ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

OVERVIEW

Nature's Frontiers

Achieving Sustainability, Efficiency, and Prosperity with Natural Capital

Richard Damania, Stephen Polasky, Mary Ruckelshaus, Jason Russ, Markus Amann, Rebecca Chaplin-Kramer, James Gerber, Peter Hawthorne, Martin Philipp Heger, Saleh Mamun, Giovanni Ruta, Rafael Schmitt, Jeffrey Smith, Adrian Vogl, Fabian Wagner, Esha Zaveri

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Overview

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This booklet contains the overview from *Nature's Frontiers: Achieving Sustainability, Efficiency, and Prosperity with Natural Capital,* doi: 10.1596/978-1-4648-1923-0. A PDF of the full book is available at https://openknowledge.worldbank.org/ and http://documents.worldbank.org/, and print copies can be ordered at www.amazon.com. Please use the full version of the book for citation, reproduction, and adaptation purposes.

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Foreword

What an exciting World Bank report, breaking new ground! *Nature's Frontiers: Achieving Sustainability, Efficiency, and Prosperity with Natural Capital* is timely, given the explosion of interest in bringing nature into decision-making. It is also urgently needed. With the focus on natural capital as central for prosperity, the report makes abundantly clear that this is about so much more than nature-based or nature-positive solutions. Accounting for the work of nature is about accounting for the very foundation for sustainable futures—that is, the capacity of nature and its biodiversity to provide the essential ecosystem services that economic progress and societal development, as embedded parts of our living planet, ultimately rest upon.

This essential interplay is beautifully captured in the report's analyses of the efficiency gap: the difference between the set of goods and services that could be provided in a sustainable way and what is currently provided, without sacrificing other benefits. By combining innovative science, new data sources, and cutting-edge biophysical and economic models, the highly innovative NatCap team and colleagues from the World Bank derived, in an impressive manner, sustainable resource efficiency frontiers. Through these frontiers they assessed how as many as 146 countries can use their natural capital in more efficient and sustainable ways. This work is highly innovative, impressive, and significant!

They found that closing efficiency gaps in relation to biodiversity, carbon storage, agriculture, grazing, and timber returns can account for many of the world's pressing economic and environmental problems, like health, food and water security, climate change, and economic productivity. The report is truly encouraging and inspirational.

Science plays a vital role in making sense of the world, now more than ever in these turbulent times. Here, leading scientists forming the research front, in collaboration with leading policy experts, have generated stunning results of great value for guiding the urgently needed transformation toward biosphere stewardship and sustainable futures. Their novel and pathbreaking approach clearly shows that this way forward is not only environmentally and economically feasible but also hugely desirable.

Carl Folke
Professor and director, Beijer Institute,
Royal Swedish Academy of Sciences
Founding director and chair of the board,
Stockholm Resilience Centre

Stockholm, December 2022

Acknowledgments

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The landscape modeling, analysis, and drafting were carried out by the Natural Capital Project team, led by Stephen Polasky (University of Minnesota) and Mary Ruckelshaus (Stanford University) and comprising Kate Brauman, Jinfeng Chang, Rebecca Chaplin-Kramer, Adam Charette-Castonguay, Gretchen Daily, James Douglass, James Gerber, Peter Hawthorne, Matthew Holden, Justin Johnson, Ginger Kowal, Ian Madden, Saleh Mamun, Lisa Mandle, Eve McDonald-Madden, Issoufou Ouedraogo, Deepak Ray, Rafael Schmitt, Jeffrey Smith, Brent Sohngen, Adrian Vogl, Paul West, and Stacie Wolny.

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Main Messages

The great expansion of economic activity since the end of World War II has caused an unprecedented rise in living standards, but it has also caused rapid changes in earth systems. Nearly all types of natural capital—the world's stock of resources and services provided by nature—are in decline. Clean air, abundant and clean water, fertile soils, productive fisheries, dense forests, and healthy oceans are critical for healthy lives and healthy economies. Mounting pressures, however, suggest that the trend of declining natural capital may cast a long shadow into the future.

Recognizing the essential services provided by natural capital, *Nature's Frontiers: Achieving Sustainability, Efficiency, and Prosperity with Natural Capital* proposes a novel approach to address these foundational challenges of sustainability. A methodology combining innovative science, new data sources, and cutting-edge biophysical and economic models builds *sustainable resource efficiency frontiers* to assess how countries can sustainably use their natural capital in more efficient ways. The analysis provides recommendations on how countries can better utilize their natural capital to achieve their economic and environmental goals.

The report indicates that significant efficiency gaps exist in nearly every country in the world. Closing these gaps can address many of the world's pressing economic and environmental problems—economic productivity, health, food and water security, and climate change. The following is a summary of the key results:

- **Key finding 1: Significant efficiency gaps exist in the use of land in countries at all income levels and in all regions.** For most low-income countries, significant increases in net economic returns are possible without sacrificing environmental quality. In fact, there are opportunities to improve both economic output and environmental outcomes in most countries. On average, countries can almost double their performance in terms of either economic returns or environmental outcomes by improving on one dimension without a sacrifice in the other outcome.

- **Key finding 2: More efficient use of land could sequester an additional 85.6 billion metric tons of carbon dioxide equivalent with no adverse economic impacts.** This outcome is equivalent to about two years of global emissions at current rates and would give the world much-needed time to decarbonize before atmospheric greenhouse gas (GHG) concentrations reach critical levels. Because most tropical low-income countries have a comparative advantage in sequestering carbon through forests, they gain significantly more than any other group of countries from policies that reward land-based GHG sequestration initiatives.
- **Key finding 3: Better allocation and management of land, water, and other inputs could lead to increases in agriculture, grazing, and forestry annual income by approximately US$329 billion—and enough food production increases to feed the world until 2050—without net loss of forests and natural habitats.** Global populations are expected to reach 10 billion by 2050, and more food will be needed to meet global demands. Better cultivation strategies that close yield gaps, along with smarter spatial planning, can reduce the land footprint of agriculture while increasing global calories produced by more than 150 percent.
- **Key finding 4: Existing policies for reducing air pollution and the resulting mortality could be achieved with a 60 percent cost saving.** The 63 countries examined for air quality spent a total of US$220 billion—0.6 percent of their collective gross domestic product—on air pollution controls per year. These expenditures prevented 1.9 million premature deaths per year. If more economically efficient policies were adopted, the same results could be achieved at an even lower cost—only US$75 billion, or less than US$40,000 per life saved.
- **Key finding 5: More efficient air pollution policies could have saved significantly more lives with the same level of spending.** Had countries spent the same amount of money to abate particulate matter but implemented the most efficient policies instead of the abatement policies they actually implemented, they would have prevented an additional 366,000 premature deaths each year—a 20 percent improvement over the current level of avoided premature deaths.
- **Key finding 6: Although richer countries are more efficient at abating air pollution, there are examples of good performers and underperformers across all income groups.** Most high-income countries perform relatively well in terms of pollution abatement and, consequently, reducing negative human consequences, but being a high-income country does not automatically ensure good performance.

No one-size-fits-all solution exists, given the differences in endowments, needs, and capacities among countries. Instead, this report identifies what changes are needed and where these changes need to occur in a country. It also develops a policy filter for choosing the most appropriate policy mix for the country. The result is a detailed roadmap that can assist in the selection of approaches that are most feasible and affordable in each country. The report also drills down into specific country examples of priority reforms to illustrate how to put these tools into action.

Given countries' competing needs and stretched budgets, tackling inefficiencies remains among the more cost-effective and economically attractive ways to achieve global sustainability goals. As global populations expand and the climate changes, pressures on common property natural resources will inevitably escalate, and economic consequences will worsen. This report demonstrates that there are significant opportunities for using the world's scarce and valuable natural capital more efficiently. Although the approach outlined in this report will entail demanding policy reforms, the costs of inaction will be far higher.

