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Accelerating Clean, Green, and Climate-Resilient Growth in Vietnam

A Country Environmental Analysis
June, 2022

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Abbreviations

AR5	Fifth Assessment Report
ASEAN	Association of Southeast Asian Nations
BAU	business-as-usual
BLL	blood lead level
C&D	construction and demolition
CDC	Centers for Disease Control and Prevention
CGE	computable general equilibrium
CIF	climate impact factors
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
COED	costs of environmental degradation
CORSIA	Carbon Offset and Reduction Scheme for International Aviation
COVID-19	coronavirus disease 2019
CP	carbon pricing instrument
CV	cheval vapeur
CVM	cardiovascular mortality
CWOM	Comprehensive Wealth of Nations
DIVA	Dynamic Interactive Vulnerability Assessment
EAP	East Asia and Pacific
EEPSEA	Economy and Environment Partnership for Southeast Asia
EPT	environment protection tax
ETS	emissions trading system
EU	European Union
GAINS model	Greenhouse gas – Air pollution Interactions and Synergies model
GBD	Global Burden of Disease
GDP	gross domestic product
GEMM	Global Exposure Mortality Model
GHG	greenhouse gas
GSO	General Statistics Office
GTAP9	Global Trade Analysis Project
ha	hectare
HANPP	Human Appropriation of Net Primary Productivity
HCMC	Ho Chi Minh City
ICAP	International Carbon Action Partnership

IFPRI	International Food Policy Research Institute
IHME	Institute for Health Metrics and Evaluation
ILO	International Labour Organization
IMPACT	Model for Policy Analysis of Agricultural Commodities and Trade
IQ	intelligence quotient
JCM	Joint Crediting Mechanism
km	kilometer
ktCO2e	kilotonnes of carbon dioxide equivalent
LB	lower bound
LEP	Law on Environmental Protection
LGBT	lesbian, gay, bisexual, and transgender
LIC	lower-income country
LMI	lower-middle income
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MOF	Ministry of Finance
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
MRD	Mekong River Delta
MRV	monitoring/measurement, reporting, and verification system
MT	metric ton
MtCO2	metric tons of carbon dioxide equivalent
ND-GAIN	Notre Dame Global Adaptation Index
NO2	nitrogen dioxide
NPP	net primary productivity
NTFPs	non-timber forest products
OECD	Organisation for Economic Co-operation and Development
PM	particulate matter
PM2.5	particles that are 2.5 microns or less in diameter
PMR	Partnership for Market Readiness
PPP	purchasing power parity
RCP	Representative Concentration Pathway
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RISE	resilience, inclusion, sustainability, and efficiency
SEDPs	Socio-Economic Development Plans
SEDS	Socio-economic Development Strategy
SLR	sea level rise
SO2	sulfur dioxide
SOE	state-owned enterprise
tCO2e	tons of carbon dioxide equivalent
TSP	total suspended particulates

UB	upper bound
μg/dL	micrograms of lead per deciliter of blood
UHI	Urban Heat Island
UMI	upper-middle income
UNFCCC	United Nations Framework Convention on Climate Change
VND	Vietnamese dong
VSL	value of a statistical life
WB	World Bank
WHO	World Health Organization
WTP	willingness to pay

Executive Summary

Vietnam has demonstrated great and almost unrivaled development success over the past few decades as evidenced by a variety of measures, including national income, poverty reduction, and access to services. However, Vietnam's performance in terms of progress on robust, equitable and sustainable development—an overarching objective of the country's current policy framework—highlights that Vietnam is comparing less favorably when benchmarked against countries at similar income level, in the East Asia and Pacific region or globally, especially on the environment and resource efficiency.

Based on a globally comparable set of national indicators that measure key dimensions of development – resilience, inclusion, sustainability, and efficiency – a more nuanced picture of the quality of growth in recent decades emerges. Disaggregating development progress in these four dimensions show that on resilience (measuring impacts of natural and health disasters as well social vulnerability) Vietnam has performed well on food security (similar to richer middle-income countries) and epidemic response, but floods and storms have an outsized impact due to the concentration of infrastructure and people in floodplains and coastal zones. This underscores the significant natural and social vulnerability - an average natural disaster, for instance, causes damages equivalent to 1.5 percent of gross domestic product (compared to 0.6 percent for upper middle-income countries).

The performance on inclusion (measuring distributional outcomes, access to services, markets and places, and social dimension) varies, with human capital, access to electricity, health coverage, or female labor force participation among the indicators for which Vietnam ranks in the top quartile when compared to upper-middle income countries. Yet the low penetration of financial services for the poor, a low score on personal rights, limited access to roads in rural areas and that fact that only 28 percent of Vietnamese express that "most people can be trusted" are indicative of areas in which Vietnam can bolster inclusive and equitable development going forward.

Most notable though in a comprehensive comparison is the significantly below average performance on sustainability and efficiency, which holds irrespective of geographic or peer comparators. This is evidenced by threats to forests (17 percent loss since 2000) and biodiversity habitats, land degradation (nearly a third of land area is degraded), limited renewable per capita freshwater resource, low renewable energy consumption, rapid growth in per capita greenhouse gas emissions (about 20 times higher than upper-middle income countries) and population exposed to unhealthy air (about 60 percent). The inefficient use of resources is further underscored by very low productivity of water resources and agricultural workers, low carbon efficiency and negligible rapid urban transit (all well below that of lower-middle income countries). Globally, compared against countries by income, Vietnam is well below the global mean on sustainability, and on efficiency only exceeds lower-middle income and low-income countries.

The shortcomings in critical areas of development point to important areas for policy action and investments in relation to the environment, especially as Vietnam strives to ascend to upper-middle-income country status (a level at which countries' international and regional peers generally perform significantly higher). These include measures to rapidly decouple economic activities from polluting fossil fuel consumption (and advance renewable energy); make agriculture and industry more resource-efficient, cleaner, and productive; boost social resilience to natural disasters; and climate-proof infrastructure.

Drilling deeper into the areas of low environmental performance show that the degradation of the environment and the compounding effects of recent climate change, are a significant burden on Vietnam's people and the economy. The total costs of environmental degradation—benchmarked against national income—are largely dominated by air, lead, and water pollution, as well as land degradation and climate change. They amount to 10.3 percent of 2020 gross domestic product (GDP) (with a sensitivity range of 6.3 percent to 14.2 percent) when accounting for losses in welfare (notably due to premature death and disease). Using a market-based approach (measuring costs linked to market transactions only, such as losses in aquaculture due to water pollution) results in total costs of 6.9 percent of 2020 GDP (with a sensitivity range of 4.2 percent to 9.1 percent). Breaking down the costs by sectors shows the highest costs in tourism, agriculture, fisheries, and health.

Both market-based and welfare costs require a range of measures, including fiscal incentives and regulatory instruments such as setting targets for reductions in premature deaths linked to pollution. In addition, some costs, while modest today (such as those linked to plastic pollution) are growing rapidly and may affect Vietnam's growth prospects. In such cases, cleaning up after damages have materialized, and costs have increased, is not an option. Although changes in policy to reduce such costs would probably raise GDP, the links are complex and need further investigation.

Poor air quality stands out as a major burden by any measure and warrants ambitious and aggressive action. The concentration of particulate matter in Vietnam's air—on average—is four to five times higher than considered safe by the World Health Organization. Worse still, it frequently spikes to highly toxic levels (30–40 times higher than safe) for extended periods of time during the cooler seasons and particularly in densely populated urban centers. The resulting 71,000 annual premature deaths, and associated cardiovascular and pulmonary diseases, translate into annual costs of $US13.3 billion (3.9 percent of GDP). And even without the estimation of market effects (limiting the costs to direct economic losses), they amount to $US3.6 billion (1.05 percent of GDP). Polluted air is not only a burden on the health system and workers' productivity (and thus a drag on the economy) but also harms Vietnam's image as an international business location, trade partner, and tourist destination.

Many activities in the Vietnamese economy— including transport, coal-based energy production, and biomass burning—contribute to air pollution, and a multipronged approach is needed to address the problem. Cleaning up the air is also well aligned with Vietnam's international climate commitment. A progressive carbon tax—one of several available means to price carbon—is a central instrument to shift the energy mix to cleaner sources and support pathways to carbon neutrality in a socially just manner without penalizing short- and longer-term economic performance (that is, its benefits outweigh the cost, especially when accounting for the toll on human well-being). Its effectiveness can be increased if tax revenue is used to boost private investment (rather than finance public projects) and if complementary sector reforms are implemented (such as increasing the share of renewable energy sources or fuel efficiency standards for vehicles). Beyond these quantifiable benefits, a carbon tax could bring a competitive advantage in trade, notably if economies that import from Vietnam (such as the European Union and the United States) implement carbon border tax adjustments.

Another major environmental cost stems from lead pollution. Even though the heavy metal was removed from gasoline in Vietnam by 2001, it continues to leak into the environment from a variety of sources and poses a significant problem for human health (and by extension people's productivity). This is evidenced in high blood lead levels in the Vietnamese population, which is of particular concern for children, where exposure can lead to severe and long-term impacts on brain and organ development and a variety of other severe disorders. The associated loss in mental abilities is well understood and translates into significant loss in lifetime income for the Vietnamese: US$7.2 billion annually (or 2.1 percent of GDP) as a midrange estimate. To monetize the losses and understand the pathways of exposure more reliably, it is critical that the knowledge base about this source of pollution in Vietnam is improved significantly.

Despite the serious health consequences, lead poisoning often goes unrecognized. While multiple sources contribute to the overall exposure, informal lead-acid battery recycling as well as paints and contaminated water and food are major likely sources. The limited source- and location-specific knowledge in Vietnam hinder the quantification of the benefits of detailed interventions. Thus, it is critical to improve site testing of lead exposure, screening for health impacts on the at-risk population, and regular monitoring and awareness raising. For lead-acid battery recycling, it is critical to formalize and modernize the sector and introduce measures to increase recycling at licensed and safe facilities. (Incentives to informal battery collectors can be instrumental and cushion social impacts.) For paints and other consumer products, it is important to enforce monitoring of standards through effective engagement of the private sector and to introduce complementary measures such as third-party certification. Moreover, an urgent assessment is required to better understand the extent of contamination and start designing measures to reduce lead in water and food.

Domestic and industrial effluents as well as urban solid waste are polluting Vietnam's rivers, lakes, and coastal waters, and the capacity of provinces and municipalities to reduce, collect, and treat effluents and solid waste is woefully inadequate. Beyond the eyesore, the effects of this pollution are felt by households, farmers, and fishers and is reflected in 9,000 premature deaths due to polluted water sources and poor sanitation, 7 million cases of waterborne diseases annually, a reduction in yield for key crops (rice, coffee) and aquaculture losses (such as diseased shrimp populations). Combined, water pollution has a total cost of US$2.5 billion per year (0.7 percent of GDP if accounting for human welfare losses, or 0.4 percent without). If the government achieves its goal to provide improved sanitation and drinking water to 100 percent of the country's population by 2030, the losses linked to current water-related mortality and disease would be largely eliminated, and the benefits of the necessary interventions would greatly outweigh their costs across a range of scenarios and assumptions.

The volume of solid waste has been growing rapidly in Vietnam (doubling since 2010 and projected to double again by 2030). Of the 74,000 tons of waste generated daily, less than 30 percent ends up in landfills, most of which are insufficiently designed and poorly controlled (only 30 percent of sites are classified as sanitary)—contaminating not only the immediate environment but also spreading emissions, pathogens, and plastics waste through the air and contaminating soil and groundwater through leakage of leachate. This leads to depreciation of land values (for example, by US$155 million for two of several landfills in Ho Chi Minh City alone), and the environmental costs linked to the nonsanitary sites amount to US$36 million per year. In addition, the cost of plastic pollution tallies at US$156 million annually, arising largely from damage to marine ecosystems (with bottles, carrier bags, food wrappers, and sachets being the main culprits), and US$2.2–2.9 billion is lost annually in material value because of suboptimal recycling.

Stemming the waste wave requires a multipronged approach, including linking of domestic and industrial waste collection, waste separation, and recycling; use of incentive systems to change consumer behavior; promotion of alternative materials with a lower environmental footprint; and smart use of technology (for example, to connect supply and demand for waste). Fiscal instruments—such as a US$0.03 tax on plastic bags for retailers (as opposed to a consumer tax, which proves to be ineffective)—could have major environmental benefits and be very cost-effective, as recent experiences in a number of countries demonstrate. Similar incentive mechanisms could achieve better reduction and recycling rates (such as pay-as-you-throw systems or tax incentives for products with recycled content), though many have to be analyzed, tested, and costed for the Vietnam market. To minimize the future impacts of nonsanitary landfill sides, waste may need to be transferred to compliant sites (a very costly option) or the remaining sections of noncompliant sites lined, though for either option a site-specific cost-benefit analysis needs to be performed to prioritize action at the local level.

Vietnam's natural endowment —mountain forests, fertile croplands, mangroves in river deltas, and fisheries— are major national assets that have been driving growth in vital economic sectors and allowed the country to rise to become a leading global exporter of agricultural commodities, forest-based products, and seafood. This success, however, has come at a major environmental toll: Seventy-two percent of mangroves had been destroyed by the turn of the century (but partially restored since). Much of the US$36.3 million loss associated with mangrove depletion from 1997–2017 is concentrated in the Mekong Delta. Ten percent of primary forest stock has vanished since 2000 (a valued loss of US$1.46 billion). Twenty-eight percent of land area is considered uncultivable because of erosion and loss in soil fertility (an estimated loss of US$689 million a year). And fish stocks are depleted to unsustainable levels. Letting them recover to where they were a decade ago would cost US$126–150 million a year for a subset of key species alone.

As a result, the country's green infrastructure is no longer providing protection against storm surges, floods, and landslides and leaves coastal communities highly exposed. The alarming implications of the degradation have been recognized by the government, which is reflected in the significant efforts to restore forests, replant mangroves, and improve the sustainability and traceability of fisheries (to comply with import market requirements).

The total costs of degradation of land- and sea-based environmental services are small (an estimated 0.27 percent of 2020 GDP) compared with the costs of pollution, as they only capture marginal annual losses in sustainability (unlike the high human cost of debilitating and deadly pollution). However, that does not distract from the fact that, cumulatively and over time, they are eroding the very natural capital that agriculture, forestry, and fisheries depend on to remain productive and competitive. And not investing in improving sustainability could abruptly lead to loss of market access and forgone revenue. For example, the yellow card issued by the European Union in 2017 for Vietnam's seafood industry resulted in 12 percent of export losses in 2018 and spilled over to US exports with a 9 percent reduction the following year.

These costs show that the use of Vietnam's natural endowment continues to be unsustainable, although significant progress has been made to restore forests and mangroves and to introduce innovation for agricultural production. At the same time, the value of Vietnam's natural capital embedded in forests, mangroves, croplands, and fisheries shows generally an increasing trend, which is largely a reflection of higher unit values provided by these ecosystems rather than increased sustainability in their use. For instance, the value of physical infrastructure protected by mangroves, including those recently planted, is greater than in the past when urban areas were less developed. Similarly, the growing value of croplands in the national natural capital accounts is mostly a reflection of the value of today's export commodities (such as cashews or rice) rather than better environmental performance.

Investing in natural assets and boosting sustainability is thus critical, even as Vietnam becomes a sophisticated industrial and service-oriented economy. And the relative costs of doing so are generally not very high: The benefits of remediating land degradation greatly outweigh the costs (a benefit-cost ratio of well over 100 if measures are implemented cost-effectively and on selected areas that can be restored to their full potential). Similarly, the benefits of forest and mangrove restoration are significant, with benefit-cost ratios of 1.6 to 1.9 for newly planted forests and 1.8 to 2.0 for regeneration of degraded ones (even when opportunity costs relative to other land use are relatively high). Similarly, mangrove restoration pays off, especially when done cost-efficiently and in areas with high benefit (such as protecting infrastructure or rice cultivation in the Mekong Delta).

The magnitude and distribution of these costs guide important policy actions and the appraisal of their benefits. Policy actions include market-based measures (such as taxing carbon pollution or plastic bags) as well as institutional reforms and social programs (such as a lead-acid battery recycling program with associated skills training). It is important to note that addressing small absolute damages can generate significant net benefits (such as mangrove restoration to support tourism and aquaculture). Benefits will also depend on who bears the environmental costs. For instance, healthier forests and mangroves tend to benefit vulnerable and relatively poor people in rural areas, whereas cleaner air boosts productivity of urban dwellers and less-polluting production increases competitiveness of Vietnam's export-oriented value chains that feed into global markets with higher environmental standards.

Additionally, climate change has a compounding effect on most environmental stresses, and total costs already amount to US$11 billion (3.2 percent of 2020 GDP), with a range of US$6.7 to US$14.8 billion, based on impacts modeling for 2010–30. The bulk of the negative impacts arise from losses in labor productivity, fishery, agriculture, and infrastructure damage due to sea level rise. By midcentury, these costs could grow to be in a range US$43.8 billion to US$68.5 billion (3.8–5.9 percent of GDP) depending on the trajectory of global greenhouse gas emissions (which is a function of the global effort to reduce them). This stresses the importance of building more resilience in Vietnam's future development and of maximizing the cobenefits of action on environmental sustainability and climate change. In terms of climate change mitigation, this entails avoidance of high-carbon lock-in (such as long-lived energy projects with high carbon intensity and associated air pollution, notably coal-based energy) and of building new infrastructure in vulnerable locations. Also, in the agriculture and the water sectors it is critical to enhance resource efficiency (such as water and fertilizers).

In light of today's rampant pollution and highly concerning degradation of the natural environment, it is critical that Vietnam accelerates its shift to a growth model that is cleaner, greener, and more climate-resilient. The current 2021–30 Socio-Economic Development Plan (SEDP) and subordinate strategies (such as the new Green Growth Strategy) are already motivated by the overarching policy orientation toward sustainability. And the recent commitment to achieve a carbon-neutral economy by midcentury gives additional impetus to this critical transition. Moving toward a more circular economy—in essence a more resource-efficient industry and harnessing the potential of renewable resources to reduce leakage and pollution—in key sectors and value chains can unlock significant growth potential and help reverse the current trends. Many of the necessary interventions, based on first-order estimates, can yield significant benefits relative to costs. Conversely, continuing the growth model of the past decades would result in cumulative costs that create a drag on the economy. Market-based instruments (including taxing carbon emissions and polluting materials such as plastics), if designed well, can unleash economic forces and leverage private sector investments that can simultaneously boost Vietnam's sustainability, economic growth, and competitiveness.

1 Vietnam's Ambitions: Growing Green?

Vietnam has transformed from a low-income to a middle-income economy in one generation. Since the 1980s, Vietnam has steadily increased its gross domestic product (GDP) per capita, growing at an annual rate of 5.5 percent since the 1990s,[1] and has lifted 45 million citizens above the poverty line. Poverty rates sharply declined from about 70 percent to below 6 percent over the last quarter century.[2] This growth has driven employment; in 2020, the unemployment rate was about 2.02 percent,[3] and about 69 percent of Vietnam's population (comprising those aged 15 to 64) are part of the workforce (36.2 percent in agriculture, 28.4 percent in industry, and 35.4 percent in services).[4]

This economic growth was accompanied by an increase in Vietnam's human capital. From 2010 to 2020, the Human Capital Index for Vietnam increased from 0.66 to 0.69, which is the highest among middle-income countries. Average years of schooling among the working population doubled from four in 1990 to eight in 2018.[5] Health outcomes improved as living standards rose; for example, from 1990 to 2016, life expectancy increased from 70.5 years to 76.3, and with 87 percent of the population covered, Vietnam's universal health coverage index is 73.

The economic success was accompanied by rapid demographic and social change. Vietnam's population reached 96.2 million in 2019 (up from about 60 million in 1986) and is expected to reach 120 million by 2050. While today's population is young (55.5 percent of people are under 35 years of age),[6] it is rapidly aging. In addition, Vietnam's middle class (13 percent of the population in 2019) is projected to double by 2026, driving a massive transformation in consumer behavior.

Trade has been an important part of the success and transformation of the economy. Today's national share of trade (export and import) to GDP is 200 percent, one of the highest globally. Vietnam has become a central assembly hub in several global value chains, ranging from garments to mobile phones and computers, and continues to attract an increasing amount of foreign direct investment.[7] Merchandise exports have been fairly diversified, underpinned by trade relationship openness and stable export market shares.

Vietnam has leaped into the top-five global suppliers of agricultural commodities. In 2019, it was a major supplier in more than eight key global food value chains (fish, rice, coffee, tea, cashew nuts, black pepper, rubber, and cassava), on average taking in over US$3 billion from each commodity, resulting in a total agricultural export revenue of US$40 billion in 2018 and 2019. In the past decade, the agriculture sector (fisheries, farming, and forestry) contributed approximately 15 percent to national GDP, while industry (energy, manufacturing, and

1 World Bank 2016.
2 GSO 2019c.
3 https://www.statista.com/statistics/444617/unemployment-rate-in-vietnam/.
4 https://www.statista.com/statistics/454920/employment-by-economic-sector-in-vietnam/.
5 UNDP 2018.
6 GSO 2019c.
7 https://www.oecd-ilibrary.org/sites/2f712dad-en/index.html?itemId=/content/component/2f712dad-en#figure-d1e1322.

construction) accounted for about 34 percent, and services (government activities, transportation, communications, finance, and all other) 41 percent.[8]

Vietnam has also become the second-largest furniture producer in Asia and the fifth-largest globally. The industry is heavily dependent on imported wood for furniture, while wood chips come largely from Vietnam's plantations. The country's wood products had an export value of US$8.5 billion in 2018[9] (China, Japan, and the Republic of Korea are the three largest importers of wood chips from Vietnam and accounted for more than 90 percent of Vietnam's total annual volume of timber exports).[10] The outlook for the sector is more uncertain though as Vietnam is facing a supply gap from its own forests and struggles to meet sustainability and legality standards for wood products required by importing countries.[11]

At the same time, Vietnam has become one of the region's top tourist destinations. Capitalizing on increasing regional and global demand, Vietnam has captured market share from its regional competitors and achieved record growth in both international and domestic visitors. More than 18 million tourists visited Vietnam in 2019 compared to 3.7 million in 2009.[12] In addition, a large part of foreign investment in Vietnam has focused on tourism, especially hotel projects. In 2019, the tourism industry accounted for 12 percent of national GDP. International tourists accounted for only 17 percent of overall tourist groups yet contributed for more than 50 percent of tourism sector spending.

These fundamental shifts have been, and continue to be, accompanied by a rapid spatial transformation. In 1986, less than 13 million residents (20 percent of the population), lived in urban areas, but by 2017 the number had grown to 30 million (35 percent of the population).[13] Migration from rural areas has been increasing urban populations in major cities. In the southeast, where Ho Chi Minh City is located, the urban population increased from 30.1 percent to 57.1 percent. In the Red River Delta, with the presence of Hanoi and Hai Phong, the urban population increased from 19.9 percent to 29.2 percent.[14]

As a result of such changes, Vietnam has experienced an enormous increase in energy demand over the past 20 years. Energy consumption has increased about 13 percent per year, driving the increase in generating capacity of 48 gigawatts in 2018 from 27 gigawatts in 2000.[15] The rapid increase in energy demand is attributed mostly to expanding industrial and construction sectors,[16] the largest contributors to which are the cement, paper, steel, and fertilizer industries.[17] Coal, hydropower, oil, and natural gas are the primary fuels for power

8 https://www.statista.com/statistics/444611/vietnam-gdp-distribution-across-economic-sectors/.
9 Das 2018.
10 Phuc and Cam 2021.
11 World Bank 2019a.
12 https://vietnamtourism.gov.vn/english/index.php/statistic/international.
13 GSO 2020.
14 OECD 2018.
15 Le 2019.
16 FPT Securities 2015.
17 Le 2019.

generation in the country. Both primary energy and electrical power for industrial and civil sectors in Vietnam are relatively cheap compared to other countries in the region due to low energy pricing and primary fuels substitution, which has limited investment in the power sector.

In 2020, Vietnam's economic performance contracted sharply due to the COVID-19 pandemic. After a sharp dip in the second quarter of 2020, with GDP growth of 0.4 percent (year-over-year), by the fourth quarter GDP growth accelerated to 4.48 percent (year-over-year)[18] as the situation improved after loosening the lockdown measures. In 2020, the tourism sector experienced a decline, with about an 80 percent drop in international visitors (which was its main component) due to the COVID-19 pandemic. Recovery has been slow and largely driven by domestic travel[19].

But there is a blemish: Vietnam's rapid growth and industrialization are increasingly detrimental to the environment. Over the past two decades, Vietnam has emerged as one of the fastest-growing per capita greenhouse gas (GHG) emitters in the world, growing at about 5 percent annually. As GDP per capita increased from US$390 to US$2,000 from 2000 to 2015, carbon dioxide (CO2) emissions nearly quadrupled, following faster relative growth than other East Asian countries.[20] While bad for the global climate, these emissions are also associated with toxic air pollution that characterizes many parts of urban Vietnam today.

Once pristine and iconic, natural destinations are now plagued by the byproducts of mass tourism: beaches littered with plastic and coastlines built up by outsized tourist infrastructure. And it is often the same locations that suffer the effects of the loss of key natural assets, such as forests and mangroves, that have become so degraded and fragmented that they can no longer provide the critical protection needed during annual storm and flood seasons, which are already amplified because of climate change.

Rapid urbanization and economic success are fueling pollution challenges in Vietnam.[21] Untreated urban and industrial wastes are the major cause of water pollution in Vietnam, as about 105 million liters of mostly untreated wastewater are discharged daily into the waterways.[22] Also, car and motorcycle ownership grew by 122 percent and 233 percent, respectively, during the first decade of the twenty-first century, contributing to air and noise pollution. Transport GHG emissions are expected to double from 40 million to 80 million tons cumulatively between 2016 to 2030.[23] The 27 million tons of waste generated annually in Vietnam are projected to double by 2030,[24] when Vietnam is already struggling with waste collection (only 40–60 percent of waste ends up in dump sites, while the rest is discharged directly into canals and rivers that flow into the sea).

18 https://tradingeconomics.com/vietnam/gdp-growth-annual.
19 World Bank 2019b.
20 Ritchie, Roser, and Rosado 2017.
21 Oh et al. 2019.
22 World Bank 2019c.
23 Oh et al. 2019.
24 Strauch, du Pont, and Balanowski 2018.

Industry is highly energy intensive. The elasticity of electricity to GDP (growth rate of electricity consumption/GDP growth rate) is a clear indicator of the high energy intensity in Vietnam and has been astoundingly high relative to comparable countries for the past decade, reaching 1.5 to 2.0 times the GDP growth rate.[25] By 2025, the energy intensity will be 40 percent higher than the current use rate.[26]

Agriculture is a major contributor to pollution and consumer of natural resources. While Vietnam enjoys top rankings among fish and agricultural commodity exporters, domestic production levels are unsustainable due to poor farm management practices. Intensive monocultures, such as rice in the Mekong Delta, require large amounts of inorganic fertilizers and pesticides that contaminate water and soil. (The current mix of pesticides is also highly toxic, with 85 percent of pesticides used by farmers in the Red River Delta categorized as "highly hazardous" or "moderately hazardous" according to World Health Organization [WHO] standards).[27] Intensive production of coffee and pepper in Vietnam's Central Highlands cause groundwater depletion and drive deforestation. Expansion of shrimp farming along the coast has caused serious destruction of mangrove forests and ecosystems.[28] Open burning of crop residues from maize, rice, and wheat is a major source of air pollution.

The expansion of agriculture in recent decades has come at a great expense to forests. While deforestation rates have come down in recent years, natural forest continue to be lost, with aggressive replanting programs not able to make up for the quality and extent of lost forest. In addition to pressure from agriculture, natural forests are being lost to infrastructure developments and converted to plantations, whose productivity is well below international standards. As a result, the quality of Vietnam's forests is poor.

Recognizing these challenges, the government of Vietnam aims to embark on a more sustainable and resilient growth path, as laid out in the 2021–2030 Socioeconomic Development Strategy. The strategy, built on the 2016–2020 Socioeconomic Development Plan and the National Strategy on Environmental Protection and National Green Growth Strategy (see box 1.1), includes actions to respond to climate change, prevent natural disasters, enhance natural resource management and environmental protection with the aim to transitioning to a low-carbon, green economy. For Vietnam to transition sustainably from a middle-income to a high-income economy in the coming decades requires a different growth model, one that is built on quality rather than quantity.

Against this backdrop, this report presents important diagnostics of Vietnam's current growth model employing three complementary analytical frameworks. These highlight how certain aspects of the economy may need to be modernized and rebalanced to minimize the impacts on the environment and human health. This is presented in a context in which Vietnam

25 FPT Securities 2015.
26 Dapice and Le 2018.
27 Thanh 2017.
28 Giap 2019.

is striving to become a competitive economy with strong linkages into global trade and a critical global partner to address global issues such as climate change. Specifically, the report

1. Assesses Vietnam's performance with respect to resilience, inclusion, sustainability, and efficiency (RISE), four critical dimensions associated with a more robust, equitable, efficient, and sustainable economy. Such an analytical lens allows Vietnam's growth to be compared against other peers, including high-middle-income countries (the category of countries Vietnam endeavors to belong to in about a decade) and serves an important benchmark.
2. Performs a comprehensive assessment of the current costs of environmental degradation (COED) that arise from pollution and an unsustainable use of resources. The size of these costs—benchmarked against GDP—provides not only an important metric to identify key areas of policy actions to reduce harm to the environment and people, but also opportunities to grow the economy more efficiently.
3. Analyses the costs and benefits of priority intervention areas emanating from the RISE and COED diagnostics and provides a first-order cost-benefit analysis (CBA) where available data allows for a rigorous analysis. Here the focus is on mechanisms to support the decarbonization of the economy; the role of a circular economy as a model to enhance not only better resource efficiency, but also the competitiveness and transformation of key industries; and investments in natural assets—forests, mangroves, and agricultural lands—as important factors in future growth.

BOX 1.1 **National Targets, Then and Now**

In Vietnam, the government's main strategy for development is captured in a 10-year Socio-Economic Development Strategy (SEDS), which is translated into action through two 5-year Socio-Economic Development Plans (SEDPs). Each SEDP provides medium-term direction for different sectors and guides relevant ministries to develop their own implementation plans. The 2021–2030 SEDS was adopted by the National Assembly in April 2021. It contains ambitious targets, including on the environment and climate.

For 2011 to 2020, one of the SEDS' main objectives was to improve the quality of the environment. While progress has been made, challenges remain:

- *Increasing forest cover.* In 2020, the total forest area in Vietnam was approximately 14.6 million hectares (up from 13.5 million hectares in 2011). The increase in forest area as a proportion of total land area (FAO 2020b, World Bank 2019a), however, masks the poor quality of forests: As of 2019, two-thirds of Vietnam's natural forests are considered in poor condition or regenerating, while rich and closed-canopy forest constitutes only 5 percent.
- *Increasing access to clean and hygienic water.* Vietnam has a sound record in the provision of water services, with 95 percent and 70 percent coverage of urban and rural populations, respectively. However, with rapid urbanization and increasing population, the sector is stressed and pollution is emerging as a key threat (World Bank 2019c).
- *Improving collection and treatment of wastewater.* With the low rate of collection and treatment and a prevalence of outdated septic tanks, water contamination is widespread. Only 46 percent

BOX 1.1 **National Targets, Then and Now (cont.)**

of urban households have connections to drainage systems, and only 12.5 percent of municipal wastewater is treated. Much industrial wastewater continues to be discharged without pretreatment (World Bank 2019c).

- *Improving solid and toxic waste management.* Only about 10 to 15 percent of collected waste is reused or recycled, with much of the remainder being sent to dumpsites and incineration facilities (Jäger and Münchau 2020), about 85 percent of waste generated is buried without treatment in landfills (Mordor Intelligence 2020). And only around 24 percent of businesses have applied cleaner production measures (for example, waste audits), despite a National Strategy on Cleaner Industrial Production to 2020 being enacted.
- *Increasing resilience to climate change and natural disasters.* The integration of climate change response solutions in development planning is already mandatory for ministries, sectors, and local levels in Vietnam, but implementation progress is mixed. While the Ministry of Planning and Investment and the Ministry of Natural Resources and Environment (MONRE) have issued implementation guidelines, other ministries and industries have their own action plans. And provinces, districts, and communes have made limited progress beyond piloting (KEI 2017).

Vietnam's commitment to environmental sustainability is captured at the very highest levels, including through the Constitution of the Socialist Republic of Vietnam, which was adopted in 2013. All of the environmental management and development objectives under the 2011–2020 SEDS had the full support of the Communist Party, and relevant resolutions or decisions at the sectoral level were approved by the prime minister. However, coordination across ministries and at different levels of governance, financial and infrastructure resources, and limited implementation continue to be challenging.

The translation of high-level policy priorities into national development plans or action plans at the ministerial level is incomplete. For example, the 2012 Law on Water Resources mandates an integrated water resource management approach as the basis for water resources planning, development, and management. The National Strategy on Water Resources to 2020 reiterates that "water resource management must be implemented in an integrated manner on a river basin basis." Circular 42 Regulations on Water Resources Planning Techniques issued by MONRE in 2015 outlines implementation of the ministry's planning functions under the law. However, as of 2019, without the approval of the Master Plan on Water Resources, there is little comprehensive planning in practice (in its absence, provinces have started to develop and approve their own water resources master plans). As a result, planning often sets out conflicting objectives at different levels, as guidance on the implementation of laws and regulations is often lacking (World Bank 2019c).

Enforcement is also generally uneven despite existing rules and regulations. A lack of coordination, both horizontally (that is, among line ministries) and vertically (that is, among national, provincial, district, and communal levels) hampers implementation. Often, this is amplified by high fragmentation of implementation responsibility and overlapping or conflicting mandates. For example, on waste management there are six ministries directly involved in managing and instructing local authorities, plus others that play a more indirect role. Often poor coordination starts within the same ministry or department, as is the case for MONRE (which includes the Vietnam Administration of Seas and Islands and the Vietnam Environment Administration) and the Department of Natural Resources and Environment (which includes an Environmental Protection Agency, the Seas and Islands Agency, and other specialized agencies). Consequently, roles and responsibilities are ill-defined and enforcement ineffective.

BOX 1.1 **National Targets, Then and Now (cont.)**

This is compounded by varying capacities to implement action plans, with stakeholders being constrained by inadequate technical knowledge or physical and financial resources. In solid and toxic waste management, for example, there were only 36 treatment facilities (incinerators and composting sites) in the country as of 2018. In 2019, the Vietnam Environment Administration also indicated that there was no solid waste treatment model in Vietnam that met all its technical, economic, social, and environmental requirements (Van 2019). Similarly, there is limited investment in the collection and treatment of wastewater. In 2018, there were 251 industrial zones that were operational out of a planned 326 (of these, only 220 had wastewater treatment plants). Also, most wastewater from about 5,000 craft villages, several big industrial factories outside industrial zones, and most local hospitals and private clinics goes untreated (World Bank 2019c).

Going forward, with implementation lacking, the 2021–2030 SEDS renewed and enhanced the objectives of the previous strategy. It sets out effective management and use of natural resources; enhanced environmental protection and response to climate change; and natural disasters preventiona and makes provision for

- **Building technical capacity,** for example, through the creation of a digital marine database to facilitate sharing and updating information, as well as strengthening environmental monitoring capacity (for example, sea level rise) and forecasting capacity (for example, natural calamities);
- **Adequate resourcing,** for example, for "policies and regulations to be improved and aligned to ensure more transparency as the basis for capitalization of natural resources," to improve resource allocation; and
- **Stricter enforcement and monitoring,** for example, air quality in urban areas will be more closely monitored and disclosed; pollution violations to be more strictly handled; and environmental protection regulations, environmental impact assessments, and strategic environmental assessments more seriously implemented.

More broadly, the 2021–2030 SEDS also includes strengthening of coordination among administrative levels so that decentralization is effective and local governments are equipped with a clearer definition of their roles and responsibilities so that implementation on the ground is facilitated.

Consistent with the 2021-2030 SEDS, the government adopted the National Green Growth Strategy for 2021-2030 with a vision to 2050, and an Action Plan for its implementation, with the overall objective to contribute to Vietnam's economic restructuring, and to achieve economic prosperity, environmental sustainability, and social equality with a goal of a green and carbon-neutral economy. It includes specific targets to reduce emissions, increase waste collection, apply a circular economy model across various industries, modernize agriculture and forestry, and boost renewable energy, amongst others. Internationally, the Prime Minister announced Vietnam's goal to achieve carbon neutrality by 2050 at the 26th Conference of Parties under the Climate Change Convention in November 2021, which implies even deeper emissions reductions than targeted in the SEDS and National Green Growth Strategy.

a. These objectives include the following: reduce emissions by at least 9 percent; meet environmental standards for 100 percent of production and business entities; establish marine and coastal reserves to make up 3–5 percent of the natural national sea area; access to clean water for urban households (90 percent); and proper waste collection and treatment covering urban (87 percent) and industrial (91 percent) zones.

2 Benchmarking Vietnam's Quality of Growth

This chapter presents a data-driven, evidence-based diagnosis of Vietnam's status in relation to key elements of green, resilient, and inclusive development. The analytics presented here are deliberately kept broad and include a set of indicators that measure achievements in a comprehensive manner across key areas of development. This is done to show how the relative performance with respect to the environment and natural assets relate to other areas of progress, such as social or infrastructure development. The analysis is performed in a manner that allows robust cross-country comparisons using globally comparable datasets, including quantitative benchmarking with countries in the same region or with similar economies.

