

CHAPTER 1: INTRODUCTION TO SUSTAINABLE DEVELOPMENT

PART I. SUSTAINABLE DEVELOPMENT AS AN ANALYTICAL AND NORMATIVE CONCEPT

I. What is Sustainable Development?

Sustainable development is a central concept for our age. It is both a way of understanding the world and a method for solving global problems. This book offers you an introduction to this fascinating and vital field of thought and action.

Our starting point is our crowded planet. There are now 7.2 billion people on the planet, roughly 9 times the 800 million people estimated to have lived in 1750, at the start of the industrial revolution. The world population continues to rise rapidly, by around 75-80 million people per year. Soon enough there will be 8 billion by the 2020s, and perhaps 9 billion by the early 2040s.

These billions of people are looking for their foothold in the world economy. The poor are struggling to find the food, safe water, health care, and shelter they need for mere survival. Those just above poverty are looking for improved prosperity and a brighter future for their children. Those in the high-income world are hoping that technological advances will offer them and their families even higher levels of wellbeing. It seems that the super-rich also jostle for their place on the world's rankings of richest people.

In short, 7.2 billion people are looking for economic improvement. They are doing so in a world economy that is increasingly connected through trade, finance, technologies, production flows, migration, and social networks. The scale of the world economy, now estimated to produce \$90 trillion of output per year (a sum called the Gross World Product, or GWP), is unprecedented. By crude statistics, the GWP measures at least 100 times larger than back in 1750. In truth, such a comparison is not all that meaningful, since most of the world economy today consists of goods and services that did not even exist 250 years ago.

What we know is that the world economy is vast, growing rapidly (by 3-4 percent per year in scale), and highly unequal in the distribution of income within countries and between countries. Ours is a world of fabulous wealth and extreme poverty, of billions of people enjoying longevity and good health unimaginable in previous generations. Yet it is also a world in which at least 1 billion people live in such abject poverty that they struggle for mere survival every day. The poorest of the poor face the daily life-and-death challenges of insufficient nutrition, lack of health care, unsafe shelters, and the lack of safe drinking water and sanitation.

The world economy is not only remarkably unequal, but also remarkably threatening to the planet itself. Like all living species, humanity depends on nature for the provision of food and water, materials for survival, and safety from dire environmental threats, such as disease epidemics or natural catastrophes.

Yet for a species that depends on the beneficence of nature, or on what the scientists call “environmental services,” we are doing a poor job of protecting the physical basis of our very survival. The gigantic world economy is creating a gigantic environmental crisis, one that threatens human wellbeing and even the survival of millions of other species on the planet, if not our own.

The environmental threats, we shall learn, are arising on several fronts. Humanity is changing the Earth’s climate; the availability of fresh water; the ocean chemistry; and the habitats of other species. These impacts are now so large that the Earth itself is undergoing unmistakable changes in the functioning of key processes – such as the cycles of water, nitrogen, and carbon – upon which life depends. We don’t know the precise scaling, timing, and implications of these changes, but we do know enough to understand that they are extremely dangerous, and unprecedented in the span of humanity’s 10,000 years of civilization.

Thus we arrive at sustainable development. As an intellectual pursuit, sustainable development tries to make sense of the interactions of three complex systems: the world economy, the global society, and the Earth’s physical environment. How does an economy of 7.2 billion people, and \$90 trillion Gross World Output, change over time? What causes economic growth? Why does poverty persist? What happens when billions of people are suddenly interconnected through markets, technology, finance, and social networks? How does a global society of such inequality of income, wealth, and power, function? Can the poor escape their fate? Can human trust and sympathy surmount the divisions of class and power? And what happens when the world economy is on a collision course with the physical environment? Is there a way to change course, a way to combine economic development with environmental sustainability?

Sustainable Development is also a normative outlook on the world, meaning that it recommends a set of *goals* to which the world should aspire. In this normative (or ethical) sense, sustainable development calls for a world in which economic progress is widespread; extreme poverty is eliminated; social trust is encouraged through policies that strengthen the community; and the environment is protected from human-induced degradation. Notice that sustainable development recommends a holistic framework, in which society aims for economic, social, and environmental goals. Sometimes the following shorthand is used: sustainable development calls for *socially inclusive and environmentally sustainable economic growth*.

To achieve the economic, social, and environmental objectives, a fourth objective must also be achieved: good governance. Governments must carry out many core functions to enable societies to prosper. Among these core functions of government are the provision of social services such as healthcare and education; the provision of infrastructure such as roads, ports, and power; the protection of individuals from crime and violence; the promotion of basic science and new technologies; and the implementation of regulations to protect the environment. Of course, this list is just a brief subset of what people around the world hope for from their governments. In fact, all too often they get the reverse: corruption, war, and an absence of public services.

In our world today, good governance cannot refer only to governments. The world's multinational companies are often the most powerful actors. Our wellbeing depends on these powerful companies obeying the law, respecting the natural environment, and helping the communities in which they operate, especially to overcome extreme poverty. Yet as with governments, reality is often the reverse. Multinational companies are often the agents of public corruption, bribing officials to bend regulations or tax policies in their favor; tax evasion; money laundering; and reckless environmental damage.

Thus, the normative side of sustainable development envisions four basic pillars of a good society: economic prosperity; social inclusion and cohesion; environmental sustainability; and good governance of major social actors, including governments and business. It's a lot to ask for, and there is no shortage of challenges to achieving sustainable development in practice. Yet the stakes are high. Achieving sustainable development on our crowded, unequal, and degraded planet is the most important challenge facing our generation.

II. Embracing Complexity

Sustainable development is a science of complex systems. A system is a group of interacting components, together with the rules for their interaction, constituting an interconnected whole. The brain is a system of interacting neurons; the human body is a system of some 10 trillion individual cells; the cell is a system of interacting organelles; and the economy is a system of millions of individuals and businesses, bound together through markets, contracts, laws, and regulations.

We talk about these systems as complex because their interactions give rise to behaviors and patterns that are not discernible from the underlying components themselves. The conscious brain cannot be reduced to a list of its neurons and neurotransmitters. A living cell is more than the sum of the nucleus, ribosomes, and other components. A growing economy is more than the sum of its individual businesses and workers. Complexity scientists speak of the *emergent properties* of a complex system, meaning those characteristics that emerge from the interactions of the components to produce something that is "more than the sum of the parts."

Complex systems have many unexpected characteristics. They often respond in a non-linear way to shocks or changes, meaning that even a modest change in the environment can cause a large, perhaps catastrophic, change in the performance of the system as a whole. A small change in the cell's chemistry can lead to its death; a small change in the physical environment may cause large and cascading changes to the relative abundance of the species in that environment. The failure of a single business can lead to a financial panic and a global downturn, such as occurred when the Lehman Brothers investment bank failed in September 2008.

Sustainable development involves not just one but four complex systems. It deals with a global economy that now spans every part of the world; it focuses on social interactions of trust, inequality, and social support in communities (including new global online communities made possible by the revolutions of information and communications technologies, or ICTs); it analyzes the changes to

complex Earth processes such as climate and biodiversity; and it studies the problems of governance, regulation, and performance of governments and businesses. In each of these complex systems – economic, social, environmental, and political – the special phenomena of complex systems, such as emergent behavior and strong, non-linear dynamics (including booms and busts) are all too apparent.

Complex systems require a certain complexity of thinking as well. It is a mistake to believe that the world's sustainable development problems can be boiled down to one idea or one solution. A complex phenomenon, such as poverty in the midst of plenty, has many causes that defy a single diagnosis or prescription; just as with environmental ills or communities torn asunder by mistrust and violence. Medical doctors are trained to understand and respond to the complex system known as the human body. Medical doctors know that a fever or a pain can have countless causes. Part of the job of a skilled medical doctor is to make a differential diagnosis of the specific cause of a fever in a particular patient. A skilled sustainable development practitioner needs to be a complex-systems expert in the same way, acknowledging the complexity of the issues and looking to make a specific diagnosis of each specific case.