Abbreviations

CO_2eq	carbon dioxide equivalent
GDP	gross domestic product
GHG	greenhouse gas
PES	payment for ecosystem services
PM	particulate matter

Overview

Introduction

All economies rely on a combination of both natural and produced capital to develop and grow. Both types of capital are critical to supporting food and supply chains, protecting against extreme weather events, regulating climate, and maintaining nutrient balances. However, the complementarity between these two forms of capital is often taken for granted. Indeed, for most of human history natural capital was plentiful, so progress was based on building new physical capital rather than sustaining natural capital.

The resulting expansion of economic activity over the last century has lifted billions of people out of poverty and raised living standards. But it has also caused rapid changes in the planetary systems. Air pollution from fine particulate matter ($PM_{2.5}$) and other emissions now kill more people than all wars and forms of violence combined. The dismantling of forests, degradation of soils, and destruction of wetlands have reduced the fertility of land and the functionality of watersheds. Land use change alone has contributed 4.8 billion metric tons of carbon per year to the atmosphere since 1900, representing a 35 percent of total carbon dioxide (CO_2) emissions over that time period.[1] And natural habitat conversion is accelerating the loss of flora and fauna with impacts on biodiversity and critical ecosystem services such as pollination, water purification, and pest control that are vital to healthy economies and healthy populations. Natural capital, once plentiful, is on the decline almost everywhere on earth.

To some observers, the degradation of natural capital, like the canary in the coal mine, is an obvious sign of unsustainable economic activity. Others, however, note that economic growth continues unabated and that living standards have improved significantly since the Industrial Revolution, despite environmental stresses. According to this view, environmental and natural resource degradation is the price to be paid for progress. Balancing increases in living standards and well-being with maintaining natural and other forms of capital that enable future growth is the crux of the sustainability problem. Although few issues are as important for the planet and the economy, none is more complex and controversial. And yet in practice, it has proven difficult to determine whether a particular country is on a sustainable economic trajectory. Difficulties arise because these issues transcend disciplines—ecology, economics, and ethics—with each offering different insights, perspectives, and answers. Bridging disciplinary divides, though difficult, is necessary to address this challenge.

Based on a study that combines innovations in interdisciplinary modeling with new data, this report provides for the first time a set of statistics that can be used by countries to identify inefficiencies in natural resource allocation, evaluate trade-offs across assets, and guide policies. State-of-the-art analyses utilizing big data and integrated natural science and economic models are employed to estimate the opportunities in each country to close the resource efficiency gap—that is, given a country's resource endowment, the gap between what is produced and the maximum that could be produced without lessening other benefits or compromising sustainability. The results highlight the relationships—both substitutability and complementarity—between natural capital and other forms of capital.[2]

This report describes significant efficiency gaps at the global level. For example, more efficient spending on preventing air pollution would save, for the same amount already being spent, an additional 366,000 lives each year. Better allocation of land to its most productive uses would allow some countries to produce up to 80 percent more in land-based revenue without adverse environmental impacts. And improvements in allocation and efficiency would allow countries to mitigate about 20 percent more CO_2 equivalent (CO_2eq) emissions (about 78 billion metric tons) without reducing economic activity. Many of these opportunities are in low- and middle-income countries, which would benefit the most if these greenhouse gas (GHG) sequestration gains were monetized.

Such large inefficiencies are not surprising because natural capital is routinely underpriced. Underpricing leads to two kinds of economic "distortions." First, because they are underpriced or free, these resources are often used wastefully and inefficiently. Second, the "wrong" price also implies that these resources are seldom allocated in ways that maximize the value that they could produce, resulting in inefficiencies. For example, water for irrigation is typically provided for free, and so it is used wastefully and not allocated to its most productive uses. The consequence is depletion and degradation far in excess of what would be deemed economically beneficial from a benefit-cost calculus.

Inescapable trade-offs and hidden inefficiencies

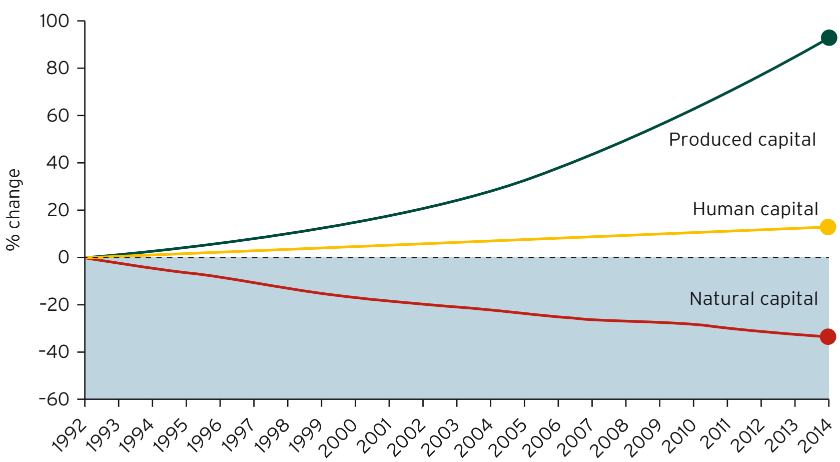
In a world beset by scarcity, where needs and wants exceed the available resources, trade-offs will always exist. Economies are constrained by the availability of finite labor, land, natural resources, and produced capital. In his well-known work *An Inquiry into the Nature and Causes of the Wealth of Nations,* British moral philosopher Adam Smith argued that the embrace of free markets, influenced by the "invisible hand," would lead to the most efficient allocation of scarce resources (though rarely the most equitable outcome). But even Smith, the father of modern economics, recognized that market failures could preclude achieving efficient outcomes. Indeed, he acknowledged that when benefits accrue to many individuals, such as from a great public work or a tract of forest or wetland, no individual has the incentive to pay for its costs or its maintenance. It took 150 years for the market failures identified by Smith to make their way into the toolbox of contemporary economics—first through the concept of "externalities" introduced by British economist Arthur Pigou in 1927 and then via the notion of the "tragedy of the commons" in the 1960s.

An inability to invest in and value natural capital for all the services it provides has been a large source of inefficiency and market failures and one of the most significant examples of the tragedy of the commons. Businesses and households benefit from natural capital, but rarely does any individual business or household have enough benefits, or enough control, to ensure its continued existence. This is largely the reason why the world has witnessed an unprecedented decline in natural capital in nearly every sector and in every corner of the planet. This decline in natural capital is summarized in figure O.1 (Dasgupta 2021).[3]

Identifying opportunities and balancing trade-offs

Correcting market inefficiencies creates opportunities to improve productivity. Indeed, the very definition of a market failure is that the best feasible outcome has not been reached, suggesting that there is scope for improvement. In developing

FIGURE O.1
Global changes in produced, human, and natural capital per capita, 1992–2014



Source: Dasgupta 2021.

country contexts, this is especially true. There, weak institutions, unpriced externalities, poor governance, and coordination failures inhibit economic growth and well-being, impede efficiency, and lead to suboptimal outcomes. Often, misaligned incentives are worsened by distortionary policies that promote pollution, degradation, and overuse of resources. Indeed, one of the many roles of multilateral financing institutions and development-related nongovernmental organizations is to assist in finding and correcting market imperfections and policy deficiencies.

In addition to the immediate causes of misallocation and inefficiency (such as "wrong" prices and distorted incentives), there are indirect drivers of change, which may have more powerful effects. Often, macroeconomic policies, trade regimes, fiscal policies, and intrusive infrastructures can have large impacts on natural resources that may negate the effects of conservation and sectoral policies. By addressing the inefficient use of natural capital countries can seek such opportunities.