Specifically, the diagnostics are based on an assessment of Vietnam's performance across four pillars: resilience, inclusion, sustainability, and efficiency (RISE):

- *Resilience* means to be prepared for natural disasters and unexpected catastrophes, such as another pandemic, climate change, or the next "flood of the century." Progress in resilience can be measured by indicators that capture a country's vulnerability and ability to cope and adapt to shocks.
- *Inclusion* refers to the reduction of disparities in opportunities and outcomes for groups that have historically been left out of enjoying the benefits of broader economic development. An inclusive society protects the dignity of individuals (and incorporates this protection in its institutions), and provides equal access to markets, services, and spaces. Progress can be measured by different indicators related to human capital outcomes.
- *Sustainability* means to grow in a way that preserves (or grows) natural, physical, human, and intangible capital and that the same opportunities are available to future generations. Tracking progress in sustainability focuses on natural capital, renewable resources, and decoupling of carbon emissions from economic growth.
- *Efficiency* means spending and using scarce resources better to maximize the returns to society while minimizing the financial, social, and environmental costs. Efficiency reflects resource constraints faced by countries as they grow. Measuring progress in efficiency captures the use of natural resources, productivity in areas such as transportation and communication, and quality of governance.

These four pillars are central to a more robust, equitable, efficient, and sustainable economy. Being designed in this manner, the RISE framework is tailored to measure quality of growth while not neglecting quantity of growth, which is central to any country's goals. It captures key interrelationships among different forms of capital that are central to a productive economy (see box 2.1). As such, it informs policy and investment decisions and the assessment of trade-offs, especially in a fiscally constrained environment. The analysis helps identify development priorities and "areas for improvement" using a variety of methods. It employs multiple metrics and methods to assure results are robust. For this analysis, the four RISE pillars are parameterized using 9–17 indicators per pillar, which are constructed from comprehensive and publicly available datasets such as the World Development Indicators. Many indicators confer benefits across multiple categories and there is no unique one-to-one mapping between RISE pillars and indicators.

BOX 2.1 **RISE and Natural Capital**

As for all countries, Vietnam's productive capacity requires physical capital (infrastructure, machines, and so forth); human capital (an adequate and skilled labor force); natural capital (land, water, ecosystems, and so forth); as well as intangible capital (such as functional institutions and laws). These capitals are interdependent and interconnected—water and air pollution affect humans' health and thus their productivity, mangroves protect coastal infrastructure from storm surges, and functioning institutions foster trust that allows companies to invest. There is ample evidence that demonstrates that if a country manages and balances these assets well, it improves development outcomes and supports consistent growth.

The RISE framework is designed to capture these features of an economy and to diagnose imbalances in asset distribution. Similar to the interrelationship of natural, physical, human, and intangible capital, the four RISE pillars—resilience, inclusion, sustainability, and efficiency—are often interconnected. For instance, the trends in the intensity of greenhouse gas (GHG) emissions are linked to the exposure of populations to hazardous air, and the degradation of coastal forests impacts the exposure of physical assets along the coast. This highlights that natural capital—a key focus area of chapter 3, on the costs of environmental degradation (COED)—is critical to support healthy life, underpins economic activity, and protects existing wealth.

For a country to grow sustainably—that is, to pursue growth that does not harm future development prospects—natural capital needs to be preserved and enhanced. To not erode an economy's productive potential, natural capital cannot be run down, just as physical capital (for example, industries), human capital (for example, skilled workers), and intangible capital (for example, courts and financial institutions) need to be maintained and invested in to support growth.

Similarly, efficiency of resource use is driven by how well a country's laws, regulations, or property rights protect natural resources (air, water, forests, fish) and provide incentives to not overuse or pollute them. In addition to public actions (such as sound regulation and laws), market instruments can provide incentives to manage scarce resources more efficiently and disincentivize behavior or activities that harm the environment. Improving efficiency means that an economy rebalances its capital wealth in a way that achieves more with less. This often means to reverse degradation of natural capital and make investments that leverage the capacity of natural capital to renew itself. For instance, degraded forests regenerate and become more productive if managed well. And sound management requires an investment in good forest managers and effective institutions (for example, that engage communities in and near forests).

A key approach to assessing a country's RISE performance is through benchmarking—that is, a relative ranking against the performance of other countries using a comparable set of indicators. To do this in a meaningful way, the set of indicators and reference countries must be tailored to the country of interest (for instance, it would not be meaningful to compare a highly forested country with a desert country on forest management). Also, for consistency and robustness of results, it is important to benchmark against multiple sets of countries. For instance, consistent relative underperformance against multiple comparators points to areas that likely require action to improve. Accordingly, this analysis benchmarks Vietnam's performance in the following three ways:

1. *A comparison with selected country peers at a similar development level.* In this case, Vietnam is compared against lower-middle-income countries (Vietnam's current comparators) and against upper-middle-income countries (Vietnam's aspirational peers). Scores are normalized so the worst performer achieves a zero score, and the ratio of Vietnam to the best performer is used.
2. *A global comparison that ranks Vietnam with the rest of the world.* Countries with available data are ranked in order of performance, and Vietnam's relative performance is given as its percentile.
3. *A regional comparison that compares Vietnam with different subgroups in the Asia region and other income groups.* The average percentile score per pillar calculated in benchmark 2 is compared against the region, income group, and subregions. This captures the performance relative to countries across the entire spectrum of development and income level.

The results of these benchmarks are presented below and are visualized using different graphic representations. These are briefly introduced and explained in the next section.

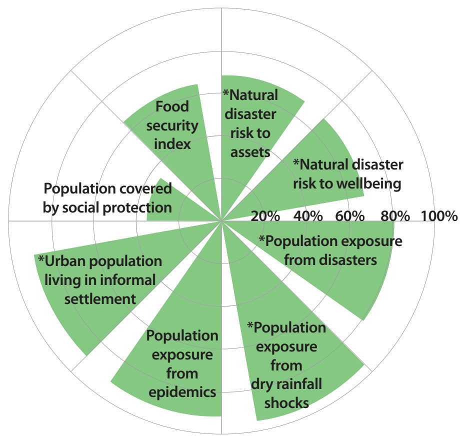
The underlying data used to parameterize the indicators come from a variety of global public datasets that are open to examination and scrutiny. Many underlying data sources are from the World Bank's World Development Indicators or based on a Sustainable Development Goals (SDG) indicator. The latest data available is used, though for indicators that have high interannual variability (for example, those related to natural disasters or deforestation) longer-term trends are taken into account if data from recent years are not representative. For consistency and robustness, overlapping indicators are considered as part of an ensemble of indicators (for example, multiple indicators on governance). More details on the data sources, methodology, and graphics are provided in Appendixes 1 and 2.

Benchmark 1: Middle-Income Countries

Comparing Vietnam against other middle-income countries on the four RISE pillars provides useful insights. In addition to lower-middle-income (LMI) countries, a comparison against upper-middle-income (UMI) countries is included as Vietnam endeavors to grow into this income group through implementation of its 2030 Socio-Economic Development Strategy (SEDS). The results for this comparison are shown in the flower diagram in figure 2.1, with each petal on the flower corresponding to one indicator. To facilitate the comparison, the value that determines the length of a petal was normalized such that better performance translates into a longer petal (irrespective of the sign of the underlying indicator). The length of the petal reflects Vietnam's performance relative (as a percentage) to the best performer in the peer group (100 percent). The center of the flower corresponds to the worst performer (zero percent). There is one diagram for each of the four RISE categories, though the number of indicators (that is, petals) varies by category.

For *resilience,* Vietnam's performance is hindered by natural and social vulnerability. Nine indicators related to natural and health disasters as well as social vulnerability (table 2.1) are used to assess performance. These include population exposure from disasters and epidemics and a food security index, among others. The comparison (figure 2.1) clearly shows Vietnam's relatively high vulnerability to natural disasters relative to other MICs, as infrastructure and people are increasingly clustering in floodplains and coastal zones. This amplifies the impacts of seasonal storms and floods (whereas droughts generally affect Vietnam to a much lesser degree than other middle-income countries [MICs]).[29] Epidemics are a relatively infrequent occurrence, and the government's response to the COVID-19 pandemic reflects the capacity to effectively respond to health disasters. On the social side, the comparison shows Vietnam's progress in addressing food security (facilitated by food affordability and availability), though UMI countries generally perform better. Prevailing malnutrition among marginalized groups is still a challenge. In stark contrast to other MICs is the relatively small share of the population covered by at least one social protection system.

FIGURE 2.1 **Resilience: Vietnam's performance relative to Best Performer in UMI Countries, by Indicator**



Source: World Bank. *Note:* UMI = upper-middle-income. *Indicates that lower values mean better performance.

TABLE 2.1. **Resilience Indicators in the RISE Framework**

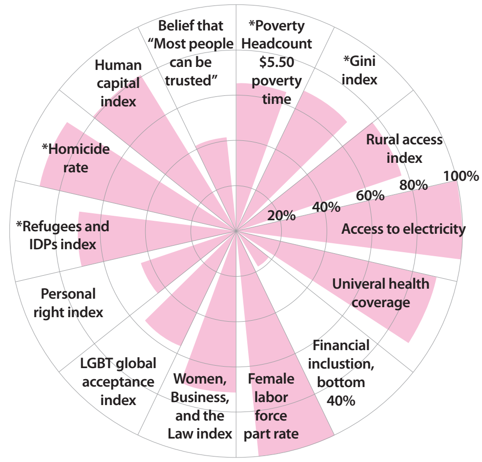
Dimension	Indicator	Vietnam	LMI mean	UMI mean
Natural disasters	*Natural disaster risk to assets (% of GDP)	1.5	0.9	0.6
	*Natural disaster risk to well-being (% of GDP)	2.0	1.4	0.9
	*Population exposure from disasters (% of total population exposed)	2.2	2.8	1.3
	*Population exposure from dry rainfall shocks (% of total population exposed)	4.8	14.9	16.8
Health disasters	*Population exposure from epidemics (% of total population exposed)	0.004	0.02	0.01
Social vulnerability	*Urban population living in informal settlement (% of total urban population)	13.8	39.0	26.2
	Population covered by social protection (% of total population)	38.8	28.1	55.8
	Food Security Index	60.3	53.1	63.4

Note: LMI = lower-middle-income; UMI = upper-middle-income. * Indicates that lower values mean better performance, and thus a higher benchmarking score and a longer petal on the graph

29 The severe 2015–17 drought that affected the southern part of the country is an indication of shifting patterns of seasonal weather risk driven by climate change.

For *inclusion,* Vietnam's performance varies widely. There is a large and diverse set of comparable indicators available to characterize Vietnam's progress on inclusion. Fourteen indicators measure distributional outcomes, access to services, access to markets and places, and social aspects (table 2.2). The results clearly show Vietnam's strong performance in poverty reduction, with a declining poverty rate and average headcount of 2.9 percent from 2011 to 2016 (compared with a UMI poverty headcount at US$5.5 per day). At the same time, income inequality remains a challenge, with no improvement in recent years. Access to services is relatively high in terms of health and electricity, with the exception of rural transportation access. Vietnam performs well in protecting gender equality, and women are actively engaged in the labor market (the female labor force participation rate is even higher than the UMI best performer), but there is still inadequate social acceptance of lesbian, gay, bisexual, and transgender (LGBT+) people. Vietnam can also do better in other rights, access to justice, and property rights for women, and extremely low financial inclusion of the poor. These findings are derived from inclusion related indicators based on global datasets[30]. While Vietnam has a homicide rate below the LMI and UMI average, there is moderate pressure on the country caused by internally displaced persons and refugees. Vietnam is the best performer among LMI countries in terms of social dimensions of inclusion, showing high levels of human capital and strong trust among people, but it performs inadequately in these two dimensions compared with UMIs (figure 2.2).

FIGURE 2.2 **Inclusion: Vietnam's performance relative to Best Performer in UMI Countries, by Indicator**



Source: World Bank. Note: IDPs = internally displaced persons; LGBT = lesbian, gay, bisexual, and transgender; UMI = upper-middle-income. *Indicates that lower values mean better performance.

TABLE 2.2. **Inclusion Indicators in the RISE Framework**

Dimension	Indicator	Vietnam	LMI mean	UMI mean
Distributional outcomes	*Poverty headcount US$1.90 day (% of total population)	2.9	15.3	—
	*Poverty headcount US$5.50 day (% of total population)	34.8	—	26.5
	*Gini index on income inequality	35.7	38.3	40.5
Access to services	Rural access index	66.7	38.0	41.7
	Access to electricity (% of total population)	100.0	80.9	95.5
	Universal health coverage index	75.0	57.7	68.9

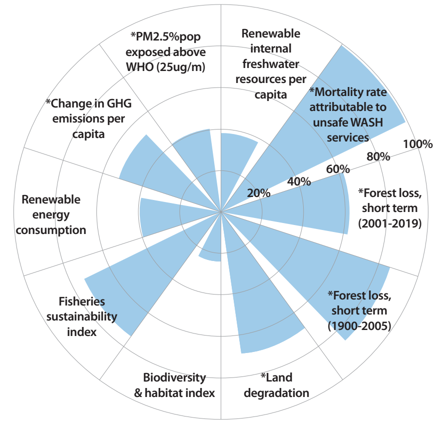
30 World development indicators, global findex database, global acceptance index, Women, Business and the Law data, social progress imperative

TABLE 2.2. **Inclusion Indicators in the RISE Framework (cont.)**

Dimension	Indicator	Vietnam	LMI mean	UMI mean
Access to markets and places	Financial inclusion, bottom 40% (% with financial account)	20.3	33.6	49.1
	Female labor force participation rate (% of female population)	72.8	50.5	47.8
	Women, Business, and the Law index	78.8	69.9	75.4
	Lesbian, gay, bisexual, and transgender (LGBT) global acceptance index	4.6	3.8	4.2
Social dimension of inclusion	Personal rights index	45.5	60.9	65.7
	*Refugees and Internally Displaced Persons index	4.4	5.9	5.2
	*Homicide rate (victims of intentional homicide per 100,000)	1.5	4.5	4.2
	Human Capital Index	0.7	0.5	0.6
	Belief that "Most people can be trusted" (% agreeing)	27.7	12.2	17.1

Note: LMI = lower-middle-income; UMI = upper-middle-income. * Indicates that lower values mean better performance

FIGURE 2.3 **Sustainability: Vietnam's performance relative to Best Performer in UMI Countries**



Source: World Bank. *Note:* IDPs = internally displaced persons; LGBT = lesbian, gay, bisexual, and transgender; UMI = upper-middle-income. *Indicates that lower values mean better performance

For *sustainability,* Vietnam is clearly lagging in virtually all sustainability indicators. Ten indicators are used to measure performance on natural resource use and carbon decoupling (table 2.3). Air pollution is a major problem, as 60 percent of the population in Vietnam is exposed to unhealthy concentrations of fine particulate matter (PM2.5) as defined by the World Health Organization. Vietnam is also water-stressed in some seasons, with very low levels of water availability in several basins. While a significant share of forest cover was lost in the twentieth century, deforestation (which has been rampant during recent decades) has started to slow somewhat. At the same time, forest quality (degradation) continues to increase despite efforts to replant forests (an effect, however, that is masked in a cross-country comparison with global datasets). The poor quality of forests correlates with land degradation, with 31 percent of the land having been degraded from 2000 to 2015. At face value, Vietnam's performance on fisheries seems moderately sustainable (though global statistics tend to mask overfishing driven by increases in vessel size), and the deterioration of habitat and terrestrial biodiversity is acute. Indicative of an unstainable trajectory are GHG emissions, which increased by 41 percent during 2008–17, exacerbated by energy consumption being heavily dependent on fossil fuels (figure 2.3).

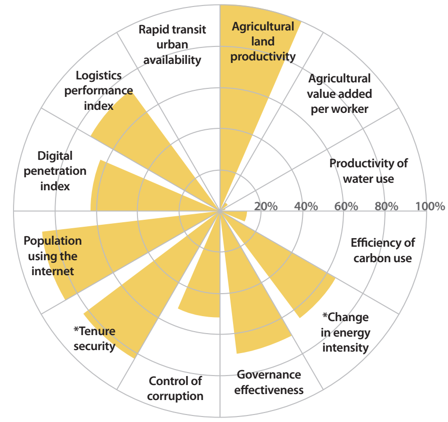
TABLE 2.3 **Sustainability Indicators in the RISE Framework**

Dimension	Indicator	Vietnam	LMI mean	UMI mean
Natural resources	*PM2.5 pollution, population exposed to levels exceeding WHO Interim target of 25µg/m (% of total)	59.6	78.2	56.6
	Renewable internal freshwater resources per capita	3,799	4,002	5,322
	*Mortality rate attributable to unsafe water, sanitation, and hygiene (WASH) services (per 100,000)	1.6	18.4	3.4
	*Forest loss, short term (% of forest loss since 2000)	17.3	8.7	6.8
	*Forest loss, long term (% of forest loss since 1900)	19.6	40.5	40.5
	*Land degradation (degraded land as share of total land area)	31.0	20.4	21.2
	Biodiversity Habitat Index	33.3	52.4	56.5
	Fisheries Sustainability Index	14.6	12.1	11.0
Carbon decoupling	Renewable energy consumption (% of total energy consumption)	32.0	42.5	20.5
	*Change in GHG emissions per capita (% change 2008–17)	41.4	11.8	2.1

Note: GHG = greenhouse gas; LMI = lower-middle-income; PM2.5 = particulate matter measuring 2.5 microns or less in diameter; UMI = upper-middle-income; WASH = water, sanitation, and hygiene; WHO = World Health Organization. *Indicates that lower values mean better performance

For *efficiency*, Vietnam's performance is greatly hindered by its inefficiency of resource use. Twelve indicators characterize resource use, governance and transport, and information and communication technology (ICT) (table 2.4). In terms of land productivity, Vietnam surpasses the UMI best performers and is ranked second in the world, behind only the Arab Republic of Egypt in the LMI group, which is nearly 2.5 times more efficient. However, labor productivity in agriculture is very low, as is economic value added per unit of GHG emission. Energy intensity of gross domestic product (GDP) did not significantly improve from 2005 to 2015. Water productivity falls far behind the LMI average and is the lowest in the peer group. Vietnam performs relatively well in regulatory efficiency but lags in control of corruption. Land tenure is overall relatively secure in Vietnam, with only 10 percent of people reporting insecure property rights. Vietnam is efficient in supplying widespread coverage of the internet and in adopting digital technologies across the country. Logistics supply chains are relatively efficient, making it one of the most open economies to international trade in Asia. A lack of rapid transit in Vietnam makes public transportation very inefficient, putting a drag on cities. See figure 2.4 for the corresponding flower chart.

FIGURE 2.4 **Efficiency: Vietnam's performance relative to Best Performer in UMI Countries, by Indicator**



Source: World Bank. *Note:* *Indicates that lower values mean better performance.

TABLE 2.4 **Efficiency Indicators in the RISE Framework**

Dimension	Indicator	Vietnam	LMI mean	UMI mean
Resource use	Agricultural land productivity ($ per hectare of agricultural land)	2,740	848	685
	Agriculture value added per worker ($ per agricultural worker)	1,202	3,874	8,353
	Productivity of water use (US$ per m3 water withdrawals)	2.1	15.9	16.1
	Efficiency of carbon use (GNI per kiloton of CO2 equivalent)	481,450	743,771	1,171,800
	*Change in energy intensity (% change in megajoule energy/GDP 2005–15)	−5.5	−9.5	−5.6
Governance	Governance effectiveness	−0.003	−0.550	−0.210
	Control of corruption	−0.49	−0.61	−0.47
	*Tenure security (% of population reporting insecure property rights)	10.0	22.6	20.1
Transport and information and communications technology (ICT)	Population using the internet (% of total population)	70.4	38.6	63.6
	Digital penetration index	0.52	0.42	0.56
	Logistics Performance Index	3.2	2.6	2.8
	Rapid transit urban availability (kilometers of rapid transit per million urban residents)	1.4	7.4	12.1

Note: CO2 = carbon dioxide; GNI = gross national income; LMI = lower-middle-income; UMI = upper-middle-income. *Indicates that lower values mean better performance.

Benchmark 2: The Rest of the World

Compared against the world, Vietnam significantly underperforms and is below the global median for resilience, sustainability, and efficiency. This is quantified in figure 2.5, which shows Vietnam's percentile rank against all countries for each indicator (grouped by the four RISE pillars). The longer the bar, the better a country is performing (scores range from zero to 100). The unweighted means of indicators across each of the four pillars give the aggregate pillar scores shown in table 2.5. Pillar scores above or below 50 percent indicate the country performs better or worse than the median country on that particular pillar.

For *resilience,* the low average score is driven by the inadequate performance on natural disasters (reflected in risks to assets and people, but also lack of safety nets), which was revealed in the comparison against MICs, above. For food security, on which Vietnam compared favorably against MICs, Vietnam is at 45 percent in the global context.

For *sustainability,* Vietnam is well below the performance of most other countries with respect to natural resources and carbon decoupling. This is driven by the increase

TABLE 2.5 **Aggregate Benchmarking Performance of Vietnam on the Four RISE Pillars**

Pillar	Dimensions		
Resilience	Natural disasters	32	▼
	Health disasters	55	▲
	Social vulnerability	54	
	Average	**43**	▼
Inclusion	Distributional outcomes	50	
	Access to services	81	▲
	Access to markets and places	45	
	Social dimention of inclusion	63	▲
	Average	**58**	▲
Sustainability	Natural resources	43	▼
	Carbon decoupling	32	▼
	Average	**41**	▼
Efficiency	Resource use	32	▼
	Governance	60	▲
	Transport and ICT	43	▼
	Average	**43**	▼

Significantly below global median ▼
Significantly above global median ▲

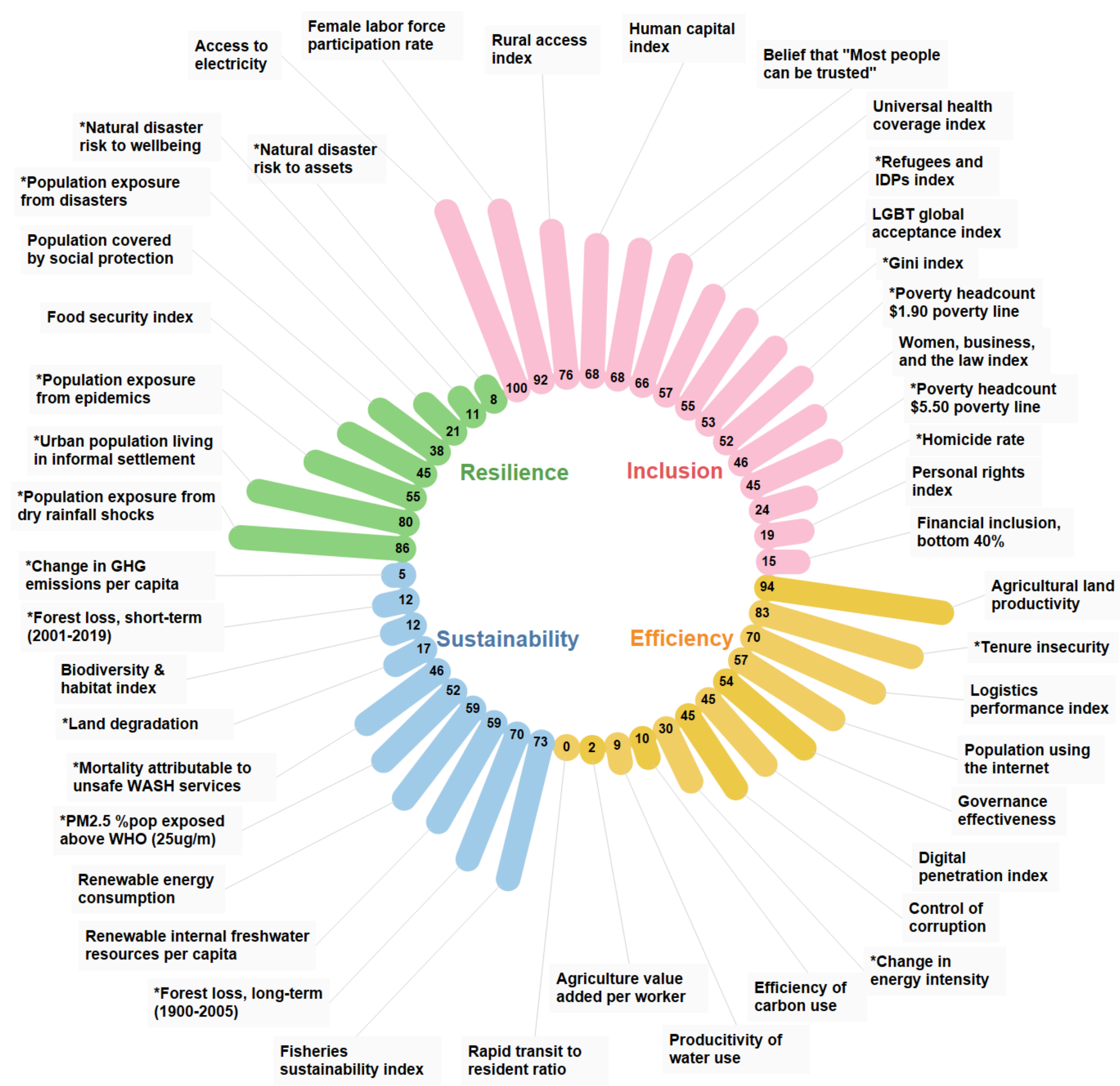
Source: World Bank. *Note:* The unweighted means of indicators across each of the four pillars give the aggregate pillar scores shown in table 2.5. Pillar scores above or below 50 percent indicate the country performs better or worse than the median country on that particular pillar. ICT = information and communication technology.

in per capita emissions, but also by the relatively high rate of forest loss in the past two decades, biodiversity values, and land degradation (for which Vietnam is in the lowest 17 percent globally). The fact that Vietnam's air quality appears in the midrange (52 percent) is mostly a reflection of the fact that an increasing number of the global population is exposed to toxic air (especially in the developing world) and does not deflect from the high levels or air pollution experienced in the country today.

The same applies to *efficiency,* for which the lowest rankings are associated with change in energy intensity (30 percent), per capita emissions (26 percent), and productivity of water use (9 percent). It also points to inefficiencies in the agriculture sector, as reflected by the very low ranking (2 percent) for value addition of agricultural workers (contrasting with the very high score on agricultural land productivity, which reflects the strong performance of the sector). Rapid urban transit is virtually absent in the country, which puts Vietnam in the lowest percentile globally.

On *inclusion,* Vietnam performs more favorably in the global context, with higher scores for access to services and social dimensions. Yet, low performance on the personal rights index and financial inclusion, as well as poverty headcounts, point to the unfinished agenda toward a fully inclusive society. Spatial and social heterogeneities, such as urban-rural differences and equal access and rights of ethnic groups, are masked by national statistics but are well known as important areas for improvement.

FIGURE 2.5. **Percentile Ranking of Vietnam against the Rest of the World on the Four RISE Pillars, by Indicator**



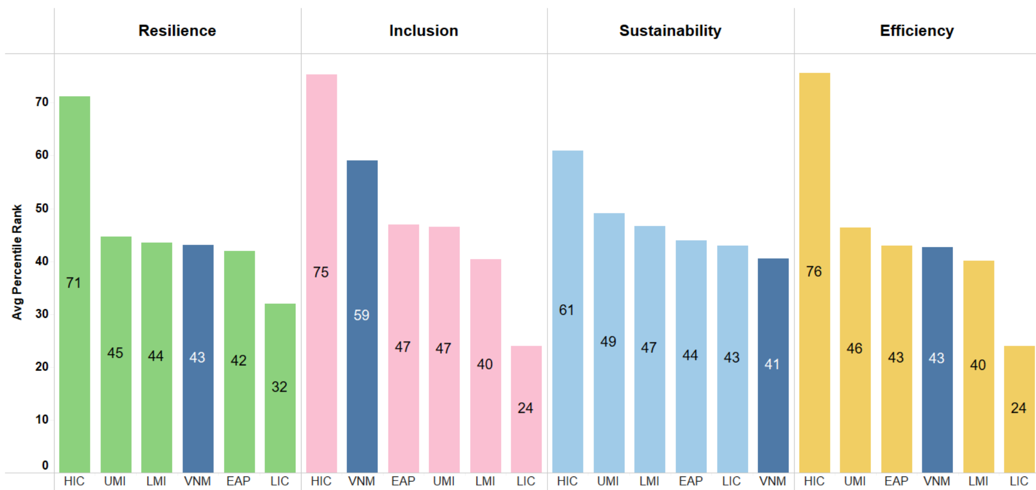
Source: World Bank. *Note:* GHG = greenhouse gas; IDPs = internally displaced persons; LGBT = lesbian, gay, bisexual, and transgender; PM2.5 = particulate matter measuring 2.5 microns or less in diameter; WASH = water, sanitation, and hygiene; WHO = World Health Organization. *Indicates that lower values mean better performance.

Benchmark 3: Regional and Income Peers

When compared against income groups and within its regional peers, Vietnam—on average—performs worst on sustainability, lower than any income group and the countries in the East Asia and Pacific region. On resilience, Vietnam is on par with its regional neighbors (including the Association of Southeast Asian Nations [ASEAN]) and just below LMI countries. For efficiency, performance is at the East Asia and Pacific average and below ASEAN and UMI countries (Vietnam only exceeds LMI and LIC countries). A noteworthy observation in figure 2.6 is the significant gap in performance between MICs and the developing countries in the Asia region overall, with high-income countries globally performing better, notably on efficiency and resilience.

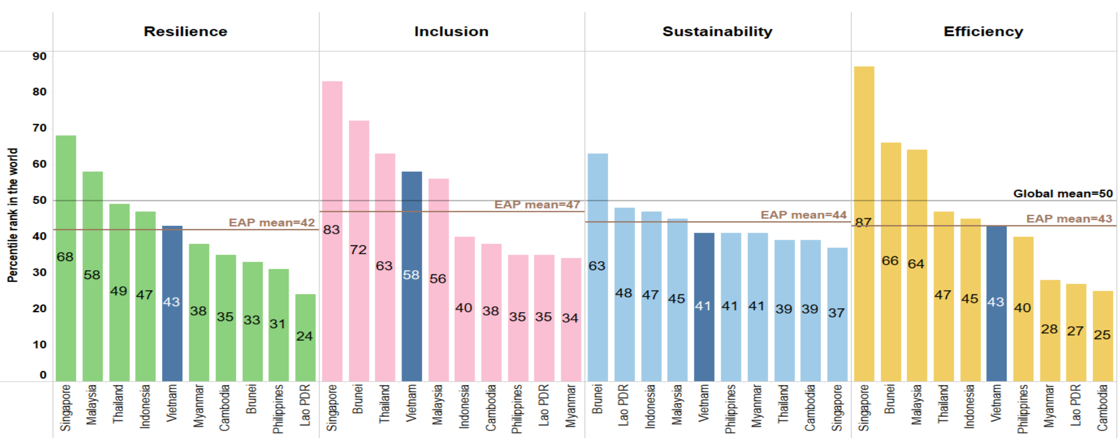
The direct comparison with ASEAN countries (figure 2.7) further highlights the shortcomings on sustainability and efficiency and the average performance on resilience. Only on inclusion does Vietnam outperform its peers in this grouping, and it is above average in the East Asia and Pacific region.

FIGURE 2.6. **Percentile Ranking of Vietnam on the Four RISE Pillars against Income Groups, ASEAN Countries, and the East Asia and Pacific Region**



Source: World Bank. *Note:* ASEAN = Association of Southeast Asian Nations; EAP = East Asia and Pacific; HIC = high-income countries; LIC = low-income countries; LMI = lower-middle-income countries; UMI = upper-middle-income countries; VNM = Vietnam.

FIGURE 2.7 **Percentile Ranking of Vietnam against ASEAN Countries on the Four RISE Pillars**



Source: World Bank. *Note:* EAP = East Asia and Pacific.

3 The Environmental Costs of Current Growth

This section quantifies the costs of the deteriorating environment in monetary terms. Specifically, the cost of environmental degradation (COED) is a common analytical framework to measure the lost welfare of a nation due to environmental degradation.[31] It identifies where the costs are high, not only in absolute terms and relative to national income but also relative to the sectors that are affected. Thus, the COED is important to formulate policies both in the environmental areas and across economic sectors. It helps make a case for further analysis to specify the most effective approach to reduce such losses and to implement measures.

The time period for the costs is usually one year. Such a loss in welfare from environmental degradation includes, but is not necessarily limited to, (a) loss of life; (b) loss of well-being caused by illness, absence of a clean environment, and discomfort; (c) economic losses (for example, reduced soil productivity and reduced value of other natural resources, lower international tourism); and (d) loss of environmental opportunities (for example, reduced recreational value for lakes, rivers, beaches, forests).

The process of estimating the COED involves placing a monetary value on the consequences of the degradation. This usually implies a three-step process:[32]

1. Quantification of environmental degradation (for example, monitoring of the quality of ambient air, river water, or soils)
2. Quantification of the consequences of degradation (for example, negative impacts on health from air pollution, changes in soil productivity, or reduced tourism demand)
3. A monetary valuation of the consequences (for example, estimating the cost of ill health, soil productivity losses, or reduced recreational values).

This report uses available information on the quantification of environmental degradation in Vietnam and the consequences of degradation. In cases for which no local information was available, data from global studies were used, taking account of differences between the locations where the estimates were made and Vietnam as much as possible. The reported costs are derived by taking the impacts of degradation in physical terms and multiplying them by the unit values of cost of degradation. The impacts have been taken for the most recent period available, 2020

31 Estimates of COED have been undertaken for many countries over the past two decades. In East Asia, the World Bank has undertaken a study for Indonesia (2009), and other researchers have done one for China. In South Asia, studies have been conducted for Bangladesh (World Bank 2006) and India (Mani et al. 2012). In Colombia, a study was undertaken in 2004 by the Republic's Ministry of Environment, Housing and Land Development. In the Middle East and North Africa, studies from the late 1990s covered Algeria (1998), the Arab Republic of Egypt (1999), Tunisia (1999), the Syrian Arab Republic (2001), the Islamic Republic of Iran (2002), Jordan (2006), Lebanon (2000,2006), Morocco (2000), and Iraq (2008) A review of these studies and their impact on policy revealed that they played a significant role in raising the awareness of the environment and of allocating resources for its protection (Croitoru and Sarraf 2010).

32 Environmental science, natural resource science, health science and epidemiology, economics, and other sciences are applied to quantify environmental degradation or conditions and their consequences. For valuation of the consequences, and sometimes to quantify the consequences of degradation, environmental economics and natural resource economics are applied.

for most cases, based on the data availability. Finally, costs are reported as a percentage for 2020 gross domestic product (GDP). The reliability of estimated costs in different sectors varies; consequently, a statement is made on how reliable each estimate is for policy purposes and what further work would further refine the estimation.

The work presented here provides first-order estimates of the cost of environmental degradation in Vietnam and a brief discussion of the policy implications of the estimates. An attempt has been made to capture what may be expected to be the most significant costs of degradation, organized into three categories and eight impacts:

- Pollution
  - Ambient air
  - Lead
  - Water
  - Solid waste, including plastics
- Environmental services
  - Forests, including mangroves
  - Agricultural land
  - Fisheries
- Climate change.

The selection of these eight impacts under the three categories is based on an extensive literature documenting the environmental impacts of Vietnam's remarkable economic development in recent decades. However, owing to data limitations, estimates in some environmental areas are not included; therefore, the total estimate of environmental degradation, as presented here, is likely to underestimate the true costs of degradation. A summary of the methods used to value the impacts in each case are given in table 3.1.

33 Impacts not included in the analysis due to data limitations and other considerations are (a) indoor air pollution and health impacts of various chemicals used in the workplace or the home, and (b) impacts of nitrogen oxide (NOX) and other air pollutants. One category not normally included in COED is greenhouse gas (GHG) emissions, which cause climate changes across the globe. The social cost of carbon that is used to value these costs is a measure that includes costs everywhere. Only a very small percentage of the global total would be the damage in Vietnam. However, the loss of sequestration capacity from forests, mangroves, and other land areas that removed carbon dioxide (CO2) from the atmosphere is included as a loss. This study follows a similar convention in that sequestration is valued for forests, mangroves, and other land areas.

TABLE 3.1. **Summary of Methods Used to Value Environmental Impacts**

Sector	Negative Impact	Valuation Method
Air Pollution	Impact of fine particles on heath (respiratory and cardiac illnesses, cancer)	Premature mortality using value of statistical life (VSL). Morbidity using link between cost of illness and VSL. Loss of productivity using loss of earnings.
Lead Pollution	Impaired intelligence and increased incidence of mild mental retardation in children	Product of loss of income per lost IQ point and number of children who are expected to enter labor force.
Primary Forests and Mangroves	Loss of forest area leading to loss of provisioning, regulating and cultural services	Market values of provisioning services. Use of meta-analysis and global studies for other services.
Fisheries	Overfishing	Costs of restoring stocks to sustainable levels.
Land Degradation	Loss of net primary productivity, resulting in loss of ecosystem services	Market values for provisioning services. Meta-analysis and global studies for other services.
Water Pollution	Waterborne diseases, especially for children Loss of productivity for rice, coffee, and aquaculture	Loss of life valued using VSL. Morbidity effects valued using costs of illness. For others, loss of net output.
Sector	Negative impact	Valuation method.
Solid Waste	Loss of amenity near landfills Leaching from landfills not meeting sanitary standards	Depreciation of property values near landfills. Costs of upgrading landfills.
Plastics	Air emissions in production and disposal Litter Damages to marine ecosystems	Same as methods used for air pollution. Costs of collection and loss of tourism. Losses in fisheries and other services.
Climate Change	Biodiversity fragmentation and loss of habitat Higher costs of cooling homes and workplaces Decline in labor productivity Sea level rise Change in supply of freshwater Changes in agricultural yields and fish stocks Changes in forest growth rates Increases in extreme events Changes in hydro energy Changes in tourism Health impacts of heatwaves, vector and waterborne diseases, and extreme events.	Losses of market crops and cultural services. Additional costs incurred. Value of output lost. Costs of additional protection or retreat. Costs of meeting demand for water from other sources. Value of change in output and capture fishery. Value of changes in forest biomass. Damages to infrastructure from extreme events. Changes in value of hydro energy. Changes in receipts from tourism. Loss of life using VSL. Morbidity costs linked to VSL.