III. The Role of Technological Change

The Maglev in Shanghai is a remarkable piece of technology that carries people at speeds of more than 200 miles per hour to and from Shanghai and its international airport. It is a product of joint work between engineering companies from Europe and China, and has been operating for the past decade. It is an example of how new technology can help to achieve sustainable development. The Maglev is powered by electricity rather than by coal or petroleum, as in earlier generations of rail. If the electricity that powers the Maglev is eventually produced with a clean primary energy source (rather than the coal that today dominates China), the electric-powered inter-city travel can be part of the solution to human-induced climate change.



Figure 1.1

Throughout our study of sustainable development, we will note three aspects of technology. First, technological advances are the main driver of long-term global economic growth. The rapid growth of the world economy since 1750 is the result of 250 years of technological advances, starting with the steam engine and steam-powered transportation, the internal combustion engine, electrification, industrial chemistry, scientific agronomy, aviation, nuclear power, and today's information and communications technologies. Without these advances, the world economy and world population would have stopped growing decades or centuries ago.

Second, technological advances often have negative side effects, even when their direct effects are enormously positive. The burning of coal is both the emblem of the industrial revolution and the bane of our environmental crisis. One can say that coal enabled modern civilization through the invention of the steam engine. Yet coal is now used on such a scale that it endangers civilization itself. In 2010, humanity emitted around 14 billion tons of CO₂ through coal burning, close to half of the world's total emissions of carbon dioxide (CO₂) due to fossil fuels. Unless coal is phased out rapidly, or used with new technologies (such as carbon capture and sequestration, discussed later), the damage to the planet and the global economy will be overwhelming.

Third, technological advance is, at least to some extent, under human guidance. Sometimes technological advance is portrayed as a great lottery, determined by the luck of the draw of individual inventors and scientists. Alternatively, technological advance is sometimes described as merely following the market. Companies invest in research and development (R&D) in order to pursue profits. We end up with research on challenges sought in the marketplace, not necessarily those of vital importance for the poor or for the environment. Yet there is another side to technological change, the idea that it can be *directed* towards human goals.

We are perhaps used to the idea that governments steer technology for "reasons of state" – that is, for military purposes. Governments have long hired engineers and inventors to design and build new weapons and defenses, many involving pioneering breakthroughs in technology. World War I heralded major advances in aviation, and World War II brought advances in computers, radar, semiconductors, rocketry, antibiotics, communications, and countless other advances led by state-supported research; including America's Manhattan Project, which brought together world-leading physicists to design and construct the first atomic bombs.

Of course, we should greatly prefer to achieve technological advances through peaceful means. And indeed, there is a distinguished track record of government support for civilian technological advances (though often governments had military purposes also in mind). In recent decades, the Internet, information technology, aviation, space technology (such as global positioning systems), genomics, nanotechnology, and countless other areas of technological advance owe their development in significant measure to government support. In the age of sustainable development, we will need such

directed technological change, in order to develop new technologies for sustainable energy, transport, construction, food production, health delivery, education, and more. Governments will rely on many policy tools to drive innovations in a targeted direction, including the public financing of R&D, direct research in public laboratories, regulations, prizes for new inventions, and modifications of patent laws (e.g. to encourage R&D on specific diseases).

IV. Sustainable Development as a Normative Approach

Sustainable development is a way to understand the world, as the complex interaction of economic, social, environmental, and political systems. Yet is also a normative or ethical view of the world, a way to define the objectives of a well-functioning society, one that delivers wellbeing for its citizens today and in future generations. The basic point of sustainable development in that normative sense is that it urges us to have a holistic vision of what a good society should be. The easy answer for many people is that a good society is a rich society, where higher incomes are the ultimate purpose of economic and political life. Yet something is clearly too limited with such a view. Suppose that a society was rich on average because one person was super-rich while the rest were in fact very poor. Most people would not regard that as a very attractive society, one that is bringing wellbeing to the citizenry. People care not only about the average income, but about the income distribution as well: are some people exceedingly poor? Are the gaps between the rich and poor very wide? Can a poor person today hope to achieve economic success in the future, or are the practical barriers to advancement too high?

Most of us would like to understand more about the social conditions in the country. Is economic wellbeing widely shared among different ethnic, religious, and racial groups, or is success limited to just a few of the many groups? Is prosperity shared between men and women, or is there a share difference between men and women in economic power and perhaps even in their legal rights? Is the economy fairly equal across regions of the country, or are there just few pockets of prosperity surrounded by a sea of poverty? And if the inequalities of income, wealth, and power are wide, is there deep distrust and even social unrest in the country, as we might guess?

A third aspect of a good society is being a good steward of the natural environment. If we break the physical systems of water and biodiversity, if we destroy the oceans and the great rain forests, we will lose immeasurably. If we continue on a path that fundamentally changes the earth's climate, we are going to face grave dangers. Therefore from a normative perspective, environmental sustainability certainly seems right and compelling if we care, as we should, about the wellbeing of our children and our children's children and future generations.

Most, if not all of us, also care about how our government functions. Massive corruption, lawlessness, untrustworthy politicians, unfair government services, significant discrimination, insider dealing and so forth create a lot of unhappiness. All over the world people feel happier and better when they can trust their government. Unfortunately in many places in the world, people do not trust their governments to be honest, fair and keep them basically secure.

From a normative perspective then, we could say that a good society is not only an economically prosperous society (with high per-capita income), but also one that is also socially inclusive, environmentally sustainable and well governed. That is my working definition of the normative objectives of sustainable development. The fundamental question is how to take our knowledge of the interconnections of the economy, society, environment and governance to think through how to produce prosperous, inclusive, sustainable and well-governed societies. We shall see that there are indeed some powerful ways to achieve sustainable development as a shared set of goals for the planet.

PART 2: AN INTRODUCTION TO ECONOMIC GROWTH

I. Measuring the size of the economy

We typically summarize a country's overall economic development by Gross Domestic Product (GDP) per person. The GDP measures the market value of total production within the country in a given time period, usually a year. GDP per capita (GDP per person) is simply GDP divided by the population. Since GDP is the size of the overall economic "pie," the GDP per capita is the size of the average slice per person. Of course, the actual income distribution in any country will be uneven. Some households will have a very large slice of the pie while others will receive mere crumbs. Nonetheless, the average slice, the GDP per capita, is closely though imperfectly correlated with other measures of national wellbeing, such as life expectancy, levels of education, quality of infrastructure, and levels of personal consumption spending.

There are a few quick points to mention about the measurement of GDP. First, the GDP measures the production inside the boundaries of a country. This is different from the income earned by residents of the country. Suppose that the country is an oil exporter, and that the government owns two-thirds of the oil while foreign companies own one-third. The GDP would count all of the oil produced within the country, the full three-thirds, but only two-thirds of the oil as part of the national income. We give the name Gross National Product (GNP) to the income-based measure. In this example, GNP would be less than GDP.

Second, the GDP measures output at market prices. To put GDP in a common currency, local prices are typically converted to US dollars, so that GDPs in all countries are expressed in US dollars. Yet which prices should be used? If we measure GDP using the prices prevailing in each country, we would end up giving different weights to the very same physical production. Two countries might each produce a ton of steel, but if the price of steel (expressed in US dollars) differs on local markets, the contribution of the ton of steel to GDP would differ in the two economies. In order to make a good comparison of GDP across countries, therefore, statisticians have decided to use a common set of "international prices," which are a kind of average of observed market prices, or of the prices in a single reference country such as the United States. In general, we will use the GDP measured at international prices, which is also called the GDP at purchasing power parity (PPP), since common prices are used to assure an equal purchasing power of one dollar of GDP as measured in every country.

Third, we must also note GDP measures only the goods and services transacted in the market economy, not those that take place outside of the marketplace, such as production that occurs within the home. When a mother looks after her own children, the home daycare is not counted as GDP. If the mother looks after the neighbor's child for a fee, however, that daycare is counted as part of GDP. Also, GDP does not measure the "bads" or harms that often accompany production, such as the costs of industrial pollution or destruction by war. Therefore, GDP per person is only a rough indicator of true economic wellbeing per person. Plenty of terrible things – pollution, natural disasters, war – may afflict people in high-income countries, without GDP reflecting those costs to society.

