ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS: A CONTEMPORARY APPROACH

JONATHAN M. HARRIS AND BRIAN ROACH

ADVANCE CHAPTERS FOR FIFTH EDITION

(Due 2021: The final content and layout of the chapters may be subject to change.)

CHAPTER 10

National Income and Environmental Accounting

CHAPTER 10 FOCUS QUESTIONS

- How do traditional national income accounting measures fail to account for the environment?
- How can national accounting measures be adjusted to better reflect the importance of natural capital and environmental quality?
- What is the potential for alternative "green" measures of national welfare?

10.1 GREENING THE NATIONAL INCOME ACCOUNTS

Taking natural capital and environmental quality seriously affects the way that we evaluate measures of national income and well-being. Many economists would assert that a typical person living in a country with a high per-capita average income is essentially "better off" than a person living in a country with a low per-capita average income. But the overall well-being of people is dependent on many factors other than income levels, including health, education levels, social cohesion, and political participation. Most important from the point of view of environmental analysis, a country's well-being is also a function of natural capital levels and environmental quality.

Standard measures of **gross national product (GNP)** or **gross domestic product (GDP)** [1] measure a country's level of marketed economic activity, which often implies how "developed" a country is. (See Appendix 10.1 for an introduction to national income accounting.) Macroeconomic analyses and international comparisons are commonly based on these measures, and they are widely recognized as important standards of economic progress.

gross national product (GNP) the total market value of all final goods and services produced by citizens of a particular country in a year, regardless of where such production takes place.
gross domestic product (GDP) the total market value of all final goods and services produced within a national border in a year.

Yet many analysts have pointed out that these measures can give a highly misleading impression of economic and human development. To be fair, GDP was never intended to be an accurate measure of a country's well-being. But politicians and economists often place disproportionate importance on GDP and act as if maximizing it is the primary objective of public policy. Maximizing GDP, however, can conflict with other policy goals, such as promoting social equity or protecting the environment.

While GDP accurately reflects the monetary value of marketed goods and services, it fails to provide a broader measure of social welfare. "In spite of its apparent neutrality, GDP has come to represent a model of society, thereby influencing not only economic but also political and cultural processes."[2] Some of the common critiques of standard accounting measures such as GDP include:

- ***Volunteer work is not accounted for***. Standard measures do not count the benefits of unpaid volunteer work, even though such work clearly contributes to social well-being, often consisting of the same activities as paid work (e.g., some teacher aides are paid while others are not).
- ***Household production is not included***. While standard accounting measures include the paid labor from such market household activities as housekeeping and gardening, these services are not counted when they are unpaid.
- ***No consideration is made for changes in leisure time***. A country's GDP rises if, *ceteris paribus*, total work hours increase.[3] However, no accounting is made for the loss of leisure time.
- ***Defensive expenditures are included***. Recall from Chapter 6 that defensive expenditures that people incur to avoid environmental harms can be used to infer the value of some natural resources. Defensive expenditures also occur not just to avoid negative environmental impacts, but for many other reasons. One example is expenditures on police protection. If police expenditures are increased to counter a rise in crime levels, the increased spending raises GDP, but no consideration is made for the negative impacts of higher crime rates.
- ***The distribution of income is not considered***. Two countries with the same GDP per capita may have significantly different income distributions and, consequently, different levels of overall well-being.
- ***Non-economic contributors to well-being are excluded***. GDP does not consider the health of a country's citizens, education levels, political participation, or other social and political factors that may significantly affect well-being levels.

In our study of environmental issues, we must add another major criticism of standard accounting measures—they fail to account for environmental degradation and resource depletion. This issue can be important especially in developing countries, which depend heavily on natural resources. If a country cuts down its forests, depletes its soil fertility, and pollutes its water supplies, this surely makes the country poorer in some very real sense. But national income accounts merely record the market value of the timber, agricultural products, and industrial output as positive contributions to GDP. This may lead policy makers to view the country's development in an unrealistically rosy light—at least until the effects of the environmental damage become apparent, which in some cases may be decades.

If we are measuring social welfare with, so to speak, the wrong ruler, we may obtain policy prescriptions that could actually make a country worse off, rather than better off. Economic growth alone does not necessarily represent true economic development and may even lower human well-being if it is accompanied by growing inequity and environmental degradation. Attempts to define and estimate better measures of development has led to proposals to adjust

or replace traditional accounting measures in order to integrate resource and environmental factors. In this chapter, we discuss the estimation and application of several of these alternatives.

System of Environmental-Economic Accounting (SEEA) a framework developed by the United Nations and other international organizations to provide standards for incorporating natural capital and environmental quality into national accounting systems.

There have been numerous efforts to develop "greener" accounting measures. Interest in inclusion of the environment in national accounting began in the 1970s and 1980s, when several European countries began to estimate physical accounts for natural resources, such as forests, water, and land resources.[4] In 1993 the United Nations published a comprehensive handbook on environmental accounting, which was revised in 2003 and again in 2014.[5] The 2014 **System of Environmental-Economic Accounting (SEEA)** report describes three basic approaches to environmental accounting:

1. **Measuring the physical flows of materials and energy**. This approach looks at physical flows from the environment to the economy—the utilization of natural capital as inputs into production, such as cutting trees, harvesting fish, mining metal ores, or drilling for oil. It also looks at flows in the opposite direction, from the economy to the environment. This includes the disposal of solid wastes and emissions of air and water pollutants. Analysts construct tables that quantify physical flows into, or out of, different sectors of the economy, such as agriculture, mining, electricity generation, and manufacturing. For example, a table for air pollution might quantify the amount of different types of air pollutants, such as carbon dioxide, methane, nitrous oxides, and particulate matter, emitted by various sectors of the economy.
2. **Measuring the stocks of environmental assets**. The SEEA lists seven categories of environmental assets: mineral and energy resources, land, soil, timber, water, aquatic resources, and other biological resources. Environmental assets can be measured in both physical and monetary units. In principle, all environmental assets can be measured in physical units, such as tons of soil, acres of wetlands, or cubic meters of natural gas. Valuation of environmental assets can be done by multiplying a physical quantity by a per-unit market price, or by using the non-market valuation techniques we discussed in Chapter 6. The 2014 report notes that current levels of economic activity are depleting and degrading these resources, leading to concerns about long-term availability.
3. **The measurement of economic activity related to the environment**. This approach tabulates environmentally-related monetary transactions, such as the amount of spending on environmental protection and resource management, the collection of environmental taxes, and the quantity of subsidies. It also includes the production of environmental goods and services, such as pollution-control equipment and "environmentally-friendly" products.

Note that these three approaches are not necessarily mutually exclusive—we could theoretically implement all of them simultaneously. While many countries have adopted one or more of these accounts to some extent, no country has fully implemented the SEEA recommendations. In this chapter we will focus on the first two approaches, the measurement of physical flows and environmental assets. We will discuss environmentally-related economic activity in Chapter 14.

Beyond the SEEA recommendations, other approaches seek either to adjust existing measures of national accounting, or to devise entirely new national measures that provide a fundamentally different perspective on measuring national welfare. But before we delve into several specific measures, it is important to note that there is no universally-accepted approach to environmental accounting. Various measures have been developed and implemented by researchers and organizations, each with advantages and disadvantages. But no particular measure has yet emerged as the "best" approach.

10.2 Green GDP

Perhaps the most basic approach to environmental national accounting is to start with traditional measures and make adjustments that reflect environmental issues. In current national income accounting, it is commonly recognized that some of each year's economic production is offset by the depreciation of manufactured, or fixed, capital, such as buildings and machinery.[6] In other words, while economic activity provides society with the benefits of new goods and services, each year the value of previously produced assets declines, and this loss of benefits should be accounted for. Standard national accounting methods include estimates of **net domestic product (NDP)**, which start with GDP and then deducts the annual depreciation value of existing fixed capital:

$$NDP = GDP - D_m$$

net domestic product (NDP) gross domestic product minus the value of depreciation of produced, or human-made, capital.

where D_m is the depreciation of fixed capital. In 2019 the GDP of the United States was $21.4 trillion. But the depreciation of fixed capital that year totaled $3.4 trillion.[7] Thus the NDP of the United States in 2019 was $18.0 trillion.

Taking this logic a step further, we realize that each year the value of natural capital may also depreciate as a result of resource extraction and environmental degradation. In some cases, the value of natural capital could increase if environmental quality improves. The net annual change in the value of natural capital in a country can simply be added or subtracted from GDP or NDP to obtain what is often called **Green GDP**:[8]

$$Green\ GDP = GDP\ (-D_m) - D_n$$

Green GDP a national accounting measure that deducts a monetary value from GDP or NDP to account for natural capital depreciation and other environmental damages.

where D_n is the depreciation of natural capital. This measure requires estimating natural capital depreciation in monetary terms, rather than physical units such as biomass volume or habitat area. The methods discussed in Chapter 6 can be used to estimate such values, but obviously estimating all types of natural capital depreciation in monetary terms is a daunting task that would require many assumptions. The estimates of Green GDP that have been produced usually focus on only a subset of natural capital categories.

Attempts to estimate Green GDP date back to the 1980s. A pioneering 1989 analysis estimated the value of depreciation in Indonesia for three categories of natural capital: oil, forests, and soil.[9] The analysis found that accounting for natural capital depreciation could reduce GDP by 25 percent or more. A 2001 analysis in Sweden looked at a broader set of natural resource categories, including soil erosion, recreation values, metal ores, and water

quality.[10] The results found that accounting for these factors would reduce GDP in Sweden by about 1–2 percent for 1993 and 1997. The author noted that while the overall adjustment may seem relatively minor, the analysis did not consider some major environmental damages, such as climate change and loss of biodiversity. Also, looking at the effects of environmental degradation on the overall economy fails to recognize that some sectors are particularly affected, such as agriculture, forestry, and fisheries.

Another study estimated the value of changes in forest resources in India in 2003.[11] Based on timber and firewood market prices, the results indicated that while the overall physical stock of timber decreased, the value of timber resources actually increased due to higher prices. This illustrates the potential distortionary effect of looking at natural capital in monetary, rather than physical, terms. If we measure the value of natural capital at market prices, we can lose important information regarding the actual physical stock of those resources.

