old), ag = 2 (20-24 years old), ..., ag = 13 (75 years old and over)); l_t^{ag} is the population share of the group ag in the total population aged 15 and

46 The description of the Barro-Lee methodology draws heavily from Chapter 4 of the 2014 Inclusive Wealth Report (Fraumeni & Liu, 2014), which is the description of the methodology applied in Barro and Lee (2013).

above; s_t^{ag} is the average number of years of schooling for age group ag.

The average number of years of schooling by age group ag at time t is:

EQUATION 4 $$s_t^{ag} = \sum_j h_{j,t}^{ag} d_{j,t}^{ag}$$

where the summation is over educational attainment levels j = p, s (incomplete, complete), h (incomplete, complete); $h_{j,t}^{ag}$ is the fraction of the group ag with the educational level j; $d_{j,t}^{ag}$ is the corresponding duration of school attendance in years.

6.3. Educational Attainment, Gender Gaps and Age Differences

To examine educational attainment progress in the world and across the different regions, the 146 countries covered by the Barro-Lee data set are divided first into two broad groups: Advanced and other economies. The Advanced Economies consist of 24 countries, other economies are divided into six regions: East Asia and the Pacific (19 countries or special administrative districts); Europe and Central Asia (20 countries); Latin America and Caribbean (25 countries); Middle East and North Africa (18 countries); South Asia (7 countries); and sub-Saharan Africa (33 countries). [47]

In Table 6.1, information on the educational attainment (in terms of the average years of total schooling) is presented for the total population aged 15 and above, for both males and females, in all the seven regions over the period covered by Barro and Lee (2013), i.e. 1950 to 2010. As shown, all regions in the world have made significant progresses in educational attainment during this period.

By 2010, the Europe and Central Asia region has almost caught up with the Advanced Economies, and its average educational attainment levels for both males and females are just slightly lower than those of the latter. Until the most recent period of 2000 to 2010, the average rate of percentage increase per year for the Europe and Central Asia exceeds that for the Advanced Economies.

Unsurprisingly, the sub-Saharan Africa region has the lowest average 2010 educational attainment, and for the period as a whole (1950 to 2010), and in the first subperiod (1950 to 2000), its average percentage increase per year is not among the highest in all regions. This is also true for males in the second subperiod (2000 to 2010). Only for females and in the second subperiod has its average percentage increase per year reached the second place among all regions.

47 The 24 Advanced Economies include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. The 19 East Asia and the Pacific countries or special administrative districts include: Brunei Darussalam, Cambodia, mainland China, China – Hong Kong, China – Macao, Fiji, Indonesia, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Papua New Guinea, Philippines, Republic of Korea, Singapore, Taiwan, Thailand, Tonga, and Viet Nam. The 20 Europe and Central Asia countries include: Albania, Armenia, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Poland, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Tajikistan, and Ukraine. The 25 Latin America and Caribbean countries include: Argentina, Barbados, Belize, Bolivia, Brazil, Chile, Columbia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela. The 18 Middle East and North Africa countries include: Algeria, Bahrain, Cyprus, Egypt, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Libyan Arab Jamahiriya, Malta, Morocco, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates, and Yemen. The 7 South Asia countries include: Afghanistan, Bangladesh, India, Maldives, Nepal, Pakistan, and Sri Lanka. The 33 sub-Saharan Africa countries include: Benin, Botswana, Burundi, Cameroon, Central African Republic, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Gabon, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Reunion, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe.

Table 6.1: Educational attainment, aged 15 and above, by region and gender

	Average Years				Average increase per year (%)			
	2010		1950–2010		1950–2000		2000–2010	
	Female	Male	Female	Male	Female	Male	Female	Male
Advanced Economies	11.4	*11.7*	*1.03*	0.96	1.04	1.01	1.00	0.71
East Asia & the Pacific	7.6	8.3	3.17	2.21	3.48	*2.48*	1.67	0.87
Europe & Central Asia	11.2	11.4	*1.72*	1.35	1.90	1.51	0.82	0.54
Latin America & Caribbean	8.3	8.3	*2.04*	1.77	2.14	1.85	1.55	1.37
Middle East & North Africa	6.8	7.9	*4.75*	3.39	5.18	3.80	2.66	1.35
South Asia	4.8	7.3	*4.23*	2.62	4.68	2.86	2.03	1.41
Sub-Saharan Africa	4.8	5.9	*2.81*	2.19	2.94	2.40	2.19	1.14

For the whole period (1950 to 2010) and the first subperiod (1950 to 2000), the Middle East and North Africa region has the highest average percentage increase per year for both males and females, but in the last subperiod (2000 to 2010), although its average percentage increase per year is still the highest for females, it drops to third place for males in all regions. The South Asia region has the second highest average percentage increase per year both for the whole period (1950 to 2010) and the first subperiod (1950 to 2000), but in the second subperiod (2000 to 2010), its average percentage increase per year is the highest for males, while it falls to third place for females in all regions. For all seven regions, the average percentage increase per year is lower in 2000 to 2010 than in 1950 to 2000, regardless of gender.

The slowdown in percentage growth rate of educational attainment progress is quite noticeable in the East Asia and the Pacific, Europe and Central Asia, the Middle East and North Africa, and the South Asia regions, where the average percentage increase per year in 2000 to 2010 roughly halved for females, and more than halved for males, compared to the corresponding 1950 to 2000 percentage rates. For males in the sub-Saharan Africa region, the average percentage increase per year in 2000 to 2010 more than halved its 1950 to 2000 percentage rate.

Average yearly percentage increases tend to fall as the level of educational attainment rises, indicating that advancement relative to existing levels may be significantly easier when educational attainments are low compared to when they are higher.

Apparently, a variety of external factors in a number of countries may add to the difficulty of realizing educational gains, such as conflicts, poverty, and recessions. Since the general state of many countries in the world points to the difficulty in attaining MDGs or SDGs educational attainment goals, especially in the three aforementioned regions, more efforts are needed in order to catch up in the future.

Both MDGs and SDGs call for gender equity. As also shown in Table 6.1, in all regions, the average educational attainment of females is, in general, less than that of males in 2010. Only in the LAC region is there gender parity. In the Advanced Economies, East Asia and the Pacific, Europe and Central Asia, the difference is at most 0.7 of a year of total schooling, but in the Middle East and North Africa, sub-Saharan Africa and the South Asia regions, it is substantially greater, i.e. 1.1, 1.1 and 2.5 years of total schooling, respectively.

Table 6.2: The gender educational attainment gap*, aged 15 and above, by region

	Average gap (%)				Average reduction per year (%)			
	2010		1950–2010		1950–2000		2000–2010	
	Female	Male	Female	Male	Female	Male	Female	Male
Advanced Economies	11.4	11.7	1.03	0.96	1.04	1.01	1.00	0.71
East Asia & the Pacific	7.6	8.3	3.17	2.21	3.48	2.48	1.67	0.87
Europe & Central Asia	11.2	11.4	1.72	1.35	1.90	1.51	0.82	0.54
Latin America & Caribbean	8.3	8.3	2.04	1.77	2.14	1.85	1.55	1.37
Middle East & North Africa	6.8	7.9	4.75	3.39	5.18	3.80	2.66	1.35
South Asia	4.8	7.3	4.23	2.62	4.68	2.86	2.03	1.41
Sub-Saharan Africa	4.8	5.9	2.81	2.19	2.94	2.40	2.19	1.14

** The gender educational attainment gap in percentage points is defined as (1-(female educational attainment/male educational attainment))*100.*

Source: Authors' calculations based on Barro-Lee February 2016 version (http:/www.barrolee.com/)

However, for all periods and regions considered, the average percentage increase in educational attainment per year for females is, without exception, greater than that for males (see Table 6.1). As Table 6.2 shows, for the overall period, the Middle East and North Africa region is the leader in closing the gender gap in education, but progress is notable for all regions except in the Advanced Economies and in the LAC region, which have the smallest average educational gender gaps already in 1950.