II. Defining economic growth

Ask an economic policy-maker almost anywhere in the world about the country's main economic goal, and the answer will typically be "economic growth." Every day, the newspapers recount the recent growth rates of the major economies, as well as commentaries about the prospects for future growth. Yet what exactly is being measured by economic growth?

Economic growth, in simplest terms, measures the change in the GDP over a given period, for example the current year relative to the past year, or the current quarter of the year (January-March) compared with the preceding quarter (October-December). Economic growth signifies an increase in GDP.

Once again, we must immediately highlight some details. If the GDP rises by 100% (that is, doubles in size) but the population also doubles, then the size of the average slice of the economic pie remains unchanged. Our interest in growth is therefore typically in the rise of GDP per capita rather than GDP by itself. Moreover, we are interested in the rise of output of actual goods and services, not just the prices of goods and services. Here is an example. If the country produces one ton of steel, at \$500 per ton, the contribution to GDP is \$500. If the price of steel goes up to \$1000 per ton, while production remains at one ton, the contribution of steel to GDP rises to \$1000 even though there is no change in the actual production of the economy. Therefore, we generally are interested not in GDP at current prices (whether domestic or international), but GDP at constant prices. For example, we might decide that for the next several years, every ton of steel will be evaluated at a constant price of \$500, even if the actual market price fluctuates in the future. We call this GDP at constant prices. For reasons described, we are in fact typically interested in GDP at constant international prices.

Why are we so interested in GDP per capita at constant international prices? As mentioned earlier, that measure tends to be related to several other indicators of prosperity. When GDP per capita increases, economic wellbeing tends to rise. Yet for many reasons, some already mentioned, and others that will be mentioned later on, the rise in GDP per capita is *far from a perfect measure of wellbeing*. It is quite conceivable that GDP per capita rises but that many people in the country end up being worse off. That could be true, for example, if only a small part of the society is recipient of the higher production. It could also be true if the rise in market-based output is offset by "bads" occurring outside of the market, for example environmental destruction such as air and water pollution.

Still, let us focus on the long-term trajectory of GDP per capita, measured at constant international prices. The good news is that the world economy in total has tended to grow over the course of many decades. This means that if we add up the GDP (at constant international prices) of every country, and call the result the Gross World Production (GWP), and then divide by world population to find Gross World Product per person, we find that GWP per capita has been rising fairly consistently by around 2 to 3 percent per year. In turn, this global growth, reflecting the growth of national economies as well (using GDP per capita as the measurement), has been associated with many other gains in material wellbeing, such as improved health, better education, and more food security (though also more obesity, alas).

A handy rule of thumb for economic growth, or indeed any kind of growth, is called The Rule of 70. The idea is the following. Consider the growth rate of the world economy; say a 2 percent per year increase of the GWP per person. If we take 70 divided by the annual growth rate, in this case 70 divided by 2, or 35, we find the number of years it takes for the economy to double in size. So an economy growing at 2 percent per year will double in 35 years ($= 70/2$); if the global growth heats up to 4 percent per year, the doubling time therefore drops by half, to 17.5 years ($=70/4$).

Now the key point is that the world economy has been growing consistently since the start of the industrial revolution in the middle of the 18th century. Angus Maddison, a late economic historian, did a great service for the economics profession by estimating the GDP per person over the long time period since 1820. He measured GDP in each period and country using the same standard: international prices of 1990. By that measure, the GWP rose from \$695 billion in 1820 to around \$41 trillion by 2010. During that same period, the world population rose from 1.068 billion to 6.9 billion. Therefore, the GWP per capita (in constant 1990 international dollars) increased from \$651 to \$5942.

How fast is that growth on an annual basis? Note that there are 190 years between 1820 and 2010. Therefore, we can find the average growth rate between 1820 and 2010 by solving the following equation:

$$(\$GWP \text{ per person in 2010}) / (\$GWP \text{ per person in 1820}) = \$5942 / \$651 = (1+g)^{190}$$

Solving for the growth rate g , we find that $g = 1.1\%$ per annum is the average annual growth rate since 1820. If we make exactly the same calculation for the years 1970 to 2010, we find that the more recent growth rate is even higher, at 1.5% per annum.

Figure 1.2 shows an admittedly rough estimate of GWP per person, measured at constant international dollars, over a *very long* time period, specifically from 1 AD to 2010. Of course, the actual GWP per person in earlier centuries is based on rough estimates rather than precise data. Still we see something absolutely extraordinary about this graph. During most of the history of the past two millennia, there was little or no economic growth. GWP per person only started to rise around 1750, and then only very gradually. The whole story of economic growth in human history is a recent one, stretching over little

more than two centuries. Economic historians call the period since 1750 the “age of modern economic growth.” This period is the central period of our study.

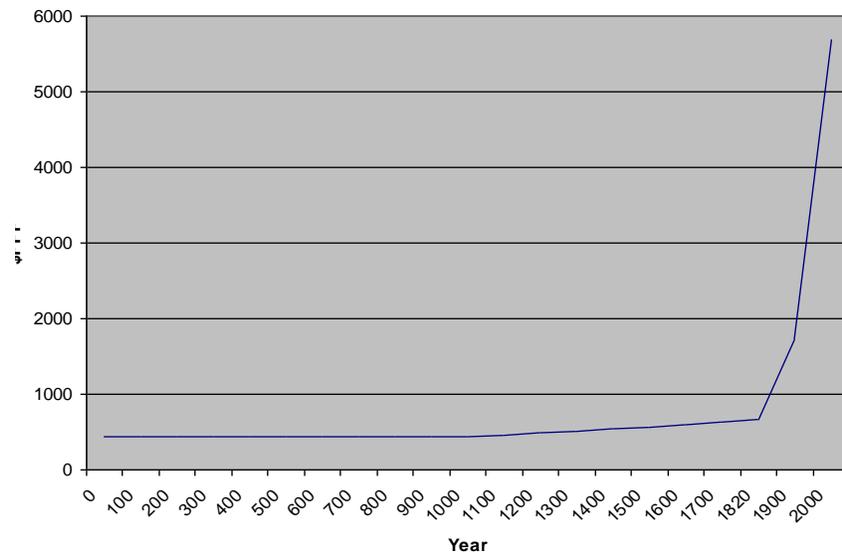


Figure 1.2: Gross World Product per Capita (1990 International Dollars)

Based on Maddison, *The World Economy*, 2001

We can say the following now, to be elaborated later. For most of human history, output per person was at a very low level, just around the level needed to survive. Most of humanity lived on farms, and grew food for their own subsistence. In most years, the food was enough to keep them alive. In bad years, with droughts or floods or heat waves or pests, the harvest might fail, and with it people would die, even in large numbers. Poor harvests might also make the population more susceptible to infectious diseases, since malnourishment weakens the body’s immune system. Starting around 1750, something fundamentally new began to occur: positive economic growth. We will see that economic growth started only in a few places, including Great Britain and the United States. Eventually it spread around the world, though quite unevenly.

The rise in GWP was first associated with the rise of industry, such as steelmaking and textile production. Indeed, we usually call the first takeoff of economic growth from around 1750 to 1850 the Industrial Revolution. More recently, after 1950 or so in the high-income countries, the rise in GWP has been associated with the rise of services, such as the banking system. The overall result is that the world’s output per person, or GWP per capita, lifted off the subsistence level and over the period of roughly 250 years, grew by a factor of around 100 times.

Figure 1.3 shows something else that is also astounding, and seems to follow a similar course. This graph looks quite like Figure 1.2, but instead of measuring GWP per person, it measures the world population over a very long stretch of time, in this case all the way back to the presumed beginning of civilization, around 12,000 years before the present day (sometimes called 12,000 BP). This is the time that human

beings shifted from hunting and gathering their food to growing it in one place; the change from nomad shifting locations to find food to sedentary farmers living in fixed villages. The period before agriculture is known as the Paleolithic era (Paleo = old + lithic = Stone Age). The period after the start of agriculture is known as the Neolithic era (Neo = new + lithic = Stone Age).