To shed light on these opportunities, this report examines land- and air quality–related market *imperfections*. Innovative science, taking advantage of novel methods and new data sources, is a source of information about ecosystems and their economic and health impacts, and it offers a standard method for evaluating the consequences of changes in natural capital. The outcome of this new approach yields the construct of a *resource efficiency frontier* (box O.1). This frontier describes the maximum sustainable outputs (economic and environmental) that can be produced with given endowments, as well as the transition costs to reach the frontier. Thus a country within the resource efficiency frontier

BOX O.1
Defining a resource efficiency frontier

The methodology of this study relies on a resource efficiency frontier estimated for each of the 146 countries and economies recognized by the World Bank with a land surface area greater than 10,000 square kilometers (exceptions stemming from data issues are noted in the online technical appendix.[a]) The efficiency frontier indicates the maximum amount of income and environmental services that could be obtained if resources are allocated and used efficiently and if behavioral biases are overcome through good policy. The efficiency frontier also indicates the maximum amount that could be produced with given endowments and technologies. Movements along the frontier define trade-offs among economic, environmental, and health goals.

Movements to the frontier represent efficiency gains that need not involve trade-offs. For example, in the landscape analysis a country could choose to maximize food production by converting all forests to intensive agriculture at the expense of the environment—point A in figure BO.1.1. On the other hand, it may choose to protect all forests and only pursue

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BOX O.1
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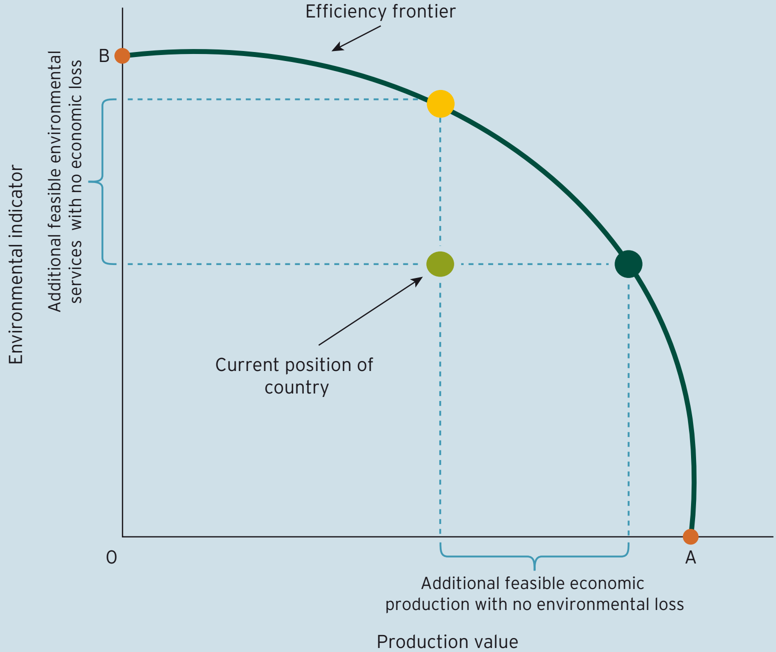
FIGURE BO.1.1
Example of efficiency frontier



Source: World Bank.

agriculture on unforested lands—point B in figure BO.1.1. Between these two extreme options is a nearly infinite set of other possibilities, which are represented by the efficiency frontier curve (dark blue curve in figure BO.1.1).

For the air pollution analysis, a similar efficiency frontier is used. In this case, the horizontal axis is replaced with spending on air pollution abatement and the vertical axis is replaced with premature deaths prevented. A country with low ambitions (that is, low levels of spending to reduce air pollution) but that is highly efficient in the little amount that it does spend would sit near point A in figure BO.1.1. Conversely, a country that has both high ambitions and efficiency of spending would sit near point B.

For each country, the shape of the efficiency frontier is unique and depends on geography, climate, economic structure, and current conditions. Comparing where a country is relative to where it could be on the frontier is an indication of the efficiency gap. In countries that are highly efficient, the current scenario will be very close to the frontier curve. Here, improving economic output or environmental outcomes may involve steep trade-offs between the two. However, for countries that are far from their frontier, opportunities may exist to improve economic and environmental outcomes simultaneously.

a. The online technical appendix (appendix B) is available with the text of this Overview booklet in the World Bank's Online Knowledge Repository, https://openknowledge.worldbank.org/handle/10986/39453.

will gain by moving toward the frontier. In countries that are already operating on or close to their efficiency frontier, trade-offs are unavoidable, and these are identified and quantified.

Key findings of this study

The efficiency frontier approach is flexible and can be used to measure outcomes across a virtually unlimited number of dimensions. This report applies this approach to two of the most significant natural capital assets—land and (clean) air. The first part of the report examines three land-based services: economic production (agricultural crops, grazing, and forestry), carbon sequestration, and biodiversity. It introduces metrics for the joint efficiency of all three indicators, as well as individual efficiency measures. The incorporation of water-related issues in the land frontier ensures that efficient outcomes are based on the sustainable use of water.

The second part of the report assesses efficiency in the control of air pollution, especially $PM_{2.5}$ emissions. Of air pollutants, $PM_{2.5}$ claims the majority of lives and has a host of other negative effects. The air pollution efficiency frontier measures the additional health benefits (lives saved) from more efficient spending on pollution abatement. However, examining the efficiency of spending on its own is seldom adequate. A country may be efficient in its spending on pollution abatement, but may spend little to prevent the loss of lives to pollution. The level of policy ambition must, then, be considered, together with the effectiveness of those policies. The analyses demonstrate that vast inefficiencies can be corrected.

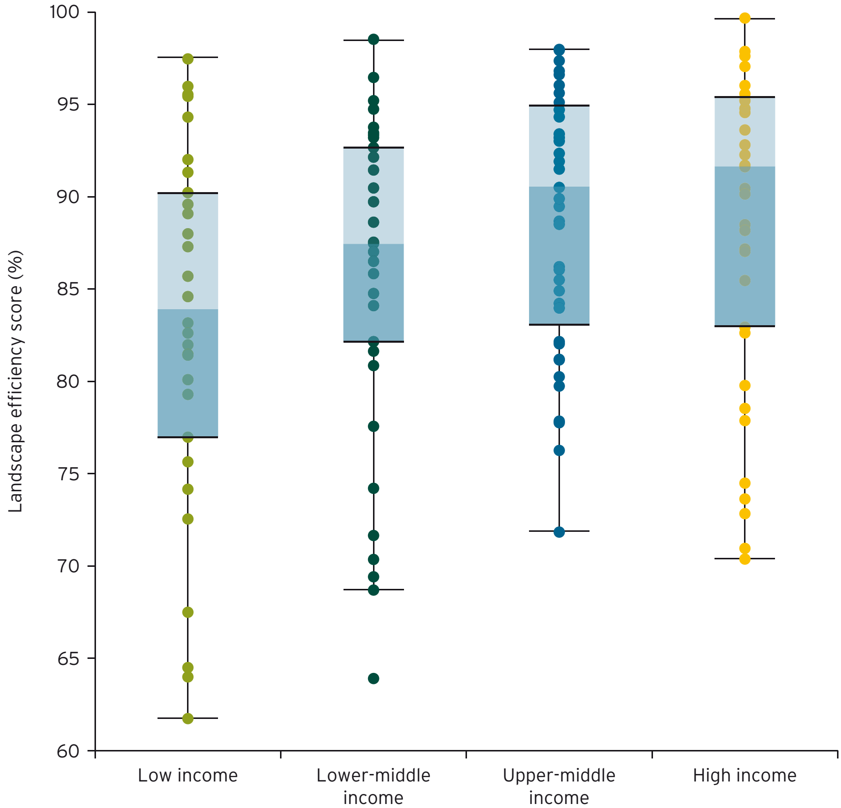
The full results of this study by country appear in appendix A of the full text of the report.