Regions which have the largest educational attainment gender gaps in 2010 (the South Asia and the sub-Saharan Africa regions) as shown in Table 6.2 are also those that have the lowest average years of total schooling as shown in Table 6.1. For the sub-Saharan Africa region, the 2010 educational attainment gender gap could be virtually eliminated by 2030 if the latest rate of average annual reduction continues, while for the South Asia region, even faster (than that shown in Table 6.2) annual reductions are needed to fill the 2010 gap, which is the largest among all regions in 2010. A literature review of private returns to schooling has demonstrated that annual reductions seem to be higher in low- or middle-income economies than in high-income economies.

Moreover, estimated returns to schooling are higher for females than for males (e.g. Psacharopoulos, 1994; Psacharopoulos and Patrinos, 2004). This conclusion holds both for the world as a whole and for all regions individually (Montenegro and Patrinos, 2014). Therefore, investments in education are more rewarding in these regions than in others, as well as for females than for males.

Table 6.3: Country distribution by educational attainment differences of younger (25–34) versus older (55–64) in 2010

Percentage range (%)	(100-500]	(50-100]	(20-50]	(0-20]	(-∞-0]	No. of countries
Advanced Economies	0	2	9	12	1	24
East Asia & the Pacific	3	7	7	2	0	19
Europe & Central Asia	0	0	1	13	6	20
Latin America & Caribbean	2	9	9	4	1	25
Middle East & North Africa	6	3	4	2	2	17
South Asia	4	2	1	0	0	7
Sub-Saharan Africa	16	11	5	1	0	33
SUM						145

Notes:

1. The educational attainment differences of younger (25–34) versus older (55–64) in percentage points are defined as (educational attainment of aged 25–34 – educational attainment of aged 55-64)/ educational attainment of aged 55–64.

2. Yemen (in Middle East & North Africa) is excluded from this table as its educational attainment of 25–34-year-olds is approximately 5,000 percent higher than that of 55–64-year-olds.

3. The symbol "(" denotes greater than and the symbol "]" denotes less than or equal to.

Source: Authors' calculations based on Barro-Lee February 2016 version (http:/www.barrolee.com/)

A comparison of educational attainment of 25–34-year-olds with 55–64-year-olds gives a sense of what the future might look like, given current levels of educational attainment of younger potential workers. Younger workers have longer remaining working years than their elder counterparts, thus they will contribute more to future economic growth. Table 6.3 reports on the educational attainment of those aged 25–34 relative to those aged 55–64 by percentage range groups. The individual cells of Table 6.3 show how many countries in each region fall in the five percentage range categories. For example, there are two countries in the Advanced Economies that have calculated percentage points between 50 percent and 100 percent, and nine countries in the range of 20–50 percent, etc.

As shown in Table 6.3, the largest concentrations of countries in sub-Saharan Africa and South Asia are in the range of greater than 50 percent to at most 500 percent. The largest concentrations of countries in Latin America & the Caribbean and East Asia & the Pacific are in the range of greater than 20 percent to at most 100 percent. The largest concentration of Advanced Economies, however, is in the range of greater than 0 percent to at most 50 percent. Finally, the largest concentration of countries in Europe and Central Asia is in the range of 0 percent or less to at most 20 percent, while the countries in the Middle East and North Africa regions are more or less evenly distributed over the 5 percent range categories.

These results in particular point towards the future educational attainment potential gains of the sub-Saharan African countries, and the potential slowdown in educational attainment gains in Europe and Central Asia, as well as in Advanced Economies.

One of the SDG 4 targets is for all youth to achieve literacy and numeracy by 2030. The facts and figures section of SDG 4 notes that almost half of all children not in school are in the sub-Saharan Africa region. This comment is also reflected in analysis results based on the Barro-Lee data set. [48] In 2010, the sub-Saharan Africa region still has a larger number of countries than other regions with a high share of individuals aged 15–19 who have no years of schooling: 17 of 33 countries with no school percentages over 20 percent. In contrast, the other regions each have at most three countries with such a high percentage of individuals aged 15–19 with no schooling.

On the other hand, almost 25 percent (eight countries) of the sub-Saharan African countries have at most 2 percent of individuals aged 15–19 without schooling. For all other regions in the Barro-Lee data set, the no-schooling category contained much larger shares of countries in each region, from a low of about 43 percent of countries for the South Asia data set to a high of 85 percent of countries for the Europe and Central Asia data set. In many countries in the regions considered, the target of universal literacy has essentially been accomplished, but in others, progress has yet to be made.

6.4. Conclusions

Based on the Barro-Lee data set, this chapter focuses on the level and trend of educational attainment progress, with reference to the MDGs and SDGs. In terms of the average years of total schooling, educational attainment has made significant progress in the world and across the regions over 1950-2010. However, in 2010 the distribution of educational attainment is still uneven across the regions considered in chapter, with some regions significantly lagging behind, if compared with Advanced Economies.

Filling these gaps by 2030 is challenging, especially for the Latin America and Caribbean, the South Asia, and the sub-Saharan Africa regions. Although some of these regions have shown considerable progress during the period 1950-2010, because of a low starting level in 1950, their educational attainment levels in 2010 are still lower than that in Advanced Economies by a sizeable margins.

The MDGs and SDGs strongly support the reduction of gender disparity in education. Over the period 1950 to 2010, the observed educational attainment gender gaps have been decreasing. In particular, significant progress has been achieved in the Middle East and North Africa, and the East Asia and the Pacific regions. However, large gaps are visible in the South Asia and the sub-Saharan Africa regions in 2010, even though annual reduction of gender gaps in the two regions has accelerated and are the highest among all regions in the last subperiod (2000 to 2010). Thus, filling these gender gaps by 2030 demands more active actions.

In many regions considered in the chapter, the goal of universal literacy had essentially been accomplished in 2010, reflected by the very low share of individuals aged 15 to 19 who have no years of schooling in the countries of these regions. Unfortunately, in other regions, and in particular, in the sub-Saharan Africa region, there are a large number of countries where youth aged 15 to 19 are without schooling, and thus substantial progress needs to be made for these countries.

As economic development necessitates a highly educated workforce in the future, and research results have shown that private economic returns on investments in higher education are larger than primary education, and the returns are highest in the least developed regions, such as the South Asia and the sub-Saharan Africa regions, more investments in higher education in these regions would provide the greatest returns.

48 Detailed analysis and the results are not fully presented here but are available upon requests.

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CHAPTER 7: THE IWR AND POLICY LESSONS

Shunsuke Managi

7.1. Introduction

The purpose of genuine savings and IW clearly lies in sustainability analysis. The analysis can indicate whether the national productive base is on the increase or decrease, in accordance with intergenerational well-being. As such, proceeding from sustainability analysis to policy implication is not straightforward. Specifically, even if the shadow price of a given asset is known to be high, it does not necessarily mean the given asset should be the focus of investment. A cost-benefit analysis, using the same set of shadow prices, should be performed to determine what kind of policy should be the means to increase social well-being (Dasgupta, 2009).

However, inclusive wealth figures on their own are not silent about policy implications. For example, if a particular component class of IW is on a rapid decline within a relatively short period of time, the necessity for policy intervention should be reflected, perhaps even in the absence of cost-benefit analysis.