12,000 years of population growth

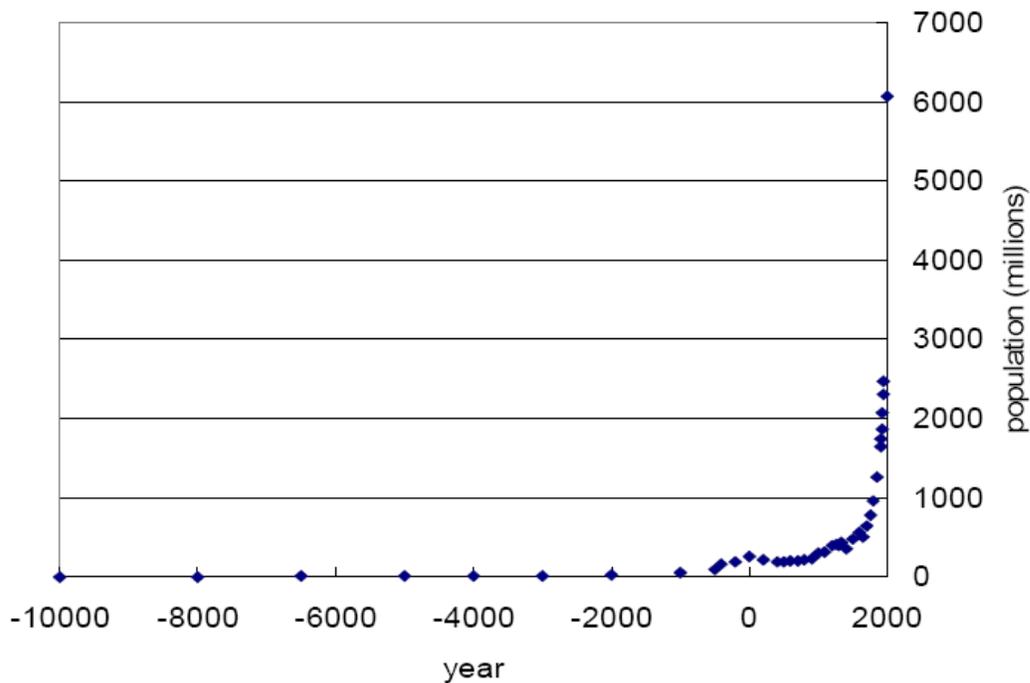


Figure 1.3

What we see is that just like GWP per capita, the global population changed fairly little over very long stretches of time, always remaining well under 1 billion people. From 10,000 BC to around 2,000 BC, the human population was well under 100 million. Around 1 AD, at the time of the Roman Empire, the world population according to Maddison's estimate was around 225 million. As of 1000, it was 267 million, on Maddison's best estimate; in 1500, around 438 million. It reached 1 billion around 1820. The world population therefore rose perhaps 4 times in the 18 centuries between 1 AD and 1820, implying an annual growth rate of just 0.08% per year. For most people in most of history, population seemed relatively unchanged over the course of a lifetime, indeed many lifetimes. The only changes were due to mass deaths due to wars, famines and plagues, followed by subsequent recoveries of population to more "normal" levels.

Then, in the same era as the Industrial Revolution, population broke free of its ancient restraints. At that point of history, the population curve turns up remarkably steeply. Around 1820 or so, humanity reached the great milestone of a billion people on the planet, then from 1820 to around 1930, in roughly

one century, the second billion was added. Then the numbers really started to soar. In just 30 years, from 1930 to 1960, the third billion was added. The world went from 3 billion in 1960 to 4 billion 1974, 5 billion in 1987, 6 billion in 1999, and 7 billion in the year 2011. Notice that the recent increments of one billion have occurred in roughly dozen-year intervals!

We are on track to reach eight billion around 2024 or 2025, and by nine billion sometime in the early 2040s. After that, the numbers become more uncertain but will probably continue to rise, at least on present patterns of fertility (childbearing) and mortality (deaths). The rise of population since the early 1800s is absolutely astounding, unprecedented in human history, just as with GWP per person. The fundamental fact is that modern economic growth and global population increases have tended to come side by side, though the relationship between the two is complicated, as we shall learn. The age of modern economic growth is one of rising output per person combined with rapid overall population growth. Together those two dynamics, more income per person and more people on the planet, have meant a massive expansion of total economic activity. Indeed, it is an obvious relationship that total output in the world, the GWP, is equal to the output per capita multiplied by the world's population:

Gross World Product (GWP) = Gross World Product per capita \times World Population

One clear reason for the rise in the world's population is the increased ability to grow more food and feed a rising population. Just as humanity learned to harness technology for industrialization, it learned to harness technology to raise food production. Since 1750 or so, farmers have been able to grow more food thanks to better seed varieties, better farm techniques (such as rotating their crops through the years to maintain soil fertility), chemical fertilizers to boost soil nutrients, and machinery to sow seeds, harvest crops, process food stuffs, and store and transport food to cities.

III. The Recent Growth of China

Let's look at what growth really means in one very important case. There has been no exemplar of rapid economic growth more remarkable than China. China's growth is superlative in every aspect. As the world's most populous country, with 1.3 billion people, anything major that happens in China is earthshaking, but since 1978, China has also been among the fastest growing economies in world history. When Deng Xiaoping came to power at that time, China undertook some basic market reforms that put the country on a trajectory of extraordinary economic growth, averaging roughly 10 percent per year in GDP growth. Remember the rule of 70. A growth of 10 percent means that China has been doubling its GDP roughly every 7 years ($= 70/10$). This is absolutely astounding. Since China has grown at this torrid rate for almost 35 years, that is roughly 5 doublings ($= 35 \text{ years}/7 \text{ years per doubling}$). That, in turn implies that the economy has grown roughly by a factor of $2^5 = 32$ times since Deng Xiaoping opened the Chinese economy to market forces and international trade! In per capita terms, the growth is only slightly less impressive, at roughly 9 percent per annum, or 11.8% times overall between 1978 and 2013.

What does such extraordinary growth signify? To appreciate China's accomplishment, take the example of Shenzhen, which is a city very close to Hong Kong in southern China. In 1980, Shenzhen was a small, mainly rural village of some 30,000 people.



Figure 1.4: Shenzhen, 1980

Compare that with Shenzhen today.



Figure 1.5: Shenzhen, 2013

Now, with nearly 10 million people, this modern metropolis is incomparable with its roots just three decades earlier. This kind of torrid growth is characteristic of China's Eastern seaboard, where coastal cities became powerhouses of international trade. More than 200 million people have flocked from the countryside to the cities in search of new jobs in industry and services. China has become the world's largest trading country and the industrial workshop of the world.

China's experience has the hallmarks of modern economic growth, albeit in a turbo-charged version. The economy has proceeded from rural to urban, from agricultural to industrial and service-oriented. It has gone from high fertility rates (many children per woman) to low fertility rates, and from high child mortality to low child mortality. Life expectancy has soared, public health has improved, and educational attainment has gone up steeply. With its vast population, and strong educational orientation, China now turns out more PhDs per year than any other place in the world. And all of this has happened in the span of just a bit over three decades. This is the kind of remarkable experience that inspires many countries to aim to end poverty in their own midst.

We mustn't leave the impression that all is well with China's economic growth. There have been at least three downsides. First, the rapid transition from rural to urban, and from farming to industry and services, has disrupted the lives of hundreds of millions of people, causing mass migration within China, and disrupting families, as fathers and mothers often went off to find work in the cities and left their children with grandparents in the countryside. Second, the inequality of income has soared, as urban workers have advanced in living standards, while the incomes of those left behind the countryside have often stagnated. Third, the physical environment has been devastated, with massive pollution coming alongside China's massive industrialization. Indeed, as we shall see, the pollution has become so bad that it actually shortens life spans and creates mass illness. China, in short, has achieved rapid economic growth but has not yet achieved sustainable development, meaning growth that is also socially inclusive and environmentally sustainable.