The efficiency of landscapes

Finding 1: Efficiency gaps are found worldwide, irrespective of income levels or the region in which a country is located. This analysis finds that across development levels are opportunities for simultaneously expanding economic output and improving environmental conditions. Globally, efficiency scores range from a low of 61.8 percent to almost full efficiency (about 99 percent). Of the 146 countries and economies included in the study, only 29 are within 5 percent of their efficiency frontiers. Thus most countries have significant opportunities to improve efficiency in at least one of the dimensions of land use investigated. This implies that in most countries, trade-offs between economic and environmental goals are not inevitable. Although there is considerable heterogeneity, on average countries can almost double performance in at least one dimension without reducing any other dimension. For most low-income countries, significant increases in net economic returns are possible without sacrificing environmental quality. In most high-income countries, substantial increases in greenhouse gas mitigation or biodiversity can be made without sacrificing net economic returns. Indeed, there are opportunities to improve on both economic efficiency and environmental services in the vast majority of countries. Richer countries are not consistently more efficient across all dimensions than their poorer counterparts, as is often assumed (figure O.2). Other factors tend to dominate in determining overall performance, and a typology of five types of countries emerges (see box O.2).

Finding 2: Significant scope exists for achieving global climate goals without economic losses (and possibly gains of land-based revenue) by means of ecosystem-based solutions. These solutions call for more efficient use of resources and better allocation of land to its most productive uses. The efficiency frontier analysis can determine the potential for GHG mitigation that

FIGURE O.2
Distribution of landscape efficiency scores, by country income group



Source: World Bank.
Note: Circles represent individual country scores. The mean value across countries in each income group is indicated by the horizontal line that extends across the box. Inside the box, the upper, light blue portion is the second quartile (25th–50th percentile), and the lower, dark blue portion is the third quartile (50th–75th percentile). Outer lines are useful for identifying outliers.

BOX O.2

Typology of countries, landscape analysis

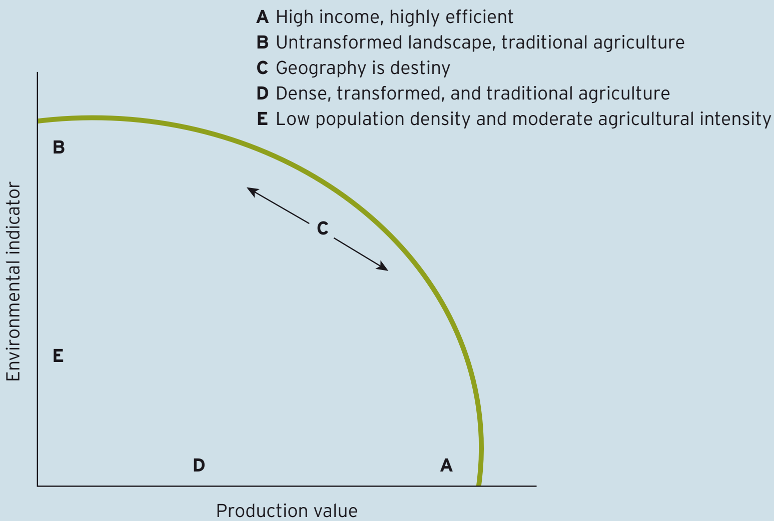
As shown in figure O.2, income level is a poor determinant of performance in the landscape efficiency score because variation in performance within country income groups tends to dominate variation in performance across income groups. Thus the typology of countries derived for this study is based on other characteristics. Figure BO.2.1 shows the general location of each type of country vis-à-vis the efficiency frontier. The types have the following characteristics:

A. *High income, highly efficient*. These mainly developed economies (such as the more advanced members of the European Union and the high-income members of the Organisation for Economic Co-operation and Development) tend to be very close to their maximum economic potential, despite not uniformly performing well on environmental goals. Thus shifts to becoming more environmentally friendly economies may require economic trade-offs or a structural change in the economy or technology that is available to shift the frontier curve.

B. *Untransformed landscape, traditional agriculture.* These countries, largely located in West Africa and the Amazon region, have more than two-thirds of their land in natural habitat and almost uniformly tend to perform close to their maximum potential on the environmental indicator. Notably, for many there is room to improve economic productivity without diminishing environmental performance, mainly via sustainable intensification of agriculture to close their often significant yield and total factor productivity gaps. Many of these countries have a global comparative advantage in terms of their greenhouse gas sequestration potential.

FIGURE BO.2.1

Typology of countries, landscape analysis



Source: World Bank.

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BOX 0.2
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C. *Countries where geography is destiny*. Usually characterized by large deserts or proximity to the Arctic Circle, these countries are located close to or on the efficiency frontier because of their resource, climate, or geographic endowments. Common to this group are extreme climatic conditions or terrain that make agriculture difficult and limit the diversity of species that can survive. Thus these countries may perform close to their maximum potential on either the environmental side or the economic side, or both. In short, when very little production is possible, these countries will be efficient.
D. *Dense, transformed, and traditional agriculture*. These middle-income economies in Asia and Africa, for the most part, have converted large amounts of natural land—often tropical forests—to agriculture, but their agricultural land productivity is low. A shift to more intensive agriculture while returning much of the landscape to its natural state could lead to gains in both economic and environmental outcomes.
E. *Low population density and moderate agricultural intensity*. In these countries, mostly located in Latin America and eastern Europe, land tends to not achieve its full potential in economic or environmental outcomes. These economies often have large swaths of mostly grasslands that have high potential for agriculture or grazing but are unfarmed. Similarly, if these lands were (re)forested, they would support much higher levels of biodiversity or carbon sequestration.

would not diminish other important services offered by the landscape such as economic returns, beneficial health impacts, and biodiversity. More efficient use of land, including restoration of degraded areas, is an opportunity to mitigate an additional 85.6 billion metric tons of CO_2eq with no trade-offs in economic production or biodiversity support. This amount, equivalent to 1.7 years of global emissions at current rates, would give the world much-needed time to decarbonize before atmospheric greenhouse gas concentrations reach critical tipping points. More significantly, most countries in the Congo Basin—the so-called second lung of the planet—have been transformed from net sinks to net sources of GHG emissions. Finding ways to reconcile growth without degrading forest cover in this region will be pivotal to meeting global climate goals and avoiding climate tipping points because there is no feasible pathway to these ambitions without addressing deforestation. This report identifies where such opportunities for growth without deforestation lie in these and other countries. It points out that low-income tropical countries would be the greatest beneficiaries of a policy that recognizes and rewards increases in greenhouse gas sequestration services because of both their natural endowments and the relative comparative advantages of low-income countries.

Finding 3: Better allocation and management of land, water, and other inputs can lead to an increase in agricultural, grazing, and forestry income of approximately US$329 billion[4]—as well an increase in food production large enough to feed the world to 2050—without loss of biodiversity or GHG

sequestration services provided by forests and natural habitats. Agricultural expansion has been among the significant drivers of the decline in natural habitats. And with the global population expected to reach 10 billion by 2050, more food and agricultural products will be needed to meet global demands. Nevertheless, better cultivation strategies and smarter spatial planning can reduce the ecological footprint of agriculture and create space to produce about 80 percent more net value of agriculture production per year without adverse consequences for GHG sequestration or biodiversity in some biomes.[5] Doing so would also increase total sustainable calorie production by over 150 percent, or well above most estimates of what will be needed to feed the world in 2050, which range from 50 to 100 percent increases. Addressing current and future food security challenges without depleting forests would be a game changer for the planet and would go a long way toward meeting several of the United Nations' Sustainable Development Goals. Approximately 55 percent of these gains would come from intensification of economic lands (agriculture, livestock, and forestry). The residual gains would come from reallocation of land to more productive uses. Notably, most low- and middle-income countries are achieving less than half of their potential output, whereas high-income countries are reaching, on average, 70 percent of their potential output.

