CHAPTER 4
How Do Our Actions Undermine Nature?

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Summary The global growth experience since the end of the Second World War has given us 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—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 10–1000 times the average rate over the past several million years (the "background rate"). The mid-twentieth century years are acknowledged to have been the beginnings of an era that environmental scientists now call the Anthropocene (Vosen, 2016), during which the processes that define the biosphere are being altered enormously (see Waters et al. 2016).

On the other hand, it is argued by many that just as previous generations in the West and (and more recently in the Far East) invested in science and technology, education, and machines and equipment so as to bequeath to the present generation the ability to achieve high living standards, we in turn can make investments that would assure still higher living standards in the future. In 1950, global income per capita was approximately 3500 international dollars (at 2011 prices) and world population was about 2.5 billion. In 2015, the corresponding figures were 15,000 international dollars and 7.5 billion. A somewhat-greater-than 12-fold increase in global income over a 65-year period is unprecedented, that too starting at a 3500 international dollars base. The years immediately following the Second World War are routinely praised by commentators for being the start of the Golden Age of Capitalism (Micklethwait and Wooldridge (2000), Ridley (2010), Norberg (2016), and Pinker (2017) are a sample of books with that message).

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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 65 years following 1950, particularly the potentially irreversible changes to the biosphere, do not receive much airing by economic commentators. That is because contemporary models of economic growth and development (e.g. Helpman, 2004) largely ignore their damaging impacts on the workings of the biosphere.

Part I

The Idea of Sustainable Development

Recently, a group of economists have studied the tension inherent in the 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 had inherited from its predecessor. If a generation follows this prescription, then the economic possibilities facing its successor would be no worse than those it faced when inheriting productive assets from its predecessor.

The problem is that the rule leaves open the question of how the productive base is to be measured. We are thus in need of an index whose movements over time track the sustainability of development programmes. Prominent attempts at constructing ways to assess sustainability have been less than satisfactory because they did not arrive at their favoured indices from a well-articulated notion of sustainable development (Fleurbaey & Blanchet, 2013; Stiglitz, Sen, & Fitoussie, 2009).

Wealth and Well-Being

In this chapter intergenerational well-being refers to not only the well-being of those who are present today, but also the well-being of people in the future. The term indicates an aggregate measure of the flow of personal well-beings across time and the generations. Now, if sustainable development is meant to indicate that intergenerational well-being should not decline over time, then the index that signals whether an economy is on a sustainable development path is an inclusive measure of wealth (see Arrow et al., 2004; Arrow et al., & Oleson, 2012, 2013; Dasgupta & Mäler, 2000). Formally, *if intergenerational well-being increases over time, inclusive wealth also increases over time; and if intergenerational well-being* *decreases over time, inclusive wealth also decreases over time.* We call this relationship the *wealth/well-being equivalence theorem*. Inclusive wealth and intergenerational well-being are not the same thing, but they move in the same way. The wealth/well-being equivalence theorem tells us that neither GDP nor the United Nations' Human Development Index should be used as an index for determining whether an economy is on a path of sustainable development.

Inclusive wealth is the dynamic version of income. It is the social worth of an economy's stock of produced capital (roads, buildings, machines), human capital (health, education), and natural capital (ecosystems, sub-soil resources). Wealth is a stock, whereas income (e.g., GDP) is a flow. In a stationary economy, the two amount to the same thing; however, they can point in different directions when an economy is not in a stationary state.

To better appreciate the notion of inclusive wealth, 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 he owns (house and belongings, e.g.). He would use their market value to compute wealth. If pressed, he would acknowledge that his future earnings at work should be included, and he would estimate that part of his wealth by making a forecast of the flow of his (post-tax) earned incomes and adding them over the working life that is ahead of him, using perhaps a market interest rate to discount future earnings. If he were pressed no further, he would probably stop there and agree that his earned incomes represent returns on the human capital he has accumulated (sociality, education, skills, health). He would also agree that wealth is important to him because it determines the opportunities he has to shape his life—the activities he can engage in, the commodities he can purchase for pleasure, and so on. But he would probably overlook that his taxes go to pay for the public infrastructure he uses, and he would almost certainly not mention the natural environment he makes use of daily, free of charge.

The notion of wealth in which a society should be interested is far wider. Inclusive 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 inclusive wealth at a point in time is able to reflect the flow of well-being across time and the generations.

Accounting Prices and the Social Environment

An asset's *accounting price* is the social worth of the stream of goods and services a society is able to obtain from a marginal unit of 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. The forest's accounting price measures its worth to society. 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 the house a family inhabits is not independent of whether society is at peace.

Accounting prices can be very different from market prices. 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 be even be judicious to impose a quota on fishing, but quotas are only an extreme form of taxation (zero tax per unit up to the quota, a prohibitive tax beyond it).