Source: World Bank.

Both welfare- and market-based estimates are important for policy. The standard definition of COED is a measure, in monetary terms, of the loss of well-being as a result of environmental degradation. This in turn is based on what individuals are willing to pay (WTP) to avoid negative environmental impacts. For many such impacts, WTP is related to a market value. For example, if a farmer loses out in terms of yield as a result of polluted water, the WTP will be closely tied to the value of the loss yield. This close relationship applies for many impacts, but not all. The one that raises major differences between welfare and market values is premature mortality. For a welfare measure this is based on WTP, which in turn is used to derive the value of a statistical life (VSL). For a market-based measure, premature mortality is based in terms of forgone earnings. The discussion on air quality elaborates on the methods for obtaining these estimates and the numbers obtained. Both measures are of interest to policy makers, but as they have different implications, it is important to provide both. There is a difference between the two only for those categories of cost where premature mortality is a component (that is, air, water, and lead pollution). In all other categories, the welfare and market-based costs are the same (see box 3.1).

A Supplementary Note provides additional technical detail on the methods and results presented in this report.

BOX 3.1 **Interpretation of COED estimates**

The COED figures give a monetary estimate of the losses caused in different areas. This allows them to be compared with losses and gains from economic activities and helps policy makers allocate resources to reduce the costs in a more efficient manner. The COED information, however, is only an input into a decision on whether expenditures should be made to reduce the costs. That will require a comparison of the amount of expenditure needed and the amount by which the environmental costs are reduced.

A high COED does not mean that interventions should have priority in that area over areas with lower costs. It may well be the case that a sector where the COED is modest can be reduced at very low cost, in which case that should be a priority. Other considerations also come into play. If the costs are borne by poor and vulnerable groups, then environmental degradation is contributing to increasing inequality and poverty, in which case action may be justified on those grounds. There is also a difference in value attached to the loss of life relative to loss of natural resources, which tends to give greater weight to pollution-related components.

COED figures are normally reported as annual costs and cited relative to GDP to put them in perspective. The validity of this comparison is limited. It does not mean, for example, that if the costs were reduced to zero, GDP would rise by that amount. Even if reductions in COED could be made at very low cost, the impacts on GDP would be complex and depend on how the economy was reconfigured after the changes.

BOX 3.1 **Interpretation of COED estimates (cont.)**

Some components of COED involve losses that are also reflected in market transactions, but this is not true for all components. Losses of yields in production as a result of pollution imply reduction in output and reduced income to people working in that sector. However, losses in the form of premature mortality do not necessarily imply such a loss. Yet, they are normally part of the COED. To provide a measure that is more closely tied to economic measures of output, the COED is sometimes reported separately for the part based on purely market transactions.

All the COED exercises conducted recognize the large uncertainties involved in the estimates. The figures should not be taken as exact, but rather as indicative of the order of magnitude of the costs. It would be desirable to report the uncertainty for each impact in comparable terms, ideally using a statistical framework that gives confidence intervals. Unfortunately, the data simply do not allow such a systematic exercise, as the component costs come from different studies with different methodologies and most do not give a statistical estimate of uncertainty. Instead, what has been done is to give a range based on parameters for which a range of values is available. The estimation process involves linking several steps, going from the environmental indicators, to the physical impacts for relevance, to the values of those impacts. Each has uncertainties, which combine multiplicatively. Thus, the reported uncertainties are only partial and indicative. They are best seen as a sensitivity analysis of the main figures presented.

Pollution

Four main sources of pollution are valued: air, lead, water, and solid waste.

Air

Impacts

Air pollution is a major environmental risk to health globally.[34] In 2019, ambient air pollution particles that are 2.5 microns or less in diameter (PM2.5) were responsible for 4.14 million deaths worldwide.[35] People living in low- and middle-income countries disproportionately experience the burden of outdoor air pollution, with 91 percent of global deaths occurring in those countries. According to the World Health Organization (WHO), Southeast Asia is one of the most seriously impacted regions.

34 "Ambient Outdoor Air Pollution," factsheet, World Health Organization (last modified September 22, 2021): https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.

35 See the Global Burden of Disease (GBD) Results Tool from the GBD Study 2019, Institute for Health Metrics and Evaluation (IHME), University of Washington, Seattle: https://ghdx.healthdata.org/gbd-results-tool.

The strongest causal associations between air pollution and health are typically between PM2.5 concentrations and cardiovascular and pulmonary disease.[36] PM2.5 particles can reach the lower respiratory tract and thus have greater potential for causing lung cancer, stroke, ischemic heart disease, chronic obstructive pulmonary disease, and acute lower respiratory disease.[37,38] Recent evidence also points to air pollution's adverse impact through illnesses such as diabetes and dementia. Additional newer research and modeling[39] suggests that ambient particulate air pollution is an even more important population health risk factor than previously thought and led to an estimated total of 8.9 million deaths worldwide in 2015. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.

Two other major pollutants from fuel combustion include sulfur dioxide (SO2) and nitrogen dioxide (NO2). SO2 can cause serious harm to the respiratory system, even with short-term exposures. People with asthma, especially children, are particularly sensitive to SO2. Several recent multicity studies, particularly in China,[40] reveal that there is consistent evidence of positive associations between short-term SO2 exposures and additional mortality. There is likely to be a causal relationship between long-term NO2 exposure and respiratory effects based on evidence for the development of asthma. Epidemiologic studies show associations of long-term NO2 exposure with decreases in lung function and development and increased respiratory disease severity in children.[41]

Vietnam's average annual concentration of particulate matter (PM) has been well above levels that are considered safe by the WHO (10 μg/m^3). Data derived from satellite observations[42] and averaged for the entire country (figure 3.1) show a slight decrease in average PM2.5 concentrations since 2010, but with levels consistently four to five times higher than the WHO's safe guideline of 10 micrograms of PM2.5 particles per cubic meter of air volume (μg/m^3). However, these national estimates mask very high seasonal and geographic concentrations in major urban areas such as Hanoi and Ho Chi Minh City (figures 3.2 and 3.3) derived from local ground-based air quality monitoring stations. This is reflected in studies of PM2.5 concentrations for a range of cities in Vietnam going back to 2001 (table3.2).

36 As recommended by the WHO, health risk factors are divided into three groups: metabolic, behavioral, and environmental (see http://ghdx.healthdata.org/gbd-results-tool). Other risk factors for cardiovascular and pulmonary disease include tobacco smoking, alcohol and drug use, dietary risks, and high blood pressure.

37 GBD Results Tool from the GBD Study 2019, IHME, University of Washington, Seattle: https://ghdx.healthdata.org/gbd-results-tool.

38 The World Bank World Development Indicators define the particulate matter (PM) indicator as follows: "Population-weighted exposure to ambient PM2.5 pollution is defined as the average level of exposure of a nation's population to concentrations of suspended particles measuring less than 2.5 microns in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage. Exposure is calculated by weighting mean annual concentrations of PM2.5 by population in both urban and rural areas. Estimations of long-term mortality are based on the long-term average concentrations. The concentrations are developed through a method of combining geophysical satellite-derived PM2.5 estimates with geographically weighted ground-based monitoring data" (van Donkelaar et al. 2016).

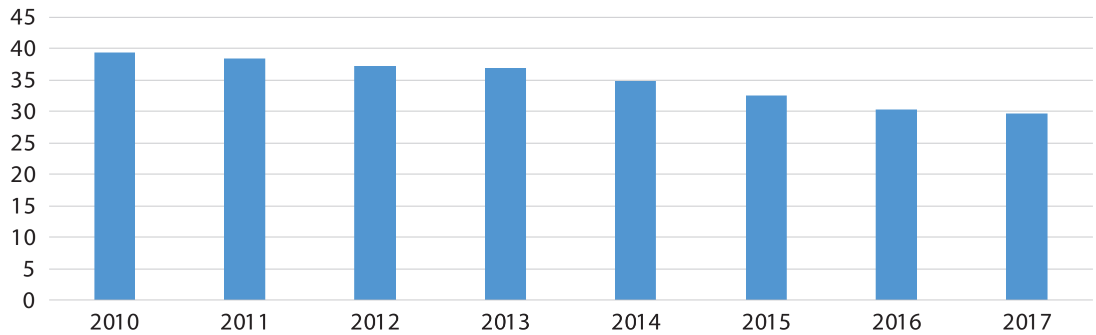
39 Burnett et al. 2018.

40 Chen et al. 2012.

41 EPA 2016.

42 Satellite-based estimates are useful as they cover large areas and can be improved on with extensive ground-based monitors.

FIGURE 3.1. **Ambient Average PM2.5 Concentration (μg/m³) for all of Vietnam (Satellite-Based), 2010–17**



Source: World Bank, World Development Indicators.

Note: PM2.5 = particulate matter measuring 2.5 microns or less in diameter; μg/m³ = micrograms per cubic meter of air.

Ground-based monitors provide a more accurate picture of local air pollution in highly populated areas. They provide individual point source estimates of pollutant concentrations, but are representative of wider areas, depending on local meteorology and topography. Real-time PM2.5 monitoring at the US Embassy in Hanoi and at the US Consulate in Ho Chi Minh City report their data online and are freely available (recent data shown in figures 3.2 and 3.3).[43] While the government of Vietnam maintains its own monitoring system, these data were not available for this analysis. These data would provide a more complete picture of air quality in various cities of Vietnam and reduce uncertainties in exposure concentrations. In addition, there are monitors reporting online in Vietnam;[44] however, long-term air quality data and sensor information that are required to study impacts on human health are not available from such networks; thus, the present study relies on observations from satellites and the above-noted monitoring stations by the US Embassy.

TABLE 3.2 **Location, Year, and PM2.5 Concentrations in Vietnam from Various Studies**

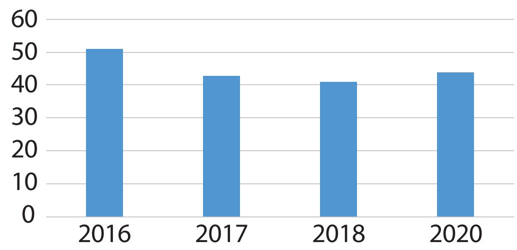
City or region	Study/sample years	Annual Average PM2.5 concentration (μg/m³)	Source
Hanoi	2017	42.6	GreenID 2018 (citing MONRE)
Viet Tri	2016	69.0	Pham et al. 2019 (PM from most recent year)
Ha Long	2017	28.0	Pham et al. 2019
Da Nang	2016	16.0	Pham et al. 2019
Nha Trang	2016	6.0	Pham et al. 2019
HCMC	2017–18	36.3	Hien et al. 2019
HCMC	2017	29.6	Green ID 2018

Note: The dry season is November to April; the wet season is May to October. HCMC = Ho Chi Minh City. MONRE = Ministry of Natural Resources and Environment; PM2.5 = particulate matter measuring 2.5 microns or less in diameter. μg/m3 = micrograms per cubic meter of air.

43 https://www.airnow.gov/international/us-embassies-and-consulates/.

44 https://aqicn.org/city/vietnam/hanoi.

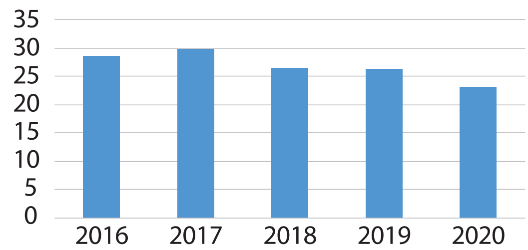
FIGURE 3.2 **Annual Average Ambient Concentrations of PM2.5 (µg/m³) in Hanoi, 2016–20**



Source: AirNow data, US Department of State: https://www.airnow.gov/international/us-embassies-and-consulates/#Vietnam.

Note: Insufficient data for 2019. PM2.5 = particulate matter measuring 2.5 microns or less in diameter; µg/m3 = micrograms per cubic meter of air.

FIGURE 3.3. **Annual Average Ambient Concentrations of PM2.5 (µg/m³) in Ho Chi Minh City, 2016–20**

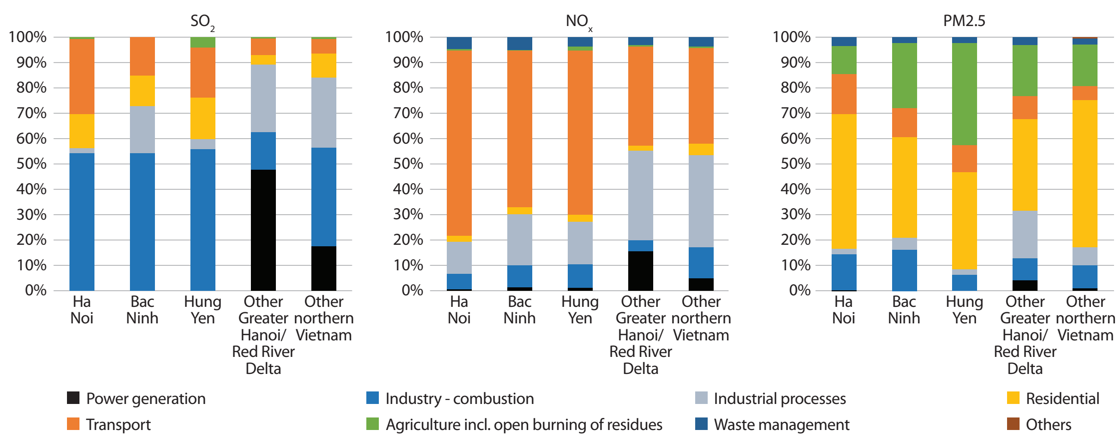


Source: AirNow data, US Department of State: https://www.airnow.gov/international/us-embassies-and-consulates/#Vietnam.

Note: PM2.5 = particulate matter measuring 2.5 microns or less in diameter; µg/m3 = micrograms per cubic meter of air.

The sources of particulate pollution across Vietnam are varied but fairly typical. They include automobiles, diesel vehicles, and other transport; smoke from forest fires and biomass burning, frequently rice straw; ferrous and cement industries; and the power sector and coal combustion. In other studies, sources include textiles and dyeing, food processing, cement, steel production, and rice processing.[45] Essentially all sectors of the Vietnamese economy are contributing to this type of air pollution (figure 3.4). Further information on the contribution of different sources is presented in box 4.2.

FIGURE 3.4 **Estimated Relative Contributions of Selected Sectors to Precursor Emissions of PM2.5 in Five regions of Vietnam, 2015**



Source: Amann et al. 2019. *Note:* Analysis uses the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model. For more information, see box 3.2. PM2.5 = particulate matter measuring 2.5 microns or less in diameter; NO_x = nitrogen oxides; SO_2 = sulfur dioxide.

45 Bang et al. 2018; Cohen et al. 2010; Hien et al. 2019; Hoang et al. 2014; Lasko, Vadrevu, and Nguyen 2018; Nguyen et al. 2020; Oanh 2013; Vu et al. 2020.

BOX 3.2. **Source Apportionment of Particulate Pollution – The GAINS Model**

This source apportionment with management scenarios by the International Institute for Applied Systems Analysis (IIASA)[a] was undertaken in collaboration with the Vietnam Academy of Science and Technology (VAST). It covered the Hanoi region and used the GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) model.

The GAINS model[b] is a tool used to analyze air pollution and climate change emissions. The model explores cost-effective emission control strategies for both local air quality and greenhouse gases so as to maximize benefits. GAINS is used for policy analyses under the Convention on Long-Range Transboundary Air Pollution and by the European Commission for the European Union (EU) Thematic Strategy on Air Pollution and the air policy review.

Sources include combustion of fossil fuels and biomass, including forest and peat fires, and from industrial processes in general. Emissions from natural sources such as soil dust and sea salt are considered. Another substantial fraction of fine particles is from atmospheric transformations of sulfur dioxide, nitrogen oxides, and volatile organic compounds from fuel combustion and industrial processes, possibly from other countries. Nitrogen oxide and sulfur oxide are not included in this study.

Road traffic data were estimated at the national level and distributed to the regions based on suitable proxies. Fuel consumption, both diesel and gasoline, was estimated from the number of vehicles' average annual mileage and average fuel economy. Agricultural residues, primarily rice straw and husk, are either open burned on the field or used as cooking fuel. Management of uncollected waste (scattered or openly burned) create significant uncertainty because these data are generally not included in the statistics. Initial results of the source apportionment using the GAINS model are summarized in figure 4.4 in the text.

a. *Amann et al. 2019.*
b. *For details, see: https://iiasa.ac.at/web/home/research/researchPrograms/air/GAINS.html.*

Valuation

Vietnam's PM pollution results in an estimated 70,960 premature deaths in 2017.[46] This estimate was derived with the Global Exposure Mortality Model (GEMM), which generates a robust and well-documented relationship between long-term exposure to PM and mortality (see box 3.3). A principal input is long-term average PM2.5 exposure concentrations, which were derived from long-term satellite observations and ground-based monitoring stations noted above.

46 Latest year for which figures are available.

BOX 3.3 **Modeling Mortality Attributable to PM2.5**

Using the Global Exposure Mortality Model (GEMM),[a] the PM2.5 mortality hazard ratio function was developed from cohort studies of outdoor air pollution over the entire global exposure range and using nonaccidental mortality using data from 41 cohorts from 16 countries. This model leads to higher estimates of particulate pollution attributable mortality[b] than previously estimated. This is due to other models that incorporate risk information from non-outdoor particle sources that require strong assumptions about equal toxicity of inhaled dose.[c]

The model requires a long-term average PM2.5 exposure concentration (typically an annual average). In this case, the whole country concentration was taken from the World Bank's World Development Indicators, and the concentrations for Hanoi and Ho Chi Minh City were taken from the US monitorsc at the US Embassy and Consulate. The model can be run without available detailed disease-specific hazard functions for countries with poor or no public age-specific health statistics. Noncommunicable disease required estimates for the model can be taken from WHO (2018).

Like other PM hazard models, the GEMM requires a "counterfactual" that defines a background or baseline concentration of PM2.5. Given conditions in Vietnam, the COED used a counterfactual concentration estimate of 10 μg/m^3, which is the WHO Guideline value. On that basis, the average national concentration of 29.6 μg/m[d] in Vietnam in 2017, to which 94.6 million people were exposed, resulted in 70,960 premature deaths.[e]

a. *Burnett et al. 2018.*
b. *The list of authors includes many of the top PM researchers and air pollution researchers from around the world, who develop the country-wide estimates of PM2.5 concentrations used in the World Development Indicators; and researchers from the US Environmental Protection Agency (EPA) and the Institute of Health Metrics and Evaluation (IHME) at the University of Washington, Seattle.*
c. *AirNow data, US Department of State: https://www.airnow.gov/international/us-embassies-and-consulates/.*
d. *Burnett et al. 2018.*
e. *Data on population and PM concentrations are from World Bank's World Development Indicators database.*

Two methods of valuing the impacts of air pollution were used. One is based on the value of a statistical life (VSL). VSL in turn is based on the willingness to pay (WTP) to reduce the risk of death and is a measure of the welfare loss associated with the mortality. The second is a measure based on the loss of output arising from the mortality, plus the direct costs associated with the illnesses. These constitute a market cost-based estimate as they relate to losses that appear in the national accounts. Details of the valuation methods are given in the Supplementary Note; they also apply to the valuation of premature mortality in the case of lead and water pollution. Results for both methods are shown in table 4.2. In the case of the welfare-based estimate, a sensitivity analysis has been carried out using the range of parameter values recommended by the Bank for such studies.

The total cost of using the welfare-based approach is significant—US$13.3 billion annually for the country, with a sensitivity range between US$9.3 billion and US$19.1 billion based on the parameter values in the recommended welfare approach (see the Supplementary Note for details). To put it in perspective, the national figure is around 3.9 percent of Vietnam's GDP in 2020 (US$341 billion) for the mid-value of VSL. A slightly higher value was obtained for Vietnam in the World Bank/IHME (2016) study based on 2013 data.

The market-based approach, combined with the morbidity costs, gives lower figures, but still reflects high losses: the mid-value is US$3.6 billion, with a sensitivity range of US$3.2 billion to US$4.1 billion. These figures are in the range of 0.9 percent to 1.2 percent of 2020 GDP. Around one-third of the total is made up of morbidity costs and the rest productivity losses (in the mid-value case).

The estimates of physical impacts and monetary costs of air pollution can be considered as reliable. They are based on state-of-the-art models and the best data available. The welfare-based measure of cost, although reported in monetary terms, does not imply that GDP will increase by the amount of the cost; the major component of the cost includes premature mortality that is not part of GDP. The market-based measure is a measure of loss of output but here too the link to GDP is complex, as losses from mortality are spread over time, while losses resulting in morbidity actually raise measured GDP. Nevertheless, the implications for policy are clear: reductions in concentration will increase well-being and reduce the costs of illness and loss of output in the republic significantly (table 3.3).

TABLE 3.3 **Annual Costs of Air Pollution in Vietnam**

a. Welfare-based estimates									
	Premature death			**Morbidity**			**Total**		
	LB	**Mid**	**UB**	**LB**	**Mid**	**UB**	**LB**	**Mid**	**UB**
Cost (US$Bn.)	8.4	12.1	17.4	0.8	1.2	1.7	9.3	13.3	19.1
As % of GDP	2.5%	3.5%	5.1%	0.2%	0.4%	0.5%	2.7%	3.9%	5.6%
b. Market-based estimates									
	Premature death			**Morbidity**			**Total**		
	LB	Mid	UB	LB	Mid	UB	LB	Mid	UB
Cost (US$Bn.)	2.4	2.4	2.4	0.8	1.2	1.7	3.2	3.6	4.1
As % of GDP	0.7%	0.7%	0.7%	0.2%	0.4%	0.5%	0.9%	1.0%	1.2%

Source: World Bank calculations. *Note:* Cost estimates are based on a population of 94.6 million, average national PM2.5 concentration of 29.6 μg/m^3, resulting in 70,960 deaths annually. Costs are for impacts in 2017. LB = lower bound; mid = mid-value; UB = upper bound. PM2.5 = particulate matter measuring 2.5 microns or less in diameter; μg/m^3 = micrograms per cubic meter of air.

Lead

Impacts

Lead pollution is among the top-five environmental health hazards globally.[47] Lead exposure, particularly during childhood, affects the entire organ system in the body, interferes with brain development, impacts executive brain functions, and can be passed from mother to child if the mother is exposed during pregnancy. Transplacental lead exposure can have severe consequences for the developing fetus. A compelling body of evidence has demonstrated that lead causes a continuum of long-term adverse effects ranging from subtle decreases in intelligence quotient (IQ) and increased likelihood of behavioral problems such as attention deficit disorder and increased criminal activity, and, at higher levels, seizure disorder, blindness, major mental retardation, and death.[48] Lead poisoning is among the 10 most common environmental diseases of children in the world.[49]

In many countries, common sources of lead exposure include mining and smelting. Secondary smelting is of particular concern as it entails recycling of lead scrap and informal smelting of lead batteries, but also artisanal mining in older or abandoned mines. Lead is also found in consumer products, such as toys, food, spices, pottery, and cosmetics. Lead in pipes and plumbing can leach into drinking water. Another common source of lead exposure is paints, as many low- and middle-income countries have lead in paints that exceeds standards.[50]

Even though lead was removed from gasoline in Vietnam by 2001, the heavy metal continues to leak into the environment, with informal lead acid battery recycling being a major source.[51] As general lead exposures decreased rapidly following the removal from gasoline, at least in areas with many cars and trucks, there has been significant growth in the numbers of trucks, cars, and motorcycles over the last 20 years, each of which uses several lead batteries over its lifetime. Unless these vehicles are professionally serviced and batteries safely removed and taken to a recycling center with a modern environmental management system, there can be serious lead exposure. Informal battery recycling in Vietnam—often performed in recycling villages—results in significant amounts of lead being taken home on clothing, where it exposes vulnerable children.[52]

Lead exposure in Vietnam is potentially very serious, especially for children. While there are few studies, in one small pilot study in Vietnam the average child's blood lead level (BLL) was 21.5 μg/dL, or more than four times higher than the US Centers for Disease Control and

47 Awe et al. 2015.
48 Bellinger and Bellinger 2006.
49 WHO 2019a.
50 IPEN 2017; UNEP 2013.
51 World Bank 2021e.
52 Sanders et al. 2014.

Prevention (CDC) reference level (5 μg/dL).[53] Although this was a small study, it is not likely to be an isolated case. It is possible that the average child's BLLs in Vietnam (more than 3 million children are under age five) is equal to, and often higher than, the CDC reference level.[54] In another study, Daniell et al. (2015) found all 109 children in Dong Mai village had high BLLs, ranging from 12 to more than 65 μg/dL. Lead exposure was still substantial and probably associated with continued home-based battery recycling, legacy contamination, and workplace take-home exposure pathways. In another study,[55] the average household BLL of 195 children in Bac Kan province was 15.42 μg/dL. Potential sources were an old mine and high levels of lead in soils. A UNICEF and Pure Earth (2020) report estimated that over 3.2 million children in Vietnam have BLLs greater than 5 μg/dL, and 22,775 have a level of over 10 μg/dL.

Other sources of lead in Vietnam are difficult to estimate, yet observed BLLs in samples across Vietnam point to significant exposure. As in most countries, there are insufficient studies of actual lead exposure in Vietnam.[56] It is possible that another source of exposure is related to the drinking of rainwater, but there have been few resources applied to understanding sources of lead exposure in Vietnam.[57] There may also very well be lead paint, cosmetics, or foods with lead in them, but the data on these sources for Vietnam are lacking. Scientifically valid studies with statistical sample designs of BLLs that apply to a broader population coupled with investigations into specific sources can cost several hundred thousand dollars and still only be applicable to a limited geographic area and not to other hotspots or to the country as a whole.[58] That is why there are too few studies to address questions of scale of the lead exposure problem and the scale of the various sources.

Valuation

Lead exposure in Vietnam is based on measured concentrations of lead in the blood of children and adults. Lead in blood is evidence that someone has been exposed to lead pollution from at least one source. A person's actual, specific BLL is also a measure of hazard. Thus, BLL is a single number that is both an indicator of exposure and of health hazard and has been used as the gold standard for disease.[59] BLL measurements are available from many parts of the world, and the adverse health effects of BLL at various concentrations are well understood. BLL is a time-integrated measure of current and past exposure and can be translated into a socioeconomic cost of lead exposure. BLL can diminish over time if there are no continuing exposures, although the damage, particularly in early childhood, is permanent. For the estimate presented here, lead exposure in Vietnam was differentiated by age (children have a different

53 "Blood Lead Reference Value," US Centers for Disease Control and Prevention: https://www.cdc.gov/nceh/lead/data/blood-lead-reference-value.htm.
54 UNICEF and Pure Earth 2020.
55 Hai et al. 2018.
56 World Bank 2021e.
57 Havens et al. 2018.
58 World Bank 2021e, Appendix.
59 Fewtrell et al. 2004.

response function) and location (general population compared to population in hotspots) based on data blood samples of children from published studies in Vietnam.[60] There are no published studies on adult blood lead levels, so adult levels are re-extrapolated from Chinese adults. Details on the estimation of the exposure (in terms of BLL) of the general populations and hotspot populations of both adults and children in Vietnam are described in detail in the Supplementary Note. The analysis assumes that the entire population of Vietnam of 95.5 million (in 2018) was exposed to lead.

The estimated consequences of lead exposure in Vietnam are based on a well-established relationship between BLLs and IQ in children and mortality for adults. The principal consequence for children is that they experience IQ loss as lead exposure, measured by BLL, increases. To calculate the valuation of the loss of IQ points in children, the cost of lead exposure for children under five was estimated as the product of loss of income per lost IQ point and the percentage of children that might be expected to participate in the labor force.[61] For adult mortality, BLL is used to estimate the increase of systolic blood pressure in adults and the corresponding relative risk and attributable fraction of cardiovascular mortality.[62] Each case of mortality is evaluated with the welfare loss approach, using the approximation of the willingness to pay for the risk of mortality.

In Vietnam, the estimated total market-based economic damage due to the decline in lifetime income for affected children and of premature deaths in adults is 2.11 percent of 2020 GDP equivalent (with a range of 0.7 percent to 2.9 percent.[63] In US dollar terms, this amounts to US$7.19 billion (mid-estimate), US$2.35 billion (lower bound), and US$10.05 billion (upper bound). The range reflects uncertainty in the coefficients linking lead levels to loss of IQ and loss of IQ to loss of earnings.[64] Over 99 percent of the economic damage is due to IQ loss in children, as in every other country that was part of the World Bank's global study. Adult mortality is insignificant.

A comparison of the impacts and costs of air pollution and lead pollution could be useful to policymakers. There are an estimated 71,000 premature deaths a year from air pollution, while there are only about 150 deaths a year from lead exposure, a tiny number compared to air pollution.[65] However, the earnings lost due to loss of IQ are substantial, with a mid-value of US$7.2 billion a year, compared to the estimated loss of income from pre-mature death from air pollution of US$2.4 billion (table 3.2). Finally, in the case of air pollution, there is a morbidity

60 Havens et al. 2018; Sanders et al. 2014.
61 Crump et al. 2013; Lanphear et al. 2005.
62 Nawrot et al. 2002.
63 Methods available in WB 2021e.
64 For reference, Southeast Asia, overall, has higher-than-average GDP losses compared with other regions of the world, but generally lower losses compared with most of Africa or China (World Bank 2021e).
65 The costs of premature mortality were around 0.5 percent of the total—that is, US$36 million. The VSL used for Vietnam in the study was US$240,000 (mid-value), which implies the number of premature mortalities was about 150.

cost estimate of around US$1.2 billion (mid-value). There is no comparable figure for lead pollution.[66]

The estimates for lead are not as reliable as those for air pollution, as they draw on smaller samples of data that require extrapolation. Nevertheless, the estimates of impacts on IQ are large and significant and point to a potentially very serious problem of lead exposure in children. Although few in number and small in sample sizes, the various pilot studies indicate seriously high BLLs in Vietnamese children. Statistically valid studies of the magnitude of this problem and the sources of exposure are critical for the long-term health and productivity of its people. Vietnam needs to undertake statistically rigorous studies of the extent of lead exposure and identification of sources. While little is known in Vietnam about lead exposure, this pollutant can be a very serious source of harm to the health of Vietnamese children. It is critical to understand that the inability to address specific questions about the extent of lead exposure and about data on sources on lead pollution is far more likely to be due to lack of information rather than to lack of lead pollution in a country at Vietnam's stage of development.

Water

Impacts

Water pollution is the result of household and industrial effluents that are emitted into rivers and lakes. The primary source of these effluents in Vietnam is wastewater and municipal solid waste. According to the General Statistics Office, in Vietnam there were 384 industrial zones in 2017, but only 64 percent met the standard requirements of the wastewater and municipal solid waste treatments (GSO 2019a). The Red River and Mekong Deltas are two regions with the highest density of industrial zones. However, the percentage of the industrial zones that met the waste treatment standard was considerably higher in the Mekong Delta than in the Red River Delta (82 percent compared with 67 percent).[67] The North Central and Central Coast recorded that only over half of the industrial zones (about 55 percent) invested in the national standards' waste treatment system. A large amount of wastewater also comes from aquaculture production in the south. As a downstream country of the Mekong River, effluents generated by upstream countries (China, Myanmar, Thailand, Lao PDR, and Cambodia) are also significant.[68]

Solid waste generated by urban areas is also an important source of water pollution. As of 2017, Vietnam had 819 such areas, consisting of two special urban areas and 817 urban areas from class 1 to class 5.[69] Of these, only 276 urban areas (34 percent) had a municipal solid waste management system that met national standards. Ninety-three percent of urban areas did not have a wastewater treatment system or had one that did not meet national standards.

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66 The links of the losses associated with lead pollution to GDP are complex. The loss of earnings lowers GDP, but the reduction is spread over several years, so the reported loss is not a one-off hit on GDP.

67 The statistics do not include the manufacturing, economic, and high-tech zones because of the unavailability of data.

68 Lebreton et al. 2017.

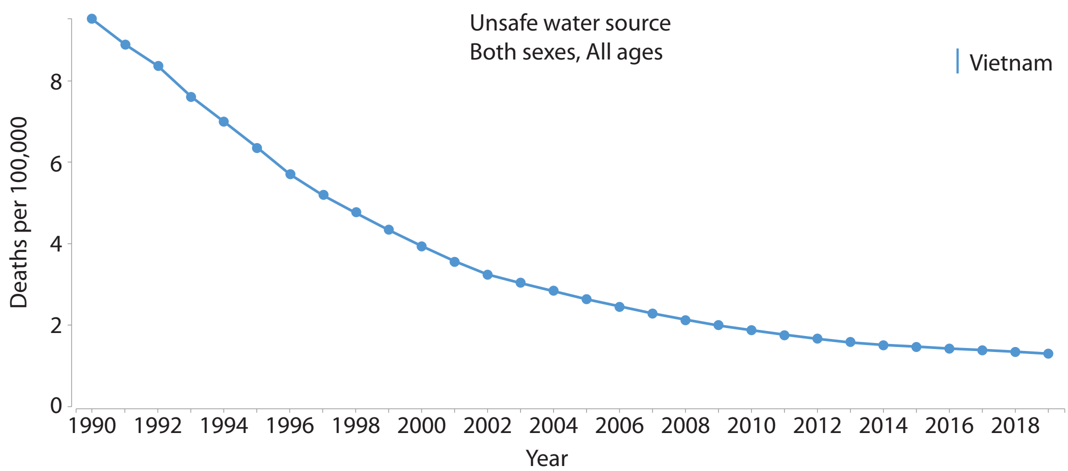
69 GSO 2019a.

The effects of the effluents are felt by households as well as by farmers and fishers. The Vietnam Household Living Standards Survey 2018 revealed that 20 percent of communes were exposed to polluted water sources.[70] About 34 percent of communes were either water-polluted or air-polluted. Although the water and air pollution level decreased during 2016–18, the reduction rate is still low, from 0.2 to 0.8 percentage points. Effluents affect agriculture and aquaculture, particularly in the Mekong Delta. Vietnamese shrimp farms have polluted surrounding waters and have themselves been hurt by poor water quality. Effluents from these ponds contain large quantities of chemicals as well as organic waste and contaminate surrounding freshwater and coastal waters.

Although the situation remains serious, some indicators related to water, sanitation, and hygiene (WASH) point to an improvement. Deaths attributed to an unsafe water source, for example, have declined from around nine per 100,000 in 1990 to less than two in 2018 (figure 4.5) as water supply has improved in urban areas and as the population has been urbanizing. Similar declines are found for deaths due to unsafe sanitation (poor latrines) and lack of access to handwashing facilities.

Trend data for other impacts of water pollution are not so positive. Evidence indicates that pollution levels are increasing for surface, ground, and coastal waters. Freshwater lakes and canals are becoming sewage sinks, and groundwater shows signs of contamination and saline intrusion in some areas.[71]

FIGURE 3.5 **Deaths per 100,000 Caused by Unsafe Water in Vietnam, 1990–2019**



Source: Institute for Health Metrics and Evaluation (IHME) data, University of Washington, Seattle.
Note: Figure is based on modeling from data on water quality.

70 GSO 2019b.
71 World Bank and IEC 2018.

Valuation

The costs of water pollution are estimated for (a) human health (that is, the premature mortality and morbidity associated with drinking unsafe water and poor sanitation which may cause water or food borne diseases like diarrhea); (b) agriculture (that is, the loss of productivity for rice and coffee due to the quality of water used for farming); and (c) aquaculture. However, owing to lack of data, not all of these identified impacts could be fully valued, and losses are estimated based on the factor described below:

Human Health

Diarrhea and waterborne diseases are the leading cause of death from poor sanitation and hygiene.[72] The health costs of water pollution are based on epidemiological studies that link the incidence of child mortality and diarrhea to the quality of drinking water and the sanitation conditions in different parts of the country. Of all sanitation-related diseases in Vietnam, diarrhea and other waterborne diseases have the most cases, at 7 million per year and 6,100 premature deaths. More recent estimates indicate a higher figure for water-pollution-related deaths: the Ministry of Natural Resources and Environment (MONRE) reported that about 9,000 annual deaths are caused by polluted water sources and inadequate sanitation.[73]

Untreated domestic and industrial wastewater also contributes significantly to disease occurrences.[74] In Vietnam, helminth infection[75] was considered the most common disease, followed by diarrhea and typhoid.[76] For example, 80 percent of the population was infected with roundworm, followed by whipworm (55 percent), and hookworm (35 percent). In 2017, 350,000 people suffered from diarrhea. Bacillary dysentery ranked third in terms of the number of people with diseases related to unsafe water. In 2017, 15,613 people were infected with bacillary dysentery due to unsafe water use. Polluted water also contributes to cancer (along with many other factors).

The method of valuation of premature mortality is the same as for mortality from air pollution.[77] In addition, there are costs arising from cases of diarrhea that do not lead to death (morbidity costs). These are estimated at the out-of-pocket expenses for treatment, plus expenditures incurred by the health service in outpatient treatment, hospitalization, and so forth. The World Bank and Ministry of Planning and Investment (2016) estimate that these at US$4.05 per case. If time losses due to illness were included, the figure would be even higher.

72 World Bank and Ministry of Planning and Investment 2016.
73 DWRM 2020.
74 Ferrer et al. 2009; GBD 2019 Risk Factors Collaborators 2020.
75 Helminth infection is caused by parasitic worms called helminths. It is among the most common infections worldwide and mainly affects poor populations who live where sanitation is poor.
76 MONRE 2019.
77 Based on the value of a statistical life (VSL) in Vietnam (see earlier discussion for details).

Such estimates, however, are not available. Total morbidity costs are the cost per case multiplied by the number of cases. Specifically,

- Premature mortality is taken as 9,000 per year based on the latest MONRE data, with the two values of each loss taken as the same as in the air pollution case (that is, US$0.17 million as a mid-value and US$0.12 million to US$0.24 million as the range for welfare estimation per person and US$33,240 for the productivity loss method). The range is derived from sensitivity analysis of VSL, based on the range of parameter values recommended in Nairain and Sall (2016).
- Morbidity cases are taken from the World Bank and IEC (2018) study as 7 million cases, with a unit cost of US$4.05 per case.