The efficiency of air pollution controls

Finding 4: Policies for reducing air pollution and the resulting mortality could be implemented more efficiently, thereby realizing a 60 percent cost saving. The 63 countries examined for air quality together spent US$220 billion—0.6 percent of their collective gross domestic product (GDP)—on air pollution controls. These expenditures prevented 1.9 million premature deaths per year, which is equivalent to preventing about 40 percent of total deaths from outdoor exposure to $PM_{2.5}$. Even before accounting for inefficiencies, these expenditures are a remarkably cheap way to save lives—approximately US$115,000 in cost per life saved. And indeed, if more economically efficient policies were adopted, the same results could have been achieved at a lower cost—only US$75 billion, or less than US$40,000 per life saved. There are several reasons for this large efficiency gap. In some cases, it stems from a lack of information that has involved either targeting the wrong pollutant or using what turned out, in retrospect, to be a less efficient technology. But it is also a consequence of permissive policy regimes that paid insufficient attention to the health consequences of air pollution in choosing technologies and fuels.

Finding 5: More efficient air pollution policies could have resulted in saving significantly more lives at the same cost. As a corollary, rather than examining potential cost savings, one could also look at the lives potentially saved. Had countries spent the same amount of money to abate $PM_{2.5}$ but implemented the most efficient policies, they would have prevented an additional

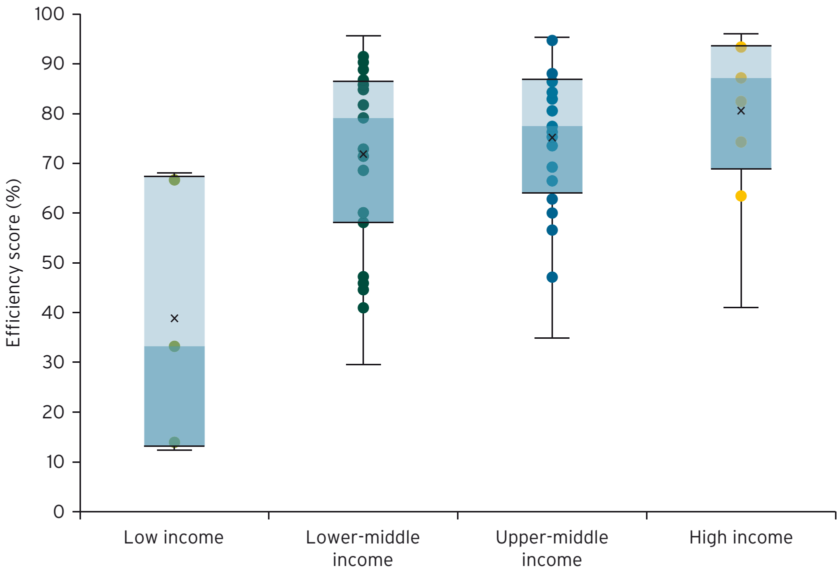
366,000 premature deaths each year (a 20 percent improvement over the current level of prevented premature deaths).

Finding 6: On average, richer countries are more efficient at abating air pollution, but there are good performers and underperformers across all country income groups. Although richer countries generally have better air pollution outcomes (that is, lower mortality rates due to less air pollution), they are not uniformly the most efficient at abating air pollution (see figure O.3). Some low-income countries abate very little pollution, but they do so in a highly efficient and cost-effective manner (see box O.3).

Headwinds to change

Policy makers seeking to achieve the efficiency gains identified in this report face significant headwinds. Indeed, if change were easy it would have already been achieved, especially in view of the magnitude of the potential gains. Many forces are working against correction of market failures. They include political economy factors such as asymmetric lobbying power and distributional concerns, challenges with incentivizing financing for protecting and managing common property resources, and the global nature of many of these externalities.

FIGURE O.3
Air pollution: Efficiency scores, by country income group



Source: World Bank.
Note: The upper and lower bounds of a box define the upper and lower quartiles of the distribution—that is, 75th and 25th percentiles. The horizontal bar inside the box indicates the median of the distribution. The whiskers indicate the maximum and minimum values, not taking into consideration outliers. The dots are observations, and the x in each box signifies the mean.

BOX 0.3
Typology of countries, air quality analysis

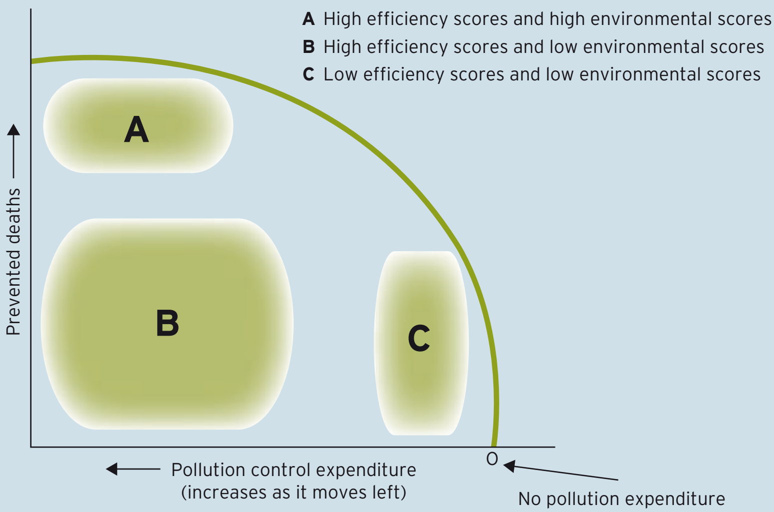
Based on the metrics on efficiency and ambition, a typology of countries , designated A, B, and C, emerges for air pollution (figure BO.3.1):

A. *High efficiency scores and high environmental scores*. Type A is mostly composed of high- and upper-middle-income countries. They curb a high proportion of pollution and therefore have high environmental scores. They also spend effectively and thus have high efficiency scores. In this group, the best performers reach efficiency scores of up to 95 percent. At the same time, scores of other countries barely exceed 60 percent, indicating significant scope for efficiency enhancements by emulating the more successful countries.

B. *High efficiency scores and low environmental scores*. Type B, composed of mostly upper- and lower-middle-income countries, is characterized by relatively low environmental scores (that is, low policy ambition), but the group achieves them in relatively efficient ways. These countries are located close to the low ambition range of the efficiency frontier, indicating that they do not implement very ambitious clean air policies, but that the ones they do implement are relatively efficient.

C. *Low efficiency scores and low environmental scores*. This group is composed of low- and low-middle- income countries that perform far from the efficiency frontier. They do not achieve much reduction in pollution, and what little pollution is reduced is not carried out efficiently. Notably, there are large differences in the efficiency scores even between countries with similar incomes and environmental scores. For example, efficiency scores of low-income countries range from 15 percent up to almost 70 percent, indicating a large potential for improvements.

FIGURE BO.3.1
Typology of countries, air quality analysis



Source: World Bank.

Addressing these challenges will require addressing the need for (1) compensation and communication; (2) commercial incentives to raise finance; and (3) cooperation and coalition building—all discussed in the sections that follow. In addition, the land-based and air pollution–based efficiency typologies have distinct policy priorities.