The assets whose accounting value adds up to inclusive wealth (i.e. produced capital, human capital, and natural capital) should be distinguished from an economy's social environment and practices. The latter pair comprises the intangible medium in which goods and services are produced and allocated across persons, time, and the generations. The social environment consists of the laws and social 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; it includes the play of politics; and it includes personal motivations and norms of conduct. The social environment is the seat of mutual trust. A strengthening of trust facilitates enterprise and exchange, thus enhancing personal well-being and thereby inclusive wealth.

Sustainable Development Goals

The practical significance of the equivalence between intergenerational well-being and inclusive wealth 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. The SDGs are noble goals; they are to be lauded. 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. But neither the SDGs nor their background documents mention the need to move to a system of national accounts that contains estimates of inclusive 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 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 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' Sustainable Development Goals do not tell us how to check that the goals are being met in a sustainable way. Managi and Kumar (2018), in their *Inclusive Wealth Report 2018*, have found that 44 out of the 140 countries in their sample experienced a decline in (inclusive) wealth per capita since 1998, even though GDP (read, "income") per capita increased in all but a handful of them. The tension I alluded to is expressed quantitatively in that study.

Part II

What Is Investment?

Today, the most commonly used measure of people's health is longevity. We routinely talk about investment in a country's health and commend it when longevity rises. But does an increase in longevity amount to investment?

The word "investment", as customarily used, embodies a sense of robust activism. But that is only because national income statisticians have traditionally limited the term's use to the accumulation of produced capital. When a government invests in roads, the picture that is drawn is one of bulldozers levelling the ground and tarmac being laid by men in hard hats. That is investment. In Part I, we found it necessary to extend the notion of capital beyond produced capital to include human capital and natural capital. So we were obliged to stretch the notion of "net investment" to mean any decision that raises future well-being. To leave a forest alone so that it can grow is in our extended sense to invest in the forest. Net investment is positive when trees grow. To allow a fishery to restock under natural conditions is to invest in the fishery. Net investment in the fishery is positive when the stock increases. And so on.

That could suggest that investment amounts to deferred consumption; however, the matter is subtler. Providing additional food to undernourished people via, for example, food guarantee schemes not only increases their current well-being, it enables them also to be more productive in the future and to live longer. Because their human capital increases, the additional food intake should count also as net investment. Note, though, that food intake by the well-nourished does not alter their nutritional status, which means the intake is consumption, not investment. By "net investment" in an asset we mean the value of the change in the stock of that asset over the past period.

To illustrate, consider a closed, egalitarian economy with constant population. Suppose in a given year it invests 40 billion dollars in produced capital, spends 20 billion dollars on primary education and health care, and depletes and degrades its natural capital by 70 billion dollars. The economy's System of National Accounts (SNA) would record the 40 billion dollars as investment ("gross capital formation"), the 20 billion dollars as consumption, and would typically remain silent on the 70 billion dollars of loss in stocks of natural capital (e.g. wetlands, the atmosphere). Proper accounting methods in contrast would reclassify the 20 billion dollars as expenditure in the formation of human capital ("investing in the young", as the saying goes) and the 70 billion dollars as depreciation of natural capital. Aggregating them and assuming that expenditure on education is a reasonable approximation of gross human-capital formation, we would conclude that, owing to the depreciation of natural capital, the economy's wealth will have declined over the year by 10 billion dollars—and that is before taking note of the depreciation of produced capital and human capital. The moral we should draw is that development was unsustainable that year.

Wealth in India: Estimates

Arrow et al. (2012) put the wealth/well-being equivalence theorem to work by estimating the change in wealth per capita over the period of 1995–2000 in Brazil, China, India, United States, and Venezuela.[1] The choice of countries was in part designed to reflect different stages of economic development and in part to focus on particular resource bases. Because of an absence of data, the authors did not study wealth inequality within countries. Their publications are like reconnaissance exercises. They explore the land mostly in the dark; you know they have got it wrong, but you have reasons to believe they are in the right territory.

Table 4.1 reproduces their findings for India. The value of produced capital in 1995, amounting to $1530 per head, was calculated from government publications on past capital investments. The implicit assumption was that prices used by the government to record expenditures are reasonable approximations of shadow (true price) prices. The value of education per person ($6420) was estimated on the basis of a functional relationship between wage differences and differences in levels of education.

No data were available for calculating the contribution of health to labour productivity and current well-being. For that reason, the authors studied longevity only. Its accounting price was estimated from the value of a statistical life (*VSL*), which is commonly obtained from the willingness-to-pay for a marginal reduction in the risk of death. Recent work suggests *VSL* in India is approximately $500,000. Arrow et al. (2012) showed that under a set of simplifying assumptions *VSL* equals the value of health per person [row (3), column (1)]. They then estimated the value of a statistical life-year and used that to value the increase in life expectancy between 1995 and 2000 [row (3), column (2)].

Four categories of natural capital were included in the study: forests (valued for their timber), oil and minerals, land, and carbon concentration in the atmosphere. Like institutions and knowledge, atmospheric carbon was interpreted to be an "enabling" asset, which is why it is excluded from columns (1) and (2) but included in the estimate of the change in wealth over the 5-year period.

[1] IHDP-UNU/UNEP (2012, 2014) used the same framework to measure wealth in 120 countries.