In this chapter, we first discuss those implications that may arise from certain classes of capital assets. Investing in human capital, which has not been the focus of previous chapters, is important, but the questions remain regarding how and to what extent this investment should be made. As our previous edition (UNU-IHDP and UNEP, 2014) elaborated, there are many critical aspects not captured by the current exercise of human capital measurement. Health status of mothers, early childhood education, home environment, vocational training, and non-cognitive development are all examples of these aspects. Among others, we highlight vocational training and child labour.

We also examine fishery resources, which is another area of contentious debate in natural capital management. Globally, it is a growing industry that is under threat from overfishing, but there are many positive sides to the industry, such as aquaculture and recent experiences of sustainable fishery and green labelling.

We next address an important area of negative capital stock, which is not previously addressed in inclusive wealth accounting (aside from carbon damage). As long as a capital-like source of pollution causes direct disutility or damage to capital stock (health capital), this source should be one of the capital assets relevant to social well-being. The World Bank has plausibly included particulate matter emission in their account of genuine savings, which we will review in our context.

Certain policy implications can also be derived for investing in technological advancements. TFP measures all the residual contributions to social well-being, after accounting for all the relevant capital assets (Arrow *et al*., 2012). It is known to affect the bottom line figure of IWI adjusted (UNU-IHDP and UNEP, 2014).

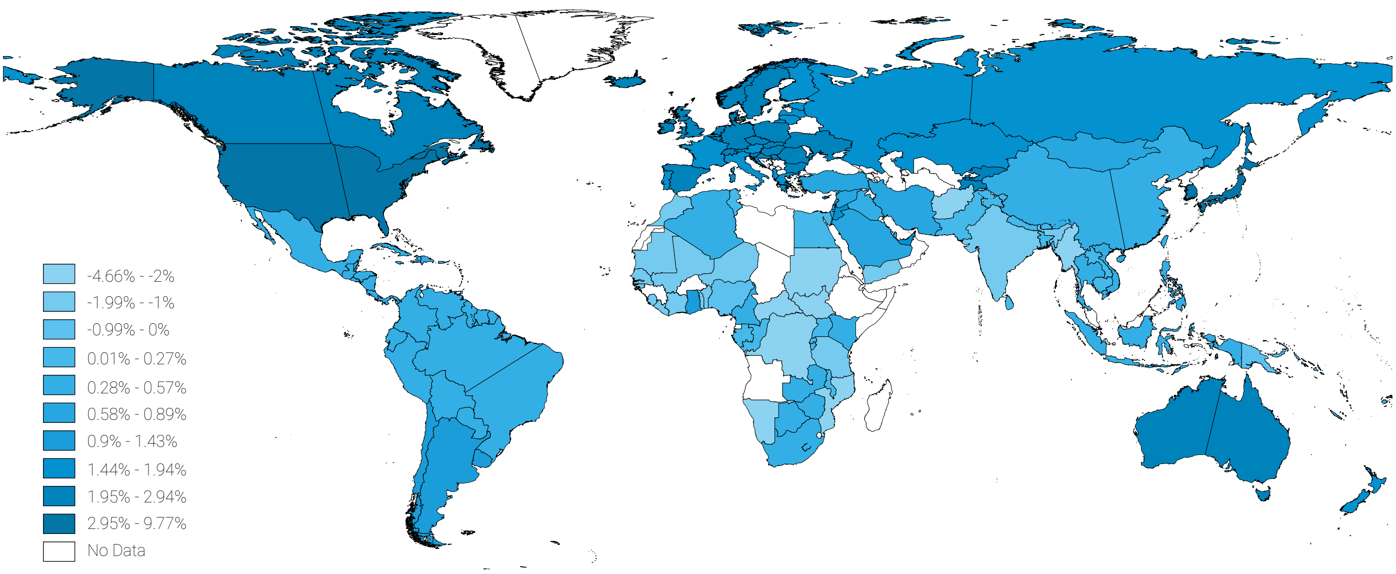
Finally, we note how to translate concepts and measurement into policy action. In this chapter, we address this issue from a different perspective. In particular, we suggest a new financial policy tool, where national or local governments may consider issuing financial bonds that are linked with the IWI of their sovereignty. As the asset side of the national balance sheet has now been expanded to include human and natural capital, the liability side can also increase, analogous to the corporate finance structure. Not only is this idea inspired by the proposal and recent practice of GDP-linked bonds, but it also appears to be more plausible than the original argument, in that the capital asset we assume is wider and more comprehensive from a well-being perspective.

7.2. Policy Lessons for Education

Education is an important contributor to human capital, and countries can increase their productivity by increasing their investment in education. Thus, investment in education provides a high rate of return to the IW of countries, both directly through accumulating human capital and through enhancing TFP adjustment.

But how can we boost investment in education? Many factors come to mind; from physical infrastructure (school buildings, toilets), to consumables (textbooks, uniforms, nutritious meals), and human capital (quantity and quality of teachers, class size). All of these can potentially be reasons behind the low average years of schooling shown in Fig 7.1.

Fig 7.1 : Average years of schooling from 1990 to 2014



Source: Author, using Barro and Lee (2016)

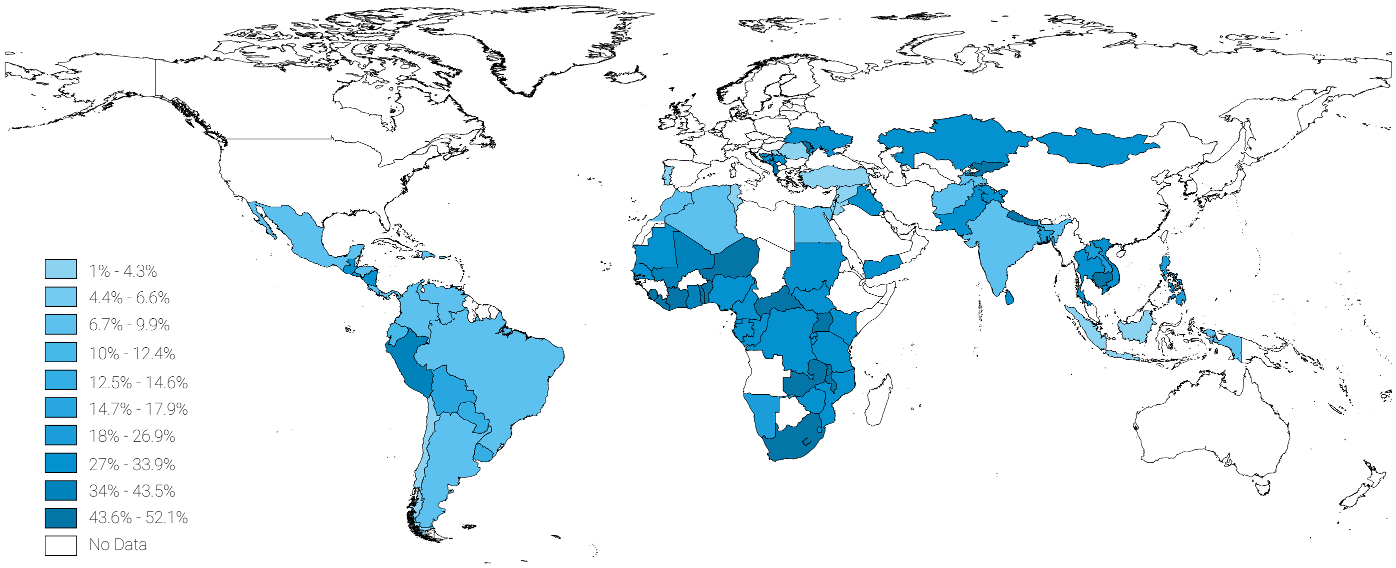
The educational portion of human capital is explained in inclusive wealth accounting. However, this accounts for only a small portion of human capital. It does not mean that the other factors are irrelevant, only that we should start from the most measurable chunk. For example, missing components could include parenting, on-the-job training, informal education/learning, adult education, health care, migration, and others (Boarini *et al*., 2012).