IV. Improvements in Global Health

Global growth in GWP per capita has been accompanied by another positive development: the improvement in public health. Higher incomes have meant improved food security for many (though also unhealthy diets leading to obesity). Advances in technology in agriculture and industry have also been accompanied by rapid advances in health technologies, including medical advances such as antibiotics, vaccinations, diagnostics, and vast improvements in surgery, as well as advances in other fields with major health benefits, such as improved provision of water supplies, sewerage and household sanitation.

Around 1950, for every 1,000 children who were born an estimated 134 would not survive till their first birthday. That number, 134 deaths under 1 year per 1,000 births, is called the infant mortality rate, or IMR. It signifies the proportion of newborns that won't survive to their first birthday, in this case, 13.4 percent (134/1,000). It is heartening that the IMR has been coming down sharply, to an

estimated 37 per 1000 today. But we must remember this means 37 of every 1,000 newborns (3.7 percent) still do not survive to their first birthday, dying of malaria, pneumonia, diarrheal disease or other preventable disease of infants. These are tragedies that continue to occur around the world, with around 5 million children, almost all in developing countries, succumbing by age 1, and around 6 million dying each year under the age of 5. Still, the drop from 134 to 37 in infant mortality is a tremendous accomplishment of economic development and public health systems (including improved medical care, greater food security, greater access to safe water and sanitation, and other contributors to improved health). The decline of mortality rates at all ages has improved the quality of life and certainly eliminated a lot of the tragedy and anguish that was part of humanity's existence until the improvements of public health and medical care in the past century.

With more children surviving and with health improving at older ages as well, the good news is that our life expectancy is also rising considerably. A good measure of this is life expectancy at birth. Life expectancy measures the average life span, taking into account the risks of death at each age. In the middle of the last century, in the five-year period from 1950 to 1955, the average life expectancy for the entire world population was around 47 years. Today, the estimated life expectancy at birth is roughly 71 years, and as high as 80 years in the high-income countries. This tremendous rise in longevity is another benefit of economic growth and material progress, and exemplifies a broad trend of improvement that is being achieved in most parts of the world.

The first major economic lesson of recent history is that the first pillar of sustainable development – prosperity achieved through economic growth – is achievable on a large scale, and indeed is being achieved in large parts of the planet. Most parts of the world have been benefitting from a rise in GDP per person. That increase in GDP per person has been accompanied by several structural changes in society: from rural life as peasant farmers to urban life with employment in industry or services. There are fewer tragic deaths of young children and greater health and longevity for most of us, with life expectancy now several decades higher than what it was in the middle of the 20th century.

China's experience, repeatedly somewhat less dramatically in many other countries, shows that high per capita incomes need not be the preserve of a small, narrow part of the world as it was until recently (covering the US, Canada, Europe, Japan, Australia and New Zealand, but very few other places), but can in fact be achieved most everywhere. However, as we noted briefly in the case of China, even rapid economic growth is not sufficient to ensure wellbeing. We must ensure that the economic growth is inclusive and does not leave millions of people behind. We must ensure that economic growth is environmentally sustainable, so that the progress does not undermine the Earth's life-support systems of high biodiversity, soil productivity, a safe climate, and productive oceans. Unless we combine economic growth with social inclusion and environmental sustainability the economic gains are likely to be short-lived, as they will be followed by social instability and a rising frequency of environmental catastrophes.

PART 3: CONTINUING POVERTY IN THE MIDST OF PLENTY

In many ways we already live in a world of plenty. Economic growth has produced incredible wealth, and most parts of the world have escaped from extreme economic hardship. Countries like China that were once very poor are now middle-income countries. Yet despite these advances, parts of the world remain stuck in extreme poverty. Perhaps the most urgent economic challenge on the planet is to help populations still living at the edge of survival to achieve economic growth and the escape from poverty.

What is extreme poverty today? Figure 1.6 shows a smallholder farmer living in northern Ethiopia, in the Koraro village of Tigray Province, the site of a Millennium Village. The farmer is hidden behind a great bale of grain, carried by his donkey. There is no modern transport, no electricity grid. The land is parched. This is a dry region of poor farm households, eking out a living and trying to ensure enough annual food production to feed themselves and their families. If they are lucky, they may produce a small surplus of grain to bring to market for a bit of cash income.



Figure 1.6

Figure 1.7 shows a street in Nairobi's Kibera slum, the urban face of extreme poverty. Hundreds of millions of people live in urban slums around the world. Often urban poverty abuts right up against great urban wealth. Looking closely, we see an unpaved muddy road that is not really passable by vehicles. As the photo shows, people living in this slum may see power lines overhead, but may be too poor to be connected. These people also probably get by without modern sewerage or household sanitation, often having to defecate in empty fields. They are perhaps buying their water from a water truck because there is piped water to the individual households and perhaps not even a shared public water stand for the community.



Figure 1.7

In short, even though these slum dwellers are living in an urban area of several million people, they are, like their counterparts in northern Ethiopia, mostly unable to secure basic needs, to access emergency health care, electricity, adequate nutrition, clean cook stoves, safe water and sanitation. They may barely eke out a living in informal employment. They may earn just enough to buy a minimum of food, water, clothing, and shelter.

Extreme poverty is a multi-dimensional concept. Poverty is typically described as the lack of adequate income, but extreme poverty should be understood in more general terms as the inability to meet basic human needs for food, water, sanitation, safe energy, education, and a livelihood. Extreme poverty means lacking modern energy for safe cooking, such as natural gas, with the household instead relying on wood-burning stoves that cause chronically smoke-filled homes and subsequent respiratory diseases of the children. Extreme poverty often means that the households cannot secure decent schooling for their children. There may be no school nearby, or no qualified teacher, or a school that charges tuition beyond the household's income.

People living in extreme poverty are, simply put, people who cannot meet their basic needs. Life is a daily struggle for dignity, and even for survival. While the numbers living in extreme poverty around the world have been declining, and the proportions of the world population living in extreme poverty have been shrinking even faster in recent decades, the numbers of people still struggling in extreme poverty are staggering. Depending on one's estimate and the exact definitions used, more than 1 billion people,

and perhaps as many as 2.5 billion people, can be categorized as living in extreme poverty. It is probably accurate to say, and shocking to think about, that around one billion people struggle each day for their mere survival. They worry about whether they will they have enough to eat; they worry that unsafe water will cause a life-threatening disease; that a mosquito bite transmitting malaria will take the life of their child because they cannot afford the 80-cent dose of medicine needed to treat the infection.

This struggle for survival occurs in both rural and urban areas. It is still predominantly rural (perhaps in a ratio of 60-40), but it is increasingly taking on an urban face in the world's slums. Where is this extreme poverty? One shortcut is to look at the GDP per person around the world. As a general principle, economies with low GDP per capita also tend to be places where households live in extreme poverty. Figure 1.8 is a color-coded map of the world, where the colors denote the GDP per capita measured in purchasing-power-adjusted terms (in 2011 prices). The map shows the huge variation in per-capita GDP around the world. The countries in red have GDP per capita above \$35,000. There are not too many of them: the United States and Canada, most of Western Europe, Japan, Australia, and a few small, oil-rich states in the Middle East. By and large, extreme poverty has been completely eliminated from those countries.