Compensation and communication

Even though reforms may confer an overall welfare gain on society, there will inevitably be resistance to change when the fruits of any transformation are not evenly distributed. As for the winners and losers, resistance from the losers will be greater than support from the winners, often because the anticipated losses from change affect concentrated interests, which could then form effective lobbying groups that stymie change. The outcome then favors the status quo, despite the inefficiencies and the net benefits that could accrue to society from reform.

Key to resolving these problems are compensation and communication to build support coalitions. A challenging and still unresolved problem is that of establishing credibility. Even if compensation paid today benefits all losers, future governments may resist sustaining those compensatory policies. Successful reform seldom involves the first-best options of economic theory, but any options may be iterative and determined by the distribution of rents and the influence they create. For example, despite the many economic benefits that a carbon tax delivers, opposition to such a tax in Europe and elsewhere remains strong despite assurances of compensation. As for communication and coalitions, the form of a coalition will depend on who benefits and who loses.

Commercial incentives

Many of the proposed solutions to increasing the efficiency of natural capital will call for additional funding to finance and incentivize the desired changes. Globally, there is a glut of savings in high-income countries in search of investments that offer investors sufficient economic returns. For example, despite the shock of COVID-19, funds in retirement savings plans grew at a rate of about 10 percent in 2021, exceeding US$56 trillion (OECD 2021). An obvious solution is to find ways to channel these financial surpluses from high-income countries to investment in opportunities in low- and middle-income countries to restore eroding natural capital. But this will not be easy because most natural capital assets (whether GHGs, $PM_{2.5}$, or forests) are "common property goods" whose benefits and impacts are shared communally. Thus no one business has sufficient control over a common property resource to gain by investing in it. For a resource to be attractive to private investors, regulations are needed to signal the scarcity value of the resource and create the enabling instruments to ensure it is used efficiently. For example, carbon markets would not exist at their current scale without enabling legislation that provides a "cap and trade" of GHGs. The "cap" is needed to provide an economic signal to investors that the carbon budget[6] is an economically scarce resource, while "trade" facilitates a transfer from lower- to higher-value uses. The tighter the cap, the greater is the scarcity signal and the higher will be the price. One of the more profitable environmental resources traded is water in Australia, with an annual turnover of about US$10 billion (Bjornlund and Rossini 2007). In summary, if there are to be significant financial flows into environmental services, legislation and institutions are needed to turn common property resources into tradable assets that can be transferred to their best uses.

Cooperation and coalition building

For many of the challenges discussed here, there is a disconnect between the scale of the externality and the scope of the regulatory body. GHGs, a global externality, will have effects worldwide regardless of where they are emitted. Meanwhile, GHG policies are largely determined at the national level (or, in exceptional cases such as in the European Union [EU], at the regional level). A transboundary solution is likely, then, to be more effective than a national solution. By taking a global rather than a national view, countries have additional opportunities for efficiency improvements if each country can play to its comparative advantage. For GHG emissions, this would mean that countries with a comparative advantage in sequestering GHGs because of their geography, climate, and population density should take the lead in doing so and should be compensated by countries with a lower comparative advantage.

Similarly, in some countries considerable shares of their $PM_{2.5}$ concentrations originate from outside their national borders. Some may actually find it more cost-effective to pay their upwind neighbors to reduce $PM_{2.5}$ emissions than to abate their own domestic emissions. This would especially be the case in countries that are already highly efficient and ambitious in terms of their own abatement, but the remaining abatement options come with a high opportunity cost. Some examples of regional cooperation already exist, such as the "good neighbor" rule in the United States, agreements among member countries of the EU, and outside the EU through the Convention on Long-range Transboundary Air Pollution.

Land-based policy priorities

Efficiency gaps in the use of natural resources typically emerge because the allocation of these resources is not related to the full environmental benefits they could confer or to the full economic benefits they could generate. As a result, most renewable natural resources are allocated inefficiently and degraded and depleted beyond what is economically justifiable. According to a decomposition analysis, there are three ways to address these problems:

- Reallocate resources toward more productive sectors that generate higher market or nonmarket returns (for example, farms to forests or vice versa)
- Change the composition of what is produced with the same configuration of inputs (say, cattle ranching to wheat or vice versa)
- Improve the efficiency of resource use for the same outputs that are produced (for example, more crop per drop of water or more crop per unit of land planted).

A toolkit of policy instruments is available for each of these options to induce shifts to the efficiency frontier. Nevertheless, priorities are not uniform across countries, and solutions should be tailored to the specific challenges facing countries. Thoughtful policies and well-placed investments can yield large benefits by improving welfare and increasing efficiency (box O.4). Although the challenges faced by every country are different, the typology of countries developed by the land-based model offers a useful way to tailor solutions. For example, in

BOX O.4

The Loess Plateau and other examples of transformational landscapes

Reaching the efficiency frontier by making better use of environmental resources while enhancing economic growth and multiplying livelihood opportunities is possible. Perhaps the most salient example of this possibility comes from the Loess Plateau in north-central China. After thousands of years of agricultural exploitation and limitless grazing, this region of China—which extends over 640,000 square kilometers—became a barren dust bowl. The degraded vegetation only accelerated the dilapidation process because nothing was left to prevent the flow of rainfall from turning into silt-filled floods and further eroding the landscape. Few would have believed that restoration of such a barren, infertile landscape would have been possible.

Over the last 40 years, however, funding from the Chinese government and the World Bank has successfully reversed this vicious cycle and restored close to 4 million hectares in the Loess Plateau. Restoration involved a three-tier strategy: (1) planting trees on the tops of hills to filter the rain and increase biodiversity; (2) building terraces for agriculture along the center of the plateau, which would then benefit from increased moisture and natural irrigation; and (3) building reservoirs to help collect excess water in the valleys. The transformation was truly revolutionary. Once dry, barren, and depleted, the land is now green, fertile, and abundant.

The economy has benefited as well. Agricultural yields have risen markedly and continuously since the restoration began, and the land is not only producing more yields, but also greater quality and variety. Meanwhile, farmers and vendors have seen higher incomes, which have improved the living standards of the entire region (Guo et al. 2014).

The Loess Plateau is not the only example of turning the tide on human-induced environmental degradation. Ethiopia recently took similar steps to reverse its historical pattern of degradation, erosion, and drought. By setting land aside and planting trees for the return of vegetation and animals in the northern village of Abraha Atsbeha and by

Continued

BOX O.4
Continued

constructing terraces and percolation channels, sterile land has been converted, farming has returned, and farmers are better protected from the risks of climate change.

As the world population—and its food requirements—grows, humans will need to make the most of the environment while still preserving it for future generations. Israel is the epitome of "necessity is the mother of invention" when it comes to land transformation. A country composed of mostly arid desert land, Israel transformed its agriculture by managing water systems, including adapting saltwater and reusing drip irrigation, transporting soil from other parts of the country, and technological innovation to maximize yields. Today, Israel not only has ensured food security for its own population but has also established an important agricultural export industry.

Land transformation need not be overbearingly expensive. It depends largely on the willingness to make a positive impact. No story better highlights this than that of Jadav Payeng, known in India as the "forest man." Over the last 40 years, he alone created a forest on the largest river island in the world, Majuli, by planting over 550 hectares of trees. Majuli, which lies on the Brahmaputra River in India, is home to over 150,000 people. Because of the annual monsoon rainfall, however, Majuli endures constant erosion and has lost half of its landmass and much of its vegetation over the last 70 years. Payeng has accomplished an incredible feat by planting trees since the late 1970s to restore the land's biodiversity. His Molai forest now houses Bengal tigers, Indian rhinoceroses, reptiles, deer, rabbits, monkeys, a large variety of bird species, and more than 100 migrating elephants for several months each year.

low-income countries where actual yields are often far below their potential, the mix of required policies might include tackling the credit constraints that smallholders endure, lack of inputs, informational constraints, insurance, skill deficits, and secure land tenure. Investments in infrastructure such as irrigation, roads, and communications—to better connect farmers to markets in both a physical sense and an informational sense—may also pay large dividends for intensifying agriculture without encroaching on the forest frontier. A nonexhaustive menu of policy options appears in table O.1.