Vocational training is an important means of education, to increase human capital in developing countries. Vocational training generally benefits low-income students, enabling them to become earners and contribute to the economy quicker than regular schooling. It is also effective in reducing child labour in many developing countries and assists in human capital performance. The vocational school should benefit a special group of students, and they should have specific skills in the sector of their own interest.

Investments in the education infrastructure can lead to improvements in both current welfare and future well-being by accumulating human capital. The majority of low-income countries have a child labour problem, which is widespread in the developing world. In particular, child labour has been known to suppress educational attainment (Psacharopoulos, 1997). Of course, poverty is one of the driving forces leading children to perform physical labour; it is easy to see why children give up schooling when given the opportunity of paid employment.

Care should be taken, however. Many factors contribute to creating this problem and thus abolishing child labour altogether may not be a solution (Basu and Tzannatos, 2003). Ranjan (1999, 2001) showed child labour might arise in poor households with credit constraints. In reality, child labour may provide the only way to finance school attendance, as agreed in a mining case study by Maconachie and Hilson (2016). Moreover, the majority of child labour exists in the agricultural sector, typically operated by family-run farms (Bhalotra and Heady, 2003).

Fig 7.2: Percentage of children (7–14 years) employed in labour



Source: Author, using Barro and Lee (2016)

Fig 7.2 shows the percentage of children (7–14 years) employed in the labour market; apparently, most of the African nations and certain Asian and Latin American countries have alarming levels of child labour. Understanding the reasons for low years of schooling and the economics of child labour can improve the education condition in low-income countries. These problems should be examined in light of poverty and credit constraints in rural households. The most obvious policy lesson for those countries, therefore, is to resolve poverty, human capital investment, child labour, and other market imperfection problems simultaneously.[49]

7.3. Regulating Pollution and Inclusion in Inclusive Wealth

It is important to include regulating ecosystem services in the inclusive wealth measure. These range from flood prevention at local scale, to climate control at global scale. IWR 2012 and 2014 have employed carbon damage to account for climate change damage. As a global public problem, climate change needs to be assessed based on the global aggregate. A flow damage cost of a nation, regardless of how much it emits, is subtracted from IWI, to reflect true social well-being. This is a plausible move to account for negative pressure on social well-being.

However, at the other end of the spatial spectrum lies local air pollution, which is yet unaddressed in inclusive wealth accounting. Local air pollution is especially relevant to policymakers at national and local scales. Regulating air pollution will benefit human health by improving the mortality rate and reducing health care expenses.

Among many potential sources of air pollution, anthropogenic sources of solid particles that are less than 2.5 micrometres across, called particulate matter 2.5 (PM2.5), are growing rapdily. The release of PM2.5 has a chronic effect on human health. PM in ambient air is considered to be related to an increased risk of premature death, as well as other less severe health end-points such as respiratory and cardiac emergencies (WHO, 2006), although some mechanisms remain uncertain (Harrison and Yin, 2000). Many sources of PM2.5 are noted: for instance, transportation, energy resource usage, construction, agriculture, and international trade are major emitting industries. In addition, the exposure exists at the local and international levels, implying that PM2.5 primarily affects people in developing economies in Asia. For instance, China, Russia, India, Viet Nam, Thailand, Indonesia and Afghanistan are encountering significant health damage due to the adverse impact of PM2.5. Fig 7.3 reports the annual average growth rate of PM2.5 damage based on the World Bank (2017) database. At the aggregate level, the intensity of damage is also very high in the United States, Japan, Brazil, and the EU (Fig 7.4), but their environmental policies seemingly significantly reduce this growth (Fig 7.3). BRICS countries also experience major damage from PM2.5 exposure.

49 See Fors (2010) for a survey. Islam and Choe (2013) have investigated the role of microcredit in child labour and human capital formation. Shimamura and Lastarria-Cornhiel (2010) discuss the effect of credit program participation.

Fig 7.3: Growth of PM2.5 damage from 1990 to 2014 (percentage)

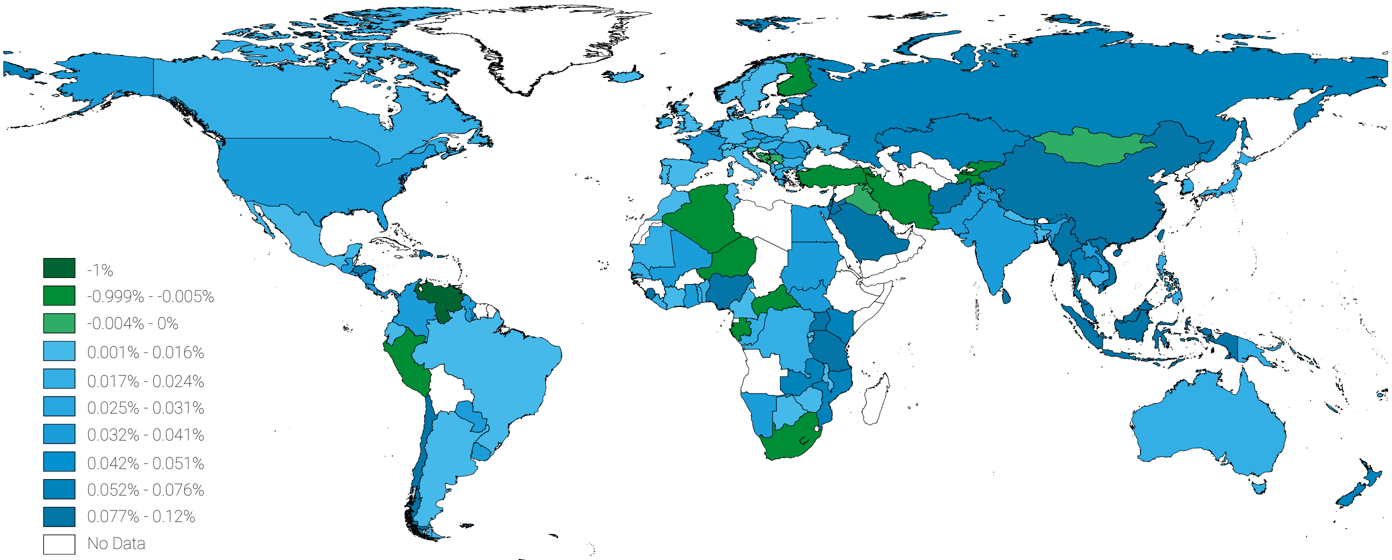


Fig 7.4: Average PM2.5 damage from 1990 to 2014 (million US dollars, 2005)