A significant effort to estimate Green GDP occurred in China in the early 2000s. In 2004 China's State Environmental Protection Agency (SEPA) announced that it would undertake a study to estimate the cost of various types of environmental damage. The initial findings released in 2006 indicated that environmental costs equalled about 3 percent of China's GDP. The report was widely criticized because it failed to include numerous categories of environmental damage, such as groundwater contamination. A 2007 report jointly produced by the World Bank and SEPA found that the health and non-health costs of air and water pollution alone were estimated at 5.8 percent of China's GDP.[12]

These results further suggested that in some Chinese provinces traditional GDP growth rates were being fully offset by environmental damages. This prompted some provincial leaders, who are largely evaluated based on provincial economic growth rates, to object to the entire project, and it was abandoned in 2007. But in 2015 China announced it was restarting its efforts with the implementation of "Green GDP 2.0," with pilot projects in certain regions. Most recently, a 2020 journal article estimated China's Green GDP in 2017 to be 4% less than traditional GDP when accounting for environmental pollution and resource depletion.[13]

A 2019 analysis calculated Green GDP for 44 countries, making adjustments for carbon emissions, waste generation, and natural resource depletion. The study found that Green GDP was lower than standard GDP in all cases, by amounts varying from less than 1% to as much as 10%. Countries with the highest environmental impacts included China (5.0%), Chile (8.9%), Norway (6.6%), Mexico (4.3%), and Australia (3.0%). Some countries, including Switzerland, Japan, Germany, and France had Green GDP adjustments of less than 0.5%.

We should note, however, that this version of Green GDP was based on using the market price of carbon emissions, during a period when this market price was generally low (represented by the European Union carbon trading system, discussed further in Chapter 13), and was considered by many analysts as a drastic underestimate of the true damages from carbon emissions. In this study developing countries tended to look worse than developed countries, based on often high rates of resource depletion. But applying a higher carbon price would give a greater weight to the significantly higher carbon emissions of most developed countries. .[14]

The limited experience with attempts to estimate Green GDP reveals three important points:

1. **Natural capital depreciation and environmental damages can amount to a significant portion of GDP**. Green GDP can be significantly lower than GDP, by perhaps 10 percent or more in some countries, particularly developing countries.
2. **Measuring the growth of GDP to illustrate changes in social welfare may not produce accurate results**. Based on GDP growth alone, China is commonly touted as

an economic development success story. But annual GDP growth in China appears to be largely or fully offset by environmental damages.

3. **Monetization of natural capital needs to be approached carefully**. As the example from India indicates, monetary estimates of natural capital, based on market prices, can fail to detect trends in physical stocks. As discussed in the SEEA, it is the physical stocks of natural resources that we are ultimately interested in measuring and tracking. Similarly, measurement of carbon emissions in monetary terms depends heavily on the carbon price chosen, and may underestimate actual climate damages.

10.3 Adjusted Net Saving

In addition to GDP, traditional national accounting methods also estimate saving and investment rates. Starting with gross savings, including savings by governments, businesses, and individuals, **net domestic saving** is obtained after subtracting for fixed capital depreciation. Net domestic saving can therefore be positive or negative. For example, from 2008 to 2011 net saving in the United States was negative, before turning positive in 2012.

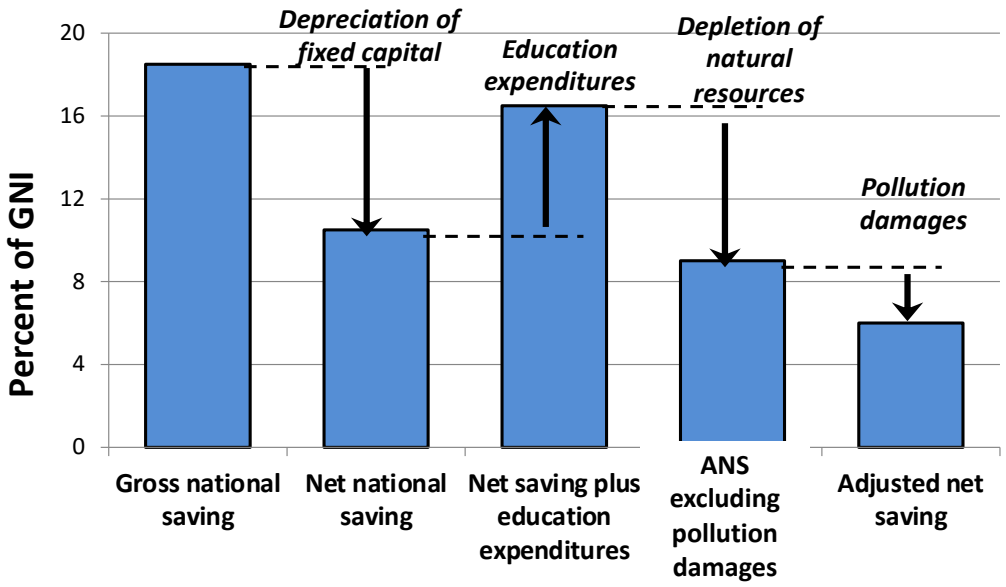
We can propose that how a country manages its natural resources and environmental quality also provides information about whether it is saving for the future or causing depletion that may make future generations worse off. As with the calculation of Green GDP, we can adjust net domestic saving to incorporate a country's management of its natural resources. The World Bank has developed such a measure, called **adjusted net saving (ANS)**.[15] Unlike standard measures of national saving, ANS:

> takes the broader view that natural and human capital are assets upon which the productivity and therefore the well-being of a nation rest. Since depletion of a non-renewable resource (or over-exploitation of a renewable one) decreases the value of that resource stock as an asset, such activity represents a *dis*investment in future productivity and well-being.[16]

net domestic saving a national accounting measure equal to gross domestic saving less manufactured capital depreciation.
adjusted net saving (ANS) a national accounting measure developed by the World Bank which aims to measure how much a country is actually saving for its future.

Like Green GDP, ANS adjusts a traditional national accounting measure to account for environmental damages. ANS is normally calculated as a percentage of national income, although it can also be expressed in monetary units. The calculation of ANS is summarized in Figure 10.1. ANS is obtained using the following steps:

Figure 10.1 Calculation of Adjusted Net Saving



Source: World Bank, n.d.
Note: GNI = gross national income.

- **Start with gross national saving and deduct the depreciation of fixed capital to obtain net national saving**.
- **Add education expenditures**. Unlike standard measures, ANS considers expenditures on education to be investments in the future of a society.[17]
- **Adjust for natural resources depletion**. This adjustment considers three categories of natural resources: energy resources, minerals, and forests. For energy resources, a deduction is made for the depletion of fossil fuels based on market prices. A deduction is made for the extraction of mineral resources, including copper, gold, lead, nickel, phosphate, and several other resources, again based on market prices. Unsustainable depletion of a country's forest resources is considered a disinvestment in the future. As forests are renewable resources, it is possible that a country could actually increase its forest resources if the growth of new forests exceeds harvesting.
- **Adjust for pollution damages**. Two pollutants are considered in this adjustment: carbon dioxide and particulate matter. Carbon dioxide emissions represent a disinvestment in a country's future as they contribute to damage from climate change. A country's annual emissions are multiplied by an assumed damage of $30 per ton of carbon dioxide.[18] Local air pollution damages from particulate matter are calculated based on lost future worker productivity due to death and illness.

The World Bank has calculated ANS rates for most countries of the world, with selected results presented in Table 10.1. The first column presents net national saving plus education expenditures, as a percent of national income. The remaining columns present the various environmental adjustments, with the last column showing ANS. For most countries, the environmental adjustments are relatively minor. For example, the ANS rates of Germany and the United States are primarily a result of their respective net national saving rates and

education expenditures. But the environmental adjustments can be quite significant in some countries.

We see in Table 10.1 that forest depletion is particularly significant as a percent of national income in Ethiopia and Uganda. Mineral depletion is highest in Chile and Uzbekistan, while energy depletion is highest in Russia and Saudi Arabia. Pollution damage from carbon and particulate matter is highest in India, Russia, and Uzbekistan.

Note that Uganda starts off with a positive national saving rate based on net savings plus education, but it ends up with a negative ANS after the environmental adjustments. About 30 countries have a negative ANS, most of them African countries. On average, ANS rates are highest in middle-income countries such as China and India, which helps explain why these countries have generally been growing faster in recent years than high-income countries. But note that their high ANS is based on a high basic savings rate; they have significant environmental adjustments in the range of 4-5% of GDP. Low-income countries have the lowest average ANS rates, suggesting that low financial saving rates and natural capital degradation are undermining future well-being in these countries.

Table 10.1 Adjusted Net Saving (ANS) Rates, Selected Countries, Percent of Gross National Income, 2018

Country	NNS + Education	Forest Depletion	Mineral Depletion	Energy Depletion	Carbon Damage	Particulate Matter Damage	ANS
Brazil	7.02	−0.14	−0.75	−1.72	−0.94	−0.16	3.31
Chile	8.92	0.00	−7.19	−0.01	−1.08	−0.11	0.53
China	25.03	0.00	−0.24	−0.71	−2.66	−0.29	21.13
Ethiopia	15.03	−5.20	−0.28	−0.00	−0.74	−0.44	8.37
Germany	15.17	0.00	0.00	−0.03	−0.63	−0.08	14.44
India	22.97	−0.12	−0.31	−0.58	−3.51	−0.80	17.66
Nigeria	8.35	−0.93	−0.01	−4.54	−1.10	−1.72	0.05
Russia	20.82	0.00	−0.55	−8.02	−3.81	−0.21	8.23
Saudi Arabia	29.20	0.00	−0.05	−9.28	−2.54	−0.16	17.16
Uganda	3.56	−7.47	−0.12	0.00	−0.71	−0.67	-5.41
United States	6.96	0.00	−0.05	−0.32	−0.83	−0.11	5.64
Uzbekistan	45.05	0.00	−5.03	−7.25	−5.62	−0.41	26.74

Source: World Bank, World Development Indicators database.