Table 4.1 Per capita wealth and its growth in India, 1995–2000 (2000 US$)

	(1) 1995 stock	(2) 2000 stock	(3) Change (1995–2000)	(4) Growth rate (% per year)
(1) Produced capital	1530	2180	650	7.30
(2) Human capital, 1 (education)	6420	7440	1020	3.00
(3) Human capital, 2 (health	500,000	503,750	3750	0.14
(4) Natural capital	2300	2280	−20	−0.15
(5) Oil (net capital gains)			−140	
(6) Carbon damage			−90	
(7) Total	510,250	515,650	5400	0.20
(8) *TFP*				1.84
(9) Wealth per capita				2.04

Source: Arrow et al. (2012), Table 5 (modified)

The value of land was taken from World Bank publications. Using market prices for timber and oil and minerals, the shadow value of natural capital in 1995 was estimated to be $2300 per person [row (4), column (1)]. Because of the lack of relevant data, the figure did not include the value of all the many ecological services that forests provide. Moreover, ecosystems such as fisheries, wetlands, mangroves, and water bodies are missing from Table 4.1. That means $2300 is an underestimate, in all probability seriously so. Adding the figures, wealth per capita in 1995 was found to be $510,250 [row (5), column (1)].

The population in India grew at an average annual rate of 1.74%. Column (3) records changes in per capita capital stocks over the period in question; and column (4) presents the corresponding annual rates of change. The former is embellished by two factors. First, India is a net importer of oil, whose real price rose during the period. The capital losses owing to that increase amounted to a wealth reduction in India, which was calculated to be $140 per person [row (5), column (3)]. Secondly, during 1995–2000, global carbon emissions into the atmosphere exceeded 38 billion tons. At the levels of concentration prevailing in 1995 (380 parts per million), carbon was a global "public bad". The theory of public goods says that the loss to India over the period would have been global emissions times the shadow price of carbon specific to India. In their base case, Arrow et al. (2012) took the global shadow price to be negative $50 per ton. The loss to India per ton of carbon emissions was taken to be 5% of the global shadow price, which is negative $2.50. This amounted to a loss per person of $90 [row (6), column (3)].

Row (7) records the change in wealth per capita in India over the period of 1995–2000. It translates to 0.20% a year, a figure so near to zero as to be alarming. However, the estimate does not include improvements in knowledge and institutions. Arrow et al. (2012) modelled the latter as "enabling assets" and interpreted improvements in them as growth in total factor productivity (*TFR*), which in India has been estimated to be 1.84% a year (row (8)). Based on a formula the authors derived for including the residual in wealth calculations, row (9) records the annual rate of growth of wealth per head in India during 1995–2000 as having been 2.04%.

The composition of wealth in Table 4.1 does not have direct implications for policy. A mere study of the relative magnitudes of the different forms of wealth would not tell us their relative importance. Suppose, for example, that the value of asset *i* swamps all other forms of capital, by a factor of 1000. That does not mean investment ought to be directed at further increases in *i*, for we do not know the costs involved in doing so. Only social cost–benefit analysis, using the same shadow prices as are estimated for sustainability analysis, would tell the evaluator which investment projects are socially desirable.

Taken at face value, Table 4.1 reveals a number of interesting characteristics of India's economic development during the final years of the twentieth century. It is helpful to highlight the most striking:

1. Of the four types of capital comprising measured wealth, produced capital is the smallest. Even though the value of natural capital in both years is in all likelihood a serious underestimate, it was considerably greater in 1995 than reproducible capital.
2. The rapid growth of produced capital (7.30% a year), as against a 0.15% annual rate of decline of natural capital, meant that by 2000 their stocks were nearly identical.
3. In 1995, human capital in the form of education was more than four times that of produced capital. However, the ratio declined over the 5-year period owing to a slower growth in education.
4. Health swamps all other forms of wealth. It was some two orders of magnitude larger than all other forms of wealth combined in 1995, in what was then a low-income country; this is unquestionably the most striking result of the exercise. That the finding is a cause for surprise is, however, no reason for dismissing it. Health has been much discussed in the development literature but has not been valued within the same normative theory as produced capital. There was no basis for a prior expectation of what the finding would be once health was placed in the same normative footing as other forms of wealth. Health dominates because of the high figure for *V* reported in the empirical literature. Longevity matters to people everywhere and matters greatly. In democratic societies, that should count.
5. Growth in wealth per capita in India has been largely a consequence of *TFP* growth (the "residual"). However, contemporary estimates of the residual should be treated with the utmost suspicion because they are based on models that do not include natural capital as factors of production. If the rate at which natural capital is degraded were to increase over a period of time, *TFP* growth obtained from regressions based on those models would be overestimated. The implication is more than just ironic. The regressions would misinterpret degradation of the environment as increases in knowledge and improvements in institutions. Worse still, the greater the under-coverage of natural capital, the greater the bias in the estimate of *TFP* growth. By plundering Earth, *TFP* could be raised by as much as the authorities like.

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