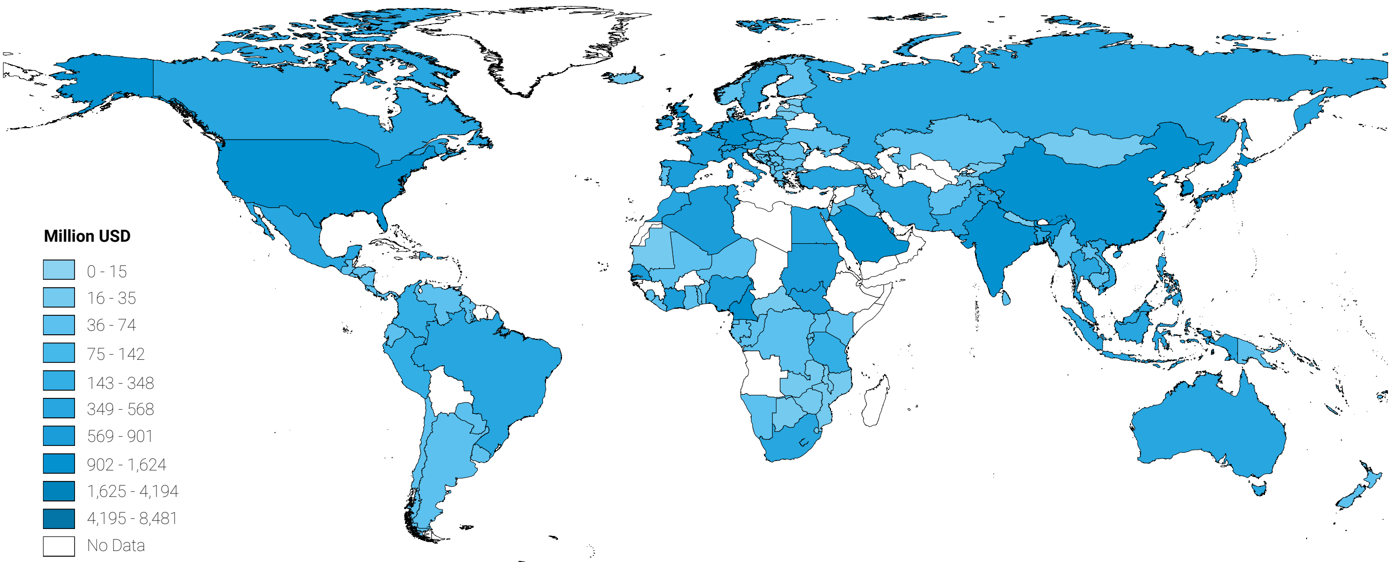


Fig 7.5 shows the growth of PM2.5 damage in per capita terms; emerging economies are increasingly vulnerable to exposure to damage. The average damage per capita over 25 years (1990 to 2014) is reported in Fig 7.6, where Saudi Arabia, South Africa, the United States, Japan, China, and EU countries show relatively high per capita damage, surpassing US$10 per person.

Fig 7.5: Growth of the PM2.5 damage per capita from 1990 to 2014 (percentage)

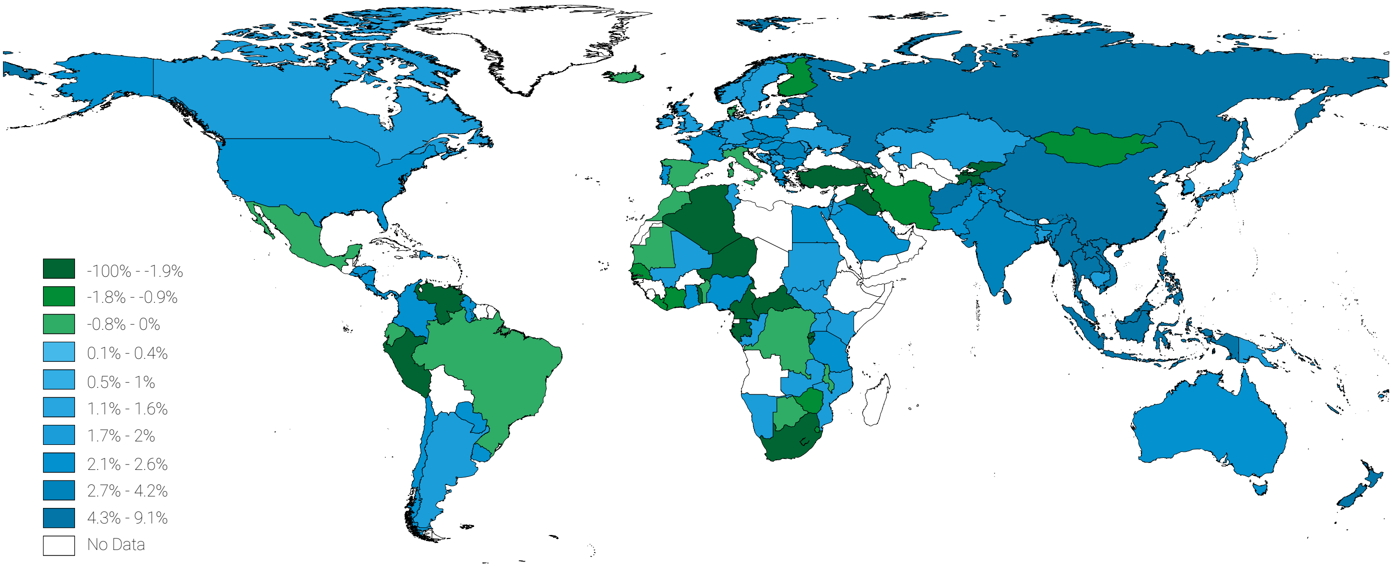
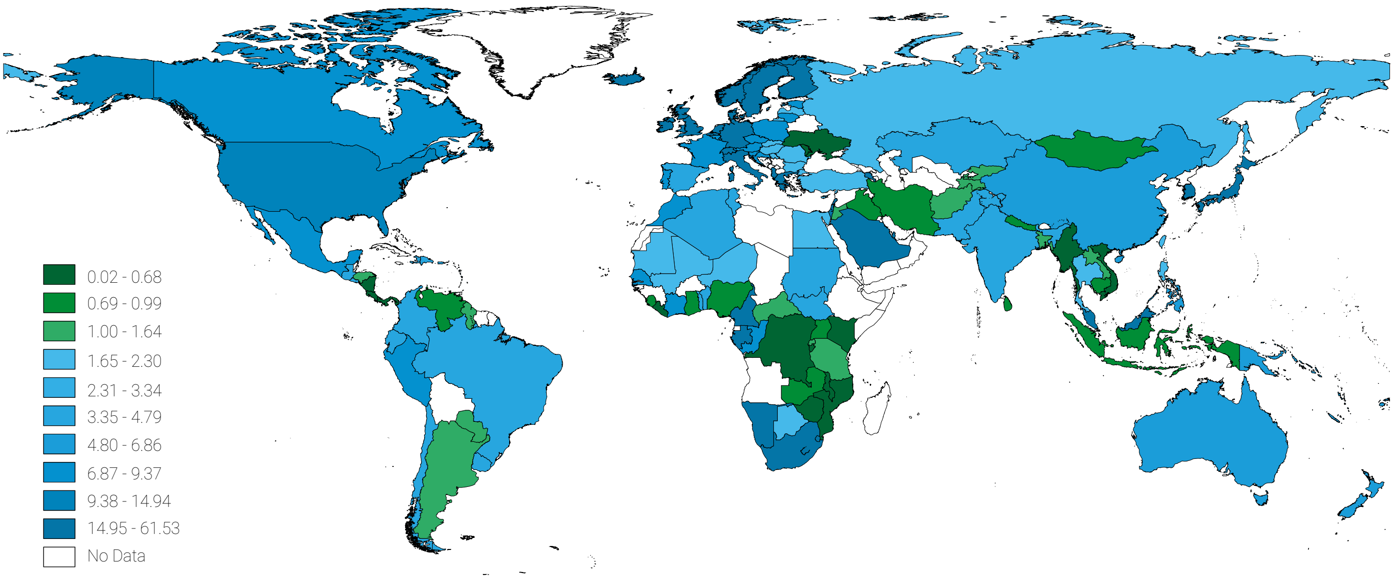


Fig 7.6: Average PM2.5 damage per capita from 1990 to 2014 (US dollars 2005)



What is distinct about ambient air pollution caused by PM is that it is transboundary (WHO, 2006; Anenberg et al., 2010). This means it should be treated as a regional public concern, if not a global one. In our inclusive wealth accounting, we adjust carbon damage as it affects human well-being globally.

We therefore might want to consider PM damage as another adjustment to IWI, while avoiding double counting with health capital accounts.