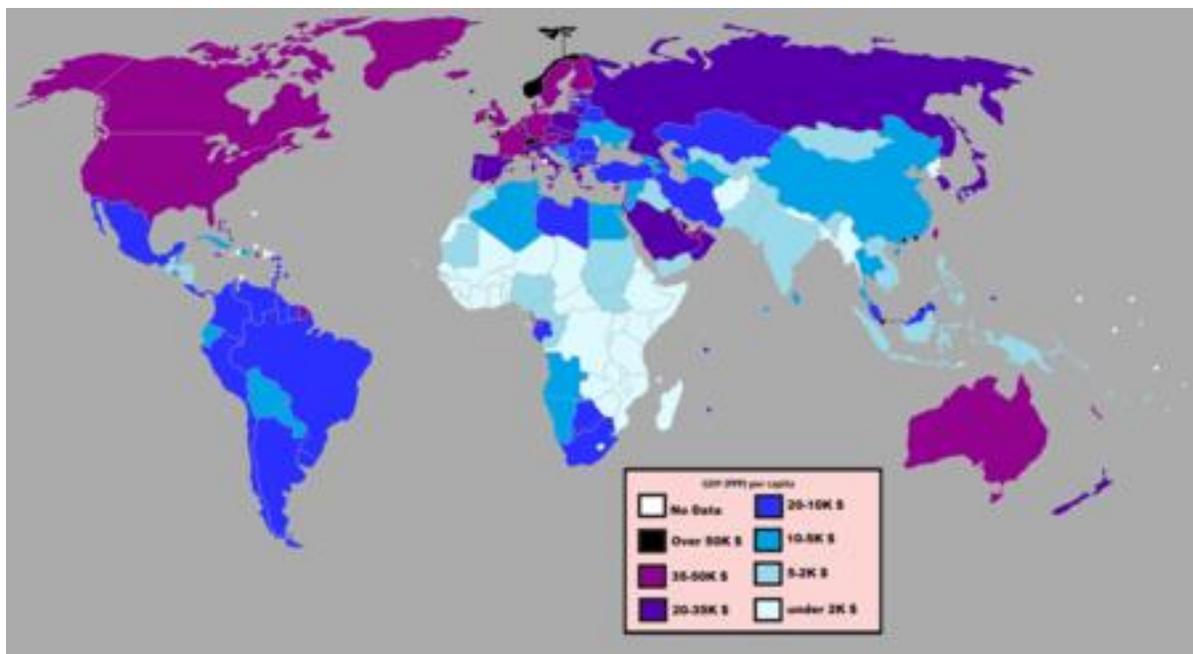


Figure 1.8

Next come the countries colored purple, with GDP per capita between \$20,000 and \$35,000, still high by world standards. These include Israel, Korea, New Zealand, Russia, and several countries in Central Europe. Contrast that with the very light blue parts of the world. These are the places of very low GDP per capita, less than \$2,000 in PPP terms, and also the highest concentration of populations living in extreme poverty. It is clear from this map that the poorest countries in the world are concentrated in tropical sub-Saharan Africa, those countries lying south of Northern Africa and north of the Southern tip of Africa. Many of these tropical African countries are very poor, with around half of the population

living in extreme poverty. The next poorest region, also home to vast numbers of people living in extreme poverty, is South Asia—including India, Pakistan, Nepal and Bangladesh. Even though the GDP per capita is typically higher in South Asia than in tropical Africa, the South Asian economies have vast populations and many people living in extreme poverty. In both Africa and South Asia, the proportions of households living in extreme poverty have been falling, but there still is a huge challenge in ending extreme poverty in both tropical Africa and South Asia, a subject we will consider in detail in a later chapter.

Notice as well a few other places with pockets of poverty, such as landlocked Bolivia in South America and landlocked countries in Central Asia such as Mongolia. These are countries where poverty is high and geography is difficult. We shall see that being landlocked makes economic growth more difficult. Economic growth often depends on international trade, but international trade is very hard for countries that are hundreds or even over a thousand kilometers from a port, and where the port is in another country to boot. (Coastal countries with ports are often relatively hostile to their landlocked next-door neighbors, since they've sometimes fought wars over access to the sea.)

Figure 1.9 maps another aspect of extreme poverty: the mortality rate of infants (deaths of children under 1 year per 1,000 births), for data around 2008. Infants living in extreme poverty face a burden of disease and much higher risks of mortality than non-poor children. Once again, where is the concentration of child mortality? Tropical Africa and parts of South Asia are again the epicenters of the global challenge.

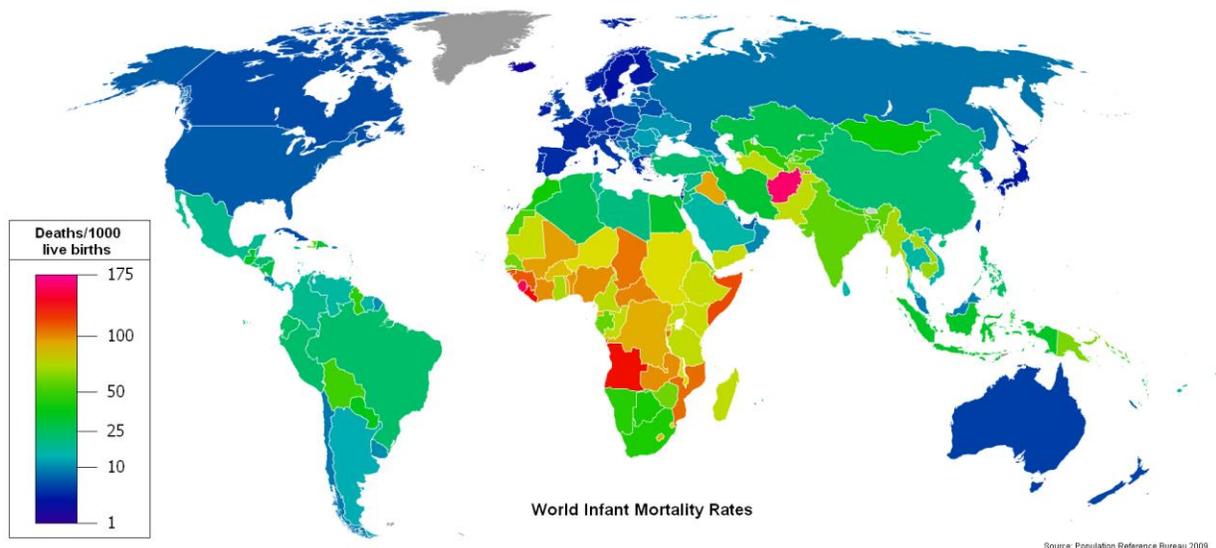


Figure 1.9

Even in countries where the vast majority of the population has escaped from extreme poverty, there can still be very significant pockets of poverty. Brazil is a case in point. Most of the poor in Brazil are

able to meet their basic needs (and hence should not be described as living in “extreme” poverty) but they are still vastly poorer and vastly disadvantaged compared with their richer urban neighbors. Sometimes the starkness of the divisions of income and social status are right in front of our eyes, and the eyes of the poor. Take for example the aerial view of Rio de Janeiro in Figure 1.10, with low-lying favelas in the foreground, and modern high-rises in the background.



Figure 1.10

As always with sustainable development there is hope for the extreme poor, and for those living in relative poverty as in Rio. There are practical approaches, things that can be done, to help even the poorest of the poor to meet their basic needs and help them succeed in the daily struggle for survival. We will be examining such approaches in detail later in the book. One that I find most exciting is the idea of Community Health Workers (CHWs) in poor villages and slums that bring health care to people who otherwise would be disconnected from the health system. We will see how modern technologies have made the CHWs especially effective in recent years.

We have noted that the extent of poverty has a strong geographical pattern. The highest proportions of extreme poverty are in tropical Africa and South Asia. We will study some of the reasons for this geographical pattern. It is not a coincidence. Geography shapes many things about an economy, including the productivity of farms, the burdens of infectious diseases, the costs of trade, and the access to energy resources. We will examine such geographical factors later in the book. Fortunately, geography is not destiny. Even if a particular region is vulnerable to specific diseases (such as malaria),

modern technologies also offer modern solutions. Geographical reasoning helps us to identify the high-return investments that can help the poorest of the poor to escape from poverty.

PART 4: GLOBAL ENVIRONMENTAL THREATS CAUSED BY ECONOMIC DEVELOPMENT

One of the most important messages of the field of sustainable development is that humanity has become a serious threat to its own future wellbeing, and perhaps even survival, as the result of unprecedented human-caused harm to the natural environment. Gross world product per person, now at \$12,000 per person, combined with a global population of 7.2 billion people, means that the annual world output is at least 100 times larger than at the start of the Industrial Revolution. That 100-time increase in world output (or even thousand-fold increase on particular dimensions of economic activity) results in multiple kinds of damage to the planet. Large-scale economic activity is changing the Earth's climate, water cycle, nitrogen cycle, and even ocean chemistry. Humanity is using so much land that it is literally crowding other species off the planet, driving them to extinction.