10.4 The Genuine Progress Indicator

Green GDP and ANS adjust traditional national accounting measures to account for natural capital depreciation and environmental damage. But neither of these alternatives purport to measure overall social welfare. Another approach to greening the national accounts is to attempt to create a measure of social welfare basically starting from scratch, including both social and environmental factors. Perhaps the most ambitious attempt to date to design a replacement to GDP is the **genuine progress indicator (GPI)**.[19]

genuine progress indicator (GPI) a national accounting measure that includes the monetary value of goods and services that contribute to well-being, such as volunteer work and higher education, and deducts impacts that detract from well-being, such as the loss of leisure time, pollution, and commuting.

One critique of GDP is that it includes all economic activity as a positive contribution to welfare. For example, all expenditures by the U.S. government Superfund for cleaning up toxic waste sites are contributions to GDP. The medical costs of treating diseases caused by air or water pollution are similarly added to GDP. By this logic, the more pollution damage and resulting cleanup expense a country makes, the better off it is. Clearly this is irrational. In contrast, the GPI differentiates

> between economic activity that diminishes both natural and social capital and activity that enhances such capital. [The GPI is] designed to measure sustainable economic welfare rather than economic activity alone. In particular, if GPI is stable or increasing in a given year the implication is that stocks of natural and social capital on which all goods and services flows depend will be at least as great for the next generation while if GPI is falling it implies that the economic system is eroding those stocks and limiting the next generation's prospects.[20]

Like the previous measures discussed in this chapter, the GPI is measured in monetary units. The starting point of the GPI is personal consumption, based on the rationale that consumption directly contributes to current welfare. The GPI then adds to personal consumption several goods and services that are considered to increase social welfare, some of which are not counted in GDP. The next step in calculating GPI is to deduct factors that are considered to decrease social welfare. Some of these deductions account for defensive expenditures—these are expenses associated with cleaning up pollution or attempting to repair or compensate for other environmental or social damage. In standard accounting, such defensive expenditures simply add to GDP.

The various steps in calculating the GPI, based on an analysis of the United States, are:[21]

- **Start with personal consumption adjusted by income inequality**. Personal consumption is adjusted to reflect the degree of income inequality in a society.
- **Add in the value of household labor, parenting, higher education, and volunteer work**. GDP includes only paid household and parenting work, such as house-cleaning and daycare services. The GPI estimates the market value of unpaid household labor and parenting.
- **Add in the social value of education**. The education component of the GPI reflects the external benefit society receives from well-educated citizens ($16,000 annually for each educated individual in the United States according to one estimate).

- **Add in the value of volunteer work**. The value of volunteer work hours is estimated using a market wage rate.
- **Add the net benefits from transportation and consumer durables**. An estimate is included for the value people derive from using highways and streets. The annual benefits consumers obtain from long-lasting goods, such as motor vehicles, appliances, and furniture, are also positive contributions to the GPI.
- **Subtract the cost of crime and underemployment**. The cost of crime includes the costs of prisons and defensive expenditures such as buying locks and alarms. Underemployed people include those who have become discouraged and given up looking for a job, people working part-time who would prefer a full-time job, and people who are willing but unable to work because of circumstances such as an inability to afford child care.
- **Subtract the loss of leisure time**. GDP may increase simply because people work longer hours. While the loss of leisure time is not considered in GDP, a deduction is included in the GPI if people are losing leisure time.
- **Subtract the costs of pollution (air**, **water**, **and noise) and environmental defensive expenditures**. Relying on studies using the valuation methodologies discussed in Chapter 6, the GPI estimates the economic damage from each type of pollution. Also, the cost of such products as air filters and water purification systems do not increase welfare but simply serve to compensate for existing pollution.
- **Subtract the value of lost wetlands**, **farmlands**, **and forests**. The GPI subtracts for losses of natural capital, including reductions in ecosystem services, lost recreation opportunities, and declining nonuse values.
- **Subtract the costs of depleting nonrenewable energy sources**. While GDP counts the market value of extracted nonrenewable energy sources as positive contributions, it fails to consider that a diminishing stock of resources imposes a cost on future generations. The GPI attempts to estimate this implied cost.
- **Subtract the damages from carbon dioxide emissions and ozone depletion**. As we will discuss in Chapter 12, numerous economists have attempted to estimate the damage associated with carbon emissions. Even though production of CFCs in the United States has been virtually phased out as a result of the 1987 Montreal Protocol, ozone damage continues as a result of past emissions.

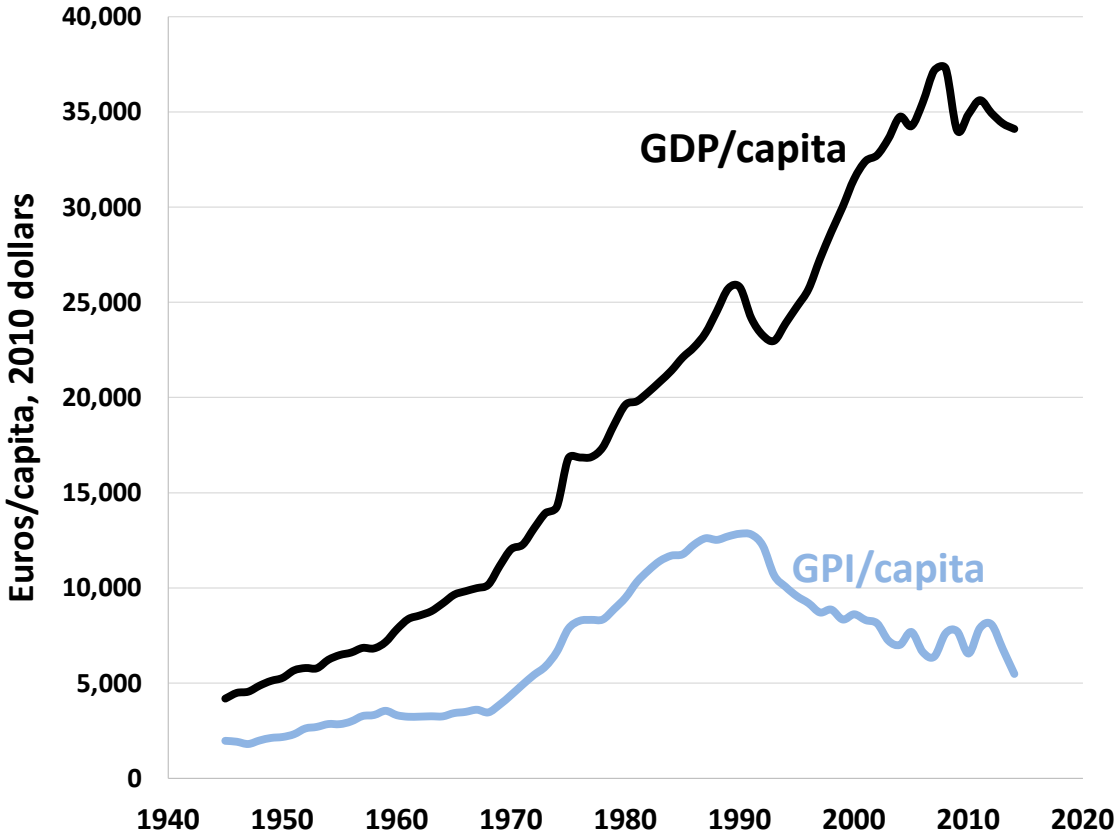
As we might expect with all these adjustments, the GPI can differ significantly from GDP in magnitude and trends. A 2013 paper summarizes the estimates of GPI for 17 countries, focusing on how a country's GPI over time relates to its GDP.[22] For several developed countries, including Germany, Sweden, and the United States, GDP per capita and GPI per capita followed similar trends from the 1950s to the 1970s, after which GDP per capita continues to increase but GPI per capita levels off or decreases.

We can see an especially dramatic example of this divergence between GDP and the GPI in Figure 10.2, showing data for Finland from 1945 to 2014. Up until around 1990 GDP per capita and GPI per capita both generally increased, although GPI per capita increased at a lower rate. But from 1990 to 2014 Finland's GDP per capita increased by more than 30% while its GPI per capita decreased by nearly 60%. This decline is a result of increasing long-term environmental damage.

Not all developed countries have followed the same pattern. For example, in the United Kingdom GDP per capita has increased rather steadily over time while GPI per capita peaked in the mid-1970s, significantly declined for about 15 years (largely as a result of a reduction in social programs), and then began to rise even more rapidly than GDP per capita in the 1990s, with environmental impact declining as the UK shifted away from coal as an energy source. In

Japan, GDP per capita and GPI per capita have increased almost in tandem, as a result of pollution reductions and a decreased reliance on domestic natural resources.[23] A 2019 analysis found that GDP and GPI both increased steadily in Australia over the last several decades, but with GDP growing about twice as rapidly.[24]

Figure 10.2 Comparison of GDP per Capita and GPI per Capita, Finland, 1945–2014



Source: Hoffrén, 2011; https://stats.unctad.org/Dgff2016/partnership/goal17/target_17_19.html.
Note: GPI = genuine progress indicator, GDP = gross domestic product.

Developing countries show varied patterns of GDP and GPI growth. China's rapid economic development in the 1990s was matched by a comparable increase in GPI per capita. But since the late 1990s China's GDP per capita has continued to increase while its GPI per capita has leveled off. This can be attributed to a significant increase in external costs, rising economic inequality, and nonrenewable resource depletion. India has experienced a rapidly increasing GDP per capita, and GPI per capita has also steadily increased for all years with available data, although at a lower rate.

Based on the results from 17 countries, there is a positive correlation between GDP and GPI per capita up to about $7,000. Further income gains boost GDP but are correlated with a decreasing GPI per capita. Based on this result, the authors recommend a more equitable distribution of global resources, allowing poorer countries to develop economically and increase genuine progress. In developed nations they recommend reducing environmental costs and exploring welfare-enhancing reductions in GDP (for example, reducing wasteful consumption patterns or increasing leisure time). They conclude that:

> If we hope to achieve a sustainable and desirable future, we need to rapidly shift our policy focus away from maximizing production and consumption (GDP) and towards improving

genuine human well-being (GPI or something similar). This is a shift that will require far more attention to be paid to environmental protection, full employment, social equity, better product quality and durability, and greater resource use efficiency.[25]

The 2019 analysis of Australia mentioned above also decomposed the GPI into its economic, social, and environmental components.[26] It found that while the economic component has steadily increased, the social component has remained steady while the environmental component shows increasing damages. This demonstrates a potential problem with any index that reduces all economic, social, and environmental factors into a single value. The overall index may fail to reflect important positive and negative trends that offset each other. Thus, we should always refer to disaggregated results to achieve a more complete understanding of the changes occurring in a society and the specific policies that may be necessary to increase social welfare.