7.4. Fisheries Policy

Fisheries are an essential part of natural capital, which significantly contribute to the total wealth. However, the ability of a marine ecosystem to provide non-declined utility is limited by its regenerative capacity; this is currently being threatened by increasing human activities to satisfy food needs and to pursue higher economic development.

The growing population of the world has led to an increase in annual global fish consumption from 9 kg/capita in 1961 to 16.5 kg/capita in 2003, and this figure is expected to increase further to 17 kg/capita in 2020 (Delgado, 2003). The increasing demand for fish was followed by the industrialization of the marine fisheries sector in the first half of the 20th Century, through the mechanization of fishing fleets and the improvement of marketing systems. This improvement in techniques led to increasing productivity and employment in the fisheries sector (Coulthard *et al*., 2011). However, despite the industrialization of the marine fisheries sector and the increasing demand for consumption, the total catches of global marine fisheries eventually reached their peak in the mid-1990s (see Fig 7.7). Subsequently there has been an increasing number of overfished and collapsed stocks (Branch *et al*., 2011; Froese *et al*., 2012) and a declining mean trophic level of catch (Myers and Worm, 2003; Pauly *et al*., 1998; Pauly and Palomares, 2005). These factors have led to persistent debates regarding the sustainability of marine fisheries over the past two decades.

Sugiawan *et al.* (2017) argue that the sustainability of global marine fisheries is correlated with economic development. The researchers find a non-linear relationship between economic growth and both marine fisheries catch and estimated stock, suggesting the existence of turning points in the economy beyond which the beneficial impacts of economic growth on a marine ecosystem will be achieved. Hence, declines in resource abundance arising due to the development of the fisheries sector are only temporary. As the economy grows, the structural changes in the economy lead to more stringent environmental regulations, better fisheries management and new technologies. These changes will lead to a decline in catch levels in the short run and stock recovery in the long run. Similarly, by using the Ocean Health Index (OHI), a novel index to quantify and observe the health of human-marine ecosystem interactions, Halpern *et al.* (2012) show that, in general, developed countries have healthier oceans than developing countries. Flaaten (2013) discusses the institutional influence on the relationship between economic growth and fishing.

In terms of wealth accounting, sustainability is achieved if the capital stock of marine fisheries is non-declining over time (strong sustainability) or if the decline in marine fisheries stock can be compensated by a sufficient increase in other types of capital stock (weak sustainability). Fig 7.8 shows a comparison of capital stock of marine fisheries in 1976, 1990 and 2014 for selected countries having fish capital of more than US$25 billion. The size of the bubble indicates the size of the population.

From Fig 7.8, we can see that in general, the wealth of fisheries declines over time as a result of continuously increasing fishing efforts, which are driven by economic development and population growth. Only a few countries, such as Canada and Spain, can maintain or increase their level of stock. From Fig 7.8, we can also see different patterns of fish stock depletion between developed and developing countries.

Certain rich countries, regardless of their population, are found to have a declining rate of fish stock depletion. This finding may have resulted from the institution of better management systems and policies and the adoption of more advanced technologies. On the other hand, developing countries, which are characterized by increasing economies of scale, tend to have a steadily declining rate of fish stock depletion. In addition, we can see that the rate of stock depletion is also influenced by the size of the population.

Countries with a relatively large population, such as China, India and Indonesia, are very likely to have an increasing rate of stock depletion. However, Sugiawan *et al.* (2017) argue this rapid depletion is inevitable but only occurs temporarily. The researchers argue that as the economy grows, there will be declining pressures on the marine ecosystem that will lead to stock recovery in the long run.

Fig 7.7: Time-series data of global marine fisheries catch, population and world GDP per capita

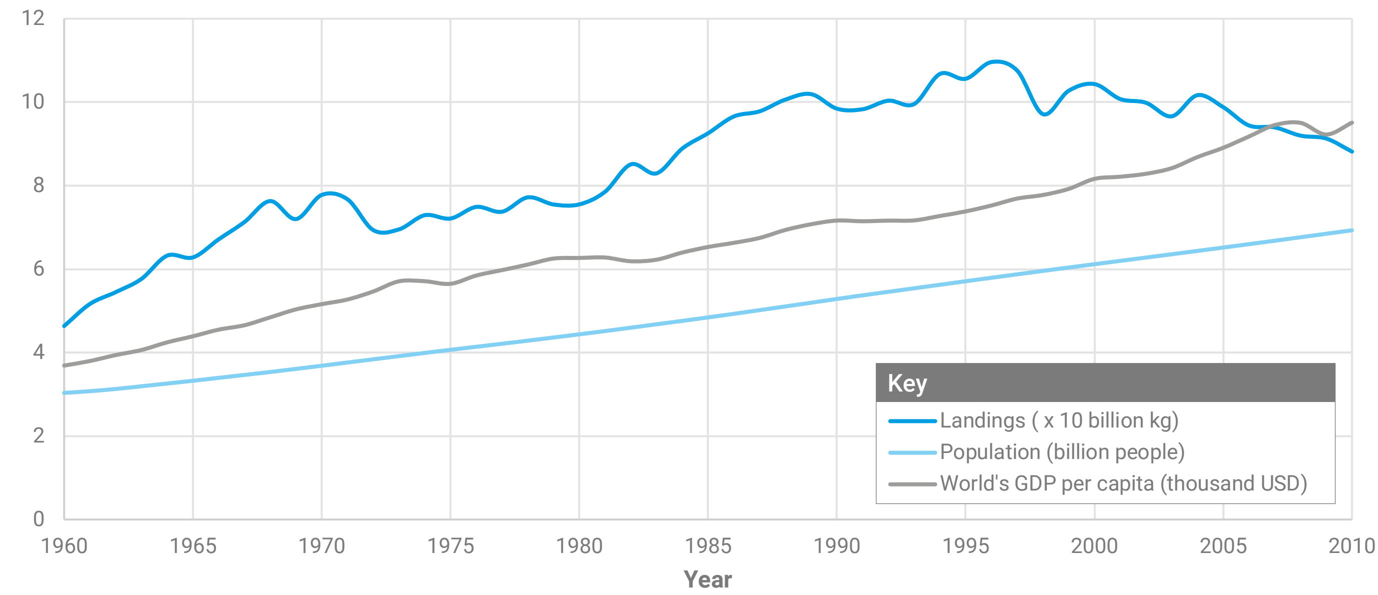
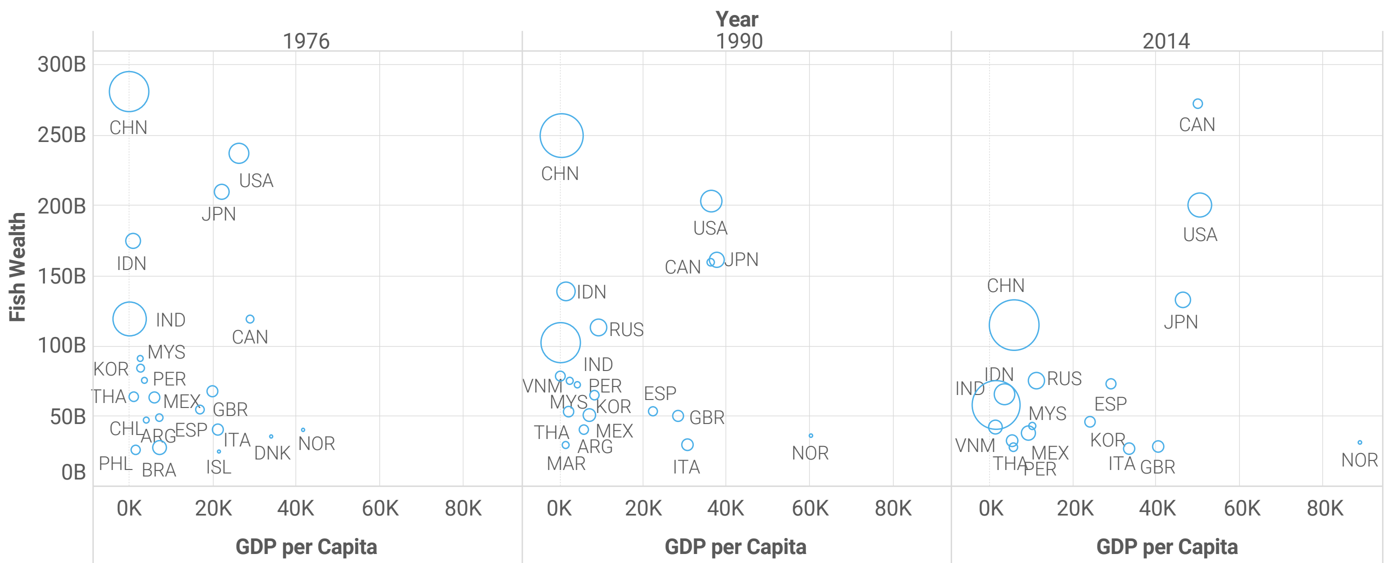