Agriculture

Impacts on rice and coffee. Impacts on rice yields are based on a statistical analysis that links yields to various inputs, including water quality and quantity. This shows that reduction in water quality lowers yields, other things being the same.[78] The direct losses are valued using market prices, and indirect impacts are based on a computable general equilibrium (CGE) model. Preliminary evidence also shows a loss of productivity owing to water supply and quantity in the important coffee sector of the economy.[79] The main problem, however, is water availability, not quality. Losses of productivity are valued at the market value of the crops. This may underestimate the costs if farmers have taken other measures to reduce the impacts of the degradation.

Losses of rice yield are based on the World Bank and IEC (2018) study as described above. It estimates the loss of rice yields at 3.6 percent of all paddies in 2012 as a result of water used for irrigation that had levels of pollution above those in areas where the quality of water was judged to be unpolluted.[80] The CGE model estimates indirect loss, resulting from backward and forward links to other sectors in the economy. They find that the total costs are 33 percent higher than direct loss. The direct loss based on 3.6 percent decline in rice yield is estimated at US$652 million. Taking account of indirect costs this is raised by 33 percent to US$867.

Initial findings of the Economy and Environment Partnership for Southeast Asia (EEPSEA) reveal that coffee production in 2018/19 decreased about 189,000 metric tons, of which about 56,000 metric tons were due to reduction in water quality which may also impact overall its

78 World Bank and IEC 2018.

79 The reasons for the crop yield drop were divided into resources and inputs, climate and weather, bugs and infestations, and water degradation. They employed the Analytical Hierarchical Process to construct the relative weights of different indicators and subindicators causing the decrease in coffee yield. To gather information for the relative weights, they had in-depth interviews and group discussion with the experts from the Dak Lak Provincial Department of Agriculture and Rural Development who are in charge of coffee farming in the province.

80 The basic study used by World Bank and IEC (2018) was Khai and Yabe (2013), who measured three indicators of water quality: dissolved oxygen (COD), total suspended solids (TSS), and ammonia (NH_3) across a range of locations in the country. They then estimated a production function for output of rice across farms, in which water quality was an explanatory variable.

availability. This is equivalent to about US$97 million at the price of about US$1.75 per kilogram. As this is not clearly a water pollution issue, however, it has not been included in the cost of degradation estimate.

Aquaculture

Aquaculture production activities are also very sensitive to polluted water sources. The quantity and quality of aquaculture have simultaneously decreased due to the problem of water pollution at the exploited rivers. According to the preliminary statistics, for each year, aquaculture of catfish, white-leg shrimp, tiger shrimp, and clams additionally spends an extra VND 1,400 billion (US$60.2 million) because of water pollution.[81] In the Mekong Delta, the impacts of water pollution on aquaculture include death and disease in tiger shrimp production. According to MONRE (2019), the total area of tiger shrimp diseased and damaged was nearly 12,410 hectares (26 percent higher than the same period last year). Specifically, over 58 percent of diseased and damaged area was caused by some environmental factor. Costs of water pollution on aquaculture have been taken from the estimates provided by MONRE of US$60.2 million for 2019 (table 3.4).

TABLE 3.4 **Costs of Water Pollution in Vietnam (US$Mn.)**

Source of cost	Welfare-based				Market-based			
	Mortality	Morbidity	Other	Total	Mortality	Morbidity	Other	Total
WASH	1,534	28	–	1,562	299	28	–	328
Loss of Rice	–	–	867	867	–	–	867	867
Costs to Aquaculture	–	–	60	60	–	–	60	60
Total	1,530	28	927	2,485	299	28	927	1,255
As % of GDP	0.4%	0.0%	0.3%	0.7%	0.1%	0.0%	0.3%	0.4%

Sources: See text.

Note: The total is the sum of Mortality, Morbidity, and Other. WASH = water, sanitation, and hygiene. — = not available

The total estimated cost of water pollution based on the welfare method is US$2.5 billion, with a range from US$2.0 billion to US$3.1 billion.[82] Specifically, on the welfare-based method, premature mortality costs are US$1,534 million, with a range from US$1,070 to US$2,201 million, based on the range of values for VSL caused by the range of elasticities for the value of VSL with respect to GDP per capita. Morbidity costs are estimated at US$28 million. Losses in rice yields are put at US$867 million,[83] and costs to aquaculture at US$60 million. As a

81 MONRE 2019.

82 The lower bound is US$1,080 + US$28 + US$867 + US$60 = US$2.0 billion. The upper bound is US$2,160 + US$28 + US$867 + US$60 = US$3.1 billion based on the VSL range.

83 The direct loss is 3.6 percent of all paddy in 2012. Paddy made up 4 percent of the GDP that year, which is equal to US$453 billion. This makes the value of paddy equal to US$18.1 billion, and 3.6 percent of that (that is, the loss) is equal to US$652 million. Adding the 33 percent indirect cost gives US$867 million. No range of estimates was given in the original study.

percent of GDP in 2020, the costs are 0.7 percent for the welfare-based estimate and 0.4 percent for the market-based estimate.

The estimates for the health costs of water pollution can be considered reliable. They are based on established methodologies and international practice. The figures for loss of agricultural yields and aquaculture are more indicative of losses but still provide a useful guide to the size of the impacts and their costs. The costs are highly relevant for supporting actions that will benefit from the estimates provided here. The impacts of all water pollution are more likely to affect poorer households, which is another factor to be taken into account. As with all measures, it is important to bear in mind limitations on the link to GDP. Welfare measures include components that are not reflected in GDP, so even if the health effects of water pollution were all removed, GDP would not go up by the amount of the loss. Market measures are closer to loss of output, but these losses take place over a number of years. Losses in aquaculture and rice yields are more closely linked to loss of output and, if avoided, should raise GDP contemporaneously.

Solid Waste including Plastics

Impacts

Urbanization, together with strong economic and population growth, is causing rapidly increasing volumes of domestic waste. Waste generation in Vietnam doubled in the past 10 years and is expected to double again by 2030. Around 74,000 tons of waste are generated daily, and there is insufficient collection; for instance, collection covers about 85 percent of waste in cities but only 40 percent in rural areas.[84,85] Nationally, 20,200 tons of waste end up in landfills daily. Most of the waste collected by municipalities is still disposed of in insufficiently designed and poorly controlled landfills, causing significant environmental issues. Of the 660 waste disposal sites across the country, only 30 percent can be classified as sanitary engineered landfills with daily coverage of waste. Hanoi and Ho Chi Minh City (HCMC) have mega landfills covering, respectively, 85 hectares and 130 hectares.[86] The waste generated, collected, and recycled in Vietnam relative to countries in the region and at similar levels of per capita income (table 3.5) is comparable to other East Asia and Pacific and lower-middle-income countries.[87]

Most landfills have no compactor, landfill gas collection, leachate treatment, or environmental monitoring system, and are poorly managed. This is causing multiple environmental and health problems and risks particularly in areas with high waste generation levels and population density, including (a) groundwater contamination having a direct impact on the water wells of the communities living around the landfills (the effect of this is picked up in the costs of unsafe water); (b) contamination of surface waters through the discharge of toxic leachate

84 World Bank 2020b.
85 Collection data tend to be overestimated in most countries.
86 World Bank 2018.
87 However, the accuracy of these figures is uncertain as they are based on modeled estimates based on country per capita GDP and not on actual data.

without adequate treatment or as a result of poor operational practices; (c) polluting emissions from landfill or from open waste burning (including particulate matter and ammonia); (d) health risks, especially for the many human scavengers; (e) insects/animals as vectors (flies, cockroaches, rats) spreading illnesses; and (f) spreading of waste, particularly plastics, to the surrounding environment and further into the river and ocean system.[88]

The quantity of plastic waste in Vietnam, which includes bottles and sachets, carrier bags, and food wrappers, is already among the highest in the world (as is the generally insufficient management of solid waste) and is a significant threat to land and marine ecosystems.[89]

TABLE 3.5 **Solid Waste Data for Vietnam Compared with Other Countries**

Category	Vietnam	East Asia and Pacific average	Lower-middle-income country average
Waste Generated per capita (kg/day)	0.67	0.56	0.61
Waste Collected (%)	**82**	**7**	51
Recycling (%)	**10**	**6**	9
Incineration (%)	12	<1	24%

Sources: MONRE 2019; Kaza et al. 2018.

Valuation

The valuation differentiates between (a) waste that is collected and disposed of in different landfills, and (b) waste that is not effectively collected and, as a result, appears in the streets and the environment more widely, including the marine environment. For the second kind of waste, a major component is made up of various kinds of plastics, which are the focus of that category. Accordingly, the costs of degradation of this waste stream are estimated for the following categories:

- *Amenity loss:* depreciation of land and building values on the surrounding land on account of the presence of a landfill and activities associated with it
- *Improper disposal:* Damage caused from the disposal of waste in open dumps and nonsanitary landfills through the leaching of liquids containing toxic material into the surrounding land
- *Plastics:* Damage caused from the improper disposal of waste, especially plastics, through increased litter, blockages to drains, and entry to marine ecosystems.

Amenity Loss

Many studies have found that properties close to a landfill depreciate in value (amenity loss) relative to similar properties farther away. Based on these studies, an estimate is made of

88 World Bank 2020b.
89 World Bank 2020b.

the loss of value of land and buildings due to a landfill.[90] Similar methods have been used to value the costs of degradation, as in, for example, Croatia.[91] A depreciation function specific to Vietnam (based on data collected in Da Phuoc) is the basis of the results reported here. The estimation of the amenity losses due to waste disposal in Vietnam is based on a hedonic analysis of the link between the value of properties and their distance from the landfill (along with other factors). Details of the estimation are given in the Supplementary Note. The key finding relevant for the estimation is that if the distance to the landfill decreases by 1 percent, the price of the property will drop about 0.2 percent after controlling for other factors that influence the value of a property.

The total depreciation due to the Da Phuoc landfill is an estimated VND 1,786 billion, equal to US$76.8 million (table 3.6). Ho Chi Minh City (HCMC) has two major landfill complexes: Da Phuoc (for which calculations are made, above, and which covers 614 hectares), and Phuoc Hiep (which covers 687 hectares). Each landfill receives nearly 5,000 tons of solid waste daily, and with similar characteristics, EEPSEA estimates that these landfills could induce a land value loss of about VND 3,600 billion (US$154.8 million) at 2020 prices. This is a partial estimate of depreciation in land values as calculations have been made for only one city. The corresponding figure in the COED is the annual loss of services from that land. Taking a discount rate of 5 percent, that would amount to US$7.7 million a year for HCMC landfills.

TABLE 3.6 **Property Value Loss Estimates due to Da Phuoc Landfill in 2020**

Zone	Total area (m2)	Estimated residential land area (m2)	Average land price (US$/m2)	Estimated value loss (US$Mn.)		
				Average loss	Lower 95% Confidence	Upper 95% Confidence
Zone 1	6,915,827	345,791	219	2.6	2.6	2.7
Zone 2	23,934,321	1,675,402	219	6.4	6.3	6.5
Zone 3	32,257,467	3,225,747	291	10.9	10.8	11.1
Zone 4	56,683,962	5,668,396	404	20.0	19.8	20.2
Zone 5	72,415,145	7,241,515	726	36.8	36.4	37.2
Total				76.8	76.1	77.6

Source: EEPSEA

Improper Disposal

The evidence of the impact of landfills and health in monetary terms is limited. A BIO Intelligence (2011) study made some estimates of the health costs of solid waste but did not include them in the final analysis as no reasonable assumptions could be made of how many people would be affected by noncompliant waste management practices. Similarly, the study did

90 See Giaccaria and Frontuto 2010; Schutt 2021; Walton et al. 2006.

91 World Bank 2020a.

not include damage estimates for ecotoxic pollutants other than zinc as no realistic assumptions could be made on the quantity of heavy metals and organic pollutants released under such practices.

At the same time, only 30 percent of sanitary landfill sites broadly meet the European Union (EU) standards in Vietnam. Waste disposal sites meeting the state-of-the-art containment standards (such as the EU's), with proper membranes and lining of the facility, have very low health or ecotoxic effects. Rabl, Spadaro, and Zoughaib (2008) looked at the problem of leaching from a landfill site and concluded that, for a site meeting current (that is, 2008) EU standards, reducing the pollutants in leachates beyond current regulations would bring negligible benefits.

Thus, one way of quantifying damage at a site that does not meet the full regulations is to use the costs of modification to meet standards. This can be justified on the grounds that the standards are set such that the marginal costs of compliance equal the marginal damage. Hence, taking the former is an approximation for the latter, and the costs of nonsanitary landfills in Vietnam are estimates using the costs of meeting the containment standards.

The costs of improper disposal are based on the sites where waste is being deposited and where the landfills do not meet the sanitary standards. Estimates of making a site compliant with sanitary standards that meet EU standards are given in BIO Intelligence (2011) at €90 per ton (US$107 per ton) for pure municipal solid waste, €35 per ton (US$42 per ton) for mixed construction and demolition (C&D) and municipal solid waste, and €75 per ton (US$89 per ton) for mixed "other waste." As the mixture of the waste going to the nonsanitary landfills is not known, the range of costs is used to obtain a range, with the mixed "other waste" taken as a mid-value. The different nonsanitary sites receiving solid waste are taken from Kaza et al. (2018), along with an estimate of the amount of waste received per year.[92] Table 3.7 presents the cost estimates.

The capital costs of upgrading sanitary landfill sites to meet standards amount to US$448.3 million. This mid-value ranges from US$209.2 million to US$538.0 million, the lower bound (LB) and upper bound (UB) reflecting the range of compliance costs for waste given above (table 3.7). As the landfill has a life of about 20 years, the annualized cost per year amounts to US$36.0 million, with a range of US$16.8 million (LB) to US$43.2 million (UB).

The losses reported above for property depreciation and noncompliant landfills have a complex link to GDP. Property depreciation does reduce rental values and if it is avoided, rental values and GDP would rise. The expenditures on noncompliant landfills, however, if undertaken, would reduce damages from leaching and the increased flow of ecosystem services would only partly work through to higher GDP.

92 The report gives the amount of waste to all sites (both sanitary and nonsanitary) in each zone and the share of sites that are nonsanitary. This information has been used to estimate the waste going to nonsanitary sites assuming that the share of total waste is in proportion to the share of sites.

TABLE 3.7 **Accounting for Compliance Costs of Waste Going to Noncompliant Landfills** (US$Mn)

Region	Number of unsanitary landfills	Waste (tons/year)	Costs of making landfills compliant		
			LB	Mid-Value	UB
Western North	27	155,302	6.5	13.9	16.6
Eastern North	51	335,715	14.0	30.0	36.0
Economic Zone Northern	85	1,306,3834	54.3	116.4	139.6
Economic Zone Red Delta River	49	321,694	13.4	28.7	34.5
Economic Zone Central	41	312,821	13.0	27.9	33.5
Economic Zone Eastern South Highland	92	821,070	34.2	73.3	87.9
Economic Zone Southern	20	1,086,972	45.3	97.0	116.4
Mekong River	91	618,113	28.6	61.2	73.5
Total	456	5,023,521	209.2	448.3	538.0

Sources: BIO Intelligence 2011; Kaza et al. 2018.
Note: LB = lower bound; UB = upper bound.

Plastic Waste

For plastics, a major problem is the failure to collect the material after use, so it appears in open places, blocks drains, and enters the marine environment. Ten types of plastics are identified, and the life cycle external costs associated with their use and disposal are estimated. Plastics are used in fishing nets, beverage bottles, beverage cups and take-away food containers, carrier bags, disposable utensils, food wrappers, sachets for food and nonfood items, beverage cartons, clothing, and diapers.

The life-cycle model used here captures material from production to disposal and tracks collected and uncollected waste to its final disposal. Thus, the effects are considered at all the stages of the life cycle, which include production, use, and disposal. In the production stage, factories that produce plastics generate emissions through their production processes and in the power generation required. Products are then transported, which involves emissions from the transport sources. Managed plastic waste may get recycled, reused, incinerated (with or without energy recovery), or disposed of in a landfill (sanitary or unsanitary). Unmanaged plastics waste becomes litter and eventually ends up as plastic marine debris (figure 3.6).

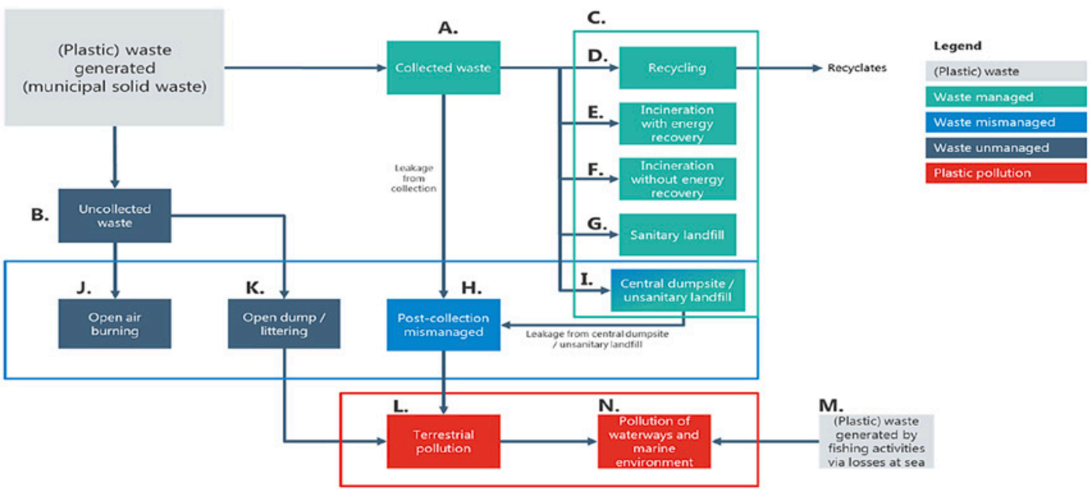
The damage caused by the waste streams is followed through to the following types of external cost:

- GHG emissions, causing direct climate change damage[93]
- Photochemical ozone formation due to emission of volatile organic compounds and NOx

93 These are not included in the study as such emissions are not normally part of a COED.

- Particulate matter resulting in an increase in ambient air pollution with health effects[94]
- Acidification of ocean water due to emissions of PM2.5, SO_2, NOx, non-methane volatile organic compounds (NMVOC), NH_3, CO, and CH_4.
- Losses of tourism from littering.
- Losses of marine ecosystem services.

FIGURE 3.6 **System Map of the Flows of (Plastic) Waste in the Solid Waste Management System**



Source: World Bank and Rebel 2021.

In its application to Vietnam, the model employs country-specific inputs whenever possible with default values based on global data used where needed. Impacts of inputs in terms of emissions and their effects are estimated from biophysical models for different media (air, water, land). The valuation of impacts is in monetary terms where possible, with qualitative estimates provided where monetization is not feasible.

Total costs associated with plastic pollution (excluding particulate pollution and climate change impacts due to GHG emissions) amount to US$156 million, with damage to marine ecosystems making up nearly two-thirds (see table 3.8).[95] The next-highest contribution comes from ozone depletion (11 percent), followed by tourism (10 percent). The uses that have the biggest impact on the damage are food wrappers (22 percent of the total), followed by sachets

94 Considered in another chapter in the study.

95 Table 3.8 reports the cost from the plastics study that are compatible with the overall methodology and with estimates made in other sector assessments to avoid double counting. In particular, two components of the original estimates are excluded. One is the costs of particulate emissions, as they have been accounted for in the air pollution estimates. The other is the costs of GHG emissions. As noted in the introduction, such emissions from the combustion of waste are not included in COED studies. The GHG costs associated with plastics are from incineration and from the transport and other stages of the life cycle of plastics production. Hence, it was decided to exclude these costs.

(20 percent), and carrier bags (17 percent). No information was provided in the original study to obtain an estimate of the uncertainty range for this category of costs. Note also that given the way the component costs are measured they will only partially feed through to losses in GDP.

There are some limitations to these estimates that require further work to address. The default values of several parameters (which were taken from global data) need to be replaced with local data, which could affect the estimates. In addition, the global data also have their limitations, since they also entail extrapolations and estimations. For example, not all data on plastic product types, of which the cost estimations are presented on table 3.8, are primary. Total plastics consumption was used as primary data,[96] but the product divisions made in the NPAP (2020) report with regard to flexibles/multilayers/rigids, were based on another study.[97] Based on the overview of the share of plastic consumption for some main types of plastic product categories in the Pew Charitable Trusts and SYSTEMIQ (2020) report, the products within the scope of the tool are interpolated as percentages of the overall plastic consumption. This interpolation caused certain categories to have the same numbers (for example, the bottles and sachets, and the carrier bags and food wrappers). These limitations could affect the estimates, particularly for tourism.

TABLE 3.8 **Costs of Plastics Solid Waste (US$Mn)**

Product	Ozone	Acidification	Marine ecosystem services	Tourism	Total without PM
Fishing nets	0.9	0.5	4.9	—	6.3
Bottles	4.0	2.2	14.6	3.2	23.9
Beverage cups	0.9	0.3	4.5	2.4	8.1
Carrier bags	2.4	0.9	22.7	1.2	27.3
Disposable utensils	0.5	0.2	2.4	—	3.1
Food wrappers	1.9	1.0	22.7	8.0	33.6
Sachets	2.5	1.1	27.3	—	30.9
Beverage cartons	0.2	0.1	2.3	2.4	4.9
Clothing	10.3	7.3	—	—	17.6
Diapers	0.3	0.2	—	—	0.5
Total	23.8	13.6	101.5	17.2	156.3

Source: Adapted from World Bank and Rebel 2021.

Note: PM = particulate matter; — = not available.

Estimates of the costs of solid waste are less reliable than those of air and water pollution and can be improved with further work. The amenity costs reported are for Ho Chi Minh City are the right order of magnitude but of course do not cover all the landfills in the country.

96 NPAP 2020.

97 Pew Charitable Trusts and SYSTEMIQ 2020.

Thus, the total would be considerably higher than what is given here. The costs of compliance for nonsanitary landfills would also benefit from being confirmed with local engineering experts in the field. The costs of plastics are based on a well-developed life-cycle model, but many of its parameters are drawn from global data, some of which may need to be significantly modified for Vietnam. This requires further research. Nevertheless, the data collected and presented here point to a major set of costs from the disposal of solid waste and can support the assessment of programs toward a circular economy.

Environmental Services

Four key areas of degradation of environmental services are valued: primary forests, mangroves, agricultural land, and fisheries.

Primary Forests

Impacts

Vietnam lost about 20 percent of its tree cover from 2001 to 2020, which resulted in the about 2 gigatons of carbon dioxide equivalent (CO2e) emissions.[98] As a subset, the area of primary forests[99] in Vietnam suffered a loss (excluding mangroves)[100] of 701,000 hectares, amounting to 10 percent of the 2000 stock (figure 3.7).[101] Two-thirds of the forest loss during these two decades resulted in deforestation (permanent loss of forest) driven by agricultural commodities, with the remaining third driven by shifting cultivation and forestry activities. Some of this tree cover loss has been offset by plantations (564,000 hectares during 2001–12). Removal of natural forests in some upland areas has contributed to more frequent and severe flooding of lower-altitude farms and human settlements. In the mountainous northwest and central areas, poorly planned expansion of agriculture has eroded soil and removed biodiverse natural forests, degrading the land.[102]

98 WRI 2021.

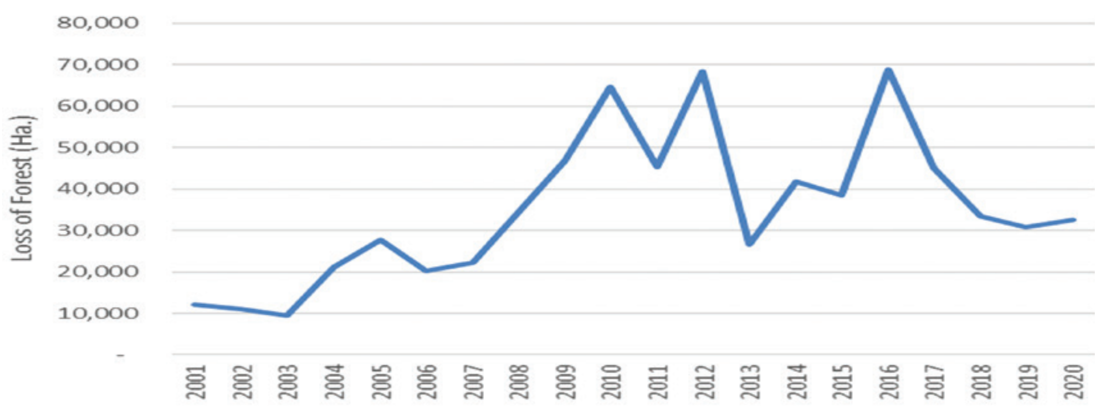
99 Primary forests are defined as "mature natural humid tropical forest cover that has not been completely cleared and regrown in recent history" (WRI Global Forest Watch). www.wri.org/gfw

100 This analysis covers primary forests as defined but excludes mangroves. In theory, WRI humid primary forests should include all types of forest (or tree-covered space) with the specified conditions and the corresponding canopy cover level (10 percent to 75 percent). However, the WRI classification somehow included very little mangrove. This was checked using a 2000 mangrove map of Giri et al. (2011), and it was found that the overlap between mangroves and WRI primary forest was minimal (about 0.01 percent of the primary forests area).

101 The figures are for a 30 percent or greater canopy cover, which is the default value in the Global Forest Watch statistics. (These figures do not agree with some of the data in the government database for forests areas.)

102 World Bank and MPI 2016.

FIGURE 3.7 **Loss of Primary Forests in Vietnam, 2001–20**



Source: WRI 2021.

Note: Ha. = hectares.

Valuation

Primary forests provide a wide range of ecosystem services. There are no direct estimates of these services for Vietnam, but a global database that includes tropical forests everywhere has been assembled by de Groot, Brander, and Solomonides (2020). In addition, a meta-analysis has been conducted from global data from which estimates have been made for some forest ecosystem

TABLE 3.9 **Global Annual Value of Ecosystem Services Provided by Primary Tropical Forests, 2020**

Ecosystem Service	Share of Services (%)	Mean market prices (US$/ha)
Food	0.5	349
Water	40.2	27,716
Raw Materials	9.9	6,797
Genetic Resources	0.0	9
Air Quality Regulation	0.3	179
Climate Regulation	0.6	381
Extreme Event Moderation	0.1	63
Water Flow Regulation	0.4	256
Waste Treatment	0.	7
Erosion Prevention	0.5	350
Soil Fertility	0.0	24
Pollination	0.7	508
Recreation and Tourism	44.4	30,565
Existence and Bequest Values	2.5	1,714
Total	100.0	68,917

Source: Adapted from de Groot, Brander, and Solomonides (2020). *Note:* ha = hectare.

services in Vietnam.[103] The original estimates were updated for the World Bank 2021 publication *The Changing Wealth of Nations 2021: Managing Assets for the Future.*[104]

The global average value of ecosystem services provided by primary tropical forests is US$68,917 per hectare (ha) based on 229 studies (table 3.8).[105] Services of water and recreation, followed by raw materials, dominate the total. Carbon sequestration has a small part, covered under climate regulation. Methods used to derive these estimates vary: market-based estimates are the main method for provisioning services such as food, raw materials, and genetic resources; replacement cost methods for water, erosion prevention, and soil fertility; travel cost methods for recreation and tourism; production function methods for pollination; and biophysical models for air quality and climate regulation.

These global ecosystem service values for primary tropical forests are adjusted to more accurately reflect Vietnam's forests[106] and to account for a wider range of forest types based on the meta-analysis of estimates across many countries referred to above.[107] Based on that, Vietnam-specific values are recreation (US$213.1 per hectare); habitat and species protection (US$49.3 per hectare); nontimber forest products (US$28.8 per hectare); and water services (US$10.1 per hectare).[108] These are derived from using the many studies that fed into the type of analysis used by de Groot, Brander, and Solomonides (2020), and seeing how unit values vary across countries according to (a) their level of development and (b) the characteristics of the sites where the individual estimates were made. The remaining services are valued based de Groot, Brander, and Solomonides (2020) and include genetic resources (US$9 per hectare), water flow regulation (US$256 per hectare), air quality regulation (US$179 per hectare), climate regulation (US$31 per hectare), extreme event moderation (US$63 per hectare), waste treatment (US$7 per hectare), erosion prevention (US$350 per hectare), soil fertility (US$24 per hectare), and pollination (US$508 per hectare). The adjusted estimate per hectare is US$2,078 per hectare per year, with the breakdown among services shown in figure 3.8.

103 Siikamäki, Santiago-Ávila, and Vail 2015.

104 World Bank 2021a.

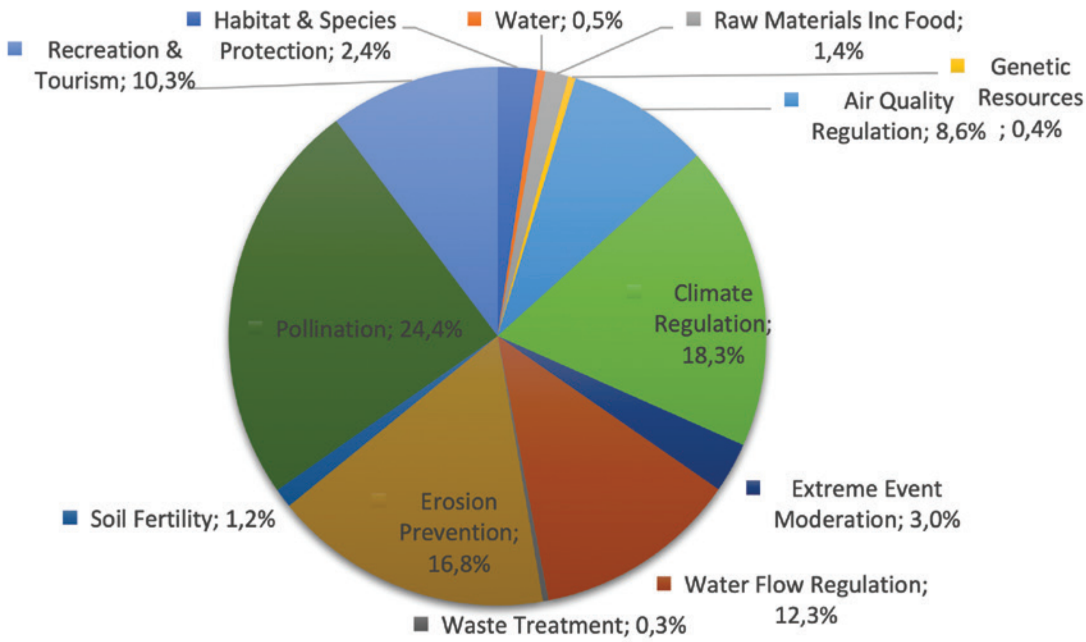
105 Estimates in the de Groot, Brander, and Solomonides (2020) study are in US dollars using purchasing power parity exchange (PPP) rates. As this report is using market rates, adjustment has been made to the values in the original study to reflect that.

106 As global averages, with a strong focus from studies in developed countries, the de Groot, Brander, and Solomonides (2020) estimates are likely to be too high for Vietnam.

107 Siikamäki et al. 2021.

108 The original figures were in 2018 US dollars, so to bring them up to 2020 dollars, an inflation factor of 3.1 percent has been applied.

FIGURE 3.8 **Share of Different Ecosystem Services in Primary Forests in Vietnam**



Source: Based on de Groot, Brander, and Solomonides 2020.

Based on these values, the ecosystem services values lost as a result of primary forest loss in Vietnam amount to US$1.457 billion for 2001–20. This is based on a reduction in primary forest area of 701,000 hectares during that period and on the ecosystem services valued above. Forest loss rates vary from year to year, and during the past two decades the highest annual loss was US$143.2 million for 2016. In 2020, 32,000 hectares of primary forest were lost, which translates into an ecosystem service loss of US$66.5 million. It is not possible to give a range as the second dataset does not have a range available.

Estimates of loss of services for forestry are of a moderate level of reliability. They have been adapted to local data through the use of meta-analysis for some but not all the ecosystem services that forests provide. Thus, further work is needed to replace the remaining ones where global values have been used. The kinds of values obtained, however, are well in excess of the costs of most interventions for forest conservation, so even if the numbers are not precisely correct, they still strongly support the case for such interventions. The links between the measured costs here and GDP is also partial. While some components of the costs such as food and materials are mostly reflected in GDP, others, such as climate regulation, are not.

Mangroves

Impacts

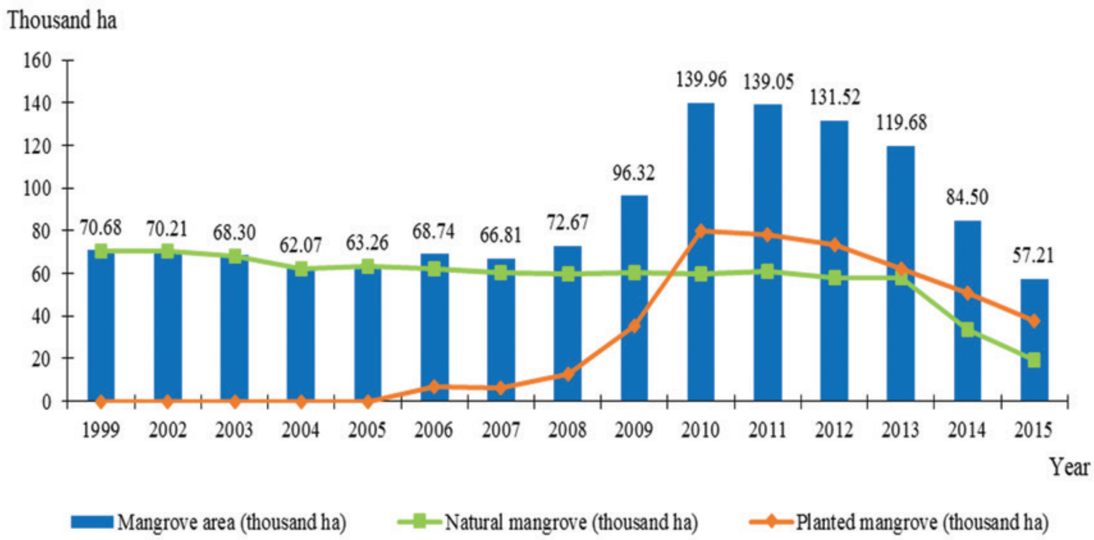
Mangrove ecosystems are among the most productive and biologically complex ecosystems on the planet. They provide myriad essential ecosystem services.[109] For example, they support commercial fisheries by acting as nursery, breeding, spawning, and hatching habitats for offshore fisheries, and they export organic matter to the marine environment, producing nutrients for fauna in both the mangroves themselves and in adjacent marine and estuarine ecosystems. Mangroves serve as natural barriers to protect shorelines, dissipating the destructive energy of waves and reducing the impact of hurricanes and storm surges. Several studies have documented that regions with intact mangroves were exposed to significantly lower levels of devastation from such events than those with degraded or converted mangroves. Mangroves also play a significant role in stabilizing fine sediments, contributing to shore stabilization and erosion control. In addition, mangrove forests are often a rich source of timber, fuelwood, honey, medicinal plants, and other raw materials. Finally, mangroves can attract tourists, providing a valuable source of income.[110]

Mangrove ecosystems in Vietnam provide good examples of these ecosystem services. For instance, in Ca Mau province, which contains the largest area of mangrove in Vietnam, the integrated shrimp-mangrove farming system accounts for approximately 80 percent of the total shrimp aquaculture area of the province. In terms of mangrove coastal protection, studies have found that mangroves in the Red River Delta of Vietnam could reduce wave height by from 13 percent to 66 percent over 100 meters of mangroves and by up to 100 percent over a 500-meter-wide mangrove belt.[111]

A significant portion of the protective mangrove forests of the country has been destroyed over a long period of time. Before 1950, the country had over 250,000 hectares; by 1999 this had decreased to 71,000 hectares, a loss of 72 percent.[112] This decrease is mainly attributed to toxic chemicals in the earlier years and shrimp farming practices more recently.[113] The last two decades or so have seen less loss: between 1999 and 2015, 13,500 hectares have been lost in net terms. This is partly because some replanting has also taken place (figure 3.9).

109 Barbier 2016; Beck and Lange 2016.
110 Salem and Mercer 2012.
111 Nam et al. 2018.
112 Nam et al. 2018.
113 World Bank and MPI 2016.

FIGURE 3.9 **Recent Trends in Mangrove Area in Vietnam, 1999–2015**



Source: Nam et al. 2018.
Note: ha = hectares.

Valuation

Different mangrove services are valued in different locations in the Mekong Delta, according to a major study conducted by Nam et al. (2018). The detailed assessment for that region, where about 60 percent of the mangroves of Vietnam are located, was then scaled up to the whole country. The ecosystem services covered in the Nam et al. (2018) study were the following (see figure 3.10):

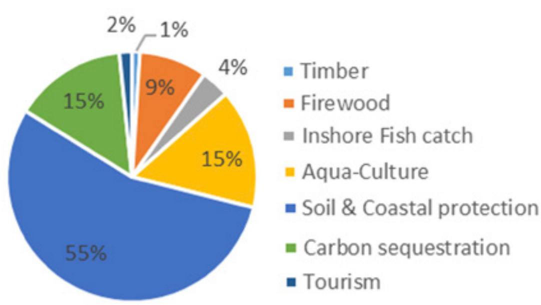
- *Timber and firewood.* Mangrove species have a high calorific wood. They are strong and durable and used by coastal communities to build houses, fences, and fishing equipment. They were valued at market prices for these products.
- *Nontimber forest products (NTFPs).* Wild animals and plants, including honey, bird's eggs, and bats. In the Mekong Delta, the most common mangrove NTFPs include wild animals and plants, providing honey, bird's eggs, and bats. They were valued at market prices.
- *Fish.* In the Mekong Delta, 1 hectare of mangrove supports a marine catch equivalent to 450 kilograms per year valued at market prices.
- *Aquaculture.* In the integrated shrimp-mangrove farming system, an increase in mangrove forest of 1 hectare increases aquaculture production by about US$1,284. In Ngoc Hien district, the value would be around US$212 for 1 hectare.
- *Storm protection.* Mangrove species effectively slow water flow and reduce wave height, thus reducing damage. The service is valued at savings in repair costs based on local costs.