A 2020 journal article assessed the research on the GPI over the last few decades and argues that it "is the only beyond-GDP indicator that tracks overall well-being by adjusting for several negative externalities of the economic process" and that because it is measured in monetary units "is uniquely suited to evaluate the welfare impact of policy proposals. But the article also notes that studies estimating the GPI have not used a consistent methodology, often due to data limitations, and that a "GPI 2.0" is needed. Ideally this revised indicator would be sponsored by a high-level international institution to allow for "adoption, local adaptation, frequent releases and tracking by governments or independent research organizations."[27]

While the GPI has several strengths, it requires converting various environmental factors into a single metric – dollars – which necessitates numerous subjective assumptions about valuation. We may question whether disparate environmental resources and natural capital can be directly compared using a common unit. Other approaches to measuring national well-being have been developed that avoid the use of a monetary metric but still consider different aspects of quality of life. One recent approach, the Happy Planet Index, incorporates data on life expectancy, inequality, ecological impacts, and self-reported happiness, as discussed in Box 10.1. We consider another non-monetary well-being measure, the Better Life Index, in the following section.

Box 10.1 The Happy Planet Index

The Happy Planet Index (HPI) is perhaps the most novel attempt to devise an entirely new approach to measuring national welfare in the context of environmental sustainability. The HPI, created by the British New Economics Foundation (NEF), asserts that the goal of society is to enable long and happy lives for all its members in an environmentally sustainable manner.[28] The HPI consists of four variables to reflect these concepts:

1. *Average life expectancy*: This measures whether a society's members lead long lives.
2. *Average subjective well-being*: This measures whether a society's members lead happy lives. The data are obtained from surveys that ask people how satisfied they are with their lives.
3. *Equality of outcomes:* This measures the distribution of well-being and life expectancy across a given society.
4. *Ecological footprint*: This measures a society's overall ecological impact (as discussed in Chapter 9).

The first three terms define the numerator of the HPI, while the ecological footprint is the denominator. The HPI is thus calculated as:

*HPI = Well-Being * Life Expectancy * Equality / Ecological Footprint*

The HPI has been calculated for 140 countries. The countries with the highest HPI scores are those whose citizens tend to be rather happy and long-lived but have a relatively modest ecological footprint, including Costa Rica, Vietnam, Panama, and Thailand. One interesting aspect of the HPI is that a country's HPI ranking tends to be unrelated to its gross domestic product (GDP). The United States ranks 108th, only slightly better than Afghanistan (110th) but lower than Ghana (104th), due to its large ecological footprint.

The interpretation and policy implications of the HPI are unclear. For example, India and Iraq have a higher HPI score than Canada or Australia. Does this imply that India and Iraq are more desirable to live in, or more ecologically sustainable, than Canada or Australia? Probably not. Another issue is whether a country's policies can affect happiness levels, which may be more a construction of inherent social and cultural factors rather than policy choices. But despite its limitations, the HPI has received attention as an alternative or supplement to GDP, especially in Europe. A 2007 report to the European Parliament cites several strengths of the HPI, including:[29]

- It considers the ends of economic activity, namely, happiness and life expectancy
- The innovative way that it combines well-being and environmental factors
- Its calculations are easy to understand
- Data can be easily compared across countries

While the HPI is unlikely to become a widespread alternative to GDP, it does provide information that is not currently captured in any other national accounting metric.

10.5 The Better Life Index

Well-being is a multidimensional concept. While material living conditions are important for well-being, so are environmental sustainability, civic engagement, work-life balance, and many other factors. Recognizing that no other indicator reflects all the different aspects of well-being, the Organization for Economic Cooperation and Development (OECD) launched the Better Life Initiative in 2011.[30] Every two to three years the project has presented updated data on the **Better Life Index (BLI),** an indicator comprised of 11 different dimensions.[31] The 2015 BLI report argues that:

> a better understanding of people's well-being is central to developing better policies for better lives. Well-being is multidimensional, covering aspects of life ranging from civic engagement to housing, from household income to work-life balance, and from skills to health status. A thorough assessment of whether life is getting better requires a wide range of metrics, captured on a human scale, and able to reflect the diverse experiences of people.[32]

Better Life Index (BLI) an index developed by the OECD to measure national welfare using 11 well-being dimensions.

The BLI's 11 dimensions are:

1. Income and Wealth
2. Work and Job Quality
3. Housing
4. Health
5. Work-Life Balance
6. Knowledge and Skills
7. Social Connections
8. Civic Engagement
9. Environmental Quality
10. Safety
11. Subjective Well-Being

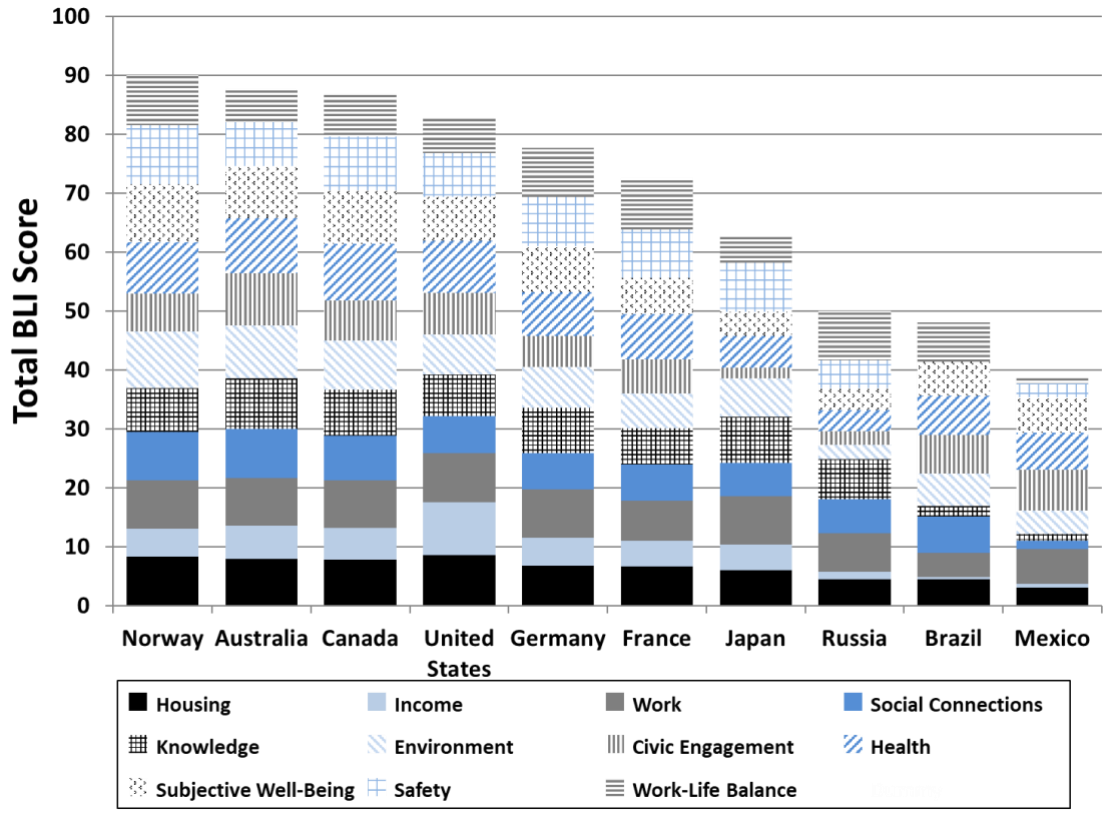
Each dimension is measured using two or more variables. For example, the civic engagement dimension is based on voter turnout rates and a survey that asks people how much of a say they think they have in government. The housing dimension is based on an affordability measure and data on the percent of people living in overcrowded conditions. The environmental quality dimension is also based on two variables: the share of the urban population with nearby access to a green space and the share of the total population exposed to particulate matter concentrations above the threshold set by the World Health organization.

The results are standardized across countries, resulting in a score from 0 to 10 for each dimension. While the BLI includes many components, it is designed to produce an overall well-being index. But how do we assign weight to the various components? One basic approach is to simply weigh each of the 11 dimensions equally. But it seems likely that some dimensions contribute to well-being more than others. The BLI report makes no specific recommendations on weighing the different dimensions. An interesting feature of the BLI is that a web site allows users to select their own weights for each of the dimensions.[33] The OECD has collected input from about 150,000 users around the world about their preferred weights for each dimension. The results indicate that the highest-rated dimensions vary considerably across countries. For

example, the highest-ranked dimensions are subjective well-being in the U.S., health in France, work-life balance in Australia, safety in Japan, and income in Afghanistan.

The BLI has been measured for the OECD member countries, as well as other countries, including Brazil, Mexico, Russia, and South Africa, with plans to expand it to other countries such as China and India. Based on equal weighing of each dimension, Figure 10.3 shows how selected countries rank. Norway, Australia, and Iceland are the top three countries. The United States ranks tenth among OECD nations, performing well in terms of housing and income but ranking lower in terms of work-life balance and social connections. As far as environmental rankings, the best performance is found in Norway, Iceland, and Sweden while the lowest performances among the countries evaluated include South Korea, Russia, and South Africa.

Figure 10.3 Better Life Index Values for Selected Countries



Source: OECD Better Life Index web site, http://www.oecdbetterlifeindex.org/.

One limitation of the BLI is the availability of data. Even for the OECD members, some results have to be estimated because of a lack of consistent data. Improving the standardization of data collection and reporting is one of the objectives of the Better Life Initiative.