Fig 7.8: Comparison of fish stock capital for selected countries



From the discussion, we highlight certain important policy implications. First, the composition and technical effect of the economy, which are marked by the institution of better management systems and policies, investment in cleaner and more advanced technologies, and adoption of more stringent environmental regulations among others, are essential for decoupling economic growth from fish stock depletion. The immediate impact of these effects would be in reducing the volume of fish catches and discards. However, stock recovery is likely to be observed only in the long term. These findings suggest the need to implement better fishing practices and fisheries management to achieve sustainability in the fisheries sector.

Second, to maintain positive growth of total wealth, the inevitable stock depletion in the earlier stage of the economy should be compensated by a sufficient increase in other types of capital. Consequently, the constant pressure of population growth on fish stock should not only be considered a threat to sustainability but should be viewed as a potential asset, which needs to be managed to increase the productive base of an economy, that will compensate the declining level of natural capital.

7.5. Total Factor Productivity (TFP) and Social Capital

7.5.1. TFP and sustainability implications

Arrow *et al.* (2004; 2012) suggested that TFP can contribute to social well-being directly. Formally, TFP can be regarded as the shadow value of time as a capital asset (UNU-IHDP and UNEP, 2012). IWR thus includes the change in TFP as an adjustment term, based on the finding that we need merely to add TFP growth to inclusive investment (Arrow *et al.,* 2012).

A in the production function A(*t*)F(K(*t*)), where K(*t*) is the vector of capital assets and F(.) is the constant-returns-to-scale production function, can be interpreted to be an aggregate index of knowledge and the economy's institutions. In conventional growth accounting, K(*t*) include produced and human capital. In a remarkable move to include natural capital in growth accounting, however, Vouvaki and Xepapadeas (2009) observe that dismissing natural capital can mislead the analyst to interpret degradation of the environment as an improvement of knowledge and institutions. Brandt *et al.* (2013) argued that failing to account for natural capital tends to lead to a biased estimation of productivity growth. Natural capital has also remained largely hidden to policymakers due to the limitations of traditional economic indices (Fujii and Managi, 2013; Managi *et al*., 2004; Johnstone *et al*., 2017; Kurniawan & Managi, 2017).

In this report, therefore, we calculated TFP as a residual by expanding natural capital (forest, agriculture land, fish, fossil, and minerals) as an explicit factor of input into the production process. By integrating natural capital, we can understand that the same productive base of a country can lead to an increase (decrease) in aggregate output over time regarding the effective utilization of its productive resources. In particular, the frontier approach in IWR 2018 measures TFP adjustment by capturing the efficient utilization of natural capital, as well as produced and human capital, by using the Malmquist Productivity Index approach. The result shows 55 of the 140 countries – more than one third of our sample – have negative average TFP. Increasing investments in R&D tend to be focused on areas revolving around produced and human capital, but we need to shed new light on ways to efficiently employ natural capital and the environment in a modern economy. This brings us to the question of how environmental policy actually improves productivity.

7.5.2. Productivity and environmental policy

Porter and van der Linde (1995) postulated an apparent link between productivity and environmental policy. According to their hypothesis, well-designed environmental regulation can provide "a free lunch" and can trigger innovation which, in turn, can decrease and offset the costs of pollution abatement and enhance competitiveness. New evidence from the OECD countries shows that the more stringent environmental policies of recent years have had no negative effect on overall productivity growth (Ambec *et al.*, 2013). The researchers found that before tighter environmental policies came into effect, the overall productivity growth of a country slowed, possibly because firms anticipated the changes and prepared themselves for new operating conditions. However, a rebound in productivity growth soon followed, with no cumulative loss reflected in the data. Lanoie *et al.* (2008) also found a positive relationship between lagged regulatory stringency and productivity; innovations may take several years to develop, and capital expenditures are often delayed for a few years through normal budgetary cycles and building lags.

These results imply that more stringent environmental policies, when properly designed, can be introduced to benefit the environment with no loss of productivity. Well-designed market-based instruments, such as taxes on externalities or cap-and-trade schemes, score better in dynamic efficiency than environmental standards and effectively induce broadly defined innovation, providing firms more flexibility in the way they adapt to new environmental policy (De Serres *et al.*, 2010). Global society is required to innovate environmental practices based on incentives for industries to perform well in their environmental management and formulate economic and environmental policies simultaneously to achieve the sustainability of the growth process.

7.5.3. Productivity at the sectoral level

Innovations have minor importance in sustainable development issues with respect to exploiting resources for production, consumption, and disposal by a better means. Thus, it has been pivotal to work towards a more advanced technological shift and shift in the progress up to this point, through the deployment of sustainable techniques and products (Hemmelskamp, 1999). Technology innovation and efficiency catch-up are driven by productivity growth. Consequently, environmentally friendly technologies, such as waste heat to electricity conversion, may lead to an improvement in productivity regarding which resources (energy) are used. It is necessary to widely adopt energy-saving technologies, to have policy-induced impulses that help companies cope with the adoption barrier. Particularly, regarding energy efficiency, Jaffe and Stavins (1994) argued that energy-efficient technologies are not widely used without policy inducement. Contributing factors are a lack of information about available technologies, particularly when there are no incentives, principal/agent problems, low energy prices, and high implicit discount rates.

The most powerful driver to support energy efficiency is profit; if an energy efficiency project is profitable, everyone will participate in the project. Investments in energy efficiency have many positive effects, not only an economic impact through maintaining energy security and increasing competitiveness but also environmental and health impacts by reducing GHG emissions. Arvanitis *et al.* (2016) proved that there is a direct positive effect of investment spending for energy-related technologies on labour productivity and indirect positive effects of energy taxes through investments in energy-related technology. Consequently, countries need to induce more investment in the energy efficiency sector.

In the agricultural sector, public policies, such as investments in research extension, education and infrastructure, and natural resource management have been the major sources of TFP growth. Chand *et al.* (2011) found that public investment in research has enhanced a significant source of TFP growth in most crops. The variables for natural agricultural resource management and produced capital have been important sources of TFP growth for most crops. Among natural resources, a dependable supply of irrigation revealed by the proportion of groundwater in total irrigation, in addition to the balanced use of fertilizers, has played a significant role in increasing TFP. Investments in agricultural technologies, such as drought-resistant seed varieties, soil-improving technologies, and solar energy sources, are options that may increase the productivity of the agricultural sector.