- *Carbon sequestration.* Studies show that mangroves capture carbon at a rate two to four times greater than mature rainforests. The service is valued at the social price of carbon based on global estimates.
- *Erosion control.* Mangroves help mitigate coastal erosion in the Mekong Delta by enhancing sediment through reduced wave energy and trapping sediment. It is valued using local replacement costs.
- *Tourism.* Most tourism value associated with the mangrove ecosystem in the Mekong Delta is potential (that is, it is not yet realized) as very few mangrove areas currently receive tourists. However, some do, and visits were valued using the travel cost method with local data.

The resulting estimates per hectare per year range from a low of US$744 in Cau Ngang district (Tra Vinh Province) to a high of US$1,085 in Thanh Phu district (Ben Tre Province).[114]

The annual loss in the Mekong Delta region for the 20-year period 1997–2017 was US$20.3 million per year, equal to 0.01 percent of GDP (table 3.10). The range of this service is defined by mangrove quality. Lowest value corresponds to heavily degraded mangroves, while highest value corresponds to dense and mature mangroves. The lower bound is US$15.9 million and the upper bound is US$25.1 million per year. In terms of shares, soil and coastal protection have the highest value, followed by aquaculture and carbon sequestration. A regional breakdown (table 3.11) shows the greatest absolute loss in Ken Giang but the greatest percentage loss in Tra Vinh. The regions that have an increase in value of service are Bac Lieu and Ca Mau, probably as a result of replanting. The locations of the different services are shown in map 3.1 (panels a.–d.) for carbon sequestration, aquaculture, tourism, and soil.

FIGURE 3.9 **Recent Trends in Mangrove Area in Vietnam, 1999–2015**



Source: Nam et al. 2018.

114 These figures can be compared with those of another study that looked in depth at two lagoons: one in the coastal communes of Quang Ninh province in the North of Vietnam, and Tam Giang–Cau Hai (TGCH) lagoon in Thua Thien Hue province in Central Vietnam (Ngoc et al. 2021). Their estimates are US$836 for the Quang Ninh mangrove system and US$4,172 for the Thien Hue system. While the first is broadly in line with the broader national study, the second is much greater. Reasons for this difference are that all tourism values in Thua Thien Hue are allocated mangroves even though they are only a small part of the attraction, values for fisheries are overestimated relative to other studies, and Quang Ninh and Thua Thien Hue should have higher protection value as these areas are more prone to storms/typhoons than the Mekong Delta.

TABLE 3.10 **Annual Loss of Value of Mangrove Service in the Mekong Delta, by Type of Service (US$Mn)**

Service	Mid-value	LB	UB
Timber	205,008	156,448	250,401
Firewood	1,780,540	1,410,732	2,213,861
Inshore Fish Catch	757,966	597,735	939,143
Aquaculture	3,150,566	2,478,304	3,890,204
Soil and Coastal Protection	11,177,214	8,699,960	13,787,374
Carbon Sequestration	2,962,619	2,333,871	3,664,678
Tourism	330,391	255,800	397,396
Total Value	20,364,302	15,932,849	25,143,056
As % of GDP	0.009%	0.007%	0.011%

Source: Economy and Environment Partnership for Southeast Asia (EEPSEA Partnership), direct communication.
Note: Table is based on 1997–2017 values. LB = lower bound; UB = upper bound.

TABLE 3.11 **Value of Mangrove Ecosystem Services and Losses in Vietnam, by region, 1997–2017 (US$)**

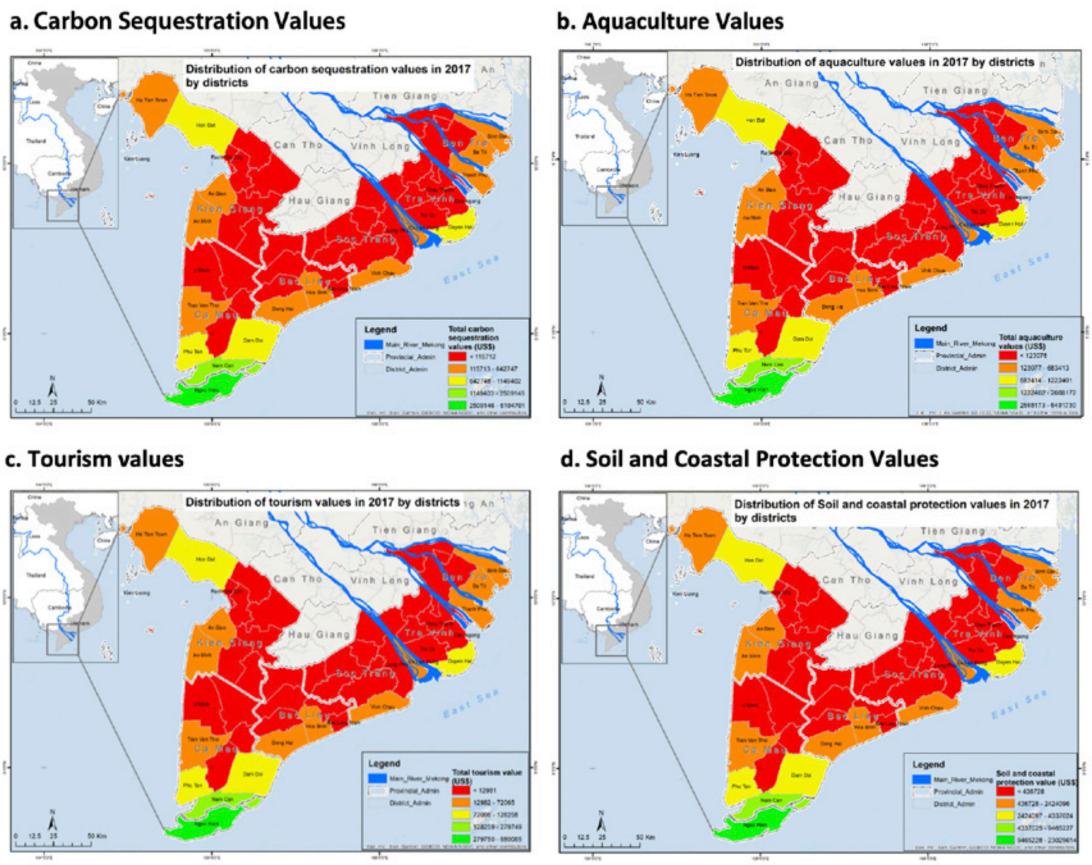
Province	Total value	Value per hectare	Annual Loss, 1997–2017
Ben Tre	9,093,755	1,001	9,340,533
Tra Vinh	8,001,457	777	12,301,543
Soc Trang	6,679,012	874	4,360,286
Bac Lieu	4,235,813	869	−1,840,236
Ca Mau	74,980,246	959	−17,875,138
Kien Giang	23,647,393	996	14,037,154

Source: Nam et al. 2018.

On a national scale, the value of mangrove loss (1997–2017) amounts to US$36.3 million, to which the Mekong River Delta contributed 55.8 percent. The annual loss for the country as a whole has a range of US$28.5 million (LB) to US$45.0 million (UB) based on the Mekong Delta values given in table 3.10. The national-scale estimate is based on the assumption of equal proportions of dense, lightly, and heavily degraded mangroves for the rest of country. The share of the Mekong River Delta in the total area of mangrove nationwide in 1997 and 2017 is assumed to be the same (56 percent based on Pham et al. [2019]).[115] The change in mangrove values during the 20 years and the calculation are shown in table 3.12.

115 These studies also reported mangrove area, but the values differed greatly from ours. We expect that there were some systematic measurement errors so that the percentage still applies.

MAPS 3.1 **Distribution of Ecosystem Services from Mangroves in Vietnam, by District, 2017**



Source: Nam et al. 2018.

Disclaimer: The boundaries, colors, denominations and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

TABLE 3.12 **Estimated Value of Mangrove Loss in Vietnam since 1997, Based on the MRD Values**

Period	MRD mangrove value (US$) per year	Share of MRD mangroves (%)	Vietnam mangrove value (US$) per year
1997	147,073,974	56	262,632,096
2017	126,727,672	56	226,299,413
Loss since 1997	20,346,320		36,332,682

Source: Economy and Environment Partnership for Southeast Asia (EEPSEA Partnership) calculations.

Note: MRD = Mekong River Delta.

The estimates of mangrove losses can be considered reliable, based as they are on detailed local data from a reputable research center. This is especially the case for the MRD region. The decrease in area in recent years has been relatively small, on account of a significant replanting program, but the figures indicate that there is still a loss, and more protection against further decline, including but not limited to replanting, is probably desirable. The data in this section should help evaluate such programs. In terms of the link to GDP the losses are, as with other ecosystem services, only partly reflected in that measure of national income. Timber, firewood, fish catch, aquaculture and tourism are included, but soil and coastal protection and carbon sequestration are not.

Agricultural Land

Impacts

About 25 percent of global land area is subject to some degree of degradation, including soil erosion, salinization, peatland and wetland drainage, and forest degradation. More than one-quarter of agricultural lands is classified as severely degraded. This is the result of soil erosion, salinization, peatland and wetland drainage, and forest degradation driven by unsustainable management practices. These practices suffer from the "tragedy of the commons," which occurs when stakeholders of a shared resource act independently, based on their own self-interest, and those actions collectively result in the depletion or degradation of the resource.[116]

Vietnam is no exception to this, and land degradation is a serious issue. Currently, 9.3 million ha (about 28 percent of total land area) are considered uncultivable, of which 7.5 million ha have been affected by desertification; that is, they are less productive than previously.[117] About 5.1 million hectares are unused land, 2 million are used but the land is seriously eroded, and another 2 million are at risk (with reduced soil fertility or severely degraded land). The total erosion-prone area amounts to 13 million hectares, or 40 percent of natural areas.[118]

Valuation

Land degradation is estimated by comparing the actual productivity of land against potential productivity.[119] Potential productivity is measured based on biomass that a land area can support sustainably (this will vary with climate change). Actual productivity—measured as net primary productivity[120]—is measured by the value of services currently provided by the land. These comprise provisioning (food, water), regulating (including pollination, erosion prevention), and cultural. The percentage loss is then multiplied by the area to which it applies,

116 Ding et al. 2017.

117 Nguyen 2013.

118 Nguyen 2010.

119 The estimation of the costs of degradation does not directly use the above combination of estimates.

120 Net primary productivity is how much carbon dioxide vegetation takes in during photosynthesis minus how much carbon dioxide the plants release during respiration (metabolizing sugars and starches for energy). It is measured as the net increase in biomass (https://earthobservatory.nasa.gov/global-maps/MOD17A2_M_PSN).

times the ecosystem service values per year per hectare for such type of land cover when it has no degradation.

Land degradation estimates are based on data on the human appropriation of net primary production (HANPP) as a supply-side measure of land degradation.[121] This provides an estimate of the actual net primary productivity. Potential productivity is based on land conditions as they were approximately 15 years ago. The analysis has been carried out for Vietnam, but it is at a highly aggregated level and not the most recent (the estimates of degradation are for 2015). Furthermore, the aggregated data cover degradation not only of actual and prospective agricultural land but also other land areas, including forests and mangroves. As the latter categories have been evaluated separately, there is an element of double counting in taking the estimates from the Sutton et al. (2016) study.

The global HANPP data were further processed to estimate degradation of agricultural land in Vietnam. Specifically, the methodology is the same, but the data are further disaggregated using a land cover map[122] to allow the valuation of ecosystem services on this land category. The different land areas in Vietnam, and the estimated losses of net primary productivity (NPP) are shown in table 3.13. NPP loss has been calculated using the NPP map[123] and the land cover map (from the Japan Aerospace Exploration Agency [JAXA]). The areas of interest are agricultural land areas (that is, items 3 [rice], 4 [other crops], and 6 [orchard/crop mosaic]).

TABLE 3.13 **Land Areas and NPP Loss in Vietnam, 2016**

Land cover	Area (ha, thousands)	Share of total area (%)	Average NPP loss (%)
Water	1,060	3.2	16.8
Urban/built up	727	2.2	19.7
Rice	4,308	13.1	21.8
Other crops	3,558	10.8	20.2
Grass/shrub	4,871	17.8	16.3
Orchard/crop mosaic	3,642	11.0	18.9
Barren land	1,301	4.0	17.7
Evergreen broadleaf forest	8,207	24.9	13.9
Coniferous forest	199	0.6	16.7
Deciduous forest	939	2.9	14.1
11. Plantation forest	3,920	11.9	19.1
12. Mangrove	214	0.7	15.6
All land cover types	32,928	100.0	100.0

Source: 2016 Vietnam Land Cover map from Japan Aerospace Exploration Agency (JAXA); www.eorc.jaxa.jp/ALOS/en/lulc/lulc_index.htm.

Note: NPP = net primary productivity.

121 Sutton et al. 2016.

122 Advanced Land Observing Satellite (ALOS) project: https://www.eorc.jaxa.jp/ALOS/en/lulc/lulc_index.htm.

123 Haberl et al. 2007.

The value of the services derived from agricultural land are from de Groot, Brander, and Solomonides (2020), with some modifications (see table 3.14). The principal changes are for water services, where the meta-analysis for forests in Vietnam gave a value much lower than the one in the de Groot study. It is unlikely that water services on cultivated land would be higher than those of forests, so the estimated forest values for Vietnam have been used instead. In addition, there is no evidence of services of recreation and tourism on cultivated land, so that category has been set at zero. Aesthetic information and inspiration for culture, art, and design are valid and relevant, so those categories have been retained. This results in a unit value of US$4,333 for nondegraded cultivated land in the country.[124]

TABLE 3.14 **Ecosystem Service Values for Cultivated Land (US$/ha)**

Ecosystem service	**Value for cultivated areas**	**Share of total area (%)**
Food (rice)	510	510
Water	604	10
Raw materials	6	6
Air quality regulation	10	10
Climate regulation	10	10
Moderation of extreme events	993	993
Regulation of water flows	17	17
Waste treatment	40	40
Erosion prevention	173	173
Maintenance of soil fertility	34	34
Pollination	1,498	1,498
Biological control	621	621
Aesthetic information	395	395
Opportunities for recreation and tourism	3,101	0
Inspiration for culture, art, and design	16	16
Sum	**8,028**	**4,333**

Sources: De Groot, Brander, and Solomonides 2020; World Bank calculations. Ecosystem services for water are based on Siikamaki et al. 2021.

Overall degradation in the country for the 15-year period across all cultivated land areas is estimated at 17.5 percent, resulting in a loss of ecosystem services of US$10.3 billion (table 3.15), or US$689 million per year. As a percentage of GDP in 2020, the loss is around 0.2 percent; however, as a share of the value of agricultural output, the annual loss is 1.4 percent,

124 The value of food has been taken at US$500 per hectare, although the value added of output from such land is much higher. In Vietnam, agricultural statistics indicate a value of US$2,270 per hectare for rice, US$1,435 for other crops, and US$3,834 for fruits and vegetables. These values include a return to labor and other inputs. To get the value of the land as the input, they have to be netted out. It is reasonable that the net return to land should be similar across crops. Estimates of such a return should be estimated for the country to confirm the figure used here (as should the other ecosystem service values).

and the overall loss of output over 15 years amounts to 21 percent of the value of current agricultural output. Thus, action to arrest and even reverse this loss is a matter of great concern. Losses of yields are reflected in GDP, but many of the other ecosystem services are not, so if the degradation were to be halted and reversed, the gain in GDP would be linked in a complex way to the costs.

TABLE 3.15 **Estimated Losses from Agricultural Land Degradation in Vietnam, 2000-2015**

Land cover	Percentage of total area (%)	Area ('000 ha)	ESV (US$/ ha/year)	Average NPP loss percentage (%)	ESF loss by NPP los US$Mns./year
Rice	13.1	3,922	4,333	21.8	3,705
Other crops	10.8	3,922	4,333	20.2	3,425
Orchard/crop mosaic	11.0	3,922	4,333	18.9	3,212
All agricultural land					10,342

Source: World Bank calculations. Based on human appropriation of net primary production (HANPP) data following Nguyen 2010.

Note: ESV = ecosystem value ha = hectare; NPP = net primary productivity.

The figures for land degradation should only be taken as indicative, and more accurate estimates need to be developed. They are still useful as a guide to the rate of loss in recent years on the potential of agricultural land to provide a range of services (not just provisioning services such as crops).

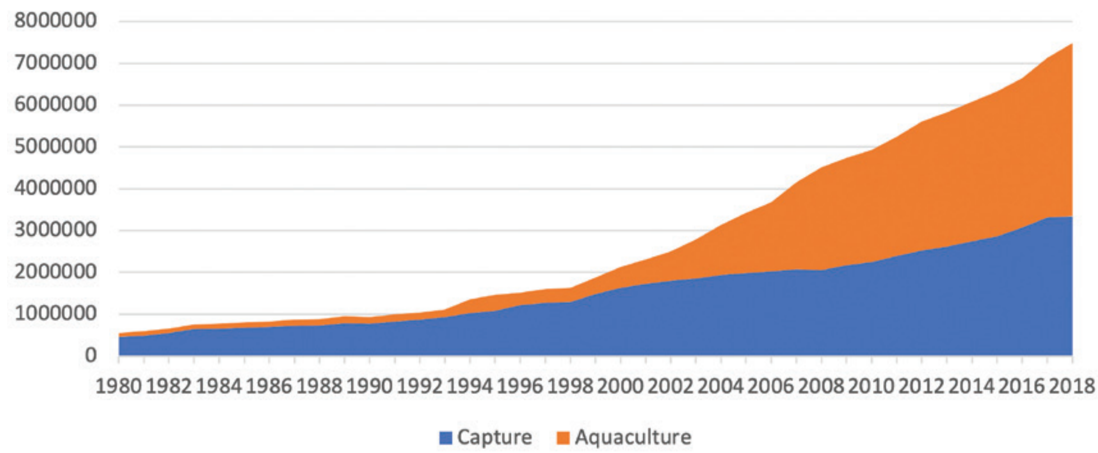
Fisheries

Impacts

Fisheries is an extremely important sector for Vietnam given its contribution to food security, the alleviation of poverty, sustainable livelihood creation, economic growth, and rural employment. In 2016, Vietnam was the fourth-largest producer of fishery and aquaculture in the world, with a total production of 6.4 million tons. Figure 3.11 shows total fish production, including both capture and aquaculture, from 1980 to 2018. It has been a continuously growing sector so has contributed much to the country. Since 2007, aquaculture has been the major contributor to total fisheries production, reaching 3.6 million tons in 2016.[125] This has, however, come at the expense of displacing large areas of coastal forests (evaluated under mangroves).

125 FAO 2019.

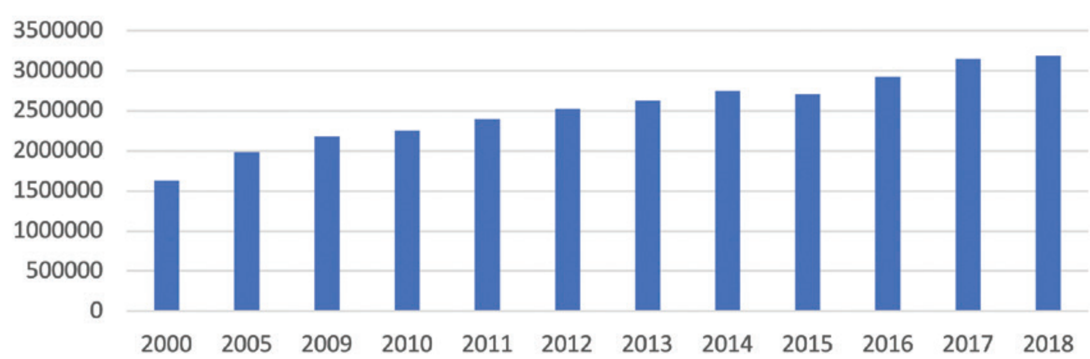
FIGURE 3.11 **Total Fish Production in Vietnam, 1980–2018 (tons)**



Source: FAO 2019.

The fisheries sector in Vietnam can be divided into three main subsectors: marine, inland, and aquaculture. Marine fisheries are the biggest contributor to fisheries production, along with aquaculture. The recreational fisheries sector is still not developed except for the production of ornamental fish. In the case of marine fishery, the catch has been growing steadily (figure 3.12).

FIGURE 3.12 **Marine Capture Fish Production in Vietnam, 2000–18 (tons)**



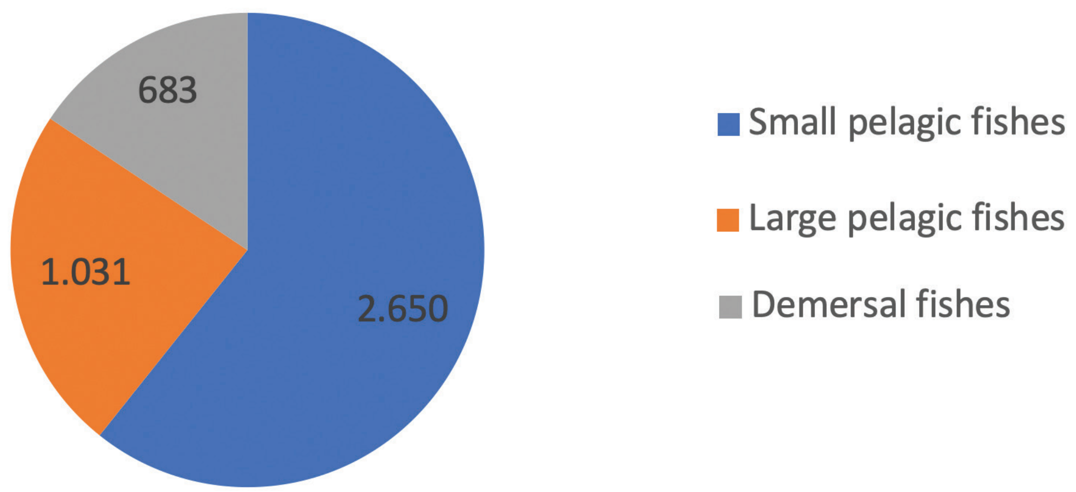
Sources: FAO 2019, 2020a, 2020b.

The increase in catch, however, is unsustainable, as reflected in high rates of exploitation and the condition of the stocks. Most stocks are considered already fully exploited or overexploited, notably tuna, anchovy, and seabream.[126] Figure 3.13 shows the overall marine fisheries stock for

126 Pelagic fish are fish that live neither close to the bottom nor near the shore, in contrast with demersal fish, which live on or near the bottom, and reef fish, which are associated with coral reefs. In Vietnam's waters, small pelagic include anchovy, round scad, Japanese horse mackerel, yellowtail scad, Indian mackerel, and Indo-Pacific mackerel. Large pelagic fish include tuna (skipjack, yellowfin, bigeye, frigate, bullet, striped, longtail), seabream, wahoo, and mahi mahi. Demersal fish include sharks, ponyfish, bream, snapper, and others.

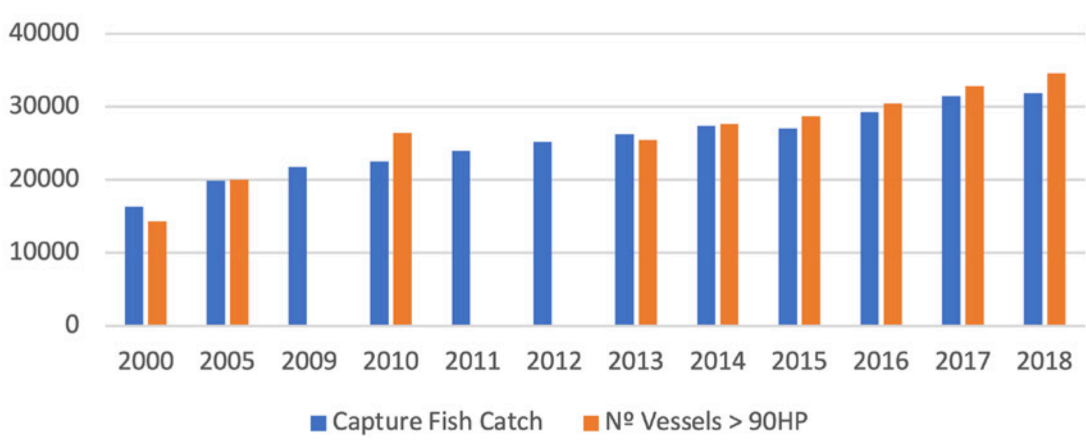
2011–15, which represents an overall decline of 13.9 percent compared with 2000–05, according to the Ministry of Agriculture and Rural Development (MARD). Despite the decline in stocks, the catch per unit effort is increasing (figure 3.14), while it might be expected to fall if other things were the same. The reason is the shift to larger, more efficient vessels that are making it easier to extract the fish (also shown in figure 3.14).

FIGURE 3.13 **Fisheries Stock in Vietnam, by Type, 2011–15 (tons, millions)**



Source: Ministry of Agriculture and Rural Development (MARD) data, courtesy of the Economy and Environment Partnership for Southeast Asia (EEPSEA Partnership).

FIGURE 3.14 **Increasing CPUE, measured by catch in tons (100s) and number of vessels > 90 HP**



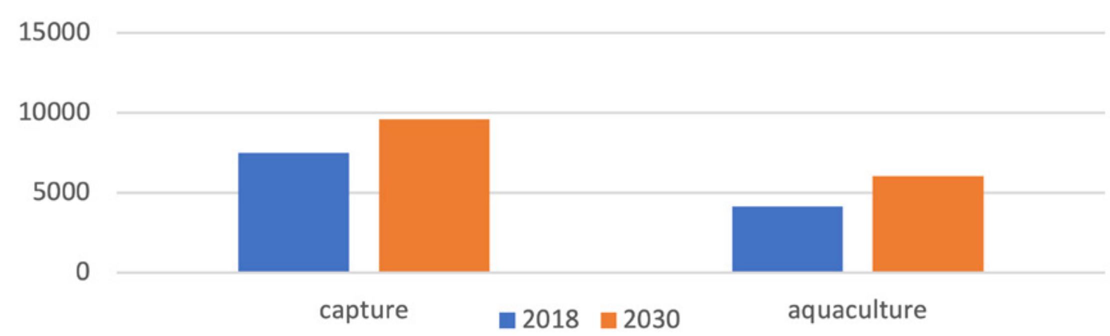
Sources: FAO 2019, 2020a, 2020b.

Note: CPUE = catch per unit effort; HP = horsepower.

Overfishing is most serious for most pelagic species, except less so for anchovy and tuna. The dynamics indicate a decline of all species except tuna. There is no third-party certification such as the Marine Stewardship Council for the harvest of any of them, and exclusivity of access is rarely available. However, critical habitats are not generally highly degraded, so recovery is possible. These insights are based on expert interviews in Vietnam performed by EEPSEA. Detailed results are given in the Supplementary Note.

Despite what appears to be unsustainable fisheries in Vietnam, projections of production for the Vietnamese fisheries are not taking account of sustainability. The Food and Agriculture Organization of the United Nations (FAO) projects future increases in production of 28 percent between 2018 and 2030 for capture fisheries and 46 percent for aquaculture (figure 3.15). The FAO model is based on sets of assumptions on population and economic growth, urbanization, dietary changes, potential fish diseases, and the future macroeconomic environment, and consider policies in China.[127] The model does not consider whether these results can be achieved sustainably.

FIGURE 3.15 **Projected Fish Production to 2030 (Tons, millions)**



Source: FAO 2020b.

Valuation

It is complex to estimate the costs of degradation for fisheries as they arise largely because of a move to unsustainable use of the resource. As the data show, stocks are declining, but catch rates are increasing. Thus, the valuation is based on a sustainable scenario approach, which aims to estimate the cost of actions needed to restore stocks to sustainable levels. That is, the past decline in stocks raised the cost of catch, and it will not only continue to raise the cost in the future but will also reduce the amount that can be caught. Using a bioeconomic model, this approach was used by Nguyen et al. (2018a), who showed that the country's marine capture fisheries are unsustainable. They estimated that fishing effort needs to be reduced between 35 percent and 39 percent of current fishing effort to achieve the maximum sustainable yield and

127 FAO 2020b.

maximum economic yield. There is, however, no indication that the country intends to go in that direction.

As part of this study, EEPSEA developed a similar bioeconomic model that estimates the relationship between stock and level of effort for large pelagic fish from 2000 to 2015 (details in the Supplementary Note). The basic notion is to use that relation to see how much effort would have to decrease to restore stock to levels present in selected previous years. The reduction of effort in turn will imply a loss of value of catch, which is the cost of restoring stocks to previous levels.

Based on this model, the annual cost of restoring the stock to levels going back to 2010, 2012, and 2013 are US$136 million, US$150 million, and US$126 million, respectively (table 3.16). It should be recalled that estimates are only for large pelagic fish. These estimates are based on the following assumptions:

- The number of vehicles in 2015 was 28,719.
- Reduction in effort to restore different levels of stock loss are measured in cheval vapeur (CV).[128] Required reductions are 2,154,000 for 20 percent, 3,591,000 for 50 percent, and 5,021,000 for a 70 percent reduction. These reductions in effort convert into reductions in vehicles of 6,587 for 20 percent, 10,581 for 50 percent and 15,373 for 70 percent.[129]
- The average catch per vehicle is 100 metric tons.
- The landed price of large pelagic fish is US$3,728 per metric ton.
- The rent for marine fisheries of the kind analyzed here is 11 percent. This is based on data for 2014 that report the value of marine catch of US$4.5 billion.[130] The World Bank's comprehensive *Changing Wealth of Nations (CWON)* natural capital study estimates the rent in that year to be US$506 million, making the latter 11 percent (World Bank 2021a).
- The annual cost is estimated by dividing the total cost by the number of years over which it occurred.

TABLE 3.16 **Reduction in Large Pelagic Catch Required to Restore Stocks to Previous Levels**

Year of recovery	Stock loss by 2015 (%)	Reduction in effort (vehicles)	Reduction in catch (megatons)	Value of reduction (US$Mn.)	Cost per year (US$Mn.)
Back to 2013 Level	20	6,587	658,700	270	135
Back to 2012 Level	50	10,981	1,098,100	450	150
Back to 2010 Level	70	15,373	1,537,300	630	126

Source: EEPSEA 2021.

128 Cheval vapeur (CV) = horsepower.

129 The data indicate that each vessel has 327 CV.

130 VIFEP 2020.

The estimates here must be considered preliminary and probably an underestimate, as the data available were preliminary and further work is needed. Only large pelagic fish have been covered in the estimation, and more should be looked at. Nevertheless, there is no doubt that a number of species are facing overfishing in Vietnam's waters, and action needs to be taken to address that. It may be possible to achieve the required reduction through better control of illegal catch. This is something that needs further investigation. It is also important to note that if the reduction in effort were to be made, initially GDP would decline, as catch levels fall. The benefit would come in the future when, by restoring sustainability, catch levels could be maintained for much longer than under business as usual.

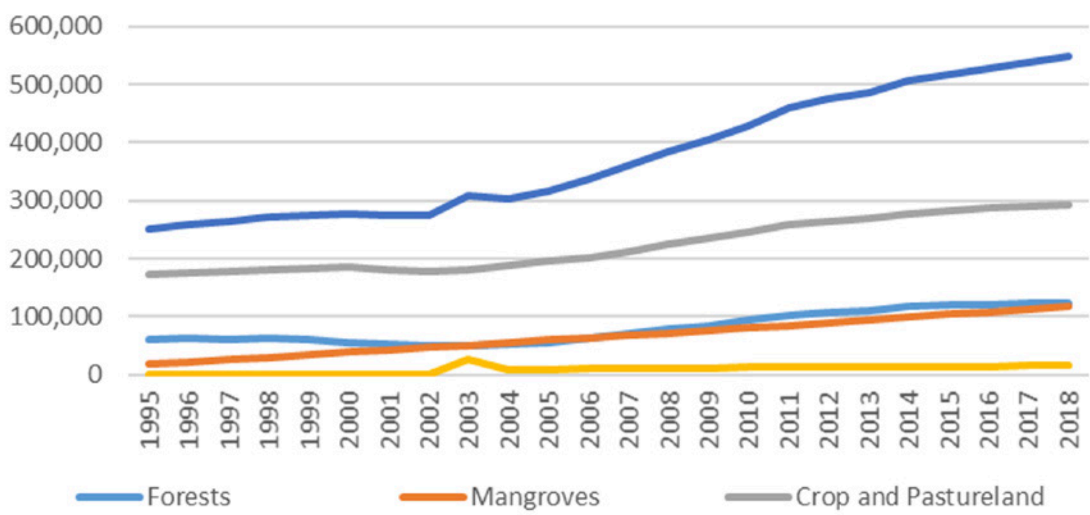
BOX 3.4 **Natural Capital Wealth and COED**

As with all countries, natural capital is a key contributor to the generation of national income in Vietnam. It is divided into renewable natural capital (such as cropland, pastureland, mangroves, forests, and fisheries) and subsoil natural capital (such as oil, gas, coal, metals, and minerals). Together they made up about 21 percent of all capital in 2018 (down from 24 percent in 1995).

Renewable capital, the bulk of all natural capital, has declined from 22 percent in 1995 to 17 percent in 2018 (figure B3.4.1, panel b). Annual movements in the amounts in millions of constant US dollars are shown in the figure B3.4.1 (panels a and b).

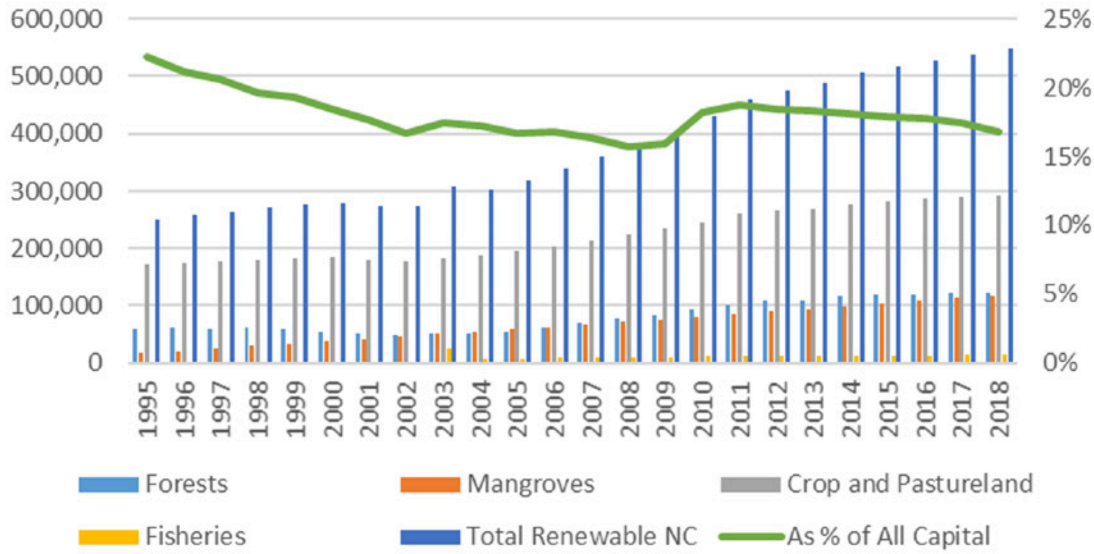
FIGURE B3.4.1 **Trends in Renewable Natural Capital in Vietnam, by Type, 1995–2018**

a. Value of Renewable Natural Capital (US$Mn.)



BOX 3.4 **Natural Capital Wealth and COED (cont.)**

b. Renewable Natural Capital as a Share of All Capital



Source: World Bank 2021a.

What do the figures on trends from the CWON study tell us about the development path in Vietnam, past and future? Overall, natural capital has been increasing in Vietnam over the last 25 years, although less rapidly than other forms of capital. This, however, does not indicate any problem of sustainability. To understand the data, it is important to remember that all capital values are derived as the present value of the flow of services the asset will provide. For natural capital, the asset is the ecosystem. In determining future flows, account should be taken of (a) the possible change in the condition of the ecosystem (for example, degradation or overuse), and (b) changes in unit values of services the ecosystem provides. As a result, the total may increase due to higher unit values even when the physical system is degrading. Closer inspection of different ecosystems reveals the following:

Forests. Forest doubled their value from 1995 to 2018. The COED study finds a loss of areas of primary forests and an associated loss rate of US$67 million a year in the last period. There are several reasons for the difference. First, COED is looking only at primary forests and not at other types, such as planation forests, which have grown in Vietnam, giving rise to the increased value. Second, the coverage of ecosystem services in the CWON is more limited than that in COED. It includes only recreation, habitat/species protection, nontimber forest products, and water services. COED coverage includes several other services. Third, the capital values are equal to the present value of continuing the flow of current services for 100 years. This does not take account of the sustainability of current rates and methods of exploitation and extraction of those services. If some services, such as timber extraction, are based on land clearance, they will not provide this continued flow. For these reasons, the values here, based on loss of forest area of high value, are complementary to the natural capital accounts, and are better able guide forest conservation policy.