While the main focus of BLI is not on environmental and natural resource issues, basing its environmental dimension on just two variables – urban green space accessibility and particulate matter levels – seems a particular deficiency. Perhaps most surprisingly, the BLI's environmental dimension doesn't include anything on carbon emissions, even though such data are widely available.

Despite these limitations, the BLI provides a comprehensive view of many factors that influence well-being. Income is not presented as the starting point but as one component of many. One of the criteria used to choose the BLI variables is policy relevance. Several of the dimensions, such as education, housing, and environmental quality, can be directly improved

with effective policies, although the linkage between other dimensions (such as subjective well-being) and policies needs further study.

The BLI is not the only composite index that has been developed. While academic researchers have developed other indices, at least one country, Bhutan, has created its own measure, **gross national happiness (GNH)**, which measures some of the same dimensions as BLI (see Box 10.2).

Box 10.2 Bhutan's Gross National Happiness

Perhaps no country has advocated the need to devise alternatives to the gross national product (GNP) as much as the small Himalayan country of Bhutan. In 1972, King H.M. Jigme Singye Wangchuck introduced the concept of **gross national happiness (GNH)** to provide an alternative development philosophy to simply maximizing economic growth. He sought to achieve progress toward GNH by focusing on four policy objectives: equitable economic development, environmental preservation, cultural resilience, and good governance.[34]

While initially it was just a guiding concept, in recent years the Centre for Bhutan Studies (CBS) has sought to operationalize GNH.[35] The Centre has defined GNH as encompassing nine domains:

- Psychological well-being
- Standard of living
- Good governance
- Health
- Education
- Community vitality
- Cultural diversity and resilience
- Time use
- Ecological diversity and resilience

In 2015 the Centre conducted an extensive survey of over 7,000 Bhutanese households to assess the country's GNH.[36] Each domain was addressed by asking several questions. For example, for the ecological domain respondents were asked questions such as how concerned they were about air pollution, water pollution, waste disposal, flooding, and soil erosion. Based on "sufficiency" thresholds set by the CBS, the responses determine whether each household is sufficient in each of the nine domains. The results indicate that 43.4 percent of Bhutanese households have sufficiency in at least six domains and are thus considered either "deeply" or "extensively" happy. This is an improvement over an earlier survey in 2010, when 40.9 percent were similarly happy. Bhutanese have the most sufficiency in health and then in ecology and community vitality. Sufficiency is greater in urban areas, among the young, and among those with a formal education.

Bhutan, unlike most other countries, appears to not only be implementing an alternative to GDP but also using these results to guide future policies in a democratic manner. Gross National Happiness seems to promote democracy in that it facilitates the process of citizens voicing their opinions on various dimensions of their lives to the Bhutanese government. The GNH survey and the index that the CBS constructs from it open a channel of communication between the government and society at large. People's voices on an array of domains reflected in the GNH index are the practical guiding forces for policy making in Bhutan.[37]

gross national happiness (GNH) the concept, originating in Bhutan, where a society and its policies should seek to improve the welfare of its citizens, as opposed to maximizing GDP.

10.6 Environmental Asset Accounts

An important issue to consider when evaluating any "green" national accounting approach is how its results can be used to assess the environmental sustainability of a society. As discussed in Chapter 9, we can define different levels of sustainability, which we identified as "weak" and "strong" sustainability. (Recall that these terms refer to different definitions, and do not imply that one is preferable to the other.) How well do the indicators introduced so far in this chapter reflect these ideas of sustainability?

Any index that monetizes various environmental factors and combines the results with traditional monetary aggregates, such as GDP, implicitly assumes a degree of substitutability among natural capital and economic production. For example, the GPI could remain constant if an increase in pollution damage is offset by an increase in personal consumption. For this reason the GPI and other aggregate indices like Green GDP and ANS can be considered appropriate metrics to address **weak sustainability** but not **strong sustainability**.[38]

weak sustainability the view that natural capital depletion is justified as long as it is compensated for with increases in human-made capital; assumes that human-made capital can substitute for most types of natural capital.
strong sustainability the view that natural and human-made capital are generally not substitutable and, therefore, natural capital levels should be maintained.

If we are interested instead in achieving strong sustainability, we need to concern ourselves with the preservation of natural capital. A further distinction emphasized by some analysts is between "strong sustainability" and "very strong sustainability." Strong sustainability seeks to maintain the overall level of natural capital but allows the substitutability of different types of natural capital, at least for noncritical resources. For example, clear-cutting a forest could be appropriately offset by improving the ecological health of a wetland. Very strong sustainability seeks to maintain the levels of specific types of natural capital, allowing for substitutability only within each category of natural capital. Taking this approach, clear-cutting a forest could only be offset by creating a forest of similar extent and ecological value elsewhere.

environmental asset accounts national accounts that track the level of natural resources and environmental impacts in specific categories, maintained in either physical or monetary units.
critical natural capital elements of natural capital for which there are no good human-made substitutes, such as basic water supplies and breathable air.

The indicators discussed so far in this chapter are not necessarily designed to provide information on stronger forms of sustainability. Still, a few of them do provide some insight into strong sustainability objectives. The environmental components of the GPI, for instance, provide information on natural capital depletion, although not the overall level of natural capital.

An alternative approach is to maintain national accounts that track the levels of different types of natural capital. The UN's System of Environmental-Economic Accounting (SEEA) framework provides guidance on the maintenance of **environmental asset accounts**, in both physical and monetary units. These accounts include various natural capital categories, such as timber resources, mineral resources, agricultural land, and groundwater. The accounts may have different degrees of aggregation. For example, the account for mineral resources might include a separate account for each mineral or be disaggregated even further based on mineral

quality, degree of accessibility, or location. The units would vary for different accounts based on the resource in question. So mineral accounts might be measured in tons, forest accounts in hectares of forest cover or board-feet of timber, groundwater accounts in acre-feet of water, and so on.

The two main strengths of measuring environmental asset accounts in physical units are:

1. They provide a detailed picture of a country's natural capital levels and trends over time. A particular focus can be on ensuring that levels of **critical natural capital** are maintained.
2. They provide a means for assessing very strong sustainability. Since each category of natural capital is quantified in a separate account, policy makers can determine whether the levels of each are being maintained.

Environmental asset accounts can also be expressed in monetary units. In most cases, this simply involves multiplying a physical unit estimate by the market price per unit. For example, if a society has a standing timber stock of 500,000 board-feet of lumber and the market price is $5.00 per board-foot, then the asset value of their timber is $2.5 million. Environmental asset accounts in monetary terms offer the benefit of comparability, both among different types of natural capital and to traditional economic aggregates such as GDP.

Unlike accounts in physical units, environmental asset accounts in monetary units can be used to give an overall measure of sustainability because gains and losses in different categories can be compared. Accounts in monetary units could be used to assess whether a society is achieving strong sustainability by adding up the value of different categories of natural capital.

This is illustrated in Figure 10.6. For simplicity, assume there are only two natural resource assets in a society: timber and agricultural land. In Year 1 the society has a stock of 500,000 board-feet of timber and 6,000 hectares of agricultural land. At the market prices indicated in Figure 10.6, the total value of the environmental assets in the society is $8.5 million in Year 1. In the next year, the society harvests some of its timber stock but brings some additional land into agricultural production, as shown in the figure. If we kept asset accounts only in physical units such as board-feet of timber and hectares of land, we would not be able to assess whether this society has maintained its overall level of natural capital (i.e., strong sustainability). But Figure 10.6 shows that the monetary value of its natural assets has actually increased in Year 2 by $500,000, indicating that the overall value of natural capital is being sustained.

Comparing different assets in monetary units has both advantages and disadvantages. Suppose that the price of timber increased in Year 2 to $7.00 per board-foot. Even though the stock of timber was reduced by 100,000 board-feet, the value of the stock in Year 2 would be $2.8 million (400,000 board feet × $7.00). Even though the physical stock of timber was reduced, its market value would increase relative to Year 1. If we looked only at the monetary units, we could wrongly conclude that the society's stock of timber had increased due to factors such as increased planting or conservation. This again demonstrates that we need to be wary of the effect of changing prices on the value of a society's natural assets. This is particularly problematic for mineral and oil assets because the price of these commodities can fluctuate considerably.

Another problem with the monetary value approach is that the estimates in Figure 10.6 do not consider the loss of ecosystem services from harvesting timber. In addition to the loss of timber, there may have been a loss of wildlife habitat, erosion control, carbon storage, and other ecological services. Ideally, assessing strong sustainability by aggregating various asset accounts should consider nonmarket benefits as well as market values. But estimating nonmarket values can be problematic, as discussed in Chapter 6. Attempts to assess strong

sustainability based on monetary values are therefore likely to be incomplete or dependent on numerous controversial assumptions.

To assess "very strong" sustainability using Figure 10.6, we would need to look at the change in physical units over time. As this society's physical stock of forest resources is declining, we would conclude that it is not achieving very strong sustainability for this resource.

Figure 10.4 Example of Environmental Asset Accounts

	Year 1		Year 2
Forest Resources		Decrease in Capital Stock	
Board-Feet of Timber	500,000		400,000
Price per Board-Foot	$5.00		$5.00
Timber Asset Value	$2,500,000		$2,000,000
Agricultural Land Resources		Increase in Capital Stock	
Hectares of Land	6,000		7,000
Price per Hectare	$1,000		$1,000
Agricultural Asset Value	$6,000,000		$7,000,000
Total Environmental Asset Value	$8,500,000		$9,000,000

Several countries have started to maintain environmental asset accounts. The United Kingdom's Office for National Statistics provides estimates for several environmental variables including energy consumption, air emissions, oil and gas resources, materials use, and environmental taxes.[39] In 2019 the UK produced an estimate of the asset value of the nation's natural capital, as shown in Table 10.1. These natural assets produce a flow of ecosystem services that benefit humans, which are divided into three categories:

1. *Provisioning services:* materials and services that are provided by nature and used to produce products consumed by humans.
2. *Regulating services:* natural processes that benefit humans such as air purification, carbon sequestration, urban cooling and noise mitigation from vegetation, and flood and erosion control (i.e., indirect use benefits).
3. *Cultural services:* recreation benefits and aesthetic benefits, including the benefits of urban green spaces reflected in house prices using hedonic valuation.