These results and previous discussions provide several noteworthy contributions to policymakers. First, these findings enhance our understanding of how particular countries can measure and manage their sustainability by incorporating natural capital into TFP. Second, countries need to develop well-designed environmental regulations to trigger innovation and utilize their productive assets in a more effective manner. Third, policymakers are encouraged to support the research and development of renewable resource technologies, although their impact on social well-being is yet to be captured (but see also Chapter 3). The contribution of investment in technology is crucial to confront dwindling natural resources and to achieve the desired productivity growth in terms of social well-being.

7.6. Policy Instruments: IWI-linked Bonds

In its inaugural report, IWR 2012 proposed that inclusive wealth, rather than GDP, interest rates, unemployment or other indicators, should be "mainstreamed" for use in economic policymaking. We believe that conventional economic indices continue to play a key role in economic policymaking, as they represent how the economy, rather than social well-being, is performing overall. Conventional aspects of the economy have many ramifications. For instance, inflation and unemployment certainly affect our short-term well-being. It is well-known that job security is an important constituent of subjective well-being and a sense of dignity. Moreover, our index of IW pertains more to the question of whether a productive base is on the increase in the long run, rather than short-run fluctuations. Thus, we should be humble in what our index says about the sustainability of social well-being and the productive base in the long run. Having acknowledged these differences in focus, we also believe that IW should be emphasized in economic policymaking, if not mainstreamed. Political administrations naturally focus on increasing their reputation and can thus be short-sighted. For example, it is expected that current administrations have an incentive to prefer policies that cater to the current generation and leave the policy burden to be dealt with by future generations. Therefore, IW can be a headline index in economic, as well as social and ecological, policymaking, as a sort of commitment device for sustainable development.

There could be many alternative means to operationalize the idea of making IW a headline index, as with the interest rates of stock prices. In a recent thought experiment, Yamaguchi and Managi (2017) proposed that national governments could issue bonds that are linked to the level or the growth rate of IW. By linking bond coupons (fixed income) to IW, holders of this financial asset would be intrinsically linked with trends in IW, an indicator of sustainable well-being.

However, the main intention of this proposal is much wider than garnering focus on IW in the policy arena. In theory, this instrument would create macro-financial markets for a previously unnoted but important portion of wealth. Kamstra and Shiller (2009) refer to human capital, which accounts for a large proportion of wealth, particularly in high-income countries, but there is no reason not to extend this discussion to natural capital. Therefore, the proposed financial vehicle can be seen as a plausible extension of the recent proposals of GDP-linked bonds (Borensztein and Mauro, 2004; Kamstra and Shiller, 2009; Barr *et al.*, 2014).

By properly designing new bonds, governments could offer institutions and other investors opportunities to mobilize their financial resources into investments in the components of IW: produced, human, and natural capital. One way to accomplish this mobilization is to set aside the proceeds from the general budget and establish a bond revenue fund to be used for reinvestment in capital assets that comprise IW.

In this case, the government, with the aid of the voice of citizens, is expected to craft investment strategies in capital assets. Suppose that, the shadow price of a forest in a given country is rising, due to aggressive deforestation and rising scarcities. Then, the national government could conduct a cost-benefit analysis, using the same shadow prices as well as cost estimates, to determine whether and how investment in the forest is justified (see, e.g. Collins *et al.*, 2017). If the investment is indeed rationalized, then the government taps into the revenue from the proposed inclusive wealth-linked bonds for afforestation, reforestation or protection from illegal logging.

A bond of this kind would face some obstacles in practice. First, government budget deficits may increase, at least in the short run, in a sluggish economy. GDP-linked bonds, it is argued, have the advantage of being countercyclical, by automatically suppressing interest payments when the output is not increasing. In the current proposal of IWI-linked bonds, interest payments are linked with a long-run productive base, which may conflict with the short-run trend in output. Second, unless we have a very transparent institution for measuring the shadow prices of the list of capital assets and democratically prioritizing public investments, the government may have an incentive to report (a growth rate in) IW that is higher than the true value. This finding is particularly true of administrations facing the threat of being expelled from power. However, this mechanism may be attenuated to a certain extent due to the obligation of the government to pay IWI-linked interests.

To fix ideas, let us take India as an example. As Table 7.1 shows, produced, human, and natural capital represented 8 percent, 61 percent and 31 percent, respectively, of total capital of the nation in 1990. The relatively high position of natural capital in IW is typical of developing countries, as discussed in Chapter 1. However, this position is reduced to as low as 15 percent in the latest figure.

More fossil fuel (oil, natural gas and coal) experienced an across-the-board decline. Fisheries nearly halved, and pastureland also witnessed a decline. In contrast, forest resources somewhat increased during the period. The past quarter century has also observed massive investment in infrastructure, contributing to the elevated share of produced capital in 2014 (24 percent). Interestingly, the relative share of human capital remained at 60 percent. Apparently, we could argue that the country has invested in produced capital, at the expense of certain natural capital resources.

Table 7.1: Inclusive wealth in India, 1990–2014

	1990		2014		Annual change rate	
	$billion	Share (%)	$billion	Share (%)	%	Weighted (%)
Produced capital	867	7.5	5,049	23.5	7.62	1.36
Human capital	7,110	61.4	13,215	61.5	2.62	1.61
Natural capital	3,605	31.1	3,242	15.1	-0.44	-0.09
Total	11,582		21,505		2.61	2.88

Let us review the order of the magnitude of this financial instrument in this example. First, we study a possible bond whose interest payment is linked with the level of IW of India. Suppose the social discount rate is 5 percent per annum. Assuming, at a cost of rigour, that the NNP is the return on wealth (the latter being US$21,505 billion in monetary units in 2014), we can simply estimate that the NNP in 2014 would be US$1,075 billion (=$21,505 billion times 0.05). The interest payment would be a share of the corresponding NNP, which should be fixed before the issuance of the bond. Suppose that this constant share is 100 billionths of the current NNP. Then, the coupon payment would be US$10.75 (=$1,075 billion/100 billion).

Second, we could also consider a potential bond linked to the growth rate of wealth. Fig 7. 1 shows IW has increased at a rate of 2.6 percent annually since 1990.[50] This growth rate can be directly used as the coupon interest rate of this possible bond. As is often the case with an emerging economy, the 10-year government bond in India is higher than its peers in developed countries, with the latest figure of approximately 6.5 percent as of September 2017.

This comparison shows that a premium would be needed to compensate investors for taking risks in the growth of IW; in this case, the interest payment could be based on a benchmark rate, such as short-term government debt.

Finally, comparisons with other similar initiatives are in order. The proposal of GDP-linked bonds was innovative and provocative (Shiller, 1993), but their focus is on fiscal sustainability and the inclusion of capital assets, the income of which is revealed in the GDP boundary. This focus naturally needs to be extended to sustainable development and the inclusion of income from the non-GDP boundary (Yamaguchi and Managi, 2017).

50 If consumption does not grow, this rate should be equal to the growth in green NNP.

Another relevant trend in the financial market is the increasing issuance of green bonds. As case studies demonstrate (European Commission, 2016), green bonds are issued for specific projects in the fields of renewable energy, energy efficiency, low carbon transport, sustainable water, and waste and pollution, some of which overlap with natural capital investments. The IWI-linked bonds have an advantage of prioritizing projects on a macro scale, based on shadow prices for a wide variety of human and natural capital. This advantage would also enable the issuer to shift investments to more needy projects when relative scarcity changes in the long run. Moreover, interest payments are linked with nationally aggregated IWI, such that the return to bond holders decreases when wealth does not increase sufficiently. This finding also demonstrates that the risk of the decreased well-being of future generations is shared with current investors.

A busy street market Vrindavan, India. Fancycrave on Unsplash.com

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