Mangroves. The natural capital value of mangroves increased sevenfold from 1995 to 2018. Over the same period as covered in the COED (that is, 1997–2017), it tripled. The COED study finds a small loss in the current flow of services from mangroves of about US$36 million. It is important to note that the

BOX 3.4 **Natural Capital Wealth and COED (cont.)**

value of the extent of the mangrove ecosystem is the expected present value of services over several decades in the future in most cases. It can increase when unit values rise faster than the extent of the mangroves declines. With rapid growth in Vietnam, the value of flooding protection, which is linked to value of physical infrastructure, has been rising rapidly in Vietnam. This can be consistent, however, with a decline of the value that would have been obtained from the mangroves that have been lost. The COED analysis provides an estimate of those losses, which should guide policy on mangrove protection at least as much as the changes in natural capital.

Cropland. The value of croplands increased by 65 percent between 1995 and 2018, and 52 percent from 2000 to 2018. The COED study, however, indicates a loss of services of around US$690 million a year over the past 15 years. Differences can be explained as follows. The CWON capital estimates take the present value of market rents from cropland, allowing for some changes in the growth of future rents on account of degradation and climate change. It also assumes land areas under crops are constant. The estimates made here account for market rents from crops but also include other services from cropland and measure the loss in services relative to the change in productive potential of that land between 2000 and 2015. It is possible that services of agricultural land have fallen relative to their potential, but the value of natural capital has increased because unit values have gone up and are projected to go up on account of growth in the economy and increased demand for food. Thus, the two approaches provide complementary information.

Fisheries. *CWON* estimates the value of natural capital for fisheries in Vietnam as the discounted present value of the rent obtained from fishery catch, assuming that the current rent will continue at its present level for 100 years at a 4 percent discount rate. The rent is the gross value of the catch minus fishing costs. The approach does not explicitly quantify the change in fisheries stocks because, unlike other natural capital assets, complete global estimates of the stocks are not currently available. The COED estimate is only for one group (large pelagic species, such as tuna) and is focused on the costs of restoring the loss of stock over the recent past. These costs are estimated from a bioeconomic model of the relation between catch, the stock, and the level of effort.

In summary, the *CWON* study paints a relatively positive picture of the trends in natural capital, but it masks the lack of sustainability of current practices in the use of renewable natural capita. This is, of course, part of the story: natural capital has supported the growth in GDP, especially in the agricultural sector, but also through the services provided by the forests, mangroves, and fisheries. The COED complements this narrative by pointing to areas where ecosystem services have been lost and delves into the reasons for the loss. These losses are not always reflected in the natural capital measures, in some cases because the latter do not take account of loss of sustainability and in others because natural capital values are also affected by expected growth in the value of output, which the COED is not.

Climate Change

Impacts

Vietnam's long coastline, geographic location, and diverse topography and climates contribute to its being one of the most hazard-prone countries of Asia and the Pacific region. Vietnam is ranked 98th on the Notre Dame Global Adaptation Index (ND-GAIN) out of 181 countries.[131]

The costs of climate change are not always included in COED studies, partly because they are difficult to quantify and partly because they are considered to be significant only in the future. They have been included here because damage estimates are now available from a number of studies. Though there is a high level of uncertainty, the figures are useful in indicating orders of magnitude of losses. In addition, as this exercise and others have shown, the costs of climate change are not only in the future: they are affecting economic activity and well-being now. Action in the form of adaptation needs to be guided by where the costs are greatest and where they will increase most rapidly. The material here helps in providing such guidance.

Changes in the climate have been observed over the six decades. Mean annual temperature has increased by 0.5°C–0.7°C since 1960, with the rate of increase most rapid in southern Vietnam and the Central Highlands. During 1971–2010 the rate of warming is estimated at 0.26°C per decade, almost twice the rate of global warming over the same period.[132] Greater warming has been identified in winter months than in summer months. The frequency of "hot" days and nights has increased significantly since 1960 in every season, and the annual frequency of "cold" days and nights has decreased significantly.

Mean rainfall over Vietnam does not show any significant increase or decrease on a national level since 1960. However, on a subnational level some changes are significant, the general trend has been toward increased rainfall in central regions and reduced rainfall in northern and southern regions.[133] El Niño remains a major influencer of trends in precipitation.

Looking to the future, the Representative Concentration Pathways (RCPs) represent four plausible futures, based on the rate of emissions reduction achieved at the global level. Table 3.17 provides information on two of the four RCPs over two time periods. Climate changes under each emissions pathway are presented against a reference period of 1986–2005 for all indicators. Vietnam is projected to experience an average temperature increase of 3.4°C by 2080–2100 under the highest emission pathway (RCP8.5). This warming is slightly less than the global average projected by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) of 3.7°C. By the end of the century, Vietnam is projected to experience three times

131 World Bank and ADB 2020.

132 Nguyen, Renwick, and McGregor 2014.

133 Nguyen, Renwick, and McGregor 2014.

greater warming under RCP8.5 when compared to RCP2.6, the lowest emissions pathway. The study suggests that temperature increases will be strongest in southern Vietnam, but uncertainty is high in subnational comparisons. There is considerable uncertainty over future precipitation change. Comprehensive analysis of climate projections at a regional level suggests that there is no strong consensus around either significant increases or decreases in annual rainfall.

TABLE 3.17 **Projected Anomaly for Maximum, Minimum, and Average Daily Temperatures in Vietnam, 2014–59 and 2080–99 (Change in °C)**

Scenario	Average daily maximum temperature		Average daily temperature		Average daily minimum temperature	
	2040–59	2080–99	2040–59	2080–99	2040–59	2080–99
RCP4.5	1.3 (-0.1–3.1)	1.9 (0.3–3.8)	1.4 (0.1–2.7)	1.9 (0.7–3.4)	1.4 (0.1–2.5)	1.9 (0.5–3.2)
RCP8.5	1.8 (0.2–3.5)	3.7 (1.8–6.1)	1.8 (0.4–3.1)	3.7 (2.1–5.6)	1.8 (0.4–3.0)	3.7 (2.1–5.4)

Source: World Bank and ADB 2020.

Note: RCP = Representative Concentration Pathway.

The socioeconomic impacts of these changes are significant. The following are the main effects that have been quantified in the literature.

Natural Hazards. Vietnam has extremely high exposure to flooding (ranked joint first with Bangladesh in the EU´s INFORM index of climatic risks),[134] including, riverine, flash, and coastal flooding. The country also has high exposure to tropical cyclones and their associated hazards (ranked eighth). Drought exposure is slightly lower (ranked 82nd) but is still significant as highlighted by the severe drought of 2015–17. Its overall ranking on the INFORM Risk Index of 91 out of 191 is somewhat mitigated by its better scores in terms of vulnerability and coping capacity. Risks are expected to increase for heatwaves, droughts, floods, and cyclones and storms.

Floods. Flood represents the largest risk by economic impact in Vietnam, accounting for an estimated 97 percent of average annual losses from hazards. As of 2010, assuming protection for up to a 1-in-25-year event, the population annually affected by flooding in Vietnam is estimated at 930,000 people and expected annual impact on GDP at US$2.6 billion.[135] A study by the World Bank suggests that around 33 percent of the national population are vulnerable to flooding at a return level of 1-in-25 years, but this will increase to 38 percent under RCP2.6 and 46 percent under RC8.5 by 2100.[136] The climate change component, when isolated, is projected to increase the annually affected population by 433,000 people, and the impact on GDP by US$3.6 billion by 2030 under the RCP8.5 emissions pathway.

134 The INFORM Risk Index is a global, open-source risk assessment for humanitarian crises and disasters. It can support decisions about prevention, preparedness, and response. For details, see the INFORM website: https://drmkc.jrc.ec.europa.eu/inform-index.

135 Data from the AQUEDUCT Flood Analyzer of the World Resources Institute (WRI): https://floods.wri.org/.

136 Bangalore, Smith, and Veldkamp 2016.

Heatwaves. The current daily probability of a heat wave is around 3 percent. Temperature rises in Vietnam are expected to lead to chronic heat stress in some areas, even under lower emissions pathways. Modeling indicates that the probability of a heatwave is likely to increase significantly by 2080–99. Under RCP8.5, the daily probability could rise to as much as 40 percent. Under RCP2.6, however, that probability is estimated at around 8 percent, with RCP4.5 and RCP6.0 lying in between.[137]

Droughts. Vietnam currently faces an annual median probability of severe meteorological drought of around 4 percent. Projections for Southeast Asia suggest that the return periods of droughts will reduce. This trend is less significant under lower levels of global warming. The modeling projects an increase in the annual probability of drought in Vietnam of around 10 percent under all emissions pathways, and this increase remains relatively constant over the period from 2020–2100. Analysis suggests these changes apply across all of Vietnam's regions.[138]

Tropical Cyclones and Storm Surges. Vietnam has very high exposure to tropical cyclones, with a particularly high rate of landfall along its northern coast. Climate change induced sea-level rise is likely to increase the potential risk associated with storm surges driven by tropical cyclones. Studies estimate that, without adaptation, 9 percent of national GDP will be at risk from the impact of a 1-in-100-year storm surge impacting the Red River Delta region in 2050.[139]

Water Availability. Considerable uncertainty clouds projections of change in future precipitation and cyclone activity. Most studies, however, suggest such changes will have a markedly smaller impact on water supply relative to demand than human development impacts. The climate modeling is mixed in terms of its impacts on water availability and mostly shows relatively small impacts. The growth in demand for water, however, from economic growth and population growth is inexorable and dominated any analysis of future shortages.[140]

Coastal Areas. Sea level rise threatens significant physical changes to coastal zones around the world. Vietnam is one of the world's most vulnerable countries to sea level rise. Without adaptation, an estimated 12 million people face permanent inundation on higher emissions pathways, primarily concentrated in the nation's two low lying mega-river deltas.[141] An estimated 2.4 percent of Vietnam's GDP is at risk from permanent inundation in the Red River Delta region.[142] In addition to the threat of permanent inundation, livelihoods in Vietnam's low-lying areas face major challenges from saline intrusion, which has already forced land-use changes, abandonment, and reduced yields in many provinces. Coastal erosion exacerbated by climate change is also an increasing threat to Vietnam's extensive coastline.

137 World Bank and ADB 2020.
138 World Bank and ADB 2020.
139 World Bank and ADB 2020.
140 World Bank and ADB 2020.
141 World Bank and ADB 2020.
142 Neumann et al. 2015.

Fisheries. Fisheries and aquaculture represent major components of the Vietnamese economy, typically contributing around 6–7 percent of GDP and a similar proportion of employment. The most significant climate impact is expected to be the change in the maximum catch potential in ocean fisheries resulting from drivers such as raised sea-surface temperatures and acidification. Modeling by the FAO points to changes ranging between –6 percent and –11 percent by 2050, with the variation influenced by the different potential emissions pathway.[143]

Agriculture. Climate change will influence food production via direct and indirect effects on crop growth processes. At an international level, these impacts are expected to damage key staple crop yields, even on lower emissions pathways. Studies estimate 5 percent and 6 percent declines in global wheat and maize yields, respectively, even if the Paris Climate Agreement is met and warming is limited to 1.5°C.[144] A further influence of climate change on agricultural production is through its impact on the health and productivity of the labor force. A study suggests that labor productivity during peak months has already dropped by 10 percent as a result of warming and that a decline of up to 20 percent might be expected by 2050 under the highest emissions pathway (RCP8.5).[145] Research focused on laborers in Da Nang has shown the high likelihood that, by 2050, temperatures will regularly exceed thermal comfort levels set by the Vietnamese Ministry of Health, an issue which will likely impact several million laborers in agriculture and other industries.

Rice is the most important crop in Vietnam's agricultural sector. It is estimated that climate change may damage rice yields in the Mekong River Delta in the long term. The outlook reported for rainfed rice is particularly poor across all time horizons with yield declines potentially over 50 percent on higher emissions pathways by 2040. Irrigated rice fares better in the shorter-term showing some yield improvements up to 2030, but by the 2040s irrigated rice could also face yield reductions of up to 23 percent under higher emissions pathways.[146]

Maize is the second most important food crop, substituting as a staple good in periods of rice shortage. The outlook for maize production is also poor because of its sensitivity to high temperatures. Concerns have also been raised regarding potential future climate stressors affecting cash crops grown in Vietnam's Central Highlands region, notably tea, coffee, pepper, and rubber.

Energy and the Urban Sector. Research has established a reasonably well constrained relationship between heat stress and labor productivity, household consumption patterns, and (by proxy) household living standards. The impact of an increase in temperature on these indicators depends on whether the temperature rise moves the ambient temperature closer

143 Barange et al. 2018; Nguyen et al. 2018.
144 Tebaldi and Lobell 2018.
145 Dunne, Stouffer, and John 2013.
146 Dunne, Stouffer, and John 2013.

to, or further away from, the optimum temperature range. The Vietnam Ministry of Health sets a threshold of 28°C as a maximum for safe heavy labor. The effects of temperature rise and heat stress in urban areas are increasingly compounded by the phenomenon of the urban heat island (UHI). Hard surfaces, residential and industrial sources of heat, and air pollution can push temperatures higher than those of the rural surroundings, commonly anywhere in the range of 0.1°C–3°C in global megacities. Studies suggest Ho Chi Minh City experiences around 0.5°C–0.8°C of UHI.[147] Research suggests that on average a 1 degree increase in ambient temperature can result in a 0.5 percent to 8.5 percent increase in electricity demand. Notably this serves business and residential air-cooling systems.

Heat-Related Mortality. Research has placed a threshold of 35°C (wet bulb ambient air temperature) on the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death. Climate change will push global temperatures closer to this temperature "danger zone" both through slow onset warming and intensified heat waves. Matthews, Wilby, and Murphy (2017) identify both Ho Chi Minh City and Hanoi as among the world's most vulnerable to deadly temperatures. Work by Honda et al. (2014), which utilized an emissions scenario comparable to RCP6.0, estimates that without adaptation, annual heat-related deaths in Southeastern Asia will increase 294 percent by 2030 and 691 percent by 2050.

Other Diseases. The WHO estimates that a temperature increase in the region of 2°C–3°C will increase the incidence of malaria by around 3 percent to 5 percent.[148] Similar trends are also suggested for dengue fever and diarrheal disease, but actual changes will be highly context dependent and further research is required.

Poverty and Inequality. Many of the changes projected are likely to disproportionately affect the poorest groups in society. Heavy manual labor jobs are commonly among the lowest paid while also being most at risk of productivity losses due to heat stress. In the case of Vietnam, work by Bangalore, Smith, and Veldkamp (2016) concludes that flooding in urban areas will affect the poorest communities most strongly due to the common occurrence of more deprived households adopting residence on land with high hazard exposure or low levels of protection. Gender is also linked into this issue, as Tu and Nitivattananon (2011) show that women tend to be most exposed to the risks of living in this precarious environment. Similar issues have been identified in flood-prone rural areas, notably Vietnam's major river deltas, where poorer and particularly landless households hold lowest resilience.

147 World Bank and ADB 2020.
148 World Bank and ADB 2020.

Valuation

Vietnam can do very little to avoid costs that arise as a result of a global phenomenon, not something that has been done inside the country, and it can only take actions to adapt to them and reduce their impacts. In valuing the costs of climate change it is important to recognize an important distinction between this category and the others considered so far. In order to do this and to design a program of action, the data on the costs across different sectors estimated here will be of great value. Thus, the role the analysis plays for this category is different from the other categories of cost, where local actions can be evaluated with respect to how much they reduce the damages.

While some socioeconomic impacts described above have estimates of the costs associated with them, not all do. Moreover, the climate projections they are calculated for vary. Hence it is desirable to undertake a systematic assessment of costs by area of impact for the same RCPs and for the same dates. This has been attempted based on the following:

- A base set of estimates for all sectors for 2010 and 2030 was undertaken by DARA (2012) for all countries, including Vietnam. This brought together a very wide set of studies which had used a mixture of methods, including partial equilibrium models, general equilibrium models and a range of engineering cost models, combined with climate models. The methodology consists of estimating a baseline scenario without climate change and then estimating a second scenario in which the same economic and environmental structures face climatic changes. The actual estimates of losses and gains with climate change are the difference between the two scenarios. In general, the socioeconomic baseline is GDP in 2010 and estimates of losses or gains are made against what that GDP would have been without the climate change that was experienced.
- In some areas more recent estimates that are available have been used instead of the ones in the DARA (2012) study. These include:
    - *Sea level rise (SLR).* Impacts of SLR are from Lincke and Hinkel (2018), who extend the analysis to 2050 and beyond. The study also covers more scenarios and looks at outcomes under the probability distribution of sea level rise in all countries.
    - *Health.* WHO (2014) and some online information was used to update impacts to 2050. As all these studies gave only physical impacts, a valuation of morbidity and premature mortality has also been undertaken, which was not part of the DARA and WHO estimates.
    - *Agriculture.* The International Food Policy Research Institute (IFPRI) has made estimates based on their International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) of the agricultural effects of climate change for most countries in the world. IMPACT is a network of linked economic, water, and crop models (IFPRI 2017). It is a partial equilibrium multimarket economic model

which simulates national and international agricultural markets. The model focuses on national and global markets over 159 countries (including Vietnam).

- *Tourism.* The estimates taken here are based on the modeling of Hamilton, Maddison, and Tol (2005), in which arrivals and destinations are a function of, among other variables, temperature. The relationship is nonlinear, with 18.6°C being a turning point, above which departures from the country for tourism increase and arrivals decrease. Losses or gains arising from changes in temperature have been modeled by Roson and Sartori (2016).

- In addition, the estimates have been extended to 2050, and an interim estimate has been made for 2020 (based on those for 2010 and 2030). The extension to 2050 uses the projections of climate indicators (mainly temperature) given in table 3.18 to construct the 2050 estimates. Because these projections vary by RCP, the projections of costs also vary by RCP.[149] The 2020 estimation is derived assuming constant growth of costs between 2010 and 2030.

The estimation methods for the different sectors are granular, insofar as they apply the estimation of physical impacts on a spatially disaggregated basis within each country (although trade and other modelling is at the national level). A summary of the valuation of each area of impact is given in the Supplementary Note.

Total costs in 2020 are estimated at US$11.0 billion, with a range of US$6.7 to US$14.8 billion. As a percent of GDP in that year the mid-value is 3.2 percent (range is 2.0 percent to 4.4 percent). The largest item is fishery, followed by labor productivity, agriculture, sea level rise, and extreme events.

The estimates for 2020 are given in table 3.18, with ranges based on projections for 2030, which are in turn based on the temperature ranges in table 3.17. Negative values indicate a gain in services as a result of climate change. They arise for example when increased precipitation raises water flow in river basins where hydro energy is being generated. They also arise when projections are for a temperature decrease (which is relevant in the lower bounds of some of the projections).

Costs for future years are summarized in table 3.19, with the 2050 figures separated for RCP2.6 and RCP8.5. Costs rise to around US$27.2 billion by 2030 and then to between US$43.8 billion (RCP2.6) and US$68.5 billion by 2050 (RCP8.5). Thus, it is clear that there is a lot hanging on whether the world manages to follow a high ambition scenario for mitigation or whether it continues under business as usual.

149 For 2030, the variation in projections by RCP is quite small, so the costs have not been projected separately.

TABLE 3.18 **Costs of Climate Change in Vietnam in 2020 (US$Mn.)**

Area of Impact	Mid- Value	LB	UB
Biodiversity	158	–14	330
Heating & Cooling	518	–47	1,082
Labor Productivity	2,807	–255	5,870
Sea Level Rise	1,474	1,254	1,493
Water	218	218	218
Agriculture	837	837	837
Forestry	4	4	4
Fishery	4,219	4,219	4,219
Hydro Energy	–66	–207	–207
Health	235	235	235
Tourism	148	–13	309
Extreme Events	447	447	447
Total	**10,999**	**6,678**	**14,836**

Source: World Bank calculations.

Note: Negative values indicate gains.

TABLE 3.19 **Estimated and Projected Costs of Climate Change, 2020, 2030, and 2050 (US$Mn.)**

Category	2020	2030	2050 (RCP 2.6)	2050 (RCP8.5)
Cooling Cost	518	2,584	6,575	13,764
Labor Productivity	2,807	3,243	7,468	14,668
Sea Level Rise	1,474	718	914	1,365
Water	218	689	2,244	2,244
Agriculture	837	1847	3,833	3,833
Forestry	4	14	42	42
Fishery	4,219	17,225	20,670	20,670
Hydro Energy	–66	–207	–331	–331
Health	235	300	432	710
Tourism	148	269	1,005	1,644
Environmental Disasters	447	1,574	4,004	8,382
Total	**10,999**	**27,199**	**43,800**	**68,542**
As % of 2020 GDP	**3.2%**	**4.8%**	**3.8%**	**5.9%**

Sources: World Bank calculations.

Note: RCP = Representative Concentration Pathway.

Estimates of the costs of climate change have the highest uncertainty of all the cost figures reported in the study. Uncertainty arises in the projected changes in temperature and precipitation, as well as in the links between climate and physical impacts and between physical impacts and values. In view of this it is helpful to compare these cost estimates with other studies for Vietnam. The World Bank study by Bangalore, Smith, and Veldkamp (2016) estimates costs of flood-related items in Vietnam to be around US$3.6 billion in 2030. Here we have a lower figure of US$2.3 billion under environmental disasters and sea level rise in 2030. A study of climate damage functions for 140 countries estimated GDP losses in Vietnam from a 3°C rise in temperature at about 7.1 percent by 2100, in the absence of adaptation efforts.[150] The estimates here do not go that far into the future but can be seen as broadly consistent with that kind of final effect. Another study on Vietnam found that, relative to a historical baseline, climate change would reduce national income by 1–2 percent by 2050, although damages would double under more extreme projections.[151] This study, however, is well below other estimates of costs, even the partial ones in World Bank and ADB (2020).

Taken together, the data on costs of climate change are already significant and expected to increase. They are therefore a clear pointer to action to adapt to the impacts and lower the costs.

Summary of Costs

The costs across the different categories of pollution, environmental services, and climate change provide a guide to how much burden the degradation of the environment is having on the country. They are an important input into decisions on where action is needed and in appraising the benefits of that action. This section brings together the different cost components. As noted, it is helpful to provide two sets of summary tables: one based on the welfare concept of costs and the other on a market value-based concept. As explained earlier, the welfare-based measures are less closely linked to market value of output than the market-based ones. In terms of policy, the market-based estimates should be more useful in evaluating measures that impact on the market value of production and consumption. Often these measures focus on fiscal incentives. The welfare-based losses, which cannot always be linked to economic gains and losses, may inform decisions requiring a more political approach, such a setting targets for reductions in premature deaths.

Welfare-based costs. The costs are dominated by air pollution, climate change, and lead pollution (table3.20), making up 38 percent, 31 percent and 21 percent, respectively. The other major shares are water pollution (7 percent) and land degradation (2 percent). It should be remembered that the calculations are not complete: solid waste only covered amenity loss in HCMC and fisheries has only looked at large pelagic fish. To provide a benchmark, the costs are also given as percentages of GDP in 2020. The figure comes out at 10 percent with a sensitivity range of 6.3 percent to 14.2 percent. This is only a benchmark: the comparison does not mean that GDP is that percent smaller on account of the environmental costs. Although changes in policy to reduce such costs would probably raise GDP, the links are complex and need further investigation.

150 Roson and Sartori 2016.

151 Arndt, Tarp, Thurlow 2015.

TABLE 3.20 **Summary of COED (Welfare-Based Estimates)**

Area of Loss	Mean $Mn.	As % of Total	As % of 2020 GDP	Range $Mn.	
				LB	UB
Ambient Air Quality	13,306	37.9%	3.90%	9,276	19,087
Lead Pollution	7,185	20.5%	2.11%	2,354	10,054
Water Pollution	2,485	7.1%	0.73%	1,997	3,128
Land Degradation	689	2.0%	0.20%	689	689
Plastic Waste	156	0.4%	0.05%	156	156
Solid Waste to Landfills	44	0.1%	0.01%	24	51
Mangrove Forests	36	0.1%	0.01%	29.0	45
Other Primary Forests	67	0.2%	0.02%	67	67
Fisheries	137	0.4%	0.04%	126	150
Climate Change	10,999	31.3%	3.23%	6,678	14,836
Total	**35,104**	**100%**	**10.3%**	**21,397**	**48,263**
As % of 2020 GDP	**10.3%**			**6.3%**	**14.2%**

Sources: World Bank calculations.

Note: COED = costs of environmental degradation; LB = lower bound; UB = upper bound.

Market value-based costs. The factor responsible for the high costs from pollution with the welfare-based measure is premature mortality, valued, as explained in the report, using the value of a statistical life. Such valuation is standard in the literature and the application here has followed the usual protocols. Nevertheless, losses due to premature mortality do not involve costs involving market transactions, and as GDP is a measure of activity based on such transactions it is worth reporting the items in COED that also involve markets separately (table 3.18).[152] Climate change is now the largest item, followed by lead pollution, air pollution, water pollution, and land degradation. As a percentage of 2020 GDP, the cost is 6.9 percent with a sensitivity range of 4.2 percent to 9.1 percent.

152 One might think that such losses also involve a loss of productive capacity in the economy and to an extent that is true. But a large part of premature mortality is among people outside the work force (that is, elderly, pensioners). Others who are affected at the lower end of the age spectrum (children) would not enter the labor force for some time.

TABLE 3.21 **Summary of COED for Items Involving Market Transactions**

Area of Loss	Mean $Mn.	As % of Total	As % of 2020 GDP	Range $Mn.	
				LB	UB
Ambient Air Quality	3,568	15.1%	1.05%	3,202	4,094
Lead Pollution	7,113	30.2%	2.09%	2,331	9,953
Water Pollution	1,255	5.3%	0.37%	1,255	1,255
Land Degradation	689	2.9%	0.20%	689	689
Plastic Waste	156	0.7%	0.05%	156	156
Solid Waste to Landfills	44	0.2%	0.01%	24	51
Mangrove Forests	36	0.2%	0.01%	30	45
Other Primary Forests	67	0.3%	0.02%	67	67
Fisheries	137	0.6%	0.04%	126	150
Climate Change	10,519	44.6%	3.08%	6,339	14,497
Total	**23,584**	**100%**	**6.92%**	**14,219**	**30,957**
As % of 2020 GDP	**6.9%**			**4.2%**	**9.1%**

Source: World Bank calculations.

Note: COED = costs of environmental degradation; LB = lower bound; UB = upper bound.

Some findings in this analysis support estimates that have been made previously while a few provide some new material. The main "new" results are the following: (a) a heightened level of impact from particulate pollution on health, (b) a much greater level of costs of lead pollution that was thought previously, (c) a quantification of the loss of amenity from the operations of landfills, (d) a greater appreciation of the extent of the costs of plastics, (e) a raised estimate of the costs of lost primary forests and of degraded land, (f) a first estimate of the costs of unsustainable practices for some fish species and (g) the very significant costs of climate change on the economy and environment.

In interpreting the numbers, it is important to recognize their implications for policy will different across sectors. One important distinction is between the costs of climate change and costs of environmental degradation in the other sectors. Climate change costs will not be useful in comparing measures that reduce such costs against the outlays needed to achieve the reduction. This is because climate impacts and the ensuing costs are determined by global factors and Vietnam's actions to reduce GHGs, which are the driver of future damages, have a negligible impact on them. The estimates of climate costs are, however, useful and an input into formulating adaptation measures that reduce the impact of climate change.

In the case of pollution and environmental services, a range of policies that reduce the magnitude of the damages are possible. They include market-based measures as well as institutional reforms and social programs. In deciding on priorities, one must remember that sectors with a small absolute value of damage does not mean they are unimportant. Reductions from a small base may be possible in a way that generates significant net benefits. Such benefits will also depend on who bears the environmental costs estimated in the previous sections. Many items related to natural resource use support vulnerable and relatively poor people, so action to reduce them has to take that into account.

COED by sector. The COED study presented above is not oriented on economic sector but on sources and areas of impact. Most sources have effects across many sectors. So, for example air pollution reduces productivity across the economy and loss of forests and mangroves effects consumers of forest products, tourists, and so on. The main sectors that are directly impacted and in which the costs can be allocated are tourism, agriculture, fisheries, and health services.

For tourism, it is losses in mangroves, losses due to plastic waste, and losses due to climate change. Gathering the estimated costs from these impact areas gives the following figures: plastics (US$17.2 million), mangrove loss (US$0.59 million), and climate change (US$148 million). These amount to only about 0.5 percent of the tourism sector's receipts of US$32 billion, but they are probably underestimated as tourism may also be affected by other factors, such as air and water pollution.

For agriculture, the losses come from land degradation plus climate change plus water pollution. The amounts are water pollution (US$867 million), land degradation (US$627 million), and climate change (US$754 million). Together, at US$3.7 billion, they make up 6.3 percent of the agriculture sector's value added in 2018.

For health, it is the morbidity effects of air pollution, of water pollution plus the impacts of climate change that result in a cost to the sector. The amounts are air pollution (US$1.2 billion), water pollution (US$32 million), and climate change (US$11 million). This is the only sector where the COED results in an increase in the level of value added. So a reduction in air pollution that reduces health expenditures would reduce GDP. It is something national income accountants have noted as one of several problems with GDP as a measure of well-being.

The COED results are based on publicly available datasets that are developed and update by international bodies such international organizations, research institutions, or think tanks. Similarly, the RISE indicators here are defined and parameterized in a manner that allow international comparison with other countries. At the national level, the government uses a subset of similar, but distinct, indicators to track the national-level targets defined in its Socio-Economic Development Strategy that defines a 10-year vision for the country's development. The progress toward these—and the key reasons behind incomplete implementation—are described in the next chapter.

4 Tackling Environmental Degradation: Opportunities, Costs, and Benefits

While Vietnam's performance on the environment and sustainability has been lackluster, addressing the causes can create many opportunities. Investing in natural capital (restoring forests, mangroves, and so forth) will improve the asset base for future growth (for example, for the domestic furniture industry that currently depends on imported timber). Making agricultural production less polluting will increase efficiency and competitiveness internationally. Market-based mechanisms that price carbon and value ecosystem services help with environmental performance and leverage finance at the same time. Addressing the significant pollution issues that have affected Vietnam's international image presents an opportunity for Vietnam to rethink its growth model, reduce the significant human toll, and make economic activities more efficient, less wasteful, and more sophisticated.

This section focuses on three main areas to tackle environmental degradation, notably through carbon pricing, advancing circularity, and investing in natural assets. Several interventions in these three domains that can reduce the environmental impacts of economic activities in the coming years are evaluated in some detail. Where the data permitted, a benefit-cost analysis (BCA) has been carried out. This was not possible in all cases, owing to a lack of data either on the cost side or the benefit side. In such cases, actions that emerge as having a lot of qualitative evidence of effectiveness are proposed. The details of the underlying analysis are available in the Supplementary Note to this report.

Pricing Carbon Pollution

The pricing of carbon can provide an effective solution to multiple pressing environmental problems and complement regulatory measures in polluting sectors. The global economy needs to become carbon neutral in coming decades to avoid catastrophic climate change. Many countries have put forward ambitious plans to reform their economies to contribute to this goal and Vietnam has made an important international commitment on carbon neutrality by 2050 to this effect[153]. Putting a price on carbon is a critical mechanism to achieve this objective and an important lever to simultaneously reduce air pollution, which closely correlates with fossil fuel-based energy production, waste management or transport[154].

Pricing carbon pollution incentivizes cleaner production (for example, of electricity)[155] and climate-friendly management of natural assets (for example, sustainable forest management).[156] While the goal of a global price on carbon remains elusive for now, there is a growing global network of carbon markets and carbon pricing initiatives, including in the major economies of the world. This growing marketplace represents an opportunity for

153 See: https://unfccc.int/documents/308938
154 Amann et al. 2019
155 Competitive electricity markets with carbon pricing can make clean energy not only profitable but also wealth creating without subsidies and even before counting local external environmental benefits.
156 Forest ecosystem services wealth increased between 1995 and 2018 in absolute and per capita terms, but the effect would have been greater in the absence of forest degradation.

countries like Vietnam to mobilize finance for sustainable investments going forward. Also, many corporations are reducing the carbon footprint of their products, and carbon border tax adjustment mechanisms are being designed for the markets in the European Union (EU) and the United States. There is also an increasing demand for nature-based solutions—that is, land- or forest-based schemes that generate carbon assets that can be made available to international buyers (and ”blue carbon” sequestered by mangroves or seagrass has additional potential).

Carbon Pricing Instruments

Carbon pricing puts a price on emitted global greenhouse gas (GHG) emissions (for example, the burning of fossil fuels) or a value on emission reductions or removals (sequestration through an industrial process or ecosystem). Assigning a cost to direct or indirect release of these emissions provides a price signal to incentivize investments in cost-effective emission reduction measures. Carbon pricing can take the form of an *emissions trading system* (ETS or “cap and trade” system) that issues limited emissions allowances (whose price is set by trading)[157], a *carbon tax* that explicitly states a price on GHGs[158], or *carbon crediting* for project or programs that generate verifiable emissions reductions over a defined period relative to an agreed baseline. Carbon credits can be used for offsetting emissions covered by mandatory domestic carbon pricing instruments (for example, a carbon tax) or to help companies achieve voluntary emissions reduction goals.[159]

The choice of carbon pricing instruments depends on the country and key emitting sectors, and are most effective when supported by complementary measures in polluting sectors. China, for instance, started operating a national ETS in January 2021 as the main mechanism to support national climate targets. China’s ETS is based on emissions intensity (emissions per unit of output—such as gross domestic product [GDP]—or unit of input) as opposed to absolute targets (total emissions during a specified period). For now the scheme only covers the power sector, which also contributes significantly to air pollution due to its reliance on coal. Over time, it is to be expanded to cover other polluting industries including petrochemical, chemical, building materials, steel, nonferrous metals, paper, and domestic aviation.[160] In Singapore, on the other hand, a carbon tax, set at unit price of S$5, came into effect in 2019 as the first carbon pricing scheme in Southeast Asia (applicable to larger facilities). It covers around 80 percent of Singapore’s total GHG emissions and the main gases that cause global and local atmospheric pollution, including carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons.[161] Globally, governments raised more than US$45 billion from carbon pricing in 2019 with about half of the revenues being used to

157 World Bank 2021b.
158 World Bank 2017.
159 World Bank 2021c.
160 ICAP 2021.
161 NCCS 2021.

fund environmental or broader development projects, and about 40 percent for general budget support.[162] Table 4.1 outlines some important considerations for implementation.

TABLE 4.1 **Comparison of ETS and Carbon Tax**

Element	ETS	Carbon tax
Certainty of emissions levels	Cap provides certainty on an upper emissions limit and thus allows alignment with policy targets.	Difficult to estimate emissions reductions *ex ante,* making it hard to align to an emissions target.
Cost effectiveness	Economically efficient, but modulated by market power, liquidity and volatility in allowance prices.	Less price flexibility for regulated entities over time.
Administration and scope	Complex to implement for regulators and regulated entities (which can limit sector participation).	Existing tax infrastructure makes it easier to implement in a broad range of sectors.
Price predictability	The carbon price is determined by the market. Price or supply adjustment measures can be used to mitigate volatility.	The carbon price is set by predefined tax rates. This provides a stable price signal to inform investment decisions.

Source: This table is based on World Bank 2021a.

Note: ETS = emissions trading system.

Vietnam has accumulated substantial experience in implementing international (bilateral and multilateral) crediting frameworks. This includes most notably the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM), where 270 projects have been registered to date, generating more than 24.3 million certified emission reductions. This has incentivized emissions reduction projects in Vietnam developed by local companies. In addition, Vietnamese companies have also developed many carbon projects under the Verified Carbon Standard and Gold Standard frameworks in the international voluntary carbon market.[163]

Building on this experience and with the support of the World Bank's Partnership for Market Readiness (PMR), Vietnam assessed various policy options to price carbon going forward. The Ministry of Natural Resources and Environment (MONRE) together with the Ministry of Planning and Investment (MPI), the Ministry of Finance (MOF), the Ministry

162 Word Bank 2020c.

163 Vietnam has an existing environmental protection tax (EPT) on coal and oil-based fuels and plastic bags (excluding those for packaging or environmentally friendly), hydrochlorofluorocarbon substances, pesticides, and other chemicals. It is not labeled as a carbon tax and differs by several orders of magnitude between fuels. However, it is contributing to increasing the cost of using fossil fuels and thus to stimulating investments into energy efficiency and renewable energy, which can boost domestic mitigation efforts. In addition to the EPT, Vietnam has an environmental protection fee aimed at wastewater, solid waste, and extractive industries.

of Industry and Trade (MOIT), and the Ministry of Construction (MOC) assessed the scope of pricing instruments, alignment and interactions with existing policies, and political acceptability, among others. The resulting recommendations are reflected in the revised Law on Environmental Protection (LEP) Vietnam's Nationally Determined Contribution (NDC) under the Paris Agreement. The respective action plan linked to the implementation of the LEP[164] details (a) the approach for political decision making to select and design carbon pricing instruments (such as the mitigation ambition level), (b) the development of the legal framework (including necessary new legislation), (c) identification of institutional development needs (such as clarifying mandates, rules and modalities), and (d) capacity building and stakeholder engagement enhancement. For implementation, key capacity gaps need to be addressed, including the establishment of a national system for GHG inventory and a monitoring/measurement, reporting, and verification (MRV) system (necessary for UNFCCC compliance and national carbon pricing); a database of large emitters for inclusion in the domestic ETS; and a national registry of GHG emission reductions.

But sustainable management of forests and mangroves can also put a price on carbon and generate revenue for managers of these resources through carbon crediting schemes (easing the demand on government budgets). Recent years have seen a significant increase in demand for nature-based solutions. These encompass a range of approaches that use natural processes including forestry and land-based activities (such as mangrove restoration) to sequester carbon. Among the key reasons why such projects have become so popular are their cost-effectiveness and their ability to generate additional cobenefits beyond emission reductions (biodiversity conservation, water regulation, and so forth). The forestry sector assumes the largest portion of credits issued over the last five years and makes up 42 percent of the global total.[165] Virtually all of the credits issued recently came from independent mechanisms (Verified Carbon Standard) as well as regional, national, and subnational mechanisms (such as the California Compliance Offset Program).