Air pollution–based policy priorities

In addition to land-based policy solutions, countries can improve the efficiency of their air pollution abatement to simultaneously promote prosperity and sustainability. Naturally, the policies they adopt will vary, based on where a country falls in terms of efficiency and ambition. Specific policy solutions have been developed for countries across the typology described earlier and summarized in table O.2:

A. *High efficiency scores, high environmental scores.* Although these countries already tend to be highly efficient and ambitious in their pollution abatement policies, many are likely still operating in a situation in which the benefits of additional pollution abatement outweigh the costs. Thus important cost-effective gains could be made by further reducing $PM_{2.5}$.

TABLE 0.1

Typology of policy solutions for more efficient and sustainable landscapes

Type	Reallocation	Composition	Investments and efficiency
A. High income, highly efficient	• *Payment for ecosystem services (PES).* These schemes, which include payments for carbon and hydrological services, have had great success in the developing and developed world alike. • *Conservation tenders.* • *Rezoning land.* When appropriate, land is rezoned for more productive uses that are aligned with comparative advantage.	• *Certification.* In conjunction with other policies, certification and green labeling schemes could incentivize firms and agricultural producers to adopt more environmentally friendly production techniques and supply chains. • *Subsidy reform.* Agricultural support in high-income countries remains very high. Countries should aim to reform this support to improve agricultural efficiency and reduce environmental impacts. Top priorities should be decoupling subsidies from production, reducing trade barriers, and linking subsidies to environmental management and pricing negative externalities where relevant.	• *Market-based instruments for externalities.* Capacities and institutions could support market-based approaches such as "cap and trade" schemes for common property resources—that is, markets or pricing for water and carbon. This support will lead to bottom-up investments in improving the efficiency of these resources. • *Pricing.* Even where markets cannot be established, pricing of underpriced resources would discourage profligacy and waste in resource use.
B. Untransformed landscape, traditional agriculture	• *Utilizing sustainable, nonconsumptive forests.* Such utilization includes ecotourism, sustainable harvest of timber, and nontimber products.	• *Reallocating from low- to high-value uses within a sector.* For example, this could involve shifting from grazing land to cropped agriculture in areas more suitable for the latter, or to sustainable silvopastoralism, which simultaneously allows foraging for livestock, sustainable harvesting of forest products, and the provision of ecosystem services by forests.	• *Providing sustainable intensification and inputs.* These countries tend to have very low input use and low yields. Sustainable intensification, involving heavier use of fertilizers, modern seed varieties, and high mechanization can boost yields with limited environmental impact. • *Behavioral change interventions.* Adoption of new technologies is often low without accompanying behavioral interventions. • *Extension services, skills, and education.* To realize sustainable intensification, farmers will need more training and skills. Agricultural extension facilities can be critical to fulfilling such needs. • *Certification schemes to market sustainable harvests at a premium.*

Continued

TABLE 0.1
Continued

Type	Reallocation	Composition	Investments and efficiency
C. Geography is destiny	• *Regenerative production*. Systems are needed to enhance agricultural production while providing key environmental benefits such as carbon sequestration, soil nutrients, and biodiversity.	• *Subsidy reform.* Particularly in very arid countries, subsidies for irrigation promote the overuse of water and often the mining of nonrenewable fossil groundwater. These subsidies signal that water is plentiful when it is indeed very scarce, leading to unsustainable practices and reducing resilience to extreme events.	• *Monitoring ecosystem function.* Such monitoring is required to ensure that these countries remain on their efficiency frontier.
D. Dense, transformed, and traditional agriculture	• *Payment for ecosystem services.* These schemes, which include payments for carbon and hydrological services, have had great success in the developing and developed world alike. • *Protected areas expansion.* Lack of protected areas and associated enforcement leads to the spillover of agriculture onto lands that are often unproductive but have high ecosystem services and biodiversity value. • *Utilizing sustainable, nonconsumptive forests.* Such utilization includes ecotourism, sustainable harvest of timber, and nontimber products.	• *Strengthening land tenure.* Land tenure has been shown in context after context to be a key requirement for improving land use efficiency. When landowners receive assurances of their continued ownership of land, they have the certainty they need to make long-term investments in that land. These investments include those in physical infrastructure and capital such as irrigation or machinery, but also those in natural capital such as retaining soil nutrients and maintaining forest cover for the ecosystem services it provides. • *Aligning incentives with productive potential.* Often market failures or policy distortions lead to less productive land use choices. This may be due to subsidies or to unpriced externalities. • *Strengthening protected area management.*	• *Restoring degraded lands.* Many countries of this type suffer from severely degraded lands resulting from decades or centuries of neglect. Investments in restoring these lands can pay large dividends in terms of productivity as well as environmental benefits. • *Groundwater recharge and restoration, which is often essential for functional landscapes.* • *Providing sustainable intensification and inputs.* These countries tend to have low input use and low yields. Sustainable intensification, involving heavier use of fertilizers, modern seed varieties, credit, insurance, and early warning systems, can boost yields with limited environmental impacts. • *Agricultural extension facilities.* These facilities can be key to distributing both information and inputs to farmers. The expansion of agriculture value chains and the adoption of digital technologies to reach new markets can increase profitability.

Continued

TABLE 0.1
Continued

Type	Reallocation	Composition	Investments and efficiency
E. Low population density and moderate agricultural intensity	• *Payment for ecosystem services.* These schemes, which include payments for carbon and hydrological services, have had great success in the developing and developed world alike. • *Reallocating from low-productivity uses to higher-productivity uses.* Many of these countries can generate considerable environmental benefits in a Pareto way by reallocating land from beef production to cropped agriculture.	• *Reallocating from lower- to high-value uses within a sector.* For example, this would involve shifting from grazing land to cropped agriculture in areas that are more suitable for the latter, or to sustainable silvopastoralism, which simultaneously allows foraging for livestock, sustainable harvesting of forest products, and the provision of ecosystem services by forests.	• *Sustainable intensification and input provision.* These countries tend to have very low input use and low yields. Sustainable intensification, involving increased fertilizers, modern seed varieties, and high mechanization, can boost yields with limited environmental impact.