Table 10.1 Economic Asset Value of Ecosystem Services in the United Kingdom

Type of Ecosystem Service	Asset Value (billion 2018 US$)
Provisioning Services	
Agricultural production	165
Water supplies	96
Fossil fuels	77
Renewable energy	12
Timber	12
Fisheries	10
Minerals	8
Regulating Services	
Carbon sequestration	136
Air purification	56
Urban cooling	17
Noise mitigation	1
Cultural Services	
Recreation	545
Green space	12

Source: UK Office for National Statistics, UK Natural Capital Accounts: 2019, https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019.
Note: Conversion from UK pounds to US dollars made by authors using 2020 exchange rates.

The total asset value of the UK's natural capital is estimated to be over $1 trillion, although this estimate excludes some values such as the benefits of biodiversity and nonuse values. One surprising result in Table 10.1 is that natural recreation is estimated to be more valuable that the provisioning services of nature. (While expenditures on recreational goods such as camping and fishing equipment do appear in traditional national accounting, the welfare benefits of recreation are not counted. As discussed in Chapter 6, we can use travel cost models to estimate these recreation benefits.)

Other countries that have prepared environmental asset accounts include Australia, Canada, Denmark, and Norway. Among the environmental categories included in these countries' accounts are water supplies, wastewater management, material flows, waste generation, and forest cover. Sweden has an especially extensive system of environmental accounts – see Box 10.3 for details.

Box 10.3 Environmental Accounts in Sweden

In 2003 the Swedish government adopted sustainable development as an overall objective of government policy. In order to monitor progress toward sustainability objectives, an extensive database of environmental indicators is published on the Internet by Statistics Sweden (see "Web Sites" at the end of the chapter). The government recognizes that

> no generally accepted set of indicators for sustainable development has been worked up yet. . . . [But] Sweden is engaged in an ongoing effort to improve its environmental accounting, monitoring of environmental objectives, public health, green key ratios and index for development in the segregated districts of its metropolitan areas.[40]

Currently, categories of environmental indicators include:

- Material flow statistics
- Energy accounts
- Environmental goods and services
- Environmental impacts from households
- Environmentally related taxes and subsidies
- Emissions to air
- Chemical indicators

In 2017 Sweden introduced a system of land accounts to track ecosystem services such as carbon sequestration and wildlife habitat. While Statistics Sweden notes that some types of natural capital can be valued using resource rent estimates or nonmarket valuation, they propose tracking biodiversity using data on species populations and habitat areas.[41]

A review of Sweden's environmental account indicates both positive trends and areas where further progress is needed. Between 2008 and 2018 national emissions of carbon dioxide declined by 16% and emissions of sulfur dioxide fell by 13%. On the negative side, during this same period the use of hazardous chemicals increased by 7% and the consumption of raw materials rose by 17%.

10.7 Evaluating Alternative Indicators

As we have seen in this chapter, numerous proposals have been made to address the deficiencies of traditional national accounting approaches in order to account for the environment or to better reflect social welfare, the ultimate goal of economic analysis. Most of these indicators provide some guidance on sustainability objectives as well. Their implementation has been limited, however, and no consensus exists on which indicators are best.

> The current state of environmental information around the world is, by most accounts, unacceptable. Environmental statistics are scattered among too many organizations. They are not coherent with one another, let alone with other types of statistics. They are incomplete and not consistent over time. This situation greatly restricts national and international capacity to develop and monitor progress toward environmental policy goals.[42]

While the SEEA provides guidance on various ways to approach environmental accounting, it indicates no particular preference for one approach over another. Instead it provides a menu of options from which a given country can choose to implement some but not

others. We remain a long way away from a universally accepted approach to environmental accounting that is adopted by the majority of countries.

Recognizing the limitations of GDP and the need to develop indicators that incorporate social and environmental factors, in 2008 French president Nicolas Sarkozy created the Commission on the Measurement of Economic Performance and Social Progress. The commission was chaired by Nobel Prize–winning economist Joseph Stiglitz and the chair adviser was another Nobel laureate economist, Amartya Sen. Other members of the commission included numerous prominent economists. The goals of the commission were

> to identify the limits of GDP as an indicator of economic performance and social progress, including the problems with its measurement; to consider what additional information might be required for the production of more relevant indicators of social progress; to assess the feasibility of alternative measurement tools, and to discuss how to present the statistical information in an appropriate way.[43]

In September 2009 the commission produced a nearly 300-page report. The commission noted that policies promoting economic growth, as measured by GDP, may be unsuccessful in increasing well-being because they fail to account for other factors, such as environmental degradation:

> traffic jams may increase GDP as a result of the increased use of gasoline, but obviously not the quality of life. Moreover, if citizens are concerned about the quality of air, and air pollution is increasing, then statistical measures which ignore air pollution will provide an inaccurate estimate of what is happening to citizens' well-being. Or a tendency to measure gradual change may be inadequate to capture risks of abrupt alterations in the environment such as climate change.[44]

The commission concluded that it is necessary to shift from an emphasis on measuring economic production to measuring well-being. It also distinguished between current well-being and sustainability. Whether current well-being can be sustained depends on the levels of capital (natural, physical, human, and social) passed on to future generations.

The commission hoped that its report would spur additional research on the topic of alternative indicators and encourage countries to investigate which indicators could provide the best information for measuring well-being and sustainability. Several countries have taken action.[45] In the UK, the Office of National Statistics was directed to conduct a survey asking people which indicators they thought should be used to measure well-being. In Germany a commission on "Growth, Prosperity, and Quality of Life" was established. Other countries attempting to reform national accounting include Canada, South Korea, Italy, and Australia. The United States established the "State of the USA Project" in 2010, whose goal was to develop a Key National Indicator System that would provide data on numerous variables "in a simple and straightforward way so that interested people can assess whether progress is being made, where it is being made, by whom and compared to what."[46] (The project is currently inactive as it is no longer funded.)

Another attempt to respond to the commission's recommendations has been the Better Life Index discussed previously. The 2011 OECD report on the Better Life Index notes that:

> The work of the Commission has been critical in giving impetus to our path-finding work on measuring progress and to a range of initiatives around the world aimed at developing better indicators of peoples' lives.[47]

The Commission's work was also an important motivation for the BRAINPOoL (Bringing Alternative Indicators into Policy) project funded by the European Union. BRAINPOoL evaluated a staggering 95 different "Beyond GDP" indicators that have been developed. Completed in 2014, the project recommended 18 indicators for further exploration, including several of the indicators we've discussed: the Better Life Index, the Genuine Progress Indicator, and Gross National Happiness. The project also identified several barriers to wider policy use of alternative indicators, including institutional resistance to change, the lack of a consensus around any single indicator, and the need for a compelling political narrative of the importance of non-GDP indicators.[48]

With no consensus regarding a single "best" alternative indicator, the research agenda appears focused on pursuing a range of indicators that are relevant to measuring well-being and sustainability. Some environmental variables that current or future indicators should consider are rather obvious, such as measuring local air pollution levels, water quality, and carbon emissions. But the measurement of a broader range of environmental impacts, such as biodiversity and ecosystem services, requires further research.[49] It also remains to be seen whether each country will rely on its own chosen set of indicators or whether a particular menu of indicators will become universally accepted. Another important objective is to develop consistent methods for measuring different variables, such as measuring carbon emissions and administering surveys to collect subjective data.

Improvement of data collection and international agreement on relevant indices may lead to better measures of "green" national income accounts and better ways to measure progress in terms of well-being and sustainability rather than simply marketed economic production. But in addition to technical concerns like collecting consistent data and making valid assumptions, any alternative indicator faces substantial resistance. As is often the case, the main barriers limiting progress toward a more sustainable economy are not being raised by economists, but by political, social, and commercial forces. A 2018 article notes:

> Generally speaking, substituting alternative welfare indicators for GDP creates resistance by those benefitting from GDP as lead indicator. First and foremost, this concerns politicians [who] might face a critical re-evaluation of their current performance or political legacy once another indicator is applied. A second, similar reason for politicians not to abandon GDP could be that a re-evaluation of their policies undermines their relative power position within the political system. … Alternative welfare indicators also face other challenges. Interest groups from polluting industries can be expected to oppose "green" indicators insofar as these might trigger stricter regulation of the dirty sectors of an economy in order to improve on the indicator's ecological dimension.[50]

Measuring well-being and sustainability is only a first step toward designing and implementing polices to promote social and environmental progress. The chapters that follow examine how we can use environmental and ecological economics to design better policies for a range of current environmental issues, including energy, climate change, population, agriculture, fisheries, forests, land, and water.

SUMMARY

Standard measures of national income such as gross domestic product (GDP) fail to capture important environmental and social factors. This can result in misleading measurements of national well-being that ignore important environmental problems and lead to misguided policy recommendations. A variety of approaches can be used to adjust existing national accounting measures or to provide alternatives.

Estimates of natural capital depreciation measure the depletion of natural resources such as oil, timber, minerals, and agricultural soils, in monetary units. Monetary estimates of these losses can be subtracted from the standard measures of national income and savings. An advantage of these measures is that they are compatible with existing national accounts. But a significant disadvantage is that they require all impacts to be converted to monetary values. Particularly for developing countries, results based on these approaches indicate a substantial impact of natural resource depletion and environmental degradation.

Various alternatives to GDP have attempted to incorporate environmental and social factors, including the Genuine Progress Indicator and Better Life Index. Results for the GPI suggest that a steadily increasing GDP is not necessarily correlated with increases in well-being, especially above moderate average income levels. Results for the BLI indicate that many other dimensions may be more important for well-being than income, such as health, education, and environmental quality.

Another approach is to maintain environmental asset accounts, tracking environmental indicators separately from GDP, either in monetary or physical units. Environmental asset accounts are particularly useful if one is interested in whether a society is achieving strong sustainability, focusing exclusively on natural capital.

Despite significant efforts to develop social and environmental accounting, no particular indicator, or even set of indicators, has yet to emerge as the preferred approach. Challenges that remain include developing consistent data collection methods and convincing politicians of the need for alternative indicators.