An important development in this regard is that international airlines have committed to stabilize their emissions from 2021 onward. Given that global aviation is projected to grow (after the 2020/21 dip due to the COVID-19 pandemic) and limited short-term options exist to make aviation less polluting, the international aviation sector is considered to be one of the most likely and largest sources of future carbon credit demand. The Carbon Offset and Reduction Scheme for International Aviation (CORSIA)[166] that was created to connect suppliers of emission reductions (such as large-scale emission reduction programs that reduce deforestation and forest

164 See: https://www.thepmr.org/country/vietnam-0
165 World Bank 2020c.
166 See the CORSIA page, International Civil Aviation Organization (ICAO) website: https://www.icao.int/corsia.

degradation) is thus an important mechanism to leverage financing through environmentally friendly investments in land and forest management. Vietnam, in the six provinces in the North Central Region, is already implementing such a program and has agreements in place to receive payment for reduced emissions across the jurisdictions. Such schemes can be further scaled up and implemented in other parts of the country to support Vietnam carbon neutrality ambitions.

Many countries are using several carbon pricing instruments to better target specific sectors and economic activities in certain jurisdictions, combined with source-specific regulation. Vietnam also has experience using several instruments—such as project-level carbon crediting under the CDM or jurisdictional programs to reduce emissions from forest areas[167] and is considering deploying new mechanisms that can lead to a carbon price that helps drive economic activities to become less polluting. The next section explores the environmental benefits of a carbon tax to drive decarbonization and reduce air pollution. It is important to note though that a carbon tax should only be considered one of several measures to address air pollution and needs to be complemented by regulatory measures (and their enforcement) that target specific sources of pollutants, such as those from fossil fuel combustion in energy production or in vehicles.

Benefits of a Carbon Tax

If the Vietnamese economy decarbonizes slowly, the negative consequences for the environment would be significant and national climate targets could not be achieved. Specifically, scenario-based analysis using a computable general equilibrium (CGE) model[168] shows that in a business-as-usual (BAU) scenario, coal's share in the power mix continues to increase (and thus a main source of air pollution), reaching 68 percent in 2030 (up from 28 percent in 2018). By 2050, total carbon dioxide (CO_2) emissions would reach 1,738 megatons (Mt) of CO2 (up from around 300 MtCO2 in 2020). The demand for road transport would more than double between 2020 and 2050, and in the share of sectors that depend on coal (for example, energy and manufacturing), CO_2 emissions would increase significantly (and so would particulate matter in the air unless mitigated by regulation). While this BAU is based on some broad assumptions, it does reflect Vietnam's current trajectory and the scale of future emissions increases.

An alternative scenario shows that a progressive carbon tax can drive decarbonization and allow the government to achieve its climate targets.[169] That is, such a tax reduces GHG emissions by 20 percent by 2030 and by about 30 percent by 2050 compared with the BAU

167 "Vietnam," Forest Carbon Partnership website: https://www.forestcarbonpartnership.org/country/vietnam.

168 World Bank calculations. The model takes into account overall economic activity, activity by sector, and environmental and social associated impacts.

169 In this scenario, a carbon price increase is introduced from 2020 and gradually increased to US$25 per ton of CO2 by 2050. Such a gradual approach price is aligned with international best practices. It was assumed that the tax will be paid by only the 18 most emitting sectors; the same scenario was also run under an ETS, with similar results.

scenario, and the energy mix shifts from coal to natural gas. The impacts of higher carbon prices can be minimized or eliminated if the collected revenues are used to increase public savings as a way to stimulate private investment. If this is done, the model predicts that the carbon tax option would result in virtually no GDP loss by 2030 and only a −0.3 percent loss per annum by 2050.

In addition to meeting national climate targets, carbon pricing can have significant local benefits and contribute significantly to the reduction of air pollution (and thus associated mortality) and, to a lesser extent, road damages, congestion, and fatalities from accidents. Comparing the carbon pricing scenario with a range of development pathways (shared socioeconomic pathways, or SSPs)[170] for Vietnam shows that the cobenefits of the carbon tax are significant. When tax revenues go to government savings, these cobenefits can outweigh any loss of GDP, notably when premature mortality is measured in welfare terms (see table 4.2).

It is important to point out the potential effect of these scenarios in creating winners and losers. Some sectors will face higher energy costs (for example, energy, transport, and heavy manufacturing), while others may see improvements (such as light manufacturing industries). Also, the wealthier may experience lower capital prices over time. Such distributional impacts need to be carefully considered by policy makers to generate support for the necessary reforms, especially in the state-owned enterprises (SOEs) in the coal energy generation sectors that need to adapt to new higher prices.

Beyond these quantifiable benefits, a carbon tax can bring a competitive advantage in trade. For example, the introduction of a carbon border tax adjustment by the EU on countries where there is no carbon tax could have a significant impact on the competitiveness of Vietnam's cement sector and also affect other sectors that trade with the EU.[171] The introduction of a carbon tax such as the one being considered here for Vietnam would avoid some of that (depending on the rate of the tax). Another benefit is that a shift to a lower carbon economy would promote the adoption of green technologies that make Vietnamese industries more competitive in world markets, making the export of products easier.

170 IIASA. https://tntcat.iiasa.ac.at/SspDb
171 ERCST 2021.

TABLE 4.2 **Costs and Benefits of a Carbon Tax in Vietnam**

Cost or Benefit Measure	Discount Rate 4%			Discount Rate 10%		
	Base Case	Low Growth	High Growth	Base Case	Low Growth	High Growth
Present Value Costs (US$Mn.)	8,119	6,697	12,297	2,286	1,909	3,401
Present Value of Benefits, Productivity Method (US$Mn.)						
Reduced CO2 Emissions	5,442	5,442	5,442	1,623	1,623	1,623
Reduced Air Pollution Mortality	1,768	1,550	2,422	630	507	823
Reduced Road Maintenance	11	11	11	4	4	4
Reduced Accident Fatalities	76	65	107	24	19	33
Total Benefits	7,296	7,068	7,982	2,281	2,153	2,483
Present Value of Benefits, VSL Method (US$Mn.)						
Reduced CO2 Emissions	5,442	5,442	5,442	1,623	1,623	1,623
Reduced Air Pollution Mortality	9,032	7,887	11,508	3,217	1,762	3,918
Reduced Accident Fatalities	11	11	11	4	4	4
Reduced Road Maintenance	388	333	507	123	64	156
Total Benefits	14,872	13,672	17,467	4,967	3,453	5,701
Net Benefits (US$Mn.)						
Productivity Method	−823	371	−4,316	−5	243	−918
VSL Method	6,753	6,976	5,170	2,681	1,544	2,300
Benefit-to-Cost Ratio						
Productivity Method	0.90	1.06	0.65	1.00	1.13	0.73
VSL Method	1.83	2.04	1.42	2.17	1.81	1.68
Reduction in GHGs Relative to BAU (%)						
By 2030	12.5	12.5	12.5	12.5	12.5	12.5
By 2050	30.0	30.0	30.0	30.0	30.0	30.0

Source: World Bank calculations.

Note: The stream of costs and benefits is discounted at 4 percent and 10 percent to obtain the present values. The costs range from US$6.7–12.3 billion at a 4 percent discount rate and from US$1.9–3.4 billion at a 10 percent discount rate. The large difference due to the discount rate is because the major costs occur in later periods, and the higher the underlying growth in the economy, the greater the losses. With the high growth scenario (SSP5), losses are 80 percent higher than with the low growth scenario (SSP3). The benefits depend a lot on the method used to value reductions in premature mortality. If the VSL method is adopted (see chapter 2), then the reductions in GHG emissions come at no cost, and the program generates a net benefit of US$5.2–6.7 billion at a 4 percent discount rate and US$1.5–2.7 billion at a 4 percent discount rate. If, however, the productivity method is adopted, the benefits cover between 65 percent (SSP5) and 106 percent (SSP3) at a 4 percent discount rate but between 73 percent (SSP5) and 113 percent (SSP3) at a 10 percent discount rate. BAU = business-as-usual; CO2 = carbon dioxide; GHGs = greenhouse gases; SSP = shared socioeconomic pathway; VSL = value of a statistical life.

In sum, modeling the economywide effect of these policy scenarios demonstrates that fiscal instruments can help achieve Vietnam's emission reduction targets in an economically efficient and socially just manner, and simultaneously achieve better outcomes for air quality. Carbon pricing can be an effective policy instrument to reduce GHG emissions without penalizing both short- and longer-term economic performance. Any potential trade-offs with growth can be minimized or even be eliminated if (a) the additional revenues from the carbon tax are used to boost private investment (rather than finance public projects); (b) complementary policies are implemented in the energy and transport sectors (see Supplementary Note); and (c) cobenefits on both human and physical capital are included.

BOX 4.1 **Electric Vehicles and Air Quality Monitoring**

At the sector level, policies to increase vehicle fuel efficiency in transport can enhance the effect of carbon pricing. Better air quality monitoring is a critical tool in the implementation of such measures.

The Ministry of Transport has recently implemented measures to control emissions by road vehicles (VNA 2021), and the domestic private sector is accelerating the production of affordable electric vehicles (EVs) such as car manufacturer VinFast. Good example of promoting EVs can be found in many countries, as in neighboring Thailand, where hybrid electric vehicles (HEVs) have started to increase rapidly since 2009. The Thai government has actively promoted EV production and use since 2015 (such as through local research and development programs, parts production, and installation of charging stations) and has stimulated the domestic market by adopting the technology in the public agencies, such as the Airport of Thailand Public Company Limited (AOT) and Industrial Estate Authority of Thailand (Changtor 2019; Kaewtatip 2019).

In managing air pollution, portable air monitoring sensors present an attractive solution to fixed air quality monitoring stations. These sensors are light and easily navigable, and communities and citizen scientists can be involved in the operation of the network. A set of sensors can be used together to collect data on air pollutants, fine particles, volatile organic compounds, temperature, and related parameters. An example is the AirMapper developed by the US Environmental Protection Agency (EPA), a portable air monitoring sensor attachable to any moving vehicle (including bicycles or motorcycles) equipped with a rechargeable battery power, global positioning system, accelerometer, a variety of sensors and capability to transmit date for analysis and online dissemination in near real time (Kimbrough et al. 2020) In Thailand, the Bangkok Metropolitan Administration (BMA) has used similar low-cost portable sensor systems to monitor a variety of air pollutants caused by traffic. The data are then analyzed and displayed as maps on the Bangkok Air Quality website (www.bangkokairquality.com).

Advancing a Circular Economy

A circular economy (CE) is an economy where resources are "roundput," not "throughput."[172] It is an economic system that is restorative and regenerative by design and anchored in three main principles: preserve natural capital by balancing a finite stock and limit use of primary resources; optimize resource yields by circulating products, parts, and materials in both industry and biosphere; and remove negative externalities and minimize systemic leakage or pollution.[173]

172 Webster 2015.

173 EMAF, SUN, and McKinsey Center for Business and Environment 2015.

Globally, circularity could help reduce GHG emissions by 2–4 percent[174] and unlock US$4.5 trillion in economic growth by 2030.[175] Building more circularity into industrial and economic processes could play a central role in Vietnam in arresting and reversing the trends in pollution and environmental degradation assessed in the previous sections.

A More Efficient and Competitive Way to Produce

As an industrial policy, a CE generates economic efficiency and creates social and economic value while reducing the impact on the environment. This allows product designers, producers, manufacturers, and consumers to work collaboratively and creatively as participants in the value chains to enhance circularity that brings economic gains, jobs, competitiveness, and social value with a reduced footprint on the environment.

The CE concept is versatile and can be applied in different industries. For instance, it could allow the automotive industry to reduce the life-cycle carbon emissions per passenger kilometers by up to 75 percent by 2030.[176] Beyond product design, circularity also applies to systems, such as urban transportation. Multimodal public transport systems can reduce the congestion and pollution that plague major cities in Vietnam such as Ho Chi Minh City or Hanoi. The city of Helsinki, for example, committed to halving emissions by 2030 and reaching zero emission by 2045 and introduced the Whim app in 2017, which offers schedules, prices, and connections of public transportation, public bikes, e-scooters, car sharing services, taxis, and rental cars in one app. The app facilitates the seamless use of multiple modes of transportation in the city. The results are impactful: Whim users make 73 percent of their trips on public transport compared with 48 percent for nonusers.[177]

For business, becoming more circular means shifting away from "selling" products to product-as-a-service (PaaS).[178] This way, manufacturers remain the product owner until the end of the product life cycle. Initially, PaaS was used mostly by corporate clients (for example, Philips provided "lighting as a service" to airports,[179] and Michelin developed a "pay by the mile" option.[180] But more recently, consumers and households have access to such service models. For example, in 2019, Electrolux launched "vacuum-as-a-service" in Sweden and China, charging households for the area cleaned by their appliance via an app. When the consumer ends the contract, Electrolux takes back the appliance and refurbishes it for the next customer. This significantly extends product life cycle. See box 4.2 on how Amsterdam is striving to become fully circular by 2050.[181]

174 AMEC and BIO Intelligence Service2013.
175 Lacy and Rutqvist 2015.
176 WEF 2020.
177 Pirelli 2020.
178 Mathieux. 2001.
179 Philips 2018.
180 Buntz 2020.
181 Bastein et al. 2021.

Recognizing the negative impacts of a linear economy, the Vietnamese government is implementing a policy on sustainable consumption and production to promote green supply chains, business practices, and consumer behavior. This policy facilitated introduction of standards for energy-efficient home appliances[182] and green buildings.[183] To create a legal basis for the implementation for both the public and private sectors, the prime minister of Vietnam has approved the National Action Plan for Sustainable Consumption and Production 2021–2030 (led and developed by MOIT in June 2020). Further, the revised 2020 Environmental Protection Act defines the CE and implementation responsibility of ministries, local authorities, and business enterprises.

The CE concept has been proposed as part of the national Social and Economic Development Strategy for 2021–2030. MONRE is a focal-point ministry for the CE and is responsible for the development of draft decree on setting criteria for CE implementation in different industrial sectors; a road map toward CE implementation at different levels of Vietnamese society, from the national to community level and in each industrial sector; and economic instruments that incentivize the industrial sectors to take a CE approach in their business models and production processes. Currently, each ministry is integrating the CE concept into their policies within their authority. For example, the Ministry of Construction has been actively promoting the "green city" concept. In this context, the ministry has organized multiple workshops targeted at promotion of ecofriendly construction materials. In general, even though the CE concept is relatively new in Vietnam, it is generally perceived by policy makers and the business sectors to bring opportunities.[184]

The revised 2020 Environmental Protection Act clearly frames CE approach as the key economic model to follow for Vietnam to increase resource efficiency, extends product life-cycle, reduce waste and minimize the negative impact to the environment. Further, the revised Act defines not only including the article 142 which specifically defines the CE and implementation responsibility of ministries, local authorities, and business enterprises, but also the other articles on Green Public Procurement, Extended Producers Responsibility, Eco-products, Best Available Technologies and recycling market promotion also applies the CE principles.

Government authorities are driving force to push CE from concept to action. MONRE is currently developing National Action Plan on CE implementation to accelerate the CE application and implementation by different stakeholders. The National Action Plan will contain the defined goals by each sector, roles and responsibilities and guidelines for CE application in industrial and business sector to navigate the private sector to apply CE approach in their businesses. MONRE also plans to build an information platform to share practices and application of CE to promote the CE application. Further, Provincial People's Committees are

182 Tuan 2012.
183 Nguyen and Bhatla 2021.
184 Chinh 2020.

also expected to develop the CE Action Plan to set the criteria for CE implementation, develop technical guidelines, and launch pilot projects.

In light of the pressing environmental issues described in this report, there are several entry points for government, private sector agents, and households to change their business models, modes of production, and consumption behavior to become more circular. Some of these entry points are described below.

BOX 4.2. **How Amsterdam Accelerated the Transition to a Circular Economy**

Amsterdam is the world's leading city that implements a circular economy. The city has placed CE high on its agenda, and in 2015 the "Amsterdam Circular 2020–2025 Strategy" set out a plan to become fully circular by 2050. The city government has prioritized three value chains: food and organic waste stream, consumer goods, and built environment. Under each value chain, it has three different ambitions, related to (a) the changing use and design of the products; (b) prolonging the life cycle of products; and (c) covering the end of life. Since its launch, more than 200 CE projects have started.

Better Management of Plastics and Solid Waste

Vietnam disposes 2.62 million tons of plastics annually and material value equivalent to US$2.2 billion to US$2.9 billion is lost every year because of suboptimal recycling.[185] To combat the plastics wave, the prime minister approved the National Plastic Action Partnership in December 2020,[186] and the government of Vietnam launched the National Action Plan for Management of Marine Plastic Litter by 2030 (Resolution NO. 1746/QD-TTg) in 2019. Also, the recently passed Law on Environmental Protection is an important step toward better regulation to extract value from waste.

Reducing and separating waste are two critical elements to reduce plastic waste. One is to take strict measures to minimize single-use plastics, as in Canada, Indonesia, and Thailand (which have all introduced bans on products like shopping bags, food containers, and straws) or Cambodia; Japan; Hong Kong SAR, China; and the United Kingdom (which have introduced fees to disincentivize plastic use). Further downstream in the plastic economy, it is critical to enhance waste collection, separation, and disposal to turn plastic waste into secondary material that can be used in new products. This can have significant benefits, as in Shibushi-city, Japan, where waste separation into 27 categories (from food waste and electric equipment) has reduced the waste going to landfills by 80 percent.[187]

185 World Bank 2021f.
186 Dinh and Nguyen 2018.
187 Ogawa et al. 2020.

Linking the domestic and industrial waste collection system with the recycling industry is critical to closing the loop on plastics. Current recycling in Vietnam mostly relies on the informal sector without employing appropriate recycling equipment and technologies to process waste. This exposes workers to health hazards. By providing formal job opportunities, monetary incentives, and protective gear to waste generators, the quality of waste that goes into material processing can be significantly improved. Producing quality recyclables very much depends on the recycling industries, while government and manufacturers need to support the industry in upgrading the recycling facilities and technologies. Creating biodegradable materials are a complementary technology (box 4.3).

Digitizing the recycling market also has a dividend by matching waste generators with waste collectors. For instance, Mall Sampah, a start-up firm in Indonesia, connects waste generators and informal waste collectors to increase the recycling rate. The platform's rating system helps create a transparent, competitive, and efficient marketplace (other examples are EcoTree in Romania[188] and Ohio Materials Marketplace in United States[189]). Banyan Nation in India, a digital platform that integrates informal waste pickers into their supply chain, has improved the quality of recycled material using proprietary cleaning technology that removes inks, coatings, and other contaminants from plastics using environmentally friendly detergents and solvents. The improved materials are used, among others, by global automotive brands in new bumpers or by a global cosmetics company to produce new cosmetic bottles.[190]

BOX 4.3. **Alternatives to Plastics**

Vietnam has a fledgling group of suppliers of biodegradable plastics. An Phat Holdings Group, the first Vietnam producer to be granted TÜV Certification,a produces biodegradable consumer products, including disposable bags, gloves, straws, and utensils from polybutylene adipate terephthalate (PBAT) and biodegradable fossil-based plastics (Huong 2020). These products, known to decompose completely within six months, are widely sold in Vietnam's supermarkets.

Among the alternative options to plastic, polylactic acid (PLA) can be produced easily at a low cost in existing bioethanol production plants. Biomass materials (including cornstarch, cellulose, vegetable oils, and so forth) can be a resource to produce biodegradable plastic. With the dominant agriculture sector, Vietnam displays high potential to the access to these resources. However, PLA decomposes only under certain pressure and temperature conditions.

Polyhydroxy compounds (PHAs) completely dissolve in the marine environment; however, industrialization of PHA has been limited owing to its high cost of production. Newlight, a technology company, produces AirCarbon, a type of PHA produced from anaerobic digestion in salt water. It has the characteristics to replace plastics, fiber, and leather, and is soluble in water. Overall production of AirCarbon has a negative carbon footprint.

188 For more details on EcoTree in Romania, see https://ecotree.ro/en/blog/the-first-digital-platform-that-simplifies-and-shortens-the-waste-recycling-process-for-romanian-companies-was-launched/.

189 For more details on the Ohio Materials Marketplace, see https://waste-management-world.com/a/platform-to-recycle-reuse-materials-online-in-ohio-circular-economy-push.

190 For more details on Banyan Nation's work, see https://www.banyannation.com/#ourworkof.

BOX 4.3. **Alternatives to Plastics (cont.)**

a. TÜV, short for Technischer Überwachungsverein in German, means Technical Inspection Association. Although originating as a standard-setting body in Germany, the TÜV is internationally recognized as a seal of quality. For more information, see the TÜV website: https://www.tuv.com/usa/en/.

Managing Plastic Waste through Market and Technical Solutions

Managing plastic waste requires a combination of fiscal and technical measures. Not all potential measures are conducive to a full benefit-cost analysis (BCA) and would require a full life-cycle analysis. Thus, this section presents a preliminary CBA of a tax on plastic bags and makes recommendations on alternative materials and recycling based on several recent studies.

The current government tax on plastic bags is ineffective. Based on the 2010 Law on Environmental Protection, the government introduced a tax for manufacturers and importers of plastic bags (which was initially VND40,000 per kilogram and progressively raised to VND50,000 per kilogram in 2019). However, this tax has had a negligible effect on the price of plastic bags for consumers. More importantly, the practice of providing bags for free to customers has not changed Vietnam. As a result, there has been no reduction in the volume of plastic bags reaching the environment (for example, increasing from 40 tons a day in 2008 to 228 tons in 2017 in Ho Chi Minh City).

A more effective alternative would be to enforce a charge on the supply of a bag to each customer by every retailer. Such a measure has been introduced in a number of countries in Europe and in the US as well as in China, and it has proved to be highly effective (for example, reducing plastic bag use by 49 percent in China and 85 percent in England). A CBA of such a tax in Vietnam (modeled over a five-year time period) reveals a benefit-cost ratio (BCR) of more than 1 (see table 4.3). Specifically, a charge of US$0.03 per bag to users reduces plastic bag use by 14.7 billion a year with an associated annual reduction in plastic waste of 98,000 tons and a decline in environmental cost of US$110 million. The BCR remains positive over range of assumptions. Such a policy would generate significant revenue (US$2.2 million over five years), which can be used to support environmental cleanup as well as information and education programs,[191] and the estimated impacts on households are negligible.

191 Because tax revenue cannot be earmarked in Vietnam, such allocation would need another policy to commit the funds for such a purpose. The exception is if the tax goes to an existing fund like the Vietnam Environmental Protection Fund.

TABLE 4.3 **Costs and Benefits of a Charge on Plastic Bags in Vietnam**

Item	Unit	Amount Year 1	Amount Years 1–5a
Benefits			
Reduction in Environmental Costs	*US$Mn.*	*109.8*	*532.8*
Savings in Costs of Bag Production	US$Mn.	132.4	573.4
Total	US$Mn.	242.2	1,106.2
Costs			
Loss of Consumer Surplus	US$Mn.	220.7	501.1
Other			
Revenue from Charge	*US$Mn.*	*459.5*	*2,230.2*
Charge Per Bag to User	US$	0.03	0.03
Net Benefits and Benefit-Cost Ratio			
Net Benefit at 5 percent Discount Rate	US$Mn.	21.5	605.4
Benefit-Cost Ratio	n.a.	1.1	2.2

Source: World Bank calculations.

Note: n.a. = not applicable.

a. Amounts for years 1–5 are present values discounted at 5 percent.

This preliminary analysis indicates that a charge on plastic bags of US$0.03 per bag would generate significant environmental benefits and is very cost-effective. A more detailed analysis, with more precise figures on costs of production of bags and damages per ton of waste, and allowing for some exemptions (for example, very small retailers and those in open markets may not have to charge for the bags) is recommended. The case in China shows that only retailers in supermarkets implemented the charge, while most retailers in open markets did not. With exemptions of the plastic bag charge for small merchants and open markets that are essential for low-income households and rural residents, the distributional impact of the charge on these people can be mitigated.

Further, there is a variety of alternative materials that could become substitutes for plastics. A recent study (World Bank and Rebel 2021) provides an analysis of the environmental costs of possible alternatives (but unfortunately does not detail their production costs, making a CBA impossible). A significant reduction in environmental costs can be achieved by making the following substitutions (environmental cost reduction in parenthesis):

- Glass or reusable polypropylene for beverage bottles (98 percent)
- Reusable polypropylene for beverage cups (92 percent)
- Paper or jute for carrier bags (80 percent)
- Disposable utensils made of wood (39 percent)
- Reusable polyethylene terephthalate for food wrappers and sachets (98 percent)
- Bamboo for clothing (29 percent) and diapers (91 percent).

A comprehensive life-cycle analysis for alternative materials is needed to determine viable options. Nonetheless, a number of conclusions can be drawn on the direction in which the government might move to reduce the environmental costs of the use of plastics and increase the efficiency of material use. Use of paper for beverage cups and carrier bags; steel for utensils; and reusable plastics for fishing nets, beverage cartons, and food wrappers and food sachets will have lower environmental costs than traditional plastic products for the same usage. However, shifts to metals such as aluminium or cotton, hemp, or jute can result in higher costs than the plastic products.

Very critically, better recycling can reduce plastic waste and increase the value of recycled products. A recent study[192] evaluated several measures with respect to increase in value yield, recycling rate, and unlocked material value. It was observed that recycling rates can be raised by 27 percent through improved waste collection and sorting; by 22 percent through encouraging the use of recycled content across all major end-use applications; by 30 percent by introducing design-for-recycling standards for all plastics, especially packaging; and by 67 percent by increasing recycling (mechanical and chemical) capacities.[193] Economic gains in terms of value of material recovered range from US$0.8 billion (use of recycled content across all major end-use applications) to US$1.8 billion (increased mechanical and chemical recycling). The total value of recovered materials amounts to US$3.8 billion, equal to 21.7 percent of the value of plastics products in Vietnam in 2019 (1.5 percent of GDP).

Market-based mechanisms are instrumental in achieving a better recycling system. Specifically, market instruments can be effectively used to

- Incentivize reduction of plastics (for example, phaseouts of unnecessary plastic items) and reuse systems;
- Incentivize use of recycled content;
- Implement a pay-as-you-throw waste collection model to encourage separation at source;
- Tax plastic applications without minimum recycled content;
- Incentivize increases in recycling capacities for polyolefins (polypropylene [PP] and polyethylene [PE]) and develop polyethylene terephthalate (PET) packaging recycling to produce higher-end recycled products; and
- Increase landfill tipping fees.

These recommendations need further analysis of the kind carried out for the carrier bags, combining data on costs and benefits to design the best form of intervention with the appropriate quantitative parameters.

192 World Bank 2021e.

193 Percentages cannot be added as measures overlap in their coverage.

The government has several targets to reduce the use of plastics and improve their collection and disposal. In order to meet these targets, a mixture of market incentives and technical solutions will be required. Market incentives for plastic bags (considered above) have a BCR greater than 1. Similar charges could be considered for other products. A CBA is not possible for the other targets as data on costs of substitutes are not available at the level of detail required. For regulations that mandate targets for producers and waste managers, the focus could be on the use of alternatives and encouragement of circularity in plastics products, with increased recycling.

Managing the Disposal of Solid Waste in Nonsanitary Landfills

The costs of environmental degradation (COED) study estimates the environmental costs of amenity loss and losses from nonsanitary landfills to be about US$36 million a year. There are 456 nonsanitary landfills that need to be treated or upgraded. One possibility is the removal and transfer of waste from nonsanitary landfills, which is an expensive option. The full cost of such a measure will depend on the quantity of waste in the present landfills. This information is not available in the published studies, but a rough cost estimate based on an application to all sites countrywide ranges between US$3.5 billion and US$6.7 billion.[194] Alternatively, unused parts of existing landfills could be lined so they meet sanitary standards. If this option is applied countrywide, cost estimates[195] would be in the range of US$89 million to US$177 million (table 4.4).

TABLE 4.3 **Costs and Benefits of a Charge on Plastic Bags in Vietnam**

Region	Sites	Annual Waste (tons, thousands)		Non-sanitary Waste Stock	Costs of Transferring to Compliant Landfill (US$Mn.)			Costs of Lining Nonsanitary Sites (US$Mn.)		
		Total	Nonsanitary		LB	Mid-Value	UB	LB	Mid-Value	UB
North	163	2,594	1,795	17,948	1,233	2,087	2,407	32	43	63
Red River Delta	49	473	322	3,217	221	374	431	6	8	11
Central	41	694	313	3,128	215	364	420	6	7	11
South	*112*	*2,802*	*1,908*	*19,081*	*1,310*	*2,219*	*2,559*	*33*	*45*	*67*
Mekong River Delta	91	822	686	6,861	471	798	920	12	16	24
Total	456	7,385	5,024	50,235	3,450	5,842	6,737	89	119	176

Sources: BIO Intelligence Service 2011; World Bank 2018.

Note: The waste stock is assumed to be 10 times the current levels of waste, and the remaining life of the sites is assumed to be 5 years at current waste disposal levels. LB = lower bound. UB = upper bound.

194 BIO Intelligence Service 2011.

195 BDA Group 2009.

The figures in Table 4.4 are only illustrative, as the detailed stock of waste at each landfill and the remaining life at current waste disposal rates are not known. Nevertheless, it is informative on multiple policy grounds:

- First, given the high costs, the transfer for waste from noncompliant sites to compliant should only be undertaken in cases where there is strong evidence of significant environmental and health damage from the current site. That will require a detailed assessment of the situation at each of the 456 nonsanitary landfills. A priority ranking can then be made based on physical indicators of damage. It is recommended that such data be collected and applied to determine priorities.
- Second, the option of lining the remaining sections of noncompliant landfills is relatively less costly. Here, too, not all sites will generate the same benefit per dollar spent. For sites where it is feasible, priority should be determined based on the types of waste being disposed of in the sites and, as with the moving of existing waste, an assessment of damage done through leaching. Account should also be taken of differences in amenity losses across sites. (Some sites will cause more loss of amenity on account of odor and other impacts to people living in the vicinity.)

A cost-effectiveness analysis—which compares the dollar cost per unit of physical and health damage avoided across sites and between options—can help prioritize and determine the right balance between these two options.

The government has made some efforts in formulating strategies and targets on solid waste management. In 2018, it issued a national strategy on integrated solid waste management to 2025, with a vision to 2050 (Decision 491/QĐ-TTg). The strategy set targets that, by 2025, 90 percent of domestic solid waste (DSW) in urban areas will be collected and properly treated, and less than 30 percent of collected DSW will be dumped in landfills. For rural areas, 80 percent of DSW will be collected, stored, and properly treated, and 100 percent of informal or open dumping landfills will be managed to meet environmental standards. These measures should be seen in the context of a circular economy, where waste separation is increased and reuse and recycling targets raised. Currently, only 25 percent of the total material value of plastics (or US$872 million per year) is unlocked, based on a 33 percent recycling rate and 77 percent value yield from plastic recycling. If all plastic resins used in Vietnam were collected and recycled into the most valuable recycled products, the potential gain from material value would equal US$3.4 billion per year (World Bank 2021e).

These high costs should motivate the advancement of policies that promote the reduction of material flows as well as material reuse and recycling (3Rs). Interventions to increase collection and recycling rates of recyclable wastes such as paper, plastic, metal, and electronic waste have been developed and implemented, not only to avoid overloading landfills but also to unlock material values. The government has emphasized the importance of the circular economy approach in the National Strategy on Green Growth for 2021–2030 (Decision 1658/

QD-TTg), and the revised Law on Environmental Protection (LEP) 2020 underscores these goals. With the increasing waste volume and environmental consequences, it is recommended that the government develop stronger 3R policies within its integrated solid management strategy (Nguyen 2017), specifically

- Developing master plans and policies on waste management with a focus on the 3Rs at both national and subnational levels;
- Promoting implementation and enforcement of existing policies on waste management such as the National Strategy on Cleaner Production in Industry for minimization of solid wastes in production, formalization of recycling activities through development of the recycling industry, and improvement of waste management infrastructure;
- Developing databases on waste management and the 3Rs that include a set of indicators and progresses for waste generation, collection, transportation, and disposal, to contribute to more effective monitoring and enforcements as well as guide policy decision-making;
- Enhancing research and technological transfer related to 3R such as waste-to-energy technologies, take-back systems, and so on; and
- Raising public awareness and creating behavioral change through informational campaigns and incentives such as a pay-as-you-go solid waste collection charge instead of the current flat fee.

Reducing Water Pollution

Even though Vietnam has been successful in providing broad access to clean water and sanitation facilities, the treatment and reuse of wastewater remains a great challenge. Almost 90 percent of urban households only have basic septic tanks to receive domestic wastewater and without regular desludging.[196] As for other forms of pollution, the concept of a CE can be applied in integrated urban development to improve wastewater.

Water infrastructure is difficult to retrofit; thus new real estate development projects are an opportunity to introduce integrated water management. Tianjin Eco-City in China (a joint project between China and Singapore), for instance, is a new development of 100,000 sustainable homes designed for 350,000 people that combines residential buildings, industrial parks, leisure facilities, and business compounds. The project uses sustainable technologies such as renewable energy, wastewater treatment, a sea desalination plant, and a tram system to reduce the overall carbon footprint. Such an approach has inspired development of big-scale residential, commercial, and social complexes such as Eco Green City in Hanoi and the LOTTE Eco-smart City project in Ho Chi Minh City, which aims to use an advanced wastewater treatment facility and reuse treated water in the complex.

196 NIES 2021.

Public-private partnerships play a key role in introducing the CE concept in wastewater treatment. Hai Phong city has leveraged such partnerships in desludging services. More than 200,000 septic tanks are managed by a geographic information system (GIS), and fecal sludge is collected every three to five years. The septage sludge is transported to the Trang Cat sludge treatment plant, with total capacity of 260,000 cubic meters per year. This arrangement was made possible by introducing a concessional arrangement between Hai Phong City and a private company. With recovered nutrients such as nitrogen and phosphorus, the sludge is used as organic fertilizer to preserve soil fertility while improving water quality.

BOX 4.4 **Decentralized Wastewater Treatment Systems**

Decentralized wastewater treatment places facilities closer to the demand and serves as a sustainable alternative to centralized, large, and costly treatment plants. Decentralized facilities are adaptable to peri-urban areas with lower population densities. Recent innovations offer scalable and portable treatment plants that are cost-effective, quick to construct, and have limited environmental impact.

An example of community-level decentralized wastewater treatment plants is provide the company Aspiral. It uses aerated biofilm reactors to remove excess nutrients in wastewater (up to 90 percent of total nitrogen and phosphorous) so the effluent meets international standards for release into the environment and irrigation. Other innovative features, such as low-pressure passive aeration, lowers operational costs, limits use of chemicals, and allows plants to be downsized to meet the needs of small towns and villages. The system was deployed in Xilingang Town in Hunan Province, China, and effectively eliminated discharge of untreated community wastewater into the Zhixi River (scaled for a treatment capacity of 800 cubic meters per day and a footprint of 3,544 square meters).

Decentralized wastewater treatment systems have been assessed as an adoptable technology in Vietnam in numerous studies, and by working with organizations like the Bremen Overseas Research and Development Association in Vietnam, there is a potential to expand the network of decentralized treatment systems.

Source: https://youtu.be/WPxomLmGBLI

Regarding these examples of waste management, better engagement of stakeholders resulted in a better and more integrated solution. In a linear approach, it was only the waste and sewage operators who were planning and designing the appropriate treatment. In a circular approach, upper-stream stakeholders such as real estate developers would need to integrate the planning on disposal stage into their development concept and coordinate with downstream operators to maximize the reuse and recycling of wastewater to ensure the circularity. This can be enhanced by better communication and a planning process involving waste and sewage operators as well as recycling companies. Decentralizing systems are a recent new technology to broaden wastewater treatment (box 4.4).

Investing in Improved Water and Sanitation

The government is committed to ensuring that all citizens have access to safe water and improved sanitation by 2030. The latest Social Economic Development Plan for 2021–2025 (Resolution 16/2021/QH15) specifies the ratio of people accessing clean and hygienic water as reaching 95–100 percent for urban residents and 93–95 percent for rural residents by 2025. In 2019, the government approved a road map for implementing the Sustainable Development Goals (SDGs) by 2030, which included the targets for water and sanitation of SDG 6.[197] In 2020, the United Nations Children's Fund (UNICEF) estimated that 6.75 percent of the population lacked improved sanitation and 3.12 percent lacked an improved water source,[198] which is broadly consistent with the General Statistics Office of Vietnam (GSO) estimate of the Vietnamese population lacking hygienic latrines and drinking water (6 percent and 2.6 percent, respectively).

The aggregate costs of providing improved sanitation and drinking water for the current decade for 100 percent of the Vietnamese population amount to between US$814 million and US$1,927 million.[199] These costs (detailed in table 4.5) are derived from global estimates of 'safely managed" levels of water supply and sanitation[200] and account for population growth until 2030—that is, approximately 6.9 million people who will need to be connected to improved sanitation and 3.2 million to safe water.[201]

The full implementation of these targets would effectively eliminate annual mortality (9,000 deaths) and morbidity (7 million diseases) from water pollution. Using the value of a statistical life (VSL) and productivity methods applied in the COED above to estimate the aggregate benefits results in BCRs in the range of 5.2 to 12.2 with VSL valuations and 1.1 to 2.6 with the productivity valuations (at a 6 percent discount rate; results are not very sensitive to the discount rate). The net benefits can be raised even further by (a) undertaking programs in a cost-effective manner, saving on costs of installation and operation; (b) accelerating implementation; and (c) focusing on areas where unit benefits are greater than those used in this analysis.

197 Decision No. 681/QD-TTg, dated June 4, 2019.

198 Data from the UNICEF Data Warehouse of the WHO/UNICEF Joint Monitoring Programme:https://data.unicef.org/dv_index/.

199 The estimate for improved sanitation is between US$293 million and US$1,115 million; and for drinking water, between US$521 million and US$812 million.