TABLE O.2

Air pollution: Priority directions for moving toward the efficiency frontier, by country type

Type A	Type B	Type C
Priority directions for efficiency improvements		
• Adjust the ambition level to optimize the use of societal resources by equalizing marginal benefits and costs. • Where necessary and possible, further increase efficiency.	• Enhance the environmental ambition to optimize the use of societal resources. • Shift focus of air quality management to public health benefits.	• Move toward the efficiency frontier by enhancing environmental and efficiency scores. • Shift the focus of air quality management to public health benefits.
Focus areas		
• Balance control efforts across a wider range of source sectors, considering, among other things, ◦ Household wood stoves ◦ Agricultural residue burning ◦ Precursors of secondary particulate matter ($PM_{2.5}$), including ammonia from manure management and fertilizer application. • Pursue transboundary cooperation with neighboring countries to reduce the need for measures with high marginal costs. • Avoid trade-offs and capture synergies with other policy priorities such as greenhouse gas (GHG) mitigation.	• Widen pollution control efforts to sectors beyond road transport and large point sources to, among other things, ◦ Solid-fuel cookstoves ◦ Agricultural residue burning ◦ Municipal solid-waste management. • Improve monitoring, compliance, and enforcement mechanisms. • Avoid trade-offs and capture synergies with other policy priorities (such as GHG mitigation and social aspects).	• Enhance governance. • Improve monitoring and compliance mechanisms. • Widen pollution control efforts to sectors beyond road transport and large point sources to, among other things, ◦ Solid-fuel cookstoves ◦ Agricultural residue burning ◦ Municipal solid-waste management. • Avoid trade-offs and capture synergies with other policy priorities (such as poverty alleviation, development, and climate change).
Relevant instruments		
• Adopt pollution taxes instead of strict performance standards. • Pursue international cooperation.	• Revisit existing fuel subsidy systems and consider alternative tax/subsidy systems that make socially desirable investments attractive to consumers and enterprises.	• Revisit existing fuel subsidy systems and consider alternative tax/subsidy systems that make socially desirable investments attractive to consumers and enterprises. • Establish enforcement mechanisms.
Knowledge gaps		
• Expertise on cost-effective air quality management to address precursor emissions of secondary $PM_{2.5}$	• Air quality monitoring representative of population exposure (for example, in residential and rural areas) • Local health impacts of air pollution • Source apportionment of $PM_{2.5}$ in ambient air	• Air quality monitoring representative of population exposure (for example, in residential and rural areas) • Local health impacts of air pollution • Source apportionment of $PM_{2.5}$ in ambient air

Continued

TABLE 0.2
Continued

Type A	Type B	Type C
	• Comprehensive emission inventories beyond large point sources and road transport • Environmental economics of cost-effective measures and instruments • Social aspects of pollution • Co-benefits with other policy priorities	• Comprehensive emission inventories beyond large point sources and road transport • Environmental economics of cost-effective measures and instruments • Social aspects of pollution • Co-benefits with other policy priorities

B. *High efficiency scores, low environmental scores.* The current focus in these countries tends to be on the lower hanging fruits of pollution control. Basic pollution controls are often limited to a small number of key sectors (such as particle filters for large point sources burning coal), where pollution abatement is relatively less expensive with established technologies. However, despite their economic efficiency, the measures are often not commensurate with the scale of the pollution problems that rapid economic growth can bring. Efforts to expand ambition should be undertaken carefully.

C. *Low efficiency scores, low environmental scores.* Typically, countries in this group have adopted only very basic measures to control air pollution, despite the serious pollution levels and the significant burden on public health and economic performance. Thus more efficient air quality management strategies could combine measures that increase both efficiency and ambition.

Caveats and extensions

As with all models, this analysis is based on assumptions imposed by tractability and the limits of scientific knowledge. Models, although simplifications, are useful for generating insights by focusing on elements that matter, while holding other factors constant. Analogously, the efficiency frontiers developed in this study focus on critical economic and ecosystem service benefits for which there are globally available data and sufficient scientific understanding for quantitative simulations.

While the analysis in this report is based on current conditions, it also discusses changes that may occur in the future, such as possible improvements in technology, ecosystem collapse, transboundary considerations, and shifts in any of the myriad ecoservices or economic variables that are held constant in the model. The analysis is focused on steady-state outcomes (that is, the long-run outcome, after transitions have taken place) because the timing of change will depend on the policy, the economic variable, and the ecosystem under consideration and so estimating the timing of changes becomes intractable.

Although the idea of an efficiency frontier is straightforward, compiling estimates of current and potential performance requires pushing methods and data to the frontiers of science in many areas. This report is the first such attempt using global data sets for biodiversity and for the market value of agricultural crops, forestry, and grazing that had not been assembled at this scale previously. As with any new analysis, over time there will be improvements in data, methods, and understanding of functional relationships that will enable more accurate diagnostics and, by implication, better policy guidance. Investing in this data and science at both the global and national levels will be critical for making evidence-based decisions and managing landscapes for multiple benefits as efficiently as possible. It will be important that future work extend and refine this effort.

Conclusions

As the global population swells toward 10 billion, as climate change threatens to displace and impoverish large groups of people, and as an ecological crisis sickens people and ecosystems alike, the world can no longer afford a business-as-usual approach. To provide their growing populations with food security and deliver on ever-increasing living standards and life expectancies, countries will need to rethink old ways of doing things and focus on producing more with a smaller environmental footprint. Correcting the externalities and market failures of the past is but one highly effective way to move toward a more efficient and sustainable future.

This report demonstrates that vast opportunities are in place to improve the efficiency with which natural resources are allocated and used in ways that can simultaneously enhance sustainability without sacrificing economic well-being. That this has not been achieved indicates that there are significant barriers to reform—political, economic, and structural. The pressures on common property natural resources will inevitably escalate over the next few decades, but with the right reforms, governments can help ensure that people and ecosystems are not left more vulnerable and exposed to the consequences of planetary change. Significantly, low-income countries would be the most significant beneficiaries of these policies, which would allow them to tackle food security, environmental security, and poverty problems simultaneously. Although addressing these challenges will be demanding, the costs of inaction are likely far higher.

Notes

1. Global Carbon Project, supplemental data, Global Carbon Budget 2021 (Version 1.0), 2021.
2. For example, at times natural capital and physical capital must work together as complements for production purposes. To illustrate, fish stocks (natural capital) and fishing vessels

(physical capital) are complements because both are needed to generate fishing rents. As for substitutability, in New York City preserving the landscapes and watershed of the upstream Catskill Mountains allows the city to avoid building costly wastewater treatment plants to deliver clean water, thereby substituting natural capital for physical capital. Understanding this distinction is key to identifying pathways to sustain both forms of capital well into the future.

3. The data underpinning this figure are from United Nations Environment Programme's *Inclusive Wealth Report 2018* (UNEP 2018) and may not capture all facets of natural capital since these often cannot be accurately aggregated into a single index as is discussed in this report.
4. This scenario is an alternative and not a "complement" to the 85.6 billion metric tons of CO_2eq mentioned in finding 2.
5. The magnitude of gains is consistent with other studies that examine output increases stemming from land and factor reallocation and also the estimates in the Global Agro-Ecological Zones data set on potential yields of major crops outlined in annex 3C in chapter 3.
6. *Carbon budget* is defined by the Intergovernmental Panel on Climate Change as "the maximum amount of cumulative net global anthropogenic carbon dioxide (CO_2) emissions that would result in limiting global warming to a given level with a given probability, taking into account the effect of other anthropogenic climate forcers."

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green press INITIATIVE

The great expansion of economic activity since the end of World War II has caused an unprecedented rise in living standards, but it has also caused rapid changes in earth systems. Nearly all types of natural capital—the world's stock of resources and services provided by nature—are in decline. Clean air, abundant and clean water, fertile soils, productive fisheries, dense forests, and healthy oceans are critical for healthy lives and healthy economies. Mounting pressures, however, suggest that the trend of declining natural capital may cast a long shadow into the future.

Nature's Frontiers: Achieving Sustainability, Efficiency, and Prosperity with Natural Capital presents a novel approach to address these foundational challenges of sustainability. A methodology combining innovative science, new data sources, and cutting-edge biophysical and economic models builds *sustainable resource efficiency frontiers* to assess how countries can sustainably use their natural capital more efficiently. The analysis provides recommendations on how countries can better use their natural capital to achieve their economic and environmental goals.

The report indicates that significant efficiency gaps exist in nearly every country. Closing these gaps can address many of the world's pressing economic and environmental problems—economic productivity, health, food and water security, and climate change. Although the approach outlined in this report will entail demanding policy reforms, the costs of inaction will be far higher.

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