KEY TERMS AND CONCEPTS

adjusted net saving (ANS)
Better Life Index (BLI)
critical natural capital
environmental asset accounts
genuine progress indicator (GPI)
green GDP
gross domestic product (GDP)
Gross National Happiness (GNH)
gross national product (GNP)
net domestic product (NDP)
net domestic savings (NDS)
strong sustainability
System of Environmental and Economic Accounting (SEEA)
weak sustainability

Discussion Questions

1. What kinds of problems arise from the focus on standard GDP measures in discussing economic policy? How do these problems differ for highly industrialized countries like the United States and developing countries like Indonesia?
2. Which of the various alternative indicators presented in this chapter do you think are the most useful for guidance on economic and environmental policy?
3. What are some of the policy implications of using a revised measure that takes into account environmental and resource depreciation? How might the use of revised measures affect such policy areas as macroeconomic policy, trade policy, and resource pricing policy?

Exercise

1. Suppose you have been hired by the developing country of Equatoria to calculate its Green GDP. Assume for simplicity that only three adjustments need to be made to account for natural capital depreciation and pollution damages: timber capital, oil capital, and carbon dioxide damages. You have been given the following data:

Economic Data	
Gross domestic product:	$40 billion
Depreciation of manufactured capital:	$6 billion
Timber Data	
End-of-year timber stocks (board-feet):	2.0 billion
Start-of-year timber stocks (board-feet):	2.4 billion
End-of-year timber price ($/board-foot):	$6
Start-of-year timber price ($/board-foot):	$4
Oil Data	
End-of-year oil stocks (barrels):	500 million
Start-of-year oil stocks (barrels):	550 million
End-of-year oil price ($/barrel):	$60
Start-of-year oil price ($/barrel):	$50
Carbon Data	
CO_2 emissions (tons):	75 million
Damage per ton of CO_2 emissions:	$20

For timber and oil, you will need to calculate the value of depreciation, or appreciation, as the change in the total market value of the resource during the year, where total market value is

the physical quantity times the resource price. What is the Green GDP for Equatoria, also accounting for the depreciation of manufactured capital? Would you recommend that Equatoria use Green GDP to measure its progress toward sustainability objectives, or perhaps some other indicator discussed in the chapter? Would you make any other recommendations to policy makers in Equatoria?

REFERENCES

Bartelmus, Peter. 2015. "Do We Need Ecosystem Accounts?" *Ecological Economics*, *118*: 292–298.

Berik, Gunseli. 2020. "Measuring What Matters and Guiding Policy: An Evaluation of the Genuine Progress Indicator." *International Labour Review*, 159(1): 71-94.

Bolt, Katharine, Mampite Matete, and Michael Clemens. 2002. *Manual for Calculating Adjusted Net Savings*. Environment Department, World Bank.

Braun, Alejandro Adler. 2009. "Gross National Happiness in Bhutan: A Living Example of an Alternative Approach to Progress." Wharton International Research Experience, September 24.

Bringing Alternative Indicators into Policy (BRAINPOoL). 2014. "Beyond GDP: From Measurement to Politics and Policy." Briefing Paper for Workshops and Final Conference, March 24.

Centre for Bhutan Studies (CBS). 2011. "2010 Survey Results." www.grossnationalhappiness.com.

Centre for Bhutan Studies (CBS). 2015. "Provisional Findings of the 2015 Gross National Happiness Survey." Thimphu, Bhutan, November. www.grossnationalhappiness.com.

Dietz, Simon, and Eric Neumayer. 2006. "Weak and Strong Sustainability in the SEEA: Concepts and Measurement." *Ecological Economics*, *61*(*4*): 617–626.

Fioramonti, Lorenzo. 2013. *Gross Domestic Problem: The Politics Behind the World's Most Powerful Number.* London, U.K.: Zed Books.

Goossens, Yanne. 2007. "Alternative Progress Indicators to Gross Domestic Product (GDP) as a Means Towards Sustainable Development.*" Policy Department, Economic and Scientific Policy, European Parliament, Report IP/A/ENVI/ST/2007*–10.

Gundimeda, Haripriya, Pavan Sukhdev, Rajiv K. Sinha, and Sanjeev Sanyal. 2007. "Natural Resource Accounting for Indian States—Illustrating the Case of Forest Resources." *Ecological Economics*, *61*(*4*): 635–649.

Hecht, Joy E. 2007. "National Environmental Accounting: A Practical Introduction." *International Review of Environmental and Resource Economics*, *1*(*1*): 3–66.

Hoffrén, J. 2011. "Future Trends of Genuine Welfare in Finland," in Trends and Future of Sustainable Development (H. Lakkala and J. Vehmas, eds.). Proceedings of the Conference Trends and Future of Sustainable Development. Tampere, Finland, June 9-10, 2011.

Kenny, Daniel C., Robert Costanza, Tom Dowsley, Nichelle Jackson, Jairus Josol, Ida Kubiszewski, Harkiran Narulla, Saioa Sese, Anna Sutanto, and Jonathan Thompson. 2019. "Australia's Genuine Progress Indicator Revisited (1962–2013)." *Ecological Economics*, 158: 1-10.

Kubiszewski, Ida, Robert Costanza, Carol Franco, Philip Lawn, John Talberth, Tim Jackson, and Camille Aylmer. 2013. "Beyond GDP: Measuring and Achieving Global Genuine Progress." *Ecological Economics*, *93*: 57–68.

Ministry of Sustainable Development (Sweden). 2006. "Strategic Challenges: A Further Elaboration of the Swedish Strategy for Sustainable Development." Government Communication 2005–2006: 126.

New Economics Foundation (NEF). 2016. "The Happy Planet Index 2016: A Global Index of Sustainable Wellbeing." www.happyplanetindex.org/.

Organization for Economic Cooperation and Development (OECD). 2011. "How's Life? Measuring Well-Being." Paris.

Organization for Economic Cooperation and Development (OECD). 2015. "How's Life? 2015: Measuring Well-Being." Paris.

Press, Eyal. 2011. "The Sarkozy-Stiglitz Commission's Quest to Get Beyond GDP." *The Nation*, May 2.

Repetto, Robert, W. Magrath, M. Wells, C. Beer, and F. Rossini. 1989. *Wasting Assets: Natural Resources in the National Income Accounts*. Washington, DC: World Resources Institute.

Skånberg, Kristian. 2001. "Constructing a Partially Environmentally Adjusted Net Domestic Product for Sweden 1993 and 1997." National Institute of Economic Research, Stockholm, Sweden.

Smith, Robert. 2007. "Development of the SEEA 2003 and Its Implementation," *Ecological Economics*, *61*(*4*): 592–599.

Statistics Sweden. 2017. Land Accounts for Ecosystem Services. Environmental Accounts MIR 2017:1.

Stiglitz, Joseph E., Amartya Sen, and Jean-Paul Fitoussi. 2009. *Report by the Commission on the Measurement of Economic Performance and Social Progress*. www.stiglitz-sen-fitoussi.fr/en/index.htm.

Stjepanović, Saśa, Daniel Tomić, and Marinko Škare. 2019. "Green GDP: An Analysis for Developing and Developed Countries." *E+M*: *Ekonomie a Management*, 22(4):4-17.

Strunz, Sebastian, and Harry Schindler. 2018. "Identifying Barriers Toward a Post-growth Economy – A Political Economy View." *Ecological Economics*, 153: 68-77.

Talberth, John, Clifford Cobb, and Noah Slattery. 2007. *The Genuine Progress Indicator 2006: A Tool for Sustainable Development*. Redefining Progress.

United Nations, European Commission, International Monetary Fund, OECD, and World Bank. 2003. *Integrated Environmental and Economic Accounting 2003*.

United Nations, European Commission, Food and Agriculture Organization, International Monetary Fund, Organization for Economic Cooperation and Development, and

World Bank. 2014. *System of Environmental-Economic Accounting 2012: Central Framework*. United Nations, New York.

Wang, Feng, Ruiqi Wang, and Junyao Wang. 2020. "Measurement of China's Green GDP and its Dynamic Variation Based on Industrial Perspective." *Environmental Science and Pollution Research*, vol. 27. doi.org/10.1007/s11356-020-10236-x.

World Bank. No date. "Calculating Adjusted Net Saving." http://siteresources.worldbank.org/ENVIRONMENT/Resources/Calculating_Adjusted_Net_Saving.pdf.

World Bank and State Environmental Protection Agency (World Bank and SEPA), People's Republic of China. 2007. "Cost of Pollution in China." Rural Development, Natural Resources and Environment Management Unit, East Asia and Pacific Region, World Bank, Washington, DC.

WEB SITES

1. https://ec.europa.eu/environment/beyond_gdp/index_en.html. The web site for "Beyond GDP," an initiative to develop national indicators that incorporate environmental and social concerns. The project is sponsored by the European Union, the Club of Rome, the WWF, and the OECD.
2. www.oecdbetterlifeindex.org. The web site for the OECD's Better Life Index. Note that you can adjust the weights applied to each dimension to create your own version of the BLI.
3. www.scb.se/en/finding-statistics/statistics-by-subject-area/environment/environmental-accounts-and-sustainable-development/system-of-environmental-and-economic-accounts/. The web site for environmental accounts in Sweden.
4. https://seea.un.org. The web site for the United Nations System of Environmental-Economic Accounting (SEEA),"a framework that integrates economic and environmental data to provide a more comprehensive and multipurpose view of the interrelationships between the economy and the environment."

APPENDIX 10.1: BASIC NATIONAL INCOME ACCOUNTING

In this chapter we have discussed several modifications and alternatives to traditional national income accounting. Standard accounting measures, such as **gross national product (GNP)** and **gross domestic product (GDP)**, are widely accepted estimates of the health of a national economy. However, these measures have numerous technical and conceptual limitations. Some background knowledge of how they are calculated and interpreted is useful for understanding the arguments for adjusting or replacing these measures. If you have not taken an introductory macroeconomics course or need to refresh your knowledge, this appendix will help you work through the concepts presented in the chapter.

gross national product (GNP) the total market value of all final goods and services produced by citizens of a particular country in a year, regardless of where such production takes place.
gross domestic product (GDP) the total market value of all final goods and services produced within a national border in a year.