This crisis is felt by rich and poor alike. In October-November 2012 there were cars floating down New York's streets during the Superstorm Sandy, one of the strongest storms to hit the Eastern seaboard in modern times. And the impact of the storm was greatly amplified because the ocean level in 2012 was roughly one-third of a meter higher than it had been a century earlier, the result of global warming causing a rise in ocean levels around the world. Earlier in the year, US crops suffered major losses as the result of a mega-drought and heat wave in the Midwest and Western grain growing regions. Halfway around the world from New York City, also during 2012, Beijing experienced massive flooding following especially heavy rains. Bangkok experienced astounding floods in October 2011. Indonesia experienced heavy flooding in early 2014, while Australia suffered another devastating heat wave. All of these events were huge setbacks for the economy, with losses of life, massive losses of property, billions or even tens of billions of dollars of damage, and disruptions to the global economy. The floods in Bangkok, for example, flooded automobile parts suppliers, shutting down assembly lines in other parts of the world when the parts failed to arrive.



Figure 1.11



Figure 1.12

The particular disasters are varied, but it is clear that one broad category – climate-related catastrophes – is rising in number and severity. One major class of climate shocks is known as “hydro-meteorological disasters.” These are water- and weather-related disasters, including heavy precipitation, extreme storms, high-intensity hurricanes and typhoons, and storm-related flood surges such as those that swept over Manhattan, Beijing and Bangkok. Massive droughts cause life-taking famines in Africa, crop failures in the US, and a dramatic increase in forest fires in the US, Europe, Russia, Indonesia, Australia, and more. Other climate-related catastrophes include the spread of diseases and pests that threaten food supplies and the survival of other species.

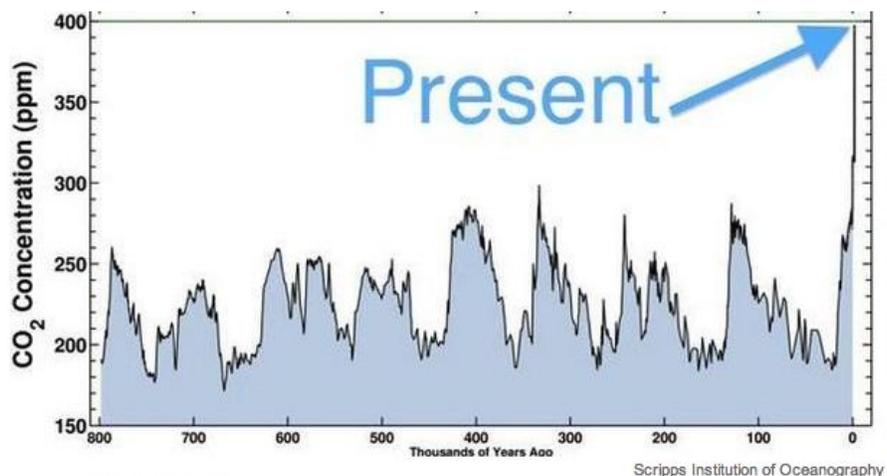
The frequency and severity of these threats have risen dramatically, and are likely to increase still further. Indeed, the re-shaping of the Earth’s physical systems – including climate, chemistry, and biology – is so dramatic that scientists have given our age a new scientific name: the *Anthropocene*. This is a new word that comes from its Greek roots: *anthropos*, meaning humankind, and *cene*, meaning epoch or period of Earth’s history. The Anthropocene is the era – our era – in which humanity, through the massive impacts of the world economy, is creating major disruptions of Earth’s physical and biological systems.

In the language of the scientists, human-induced changes are “driving” the Earth’s physical and biological changes. To a layman, the word “driving” might suggest that somebody is in control. That’s not what the scientists mean. They mean that humanity is *causing* changes that are large, serious, and highly disruptive, with most of humanity, including most political leaders, having little scientific understanding of the dangers ahead.

The study of sustainable development requires a deep understanding of these human-induced changes, most importantly so that we can change course and protect ourselves and future generations. One of the main drivers of change is humanity's massive use of coal, oil and natural gas, the primary energy sources we call fossil fuels. When we burn coal, oil and gas to move vehicles, heat buildings, transform minerals into steel and cement, and produce electricity, the combustion process produces carbon dioxide (CO₂) that is emitted into the atmosphere. The rising concentration of carbon dioxide in the atmosphere is the main, though not the only, source of human-induced climate change.

Figure 1.13 tells a remarkable story. It depicts the fluctuating levels of CO₂ in the atmosphere over the past 800,000 years. The distant past is on the left-hand-side of the figure; the present is all the way to the right. The vertical axis measures CO₂ in the atmosphere. The measurement unit is the number of molecules of CO₂ for every 1 million molecules in the atmosphere. As of today, there are around 400 CO₂ molecules per million; or 400 parts per million (ppm). That doesn't seem like very much: just 0.04%. Yet even small changes in this concentration have a big effect on the climate.

Start on the left-hand-side of the graph. 800,000 years ago, the CO₂ concentration was around 190 ppm. We see that it rose to peak around 260 ppm before falling to a low of around 170 ppm around 740,000 years ago. In general, CO₂ rises and falls like the teeth of a saw. These fluctuations are natural. They are "driven" (that is, caused) mainly by slight changes in the Earth's orbital patterns around the sun, changes involving the shape of the orbit, the slight variations in the Earth's distance to the sun, and the fluctuations in the tilt of the Earth relative to the plane of the Earth's orbit, causing slight changes in the pattern of the seasons. When the orbit changes slightly in ways that tend to heat the Earth, a feedback process tends to cause the release of CO₂ dissolved in the oceans, which then escapes into the atmosphere (just as CO₂ gas bubbles escape if one heats a pot filled with soda water). In turn, as the CO₂ rises in the atmosphere, the result is to warm the planet even more. We say that the rise of CO₂ is a "positive feedback." The change in the orbit slightly warms the planet; that releases CO₂ into the atmosphere, which in turn causes a further rise in temperature.



Ice core data before 1958

Figure 1.13

Scientists have shown that whenever the atmospheric concentration of CO₂ was high, the Earth tended to be warm (mostly because of the CO₂). Whenever CO₂ was low (because the atmospheric CO₂ was reabsorbed in the ocean), the Earth tended to be cold. Indeed, in the low phases of the natural CO₂ cycle, the Earth was actually cold enough to produce an ice age, with much of the northern hemisphere covered by a thick sheet of ice. By relating the concentration of CO₂ to the Earth's temperature (determined by other means), scientists have found a systematic relationship of high CO₂ and high Earth temperatures.

Now the far right-hand side of the graph shows that in the last blink of an eye in geological time, really in the past 150 years, the concentration of CO₂ has shot up like a vertical rocket. This is not because of natural changes in the Earth's orbit. This time, the rise in CO₂ has a human cause: the burning of fossil fuels. Notice the key and alarming point: humanity has pushed the level of CO₂ in the atmosphere to 400 ppm, higher than at any time in the past 800,000 years. Indeed, the last time the CO₂ concentration was so high was 3 million years ago, literally off the chart! And when the CO₂ level was that high 3 million years ago, the Earth was vastly warmer than today.

Why worry, you might wonder. The reason is that all of our civilization – the location of our cities, the crops we grow, and the technologies that run our industry – is based on a climate pattern that will soon disappear from the planet. The Earth will become much warmer than it has been during the entire period of civilization; the sea level will become much higher, threatening coastal cities and low-lying countries; the crops that feed humanity will suffer many devastating harvest failures as a result of high temperatures, new kinds of pests, droughts, floods, losses of biodiversity (such as pollinating species) and other calamities. We will study these threats in detail.