National income accounting was first developed in the United States in the 1930s to provide policy makers with information on the overall level of economic activity in the country. National income accounting was not designed to estimate the welfare of society—only the aggregate level of economic production. Also, at the time the accounts were being designed, environmental degradation was not an important issue.

For many years, the official measure of national economic activity in the United States was the gross national product, defined as the final market value of all new goods and services produced by the citizens of the country over a period of time (typically one year). GNP includes goods and services produced by U.S. citizens and corporations in foreign countries but not goods and services produced within U.S. borders by foreign citizens and corporations.

In the early 1990s the United States switched to gross domestic product as its official measure to conform with international standards developed by the United Nations. GDP

measures the value of goods and services produced within the national boundaries of a country regardless of the producer's nationality. Thus GDP excludes production by U.S. citizens and corporations in foreign countries. In practice, there is normally little quantitative difference between GNP and GDP. In 2019 the values differed by less than 1 percent in the United States.

It is important to note that GNP and GDP measure only the final value of goods and services. Intermediate values are excluded to avoid double counting. For example, consider some of the steps involved in producing this textbook. First, a lumber company harvested wood and sold the wood to a paper mill. Then, the paper mill produced paper and sold it to a printing company. The printing company then printed the text under contract with the publisher. The publisher then sold the book to a retail store for final sale to you. If we add up the prices paid by the paper mill, printing company, publisher, retail store, and you, we end up with a value much higher than the price you paid for the book. The greater the number of intermediate production steps taken to produce an item, the higher the sum of all the prices paid. So all the intermediate steps are not counted, and only the final price you paid is included in GNP and GDP.

Since it may be difficult in practice to distinguish intermediate from final goods, the accounting method generally used to compute GNP/GDP is the **value-added method**, in which the extra value added at each step of the production process is counted. In the textbook example, the value added for the paper mill is the value of its output minus the cost of inputs purchased from the lumber company. The sum of the values added at all stages of production is equal to the value of the final good.

value-added method the additional value of a good or service from each step in the production process.

GNP and GDP only count the production of new goods. If you purchased this book secondhand from a store or other student, then it would not be included in the national accounts. The sale of used products does not contribute to current economic production.

Adjusting for Depreciation, Population Growth, and Inflation

One reason GDP is not the best measure of national income is that a portion of investment in capital equipment, such as factories and machinery, simply replaces worn-out capital. Since capital that wears out or becomes obsolete decreases national wealth, the depreciation of this capital should be counted as a deduction from GDP. Gross investment minus depreciation is called net investment. If we deduct capital depreciation from GDP we get a measure called **net domestic product (NDP)**. The depreciation of fixed capital amounts to about 10–15 percent of GDP in the United States.

Of course, politicians and economists hope that the economy expands over time and GDP increases. But an increase in GDP does not necessarily indicate greater wealth for a country's citizens. GDP could increase simply because the country has a higher population. We can account for population growth (or decline) in national accounting by calculating GDP per capita, equal to GDP divided by population. Data on GDP per capita also allows us to compare economic production across different countries. For example, U.S. GDP is much greater than Norwegian GDP, but when we adjust for population size we find that GDP per capita is higher in Norway than in the United States.

net domestic product (NDP) gross domestic product minus the value of depreciation of produced, or human-made, capital.
constant dollars an adjustment of economic time series data to account for changes in inflation.
real GDP gross domestic product corrected for inflation using a price index.

The other factor we need to control for when comparing GDP values across time is inflation. Remember that GDP is based on market prices and it could grow simply because market prices have risen. So when comparing GDP data from different years, we need to use **constant dollars**. For example, suppose that the general level of prices in 2020 was twice as high as it was in 1990. So if we wanted to compare GDP for these two years, we could compare them using 2020 dollars by doubling the GDP from 1990. Or we could compare them using 1990 dollars by dividing the GDP for 2020 in half. The first method gives us **real GDP** in 2020 dollars, while the second gives us real GDP in 1990 dollars.

U.S. GDP has grown tremendously in recent decades. As seen in Table 10.2, GDP increased by a factor of 71 between 1950 and 2019 if we do not consider any adjustments. Adjusting for population, we find that economic production per person has increased by about a factor of 33. But most of this increase is due to inflation. When we adjust for differences in price level by calculating real GDP per capita in 2015 dollars, we discover that economic production per person has actually increased by a factor of 3.8. This still suggests a large increase in the standard of living for the average American, but a much less significant increase than would be implied looking at the unadjusted aggregate GDP data.

Table 10.2 Historical Gross Domestic Product (GDP) Data, United States

Year	Unadjusted U.S. GDP ($ Billion)	Unadjusted GDP per Capita (Dollars)	GDP per Capita in 2015 Dollars
1950	300	1,971	15,745
1960	543	3,007	18,847
1970	1,076	5,247	25,224
1980	2,863	12,598	31,093
1990	5,980	23,970	39,369
2000	10,285	36,450	48,865
2010	14,964	48,374	52,462
2019	21,433	65,304	60,552

Sources: U.S. Bureau of Economic Analysis and U.S. Census Bureau web sites.
Note: Real GDP calculated based on adjustment using the BEA's price indices for GDP.

COMPARING GDP FOR DIFFERENT COUNTRIES

A final adjustment that is made when comparing GDP data across countries is to adjust for **purchasing power parity (PPP)**. Even if we use currency exchange rates to put all countries' GDP per capita in U.S. dollars, we should still adjust for differences in what a dollar can purchase in different countries. For example, a U.S. dollar converted into Chinese currency will buy a lot more in China than it will in the United States. As mentioned above, Sweden has a higher GDP per capita than the United States, but when we adjust for PPP, GDP per capita is higher in the United States than in Sweden because of the relatively high prices in Sweden.

purchasing power parity (PPP) an adjustment to GDP to account for differences in spending power across countries.

National income accounting data illustrate the varying economic conditions of people in different countries. We can use the data to compare rates of economic development and to determine income inequality between countries. But we need to be careful about interpreting national accounting data. GDP measures only the aggregate level of economic production; it does not measure social welfare. If GDP per capita rises only because people are working longer hours, we cannot conclude that they are happier. Also, GDP per capita could increase only because the wealthy members of society are becoming wealthier. GDP data tell us nothing about the level of economic inequality in a country. This and other known problems with GDP make it important to be aware of its limits as a measure of well-being—even before we consider the environmental and resource issues discussed in this chapter.

KEY TERMS AND CONCEPTS FOR APPENDIX 10.1

constant dollars
gross domestic product (GDP)
gross national product (GNP)
net domestic product (NDP)
purchasing power parity (PPP)
real GDP
value-added method

NOTES

[1] The difference between GNP and GDP concerns whether foreign earnings are included. GNP includes the earnings of a country's citizens and corporations regardless of where they are located in the world. GDP includes all earnings within a country's borders, even the earnings of foreign citizens and corporations. In the 1980s and 1990s most countries switched from relying primarily on GNP, to GDP. The rationale is that it is more meaningful to focus on economic activity within a country's borders.

[2] Fioramonti, 2013.

[3] *Ceteris paribus* is a Latin phrase meaning "other things equal," and is often used by economists to make clear what assumptions are used as the basis for analysis.

[4] For a history of environmental accounting, see Hecht, 2007.

[5] United Nations *et al*., 2003; United Nations *et al*., 2014. https://seea.un.org.

[6] Depreciation is simply a measure of the loss of capital value through wear and tear. For accounting purposes, it can be calculated using a "straight-line" formula according to which, for example, a new machine is estimated to lose 10 percent of its original value each year over a ten-year period, or using more complex valuation methods.

[7] Estimates of fixed capital depreciation are obtained from tax records. Businesses are not taxed on the value of their fixed capital depreciation—thus they have a strong incentive to claim this deduction. Data on U.S. national accounts are available from the U.S. Bureau of Economic Analysis.

[8] Note that Green GDP can be estimated using either GDP or NDP as the starting point.
[9] Repetto *et al*., 1989.
[10] Skånberg, 2001.
[11] Gundimeda *et al*., 2007.
[12] World Bank and SEPA, 2007.
[13] Wang et al., 2020.
[14] Stjepanović et al., 2019.
[15] Adjusted net savings is also called genuine savings.
[16] Bolt *et al*., 2002, p. 4.
[17] Gross saving already includes fixed capital education expenditures, such as spending on buildings and buses. However, teacher salaries are not included, nor is spending on books and other educational supplies. ANS adds in these nonfixed capital expenditures.
[18] Some analysts consider this a low value for carbon damages. We consider the economic damages from carbon emissions in Chapter 12.
[19] An early version of the GPI was called the Index of Sustainable Economic Welfare (ISEW).
[20] Talberth *et al*., 2007, pp. 1–2.
[21] Ibid. Note that various estimates of the GPI follow slightly different approaches, including adjustments specific to different countries.
[22] Kubiszewski *et al*., 2013.
[23] Ibid.
[24] Kenny *et al*., 2019.
[25] Kubiszewski *et al*., 2013, p. 67.
[26] Kenny *et al*., 2019.
[27] Berik, 2020, p. 86.
[28] NEF, 2016.
[29] Goossens, 2007.
[30] The OECD is a group of the world's advanced industrial countries, now including some developing countries such as Mexico and Chile.
[31] OECD, 2015.
[32] Ibid., p. 17.
[33] See www.oecdbetterlifeindex.org.
[34] Braun, 2009.
[35] CBS, 2011.
[36] CBS, 2015.
[37] Braun, 2009, p. 35.
[38] Dietz and Neumayer, 2006.
[39] Office for National Statistics website, https://www.ons.gov.uk/economy/environmentalaccounts.
[40] Ministry of Sustainable Development, 2006, p. 69.
[41] Statistics Sweden, 2017.
[42] Smith, 2007, p. 598.
[43] Stiglitz *et al*., 2009, p. 7.
[44] Ibid., p. 8.
[45] Press, 2011.
[46] http://www.stateoftheusa.org/about/mission/.
[47] OECD, 2011, p. 3.
[48] BRAINPOol, 2014.
[49] See, for example, Bartelmus, 2015.
[50] Strunz and Schindler, 2018, p. 72-73.