A few years ago, a group of scientists noted that what humanity is doing, including carbon emissions but also much more, is disrupting not just the climate, but in fact several of the Earth's natural systems. These include the depletion of freshwater sources (such as underground aquifers); the pollution from heavy use of chemical fertilizers (applied in order to improve crop productivity); the change in ocean chemistry, mainly the increasing acidity of the ocean, resulting from atmospheric CO₂ dissolving into the ocean water; the clearing of forests to create new pastureland and farmland; and particulate pollution caused by many industrial processes, especially involving the combustion of coal, all pose deep threats to the Earth and the wellbeing of humanity. These scientists argued that the extent of the damage is so large that humanity is leaving the "safe operating conditions" for the planet. It is as if we are driving the car right off the road and into the ditch, or worse, right over the cliff.

The scientists argued that it is urgent to identify the safe operating limits for the planet, or put another way, to define the "planetary boundaries" beyond which humanity should not venture. For example, pushing CO₂ to 400 ppm might be dangerous, but pushing CO₂ to 450 ppm (through continued heavy use of fossil fuels) could be reckless. Depleting some ground water could be inconvenient. Depleting major aquifers could be devastating. Raising the ocean's acidity slightly could be bad for shellfish.

Raising the ocean's acidity dramatically could kill off a massive amount of marine life, including the species of fish and shellfish that humanity consumes as a vital part of our food supply.

Figure 1.14 offers the scientists' visualization of these planetary boundaries. Starting at 12 o'clock and moving clockwise around the circle we see the 10 major planetary boundaries that humanity is in danger of exceeding, starting with climate change, ocean acidification, and so forth. The red shaded area shows the scientists' assessment of how far the world is from exceeding each of these boundaries. In the case of nitrogen flux (from fertilizer use) and biodiversity loss, the entire slice of the circle is red. We have already exceeded these planetary boundaries. For other threats, we are still some way from the boundaries, though the red-shaded portions of each slice of the pie are increasing rapidly. During the 21st century, the entire circle would likely turn red unless there is a fundamental change of strategy. Put another way, humanity will exceed the safe operating limits unless the world adopts a strategy to achieve sustainable development.

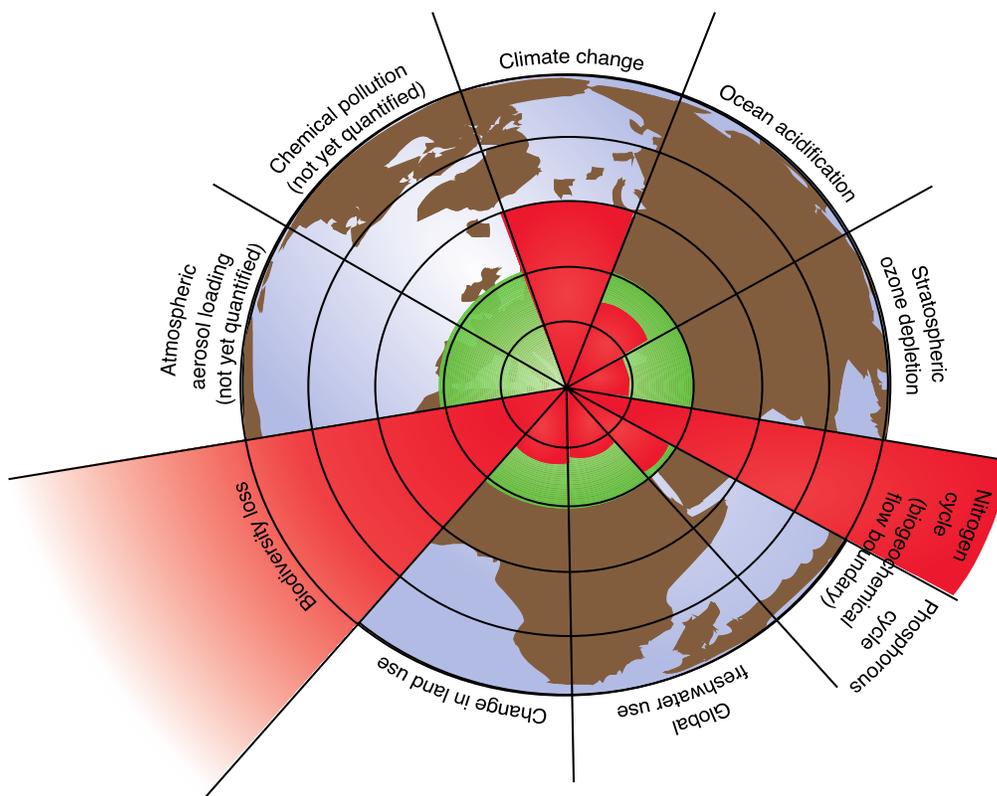


Figure 1.14

PART 5: PATHWAYS TO SUSTAINABLE DEVELOPMENT

The first part of sustainable development – the analytical part – is to understand the inter-linkages of the economy, society, environment, and politics. The second part of sustainable development – the normative part – is to do something about the dangers we face. Our goal should be to find a global

path, made up of local and national paths, in which the world promotes inclusive and sustainable economic development, thereby combining the economic, social, and environmental objectives. This can only be accomplished if a fourth objective – good governance of both governments and businesses – is also achieved. Good governance, I shall emphasize, means many things. It applies not only to government but also to business. It means that both the public sector (government) and the private sector (business) operate according to the rule of law, with accountability, transparency, responsiveness to the needs of stakeholders, and with the active engagement of the public on critical issues such as land use, pollution, and the fairness and honesty of political and business practices.

In the coming chapters, I will constantly refer to a comparison. On the one hand, we will consider the implications of humanity continuing on the current course. For example, suppose that the world economy continues as today to be run mainly on fossil fuels, so that the CO₂ concentration in the atmosphere continues to rise rapidly. Or suppose that farmers continue to overuse groundwater so much that the aquifers are depleted. These scenarios will be called Business as Usual, or BAU for short. Such scenarios will be compared with a dramatic change of course for humanity, one in which the world quickly adopts new technologies (for example, solar power to replace coal-fired electricity generation, or more efficient water use to avoid depleting the aquifers). The alternative path, one that aims not only for economic growth but also for social inclusion and environmental sustainability, will be called the Sustainable Development path, or SD for short.

We will examine and contrast the BAU and SD trajectories. If we continue with BAU, what would happen? Certainly there would continue to be many kinds of progress. Science and technology won't stand still. The poor will benefit from advances in information and communications technologies, such as access to higher education through free, online learning. Poverty would continue to fall in many places. The rich might continue to become richer for another decade or two. Yet eventually, the negative consequences of rising inequality and rising environmental destruction will come to dominate the positive tendencies. Progress will peak. Calamities, both social and environmental, will start to dominate. More than 200 years of progress could be choked off, and even sacrificed to war.

What about sustainable development? Can we find alternatives to fossil fuels, ground water, pasturelands, and the like, to meet human needs without destroying the physical environment? Some of the key solutions are likely to be more expensive in the short term, such as buildings specially designed to use less energy for heating through better design, insulation, materials, and overall systems strategy, or electric vehicles with battery power that are still expensive compared with normal gas-guzzling internal combustion engines. Some fear that we can't afford the SD path, that it might "save" humanity at the cost of ending economic progress. A major task in this book is to examine this claim. Without giving away the entire plot, I'll say at the outset that if we are clever, and apply ourselves to the study and design of new sustainable business practices and technologies, sustainable development is both feasible and affordable. Indeed, it is business as usual that eventually imposes the truly devastating costs.

The essence of sustainable development in practice is *scientifically and morally based problem solving*. We indeed have a lot of problems. We have continued life-threatening poverty in the midst of plenty. We have built up inequalities of wealth and poverty, and we have deployed technology systems that are now crossing planetary boundaries. We are going to need a coordinated global effort in a focused and relatively short period of time, a matter of decades rather than centuries, to move from the business as usual to the sustainable development trajectory. In order to accomplish that, every part of the world will have to be involved in problem solving, in brainstorming, and in determining new and creative ways to ensure inclusive and sustainable growth. The chapters ahead aim to contribute to that problem solving.