200 Hutton and Varughese 2016. The data from this study generate a wide range of estimates, depending on local conditions. In the absence of specific information of costs of Vietnam, the whole range is taken, giving low, medium, and high estimates of the cost.

201 The projections assume that any increase in population that does not have access to these facilities in the absence of further investment is equal to the same percentage of the population that does not have the facilities in 2020.

TABLE 4.5 **Benefits, Costs, and Net Benefits of Providing Improved Sanitation and Drinking Water to Vietnamese Population through 2029**

Benefit or Cost Measure	Discount Rate 6%		Discount Rate 4%		Discount Rate 10%	
	VSL Based	Prod. Based	VSL Based	Prod. Based	VSL Based	Prod. Based
Benefits (US$Mn.)	9,924	2,108	11,535	2,450	7,460	1,585
Costs (US$Mn.)						
Low	814	814	910	910	662	662
Medium	1,339	1,339	1,496	1,496	1,089	1,089
High	1,927	1,927	2,153	2,153	1,568	1,568
Net Benefits (US$Mn.)						
Low	9,110	1,294	10,625	1,540	6,798	923
Medium	8,585	769	10,039	954	6,371	495
High	7,997	181	9,382	297	5,892	17
Benefit-to-Cost Ratio						
High Cost	5.15	1.09	5.36	1.14	4.76	1.01
Medium Cost	7.41	1.57	7.71	1.64	6.85	1.45
Low Cost	12.19	2.59	12.68	2.69	11.27	2.39

Source: World Bank calculations.

Note: Prod. = productivity method; VSL = value of a statistical life method.

Addressing the Growing Problem of Lead Pollution

Creating environmentally sound lead-acid battery recycling requires interventions at multiple levels. Laws and regulation are key to establishing a proper licensing system for operators that are compliant with environmental, health, and safety standards and to ensure that battery producers take more responsibility in collecting and recycling used batteries (for example, through take-back programs, as in the EU, Japan, and North America,).

A licensing system for battery recycling operators and facilities not only ensures sound recycling but also engages the private sector. For instance, ACE Green Recycling has developed a room-temperature recycling process that turns lead from scrap batteries into briquettes of 99.95 percent purity and above.[202] New technologies can be a game changer in this most polluting industry in the world, and with government facilitation they can become commercially viable.

The introduction of a more professional battery recycling system requires accompanying measures to cushion the social impacts for those in the informal sector. Tightening the informal recycling activities and setting up recycling facilities is necessary[203] but not sufficient, as

202 Bhardwaj and Singh 2021.
203 WEF and GBA 2020.

they may simply displace contamination. A clear division of labor should be created between the informal and formal sectors so that informal sector can engage in waste collection and sorting, while formal sectors can engage in smelting and other activities that should be under strict control.[204] The integration of the informal sector (as examples from other from low- and middle-income countries show) is often constrained by policy, legal, and institutional barriers.[205]

Despite the serious health consequences of lead exposure, lead poisoning often goes unrecognized. There are insufficient studies on source identification, exposure, and associated health consequences in Vietnam, and the lack of reliable data makes it difficult to conduct a quantitatively accurate BCA of lead pollution. This lack needs to be filled to effectively design policies and interventions, especially in relation to likely major sources: (a) used lead-acid battery (ULAB) recycling hot spots, (b) general exposure to lead in paints, and (c) lead in water and food. Understanding the current limitation in Vietnam, a review of lead pollution policies in relation to these sources provides the following recommendations to fill priority knowledge and implementation gaps:

- *Site testing of lead exposure.* This includes hot spots such as ULAB recycling sites, metal mines, and hazardous workplace sites as well as general population exposure sources such as household environment, outdoor community, and specific sources such as soil, pesticides, and water pipelines, among others.
- *Screening for health impacts of exposure.* Universal pediatric blood lead testing is costly and likely not economically feasible. Therefore, targeted screening of at-risk populations located in areas with high lead exposure would be preferable.[206]
- *Timely and regular monitoring.* Develop country-level monitoring capacity for blood lead testing and monitoring mechanisms to identify lead exposure and poisoning level.
- *Awareness raising.* Public education campaigns about the dangers and sources of lead exposure are needed to equip people with knowledge of preventing lead poisoning and protecting themselves from lead exposure hazards.[207]
- *Policy design.* Evaluate the effectiveness of proposed and existing regulations on lead pollution by conducting a Regulatory Impact Analysis (RIA).[208] This method quantifies the likely effects of policy measures on lead levels, the costs to the regulatory authorities and the agents involved, and potential benefits to health. It helps to direct decision-making and ensures regulations are effectively and efficiently reducing lead exposure.[209]

204 WEF and GBA 2020.

205 Aparcana 2017.

206 Havens et al. 2018.

207 UNICEF and Pure Earth 2020.

208 RIA is an instrument by regulators or policymakers to promote coherence in regulatory policy. The use of RIA has particular prominence in OECD countries as a systemic mechanism for assessing that the estimated benefits of proposed regulation exceed the estimated costs (OECD 2009). It is overseen by the regulatory authorities, with technical support from expert consultants.

209 OECD 2009.

As for lead exposure mitigation in ULAB hot spots, a combination of site monitoring, remediation, and mitigation measures is recommended. For example, policy instruments should be put in place to promote environmentally sound management of ULAB collection and recycling. Control measures include remediation of contaminated sites, relocation of smelting areas away from residential areas, environmental standards governing emissions and discharges of lead within smelting facilities, and workplace health and safety standards and monitoring.[210] Policy instruments with economic incentives should be considered to encourage informal sector involvement in ULAB collection and prohibit their sale to unlicensed smelters. These measures could also be applied to other exposure hot spots such as metal mines and electronic waste recycling and disposal sites.

With regard to general population exposure to lead, targeted screening of at-risk populations at the local level can contribute to identify the exact exposure sources and potential mitigation measures. For likely general sources such as lead in paints, it is important that the government maintains strong enforcement and monitoring to ensure paint companies comply with the national standard of lead content limit and labeling requirements. Complementary measures such as encouraging third-party certification for labeling, public campaigns to inform consumers of lead content in paint and paint safety, and knowledge support to small paint manufacturers in low-lead paint reformulation are also recommended.

Addressing lead in water and food requires a high level of coordination across sectors, state government, and subnational authority. Initial assessments and monitoring of soil and water quality at the local level are crucial to understand the extent of heavy metal contents in agricultural outputs and identify potential contamination sources. A better understanding of the scale of the problem will help guide relevant and effective policy interventions. The promotion of good agricultural practices such as minimizing the use of fertilizer and pesticides can also contribute to mitigating the contamination of lead and other heavy metals in food and water.

Investing in Natural Assets

Healthy functioning ecosystems and productive natural assets—forests, land, oceans—are critical in a circular economy and for sustainable growth. This section thus looks at how the concept applies to sectors—such as the wood industry (see box 4.5)—that depend on these natural resources and important investments to boost their productivity through land remediation, restoration of forests, and addressing illegal and unregulated fishing.

As a major global furniture and textile producer, Vietnam finds opportunities through innovation and resource efficiency in the wood-based supply chain. Standards and certification for sustainable forest management and forest-based materials are increasingly demanded for

210 WHO 2017.

international consumer markets—notably through the Forest Stewardship Council and the Programme for the Endorsement of Forest Certification, which go beyond wood products and incorporate social aspects that support smaller enterprises and smallholder growers.

Beyond wood-based products, forests and their capacity to renew can be used in watersheds. Vietnam pioneered a Payment for Forest Environmental Services (PFES) system to leverage forest services to regulate stream flow and improve water quality for utilities and municipalities downstream. This saves costs and expensive investments in water infrastructure that would be less efficient. At the same time, communities upstream can benefit from payments made by these utilities on a regular basis for their effort to maintain and increase forest cover.[211]

BOX 4.5 **Circularity in the Wood Industry**

The CE approach is not new to forestry and industries that depend on wood-based products. Reuse and repurposing materials are common in the wood value chain (such as lumber salvage and wood-chip production). Further down the value chain, IKEA is taking a lead in standardizing furniture parts and by selling components, which extends product life cycle and allows consumers to use their furniture more flexibly. In construction—a sector with a high carbon footprinta—wood, cellulose, and its derivatives are increasingly used as a substitute for nonrenewable construction materials. There is also a growing market for cross-laminated timber, which is recyclable and reduces GHG emissions compared with nonwood materials.b

Innovative forest-based materials can replace more-polluting materials. Huhtamaki from Finland offers sustainable packaging solutions made from fully plant-based and renewable materials. Their products range from paper cups, takeaway trays, and bowls to tube laminates for toothpaste and pharmaceutical packaging and are made from certified wood fiber. Also, the fashion industry has a significant environmental footprint and has tapped forest resources for alternative materialsc to replace cotton, which saves water and reduces chemical use. Several companies and start-ups have started to commercialize textiles made from forest cellulose with materials such as Tencel, Spinnova, and Lenzing.

a. UNECE 2021.

b. Grand View Research 2021.

c. EFIMED 2021.

Remediating Degraded Land

There is no current government target for degraded land remediation. A number of proposed interventions from recent literature,[212] however, can be considered for a BCA for Vietnam. These include rehabilitation of rangelands, soil erosion control, treatment or reclamation of sodic or

211 Since the introduction of the PFES in 2008, the program has generated approximately US$400 million.

212 Markandya and Galinato 2021.

saline fields, integration of fertility management, soil and water conservation, agroforestry, silviopasture, and associated technical assistance (for example, trainings or workshops, agricultural services, improvement of institutional capacity, and project management). For the results presented here, a program of land remediation on 1.18 million hectares over the period 2022–30 was assumed.[213]

The benefits of land remediation generally outweigh the costs, but there are exceptions for high-cost, low-benefit situations. Given the wide range of possible costs of remediation based on international experience,[214] the net benefits vary significantly (see table 4.6).[215] In low-cost scenarios, the net benefits and benefit-cost ratios (BCRs) are very high—well over 100. With costs at the average level, the BCRs are between 4 and 18, depending on the benefit scenario and the discount rate. With costs at the top end of the range, however, net benefits are negative for low- and medium-benefit scenarios. For the high benefit scenario, they are still negative for a 6 percent and 10 percent discount rate but become positive for the 4 percent discount rate. The top end of the costs range would involve very costly programs that are unlikely to be undertaken in Vietnam.[216]

TABLE 4.6 **Net Benefits from Land Remediation and Benefit-Cost Ratios (BCRs)**

a. 4% Discount Rate

		Costs		
		Low	**Medium**	**High**
Net Benefits (US$Mn)				
Benefits	Low	16,913	15,022	–10,196
	Medium	25,387	23,496	–1,722
	High	33,861	31,970	6,752
BCR				
Benefits	Low	482	9	0.62
	Medium	723	13	0.94
	High	964	18	1.25

213 In the absence of specific government targets, the land area targeted for remediation is estimated to be 1.18 million hectares (13 percent of the estimated degraded land area presented in the COED to be restored by 2030). See the Supplementary Note for details.

214 Markandya and Galinato (2021) present a review of remediation costs based on data from agricultural land remediation projects funded by multilateral organizations; government and nongovernmental organization (NGO)-supported grants and programs for restoration and conservation of agricultural land; and related project reports and journal articles. See details in the Supplementary Note.

215 The Supplementary Note provides a description of how cost scenarios were constructed.

216 It is pertinent that the cost data in the one set available for the country on planting for improved productivity are around the middle of the cost range. The costs per hectare that be absorbed and still generate a positive benefit were calculated separately. It turns out that, at a 6 percent discount rate and a low benefit scenario, costs can be as high as US$14,400 per hectare. For the middle benefit scenario, the costs can be as high as US$21,600 per hectare. Last, for the high benefit scenario, the costs can be as high as US$28,640 per hectare.

TABLE 4.6 **Net Benefits from Land Remediation and Benefit-Cost Ratios (BCRs) (cont.)**

b. 6% Discount Rate

		Costs		
		Low	**Medium**	**High**
Net Benefits (US$Mn)				
Benefits	Low	11,417	9,749	−12,499
	Medium	17,141	15,473	−6,775
	High	22,865	21,197	−1,051
BCR				
Benefits	Low	369	7	0.48
	Medium	553	10	0.72
	High	738	13	0.96

c. 10% Discount Rate

		Costs		
		Low	**Medium**	**High**
Net Benefits (US$Mn)				
Benefits	Low	6,007	4,688	−12,904
	Medium	9,023	7,703	−9,888
	High	12,039	10,719	−6,872
BCR				
Benefits	Low	246	4	0.32
	Medium	369	7	0.48
	High	492	9	0.64

Source: World Bank calculations.

The results indicate that remediation is very likely to generate net benefits, but two factors are critical. One is to select the areas for remediation where the potential benefits are high—that is, land that is significantly degraded but can be restored to its full potential. Second, the costs of remediation are an important factor. The top end of the costs range involves very costly programs such as those that not only provide technical assistance but also physical infrastructure investments designed to prevent or stop land degradation and erosion. These are unlikely to be undertaken in Vietnam. It is pertinent that the cost data from the one set available for the country on planting for improved productivity are around the middle of the cost range. The discount rate also makes a difference. With the lowest rate considered (4 percent), the BCRs are 30 percent to 40 percent higher than the base case discount rate (6 percent). With a 10 percent discount rate, they are 30 percent to 40 percent lower.

Further work is needed to pin down the costs for local conditions and to identify the benefits on a spatially more disaggregated basis. Interventions identified in the land degradation neutrality[217] targets to save irrigation water such as agroforestry are likely to fall in the medium cost range. The vulnerable target areas (in North West and Central Highlands) that are highly dependent on agriculture will likely generate positive net benefit if the targets are achieved. Other low- to medium-cost measures put forward in the government SDG plan related to land may include

- Review land use planning in an effective and sustainable manner;
- Investigate and evaluate the current situation of land degradation to determine the causes and propose solutions;
- Select new plant species that are resistant to dry conditions (conversion of the crop structure);
- Increase the number of plant species used for agricultural land;
- Develop agroforestry systems in combination with cattle husbandry;
- Encourage the application of sustainable farming and land use methods, and build pilot models using technologies to restore and increase the fertility of degraded land;
- Limit the use of chemicals and inorganic fertilizers in agricultural production, and prevent erosion, leaching, and soil degradation; and
- Promote the development of ecological community models on degraded, eroded, and deserted lands to improve soil quality and reduce further degradation.

The Ministry of Agriculture and Rural Development (MARD) has been assigned by the government as the leading agency in addressing agricultural land degradation. Coordination with other line ministries is also critical to land rehabilitation, such as MONRE to address pollution issues, the Ministry of Science and Technology (MOST) to research and develop new technologies and crop species, MPI to review land use planning and invest in rehabilitation projects, and the Department of Agriculture and Rural Development (DARD) at provincial levels to implement relevant sustainable land management practices.

Recovery of Protection, Special-Use, and Mangrove Forests

The government of Vietnam continues to plan an increase in forest cover in the country, a long-standing policy objective. The targets for forest plantation for 2021–30—according to Vietnam's Forestry Development Strategy (Decision 523/QD-TTg), which covers the period until 2030—include planting of production forests (340,000 hectares per year), protection and special-use forests (4,000–6,000 hectares per year), and restoration of degraded protection and special-use forests (15,000 hectares per year).[218] Net costs of forest

217 LDN TSP 2018.

218 Forests in Vietnam are classified into three types based on management purposes: (a) protection forests designated for the protection of water sources and soil, erosion and desertification prevention, and natural disaster reduction; (b) special-use forests for biodiversity conservation, scientific research, preservation of historical and culture relics and landscape; and (c) production forests designated for timber and other forest products supply (Circular No. 34/2009/TT-BNNPTNT). The national distribution of the three forest categories is provided in the Supplementary Note.

planting and restoration[219] can be assessed relatively well based on government cost norms[220] and opportunity costs for crops that commonly displace forest cover (for example, rubber, coffee, and acacia).[221] The benefits of forest ecosystem services can be quantified based on the considerations presented in the COED estimate (chapter 3).

The net benefits of forest restoration to society are significant. Using a number of reasonable assumptions on costs and benefits, the net benefits of replanting over the next 50 years amount to between US$162 million and US$481 million (6 percent discount rate). For forest regeneration, the net benefits are between US$671 and US$977 million. The corresponding BCRs are 1.2 to 2.3 for new plantations and 1.5 to 2.1 for regeneration of degraded forests (see table 4.7). Results are sensitive to the choice of the discount rate. Net benefits rise by about 60 percent if a 4 percent rate is used instead of 6 percent, and they decline by about 36 percent if an 8 percent rate is used. For degraded forests, the impact of the discount rate is even greater. In all cases, however, the net benefits are significant and the BCR is over 2. Also, the level of the opportunity costs affects the net benefits significantly—at the lower end of the range, the BCR for new forests goes up from 1.7 to 2.4 (6 percent discount rate);[222] at the upper end of the range, the BCR falls from 1.2 to 1.1. Since these costs will vary by location, it will be important to make a careful assessment of their value across the locations in deciding on priorities.

TABLE 4.7 **Benefits and Costs of Planting New Forests and Regenerating Degraded Ones**

	Discount Rate	Total Costs (US$Mn.)			Total Benefits (US$Mn.)			Net Benefits (US$Mn.)			Benefit-Cost Ratio		
		Low	Mid	High	Low	Mid	High	Low/ Low	Mid/ Mid	High/ High	Low/ Low	Mid/ Mid	High/ High
New Forests	6%	378	526	811	859	916	973	481	390	162	2.3	1.7	1.2
	4%	514	715	1,103	1,304	1,376	1,445	790	661	342	2.5	1.9	1.3
	10%	228	317	489	420	458	498	192	141	9	1.8	1.4	1.0
Degraded Forests	6%	617	1,068	1,943	1,288	2,061	2,920	671	993	977	2.1	1.9	1.5
	4%	883	1,528	2,781	1,957	3,096	4,336	1,074	1,568	1,555	2.2	2.0	1.6
	10%	345	598	1,088	630	1,030	1,495	285	432	407	1.8	1.7	1.4

Source: World Bank calculations.

Note: The low-cost scenario is based on opportunity costs of US$318 per hectare per year. The mid-cost scenario has an opportunity cost of US$569 per hectare per year, and the high-cost scenario has an opportunity cost of US$1,056 per hectare per year.

219 In the range of approximately US$1,300–1,700 per hectare up front for planting of protection and special use forests plus management costs of up approximately US$600 per hectare for the years following planting, decreasing over time.

222 Decision 38/2016/QD-TTg.

221 Le et al. 2016.

222 Assuming the middle of the range of benefits.

The costs and benefits of mangrove restoration are relatively well understood, and there is significant experience in Vietnam in supporting the recovery of these essential ecosystems. Unit costs of replanting mangroves range from US$9,000 per hectare to US$22,000 per hectare, and the average value of ecosystem service provided by mangroves (for example, derived from fish harvesting, coastal protection, or tourism) is US$4,508 per hectare annually, though with a wide range depending on geography and economic use. Projecting the recently announced government's targets of 9,800 hectares of mangrove restoration[223] forward to 2030 shows that the BCR is well above 1 for all combinations of costs and benefits except the "high-cost, low-benefit" combination (where the BCR declines for a 10 percent discount rate compared with a 4 percent). This preliminary analysis indicates that the government's plans—on average—are very likely to generate benefits well in excess of costs (noting that net benefits are greater with cost-efficient implementation and vary by geography and use).

TABLE 4.8 **Benefit-Cost Analysis Results for Mangrove Restoration**

Scenario	Discount Rate 4%		Discount Rate 10%	
	NPV US$/ha	BCR	NPV US$/ha	BCR
Low Cost, Low Benefit	90	2.2	16	1.3
Low Cost, Mean Benefit	417	6.7	151	3.7
Low Cost, High Benefit	1,518	21.7	656	12.5
High Cost, Low Benefit	−53	0.8	−143	0.3
High Cost, Mean Benefit	274	2.3	−8	1.0
High Cost, High Benefit	1,375	7.4	497	3.3

Source: World Bank calculations. (For more details, see the Supplemental Note.)

Note: BCR = benefit-cost ratio (ratio of present value of benefits less present value of costs). NPV = net present value (of benefits less costs). ha = hectare.

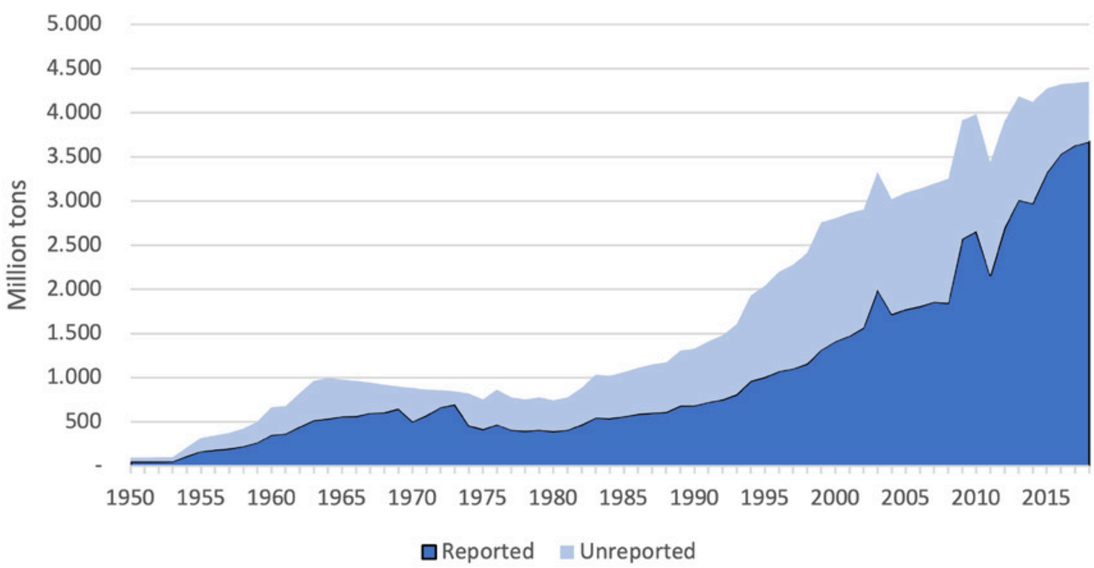
Addressing the Problems of Illegal and Unregulated Fishing

Illegal, unreported, and unregulated (IUU) fishing is a threat to the sustainable use of fisheries resources everywhere, including Vietnam. There has been an increase in IUU in Association of Southeast Asian Nations (ASEAN) waters. Action needs to be strengthened to enable effective monitoring, control, and surveillance systems—including proper catch documentation and labeling, up-to-date registry of commercial fishing vessels, training of enforcement officers and agencies, and a monitoring and policing infrastructure that befits the purpose. For 2018, it is estimated that 15.6 percent (679,000 tons) of the catch in the Vietnam exclusive economic zone (EEZ) is IUU (compared with the total of 4.35 million tons with a value of US$1,071.6 billion in real 2010 dollars; see figure 4.3).[224]

223 The proposed program put priorities on the protection and development of mangrove forests and coastal erosion prevention in the Mekong Delta and coastal provinces in the Central region that are highly exposed to natural disaster risks and desertification (Decision No. 1662/QĐ-TTg, Article 2, Key Task 4).

224 EEZ data are from the Sea Around Us data tool, https://www.seaaroundus.org/data/#/eez.

FIGURE 4.3 **Total Fish Catches, Reported and Unreported, in Vietnam's EEZ, 1950–2018 (Tons, thousands)**



Source: Exclusive economic zone (EEZ) data from the Sea Around Us data tool, https://www.seaaroundus.org/data/#/eez.

The government of Vietnam has been made aware of the problem, especially through the EU's measures, notably the October 2017 issuance of a yellow card warning for Vietnamese seafood exported to the EU's market due to Vietnam's failure to meet the EU Regulation to prevent, deter, and eliminate IUU fishing. This resulted in a 12 percent decrease of exports to the EU in 2019 (a US$183.5 million reduction compared to 2018, and a loss of US$269.5 million when accounting for projected sector growth). The EU's warning also resulted in a spillover effect for exports to other markets (for example, US exports fell by 9 percent in 2018–19, and export growth for Japan slowed considerably during the same time). The issuance of a red card by the EU could potentially result in annual losses of US$480 million (fisheries and aquaculture combined).[225]

The government is thus actively taking steps to address the European Commission's recommendations. These focus on the prevention and elimination of illegal fishing outside of national EEZs and improvements in traceability of fishery products. While some progress has been noted by recent EU inspections (for example, improved monitoring, reduction in offshore fleet size, and better licensing management), several significant shortcomings persist, such as in the installation of vessel monitoring equipment, implementation of a surveillance systems, sanctioning of violations, and traceability measures in processing plants.

225 World Bank 2021d.

The limited data available on the costs of the measures to address IUU are indicative of relatively modest costs. If the measures can address the problem effectively, the avoided losses from the issuance of future yellow and red cards should be an order of magnitude greater. Because of a lack of data, it is not possible to estimate the benefits and costs of measures to control IUU. If IUU is effectively controlled, a cobenefit will be the reduction of overfishing in the territorial waters of Vietnam as well as in the wider seas. If an estimate could be made of the amount by which such catch is reduced for different species by introducing new control measures for IUU, the benefits in terms of a reduction in overfishing could be calculated given data on the costs of the IUU measures. This information would inform a package of measures, including a restriction on legal catch for some species and the introduction of third-party certification to address the wider problem of overfishing in the region.

Beyond a more robust benefit and costs analysis, collecting adequate data on Vietnam's fisheries and managing it to inform adaptive management and policy decisions is critical to improve the sustainability of the sector. Specifically, to address the declining productivity of national fisheries and overfishing it is essential to conduct regular national stock assessments every five years and issue quotas on both fishing licenses and fisheries production (or total allowable catch), as stipulated by 2017 Law on Fisheries. As the currently available stock data is insufficient to determine science-based limits, it is critical to establish a robust fisheries data collection framework that ensures continuous and consistent data collection (time series, disaggregated by stock and fishing gear, are important given the characteristics of multi-species and multi-gear fisheries in Vietnam).

For Vietnam to more effectively tackle IUU fishing, its monitoring, control and surveillance mechanism needs strengthening. Such a system is necessary for evidence-based decision-making, building resilience into the sector, safety and enforcing regulations. It needs to include (a) operational and regulatory controls, including mandatory installation of vessel monitoring system equipment for all vessels greater than 15 meters (to ensure compliance with to seasonal or spatial closures, including marine protected areas)[226]; (b) improved catch documentation routinely generated by local authorities that have clear and strengthened responsibilities; (c) control over illegal gear, transprovincial fishing and bycatch; (d) deterrents and sanctions related to IUU fishing; and (e) provision of robust and transparent information for market traceability.

226 It is worth noting that Vietnam made great strides in expanding the coverage of vehicle monitoring system for offshore vessels – as of August 2021, for vessels greater than 15 meters coverage reached approximately 87.5 percent following the 2017 Fisheries Law. See Vietfish Magazine (2021) Determined to remove the "yellow card" of seafood by 2022 https://vietfishmagazine.com/fisheries/determined-to-remove-the-yellow-card-of-seafood-by-2022.html

5 The Way Forward: Making the Transition

This Country Environmental Analysis (CEA) is a diagnostic assessment of Vietnam's state of the environment today. The assessment was performed in 2021—the year in which Vietnam's National Assembly adopted its 2021–30 Socio-Economic Development Strategy, which sets out an ambitious plan not only for growth and development but also for the environment. It comes at a time when a global pandemic is reshaping economic sectors and highlights how natural systems and human society are closely connected.

The time frame for the analysis was approximately the last decade—that is, the period of implementation of the previous 10-year strategy. Assessing this period reveals that Vietnam has made tremendous progress in its development. However, this success increasingly comes at the expense of the environment, and that is undermining future growth potential.

The innovative resilience, inclusion, sustainability, and efficiency (RISE) framework shows how Vietnam compares internationally in its performance on key categories that define quality of growth. This demonstrates in a quantitative and transparent manner that Vietnam is starting to fall short in several key areas relative to its country peers and the performance of upper-middle-income countries (the category of countries Vietnam aims to belong to by the end of the decade). The shortcomings are notably in the areas of sustainability and efficiency, but also resilience. The quantitative analysis and country benchmarking point to areas where Vietnam needs to take action and rebalance its growth going forward. This means investing in a cleaner environment and its natural capital, which will essentially drive future growth (especially in forestry, agriculture, and fisheries).

The costs of environmental degradation (COED) estimation is the main component of any CEA. The work here presents a comprehensive assessment across a number of critical areas. What stands out is the tremendous toll on human life caused by pollution, most importantly by air pollution. This is exacerbated by the fact that more and more Vietnamese live in highly polluted urban centers. But lead and water pollution also add to the loss of life that undermines the human capital to continue to grow the economy. The degradation of critical environmental services provided by forests, mangroves, and fisheries shows that it is key to ensure that these services are maintained going forward. Not only does this preserve the natural capital of the country, but it also provides an opportunity to leverage finance for these sectors.

To address environmental issues comprehensively, an ambitious program of actions is required. This report analyzed several key interventions that are critical in transitioning to a cleaner way of growing the economy with a focus on the costs and benefits of such interventions. While many of the estimates presented here can be considered robust and reliable (such as the impacts of pollution on human health), others may require further analysis that is tailored to the Vietnamese economy (such as using market incentives to reduce and manage waste). The first-order estimates show that benefits generally outweigh the costs of cleaning up the environment and investing in sustainability. This is consistent with the experience of other economies, including many in the East Asia region (such as the Republic of Korea), that have made this transition, which has boosted their competitiveness internationally and also as a destination of international business and investments.

Three important areas of the solution space are the pricing of pollution, notably carbon, advancing circularity in Vietnam's growing industries, cities, and investing in natural capital. These action areas help with resource efficiency and a cleaner economy and environment and translate into higher competitiveness. Beyond that, many other instruments and mechanisms will need to be leveraged, including fiscal instruments and ways to mobilize the private sector. Such actions will have economywide impacts and affect distributional outcomes. Many of these impacts can be positive if combined with other policy instruments, as shown in the case of carbon pricing. Such effects and sound policy design are important areas for further work.

It is necessary for Vietnam to grow greener – business-as-usual is not an option. A deteriorating environment will be a significant obstacle in achieving the growth targets set in the 2021-2030 Socio-Economic Development Strategy. Already, pollution and environmental degradation is having a major toll on the country's human and natural capital: ten percent of annual GDP (or seven percent without accounting for human welfare) as this report estimates. And significant physical assets are destroyed annually by extreme weather events – only to be amplified by climate change going forward. Losses of such magnitude put a drag on economic growth and Vietnam's competitiveness in global trade. It is thus critical to aggressively advance the policy agenda set out by the country's leadership, including the Prime Minister's commitment to carbon neutrality by 2050, the effective implementation of the Law on Environmental Protection, and Green Growth Strategy and action plan.

Growing green is affordable and brings new opportunities. As the analyses in this report have shown, many interventions that can reduce the impact of economic activities on the environment are not costly. In fact, many such interventions have a high benefit-to-cost ratio, such as cleaning up polluted waters and remediating unsanitary landfills; or restoring mangroves and degraded land to their productive potential. And as the RISE analysis shows, the environmental performance of countries that have grown to become upper-middle income or high-income is significantly better across a wide range of indicators. It is thus essential that the policy targets set in the SEDS on the environment are achieved, or better, exceeded - environmental damages can have cumulative effects (such as the cascading effects of plastic and waste pollution on tourism, aquaculture, municipal services, land values and so forth) clean up or restoration later is more costly or becomes impossible (such as for deforested hillslopes that get washed away in a storm).

And greener growth is desirable. Just as Vietnamese are increasingly traveling the world to experience national parks and modern urban centers afar, foreign visitors – and investors alike - will find a clean and sustainable Vietnam more attractive. Heavily polluted air and littered beaches are less likely to bring in needed investments, and trade disruptions, such as those that followed the yellow card issued by the European Union for Vietnam's fish exports, are neither good for business nor the economy. Growing green can bring an important edge in a decarbonizing global economy. And healthier forests, mangroves and agricultural lands are better for those who critically depend on such natural capital for their livelihood and profit margin. But for that it is essential that these assets are properly valued to inform policy and decision-making.

A greener path needs decisive government leadership. Decision makers have already defined the general policy framework and established the legal basis for the necessary actions. The recent update of the Law on Environmental Protection is a major step in this direction, and it is now critical to advance sector-specific policy, regulations, standards, and rules to facilitate action. Government's role is essential to enable private sector action, as in the Netherlands, where amendments to waste regulations (increasing the volume of materials available for recycling as opposed to disposal in landfills) boosted the recycling industry. Similarly, central government leadership to support provinces in the implementation of sustainable land use practices that sequester more carbon attracts international finance and positions these jurisdictions well to benefit from the global demand for ecosystems services.

The transition to a greener way of growing needs different stakeholder engagement. Multistakeholder governance that engages diverse stakeholders is instrumental to address environmental challenges. This applies in the case of value chains (to ensure that materials entering the market can be recycled and there is capacity to do so) as well as in pricing of carbon for key polluting industries. As international experience shows, interministerial committees are more effective when it comes to policy implementation. Coordination can be supported by a digital platform to facilitate the necessary exchange of knowledge and information of different sectors and industries. For example, the European Circular Economy Stakeholder Platform is an initiative by the European Commission that functions as a knowledge hub.

The government's emphasis on digital technology is very timely and can be transformative. Devices and systems connected to the internet enable the product-as-a-service (PaaS) model and the sharing economy. In the product manufacturing process, digitization also minimizes resource use, waste, and transaction costs and extends product life cycles. The national government can support industry by removing the bottlenecks by revising the regulations, for instance. And transactions in a carbon market require transparent digital platforms that allow the traceability of on-the-ground efforts (such as the restoration of forests) and finance.

There is no blueprint for green - learning-by-doing is essential. While key principles of green growth – such as pollution pricing and natural capital investments – generally apply, each country needs to tailor-make its path to a greener future. That means solution need to be tested and phased, such as market incentives to reduce waste or circular economy projects. The insights from initial projects can identify priority industries and choices of policy instruments for the next phase and find models to finance the scale-up. The same applies to carbon pricing instruments that can be introduced for subsectors or in particular jurisdictions first before they are rolled out more widely. A phased road map that lays out policy, capacity support, and targets can be differentiated (for instance, for construction, textiles, or plastics) and be done jointly with industry to target priority value chains and subnational jurisdictions.

As the Government of Vietnam advances its economic and environmental objectives, the following actions are most pressing in light of the analyses presented in this report:

- *Take a comprehensive and regional approach to reduce air pollution.* Achieving the government's current climate targets as a step toward carbon neutrality by 2050 will help reduce air pollution. Introducing effective carbon pricing policy (as analyzed here) is a necessary step – but not nearly sufficient. In addition, current policies in a variety of sectors need to be significantly strengthened, regulations enforced, and cost-effective control measures implemented to meet national air quality standards. As air pollution has both local, regional and long-range sources, a regional approach is paramount. Such a portfolio of actions needs to target large power and industrial plants (including strengthened emission limits), but also craft villages, transport (emission control standards, especially for motorcycles), agriculture (including livestock that has not been strictly regulated thus far) and waste management (notably a strategy to eliminate open burning through better collection, recycling and treatment of waste). To counteract growth in pollution from projected sector growth, choosing maximum feasible options, applying proven technical measures across all sectors and pollutants, as well as enforcing current bans on open waste and crop residue burning, will be necessary to achieve acceptable levels of air quality in coming years. And ambitious policy action, regulation and implementation need to be complemented by better air quality monitoring, awareness raising and transparency.
- *Establish a program to address the growing and urgent problem of lead pollution.* This should include measures to introduce a professional battery recycling system. Also, key knowledge gaps need to be filled through site testing of lead exposure (which entail mapping priority sites), screening for health impacts (focusing on at-risk populations), establishing of a country-wide monitoring system and awareness raising. Effective policies should be assessed through a Regulatory Impact Analysis. To effectively address lead contamination in water and food, effective coordination mechanisms across sectors (including agriculture, water, industry) at the national and subnational level need to be established.
- *Assess and rapidly introduce market-based measures to reduce plastic pollution.* As shown here, a modest tax charged to customers (as opposed to retailers) can have significant benefits. Similar measures should be tested to address other plastic products that are entering the environment at a growing rate. Similarly, based on initial analyses, alternatives to plastics (bottles, sachets, utensils and so forth) are available and can reduce the environmental costs now. For a wider range of products, a comprehensive life cycle analysis focused on the Vietnamese market is an important next step. Very critically, a professional recycling system needs to be set up (the value of recovered material will go a long way of financing such a system but needs to be studied further). Market-based mechanisms (various approaches based on fees, incentive payments,

recycled content standard, taxes, among others) are used effectively in other countries and can guide this effort.

- *Accelerate and scale up investments in the protection and restoration of natural capital.* A critical element is the remediation of degraded land, starting with areas for which productive potential can be restored (this needs to be guided by a more detailed benefit-cost analysis). Such land remediation efforts need to be included in land use planning at the provincial and district level and coordinated well at the nationally. As for forests, it is critical to slow rates of deforestation and improve the quality existing forests to boost productivity. The government has significant experience in mobilizing results-based payments for reduced emissions from deforestation and forest degradation at the level of several provinces and can leverage this experience to tap into the growing international demand for nature-based solutions. Similarly, the ongoing mangrove restoration program should be further scaled up. All such interventions have a high benefit-to cost ratio that can guide government decision-making.
- *Effectively engage the private sector.* As noted throughout this report, the private sector is a critical partner in cleaning up and protecting the environment. This applies across virtually all action areas analyzed in this report, from the management of forests, mangroves or agricultural land (where private operators have a vital interested in managing their natural resource base sustainably and profitably) to the plastics value chain (where producers, retailers and recyclers need to work together to reduce waste) and technology and innovation (for instance in bringing electric vehicles to the market). The government has a critical role to play in creating a conducive environment for private sector action and participation and will need to work in partnership with the private sector to find technical and financing solution to address pressing environmental problems.

Appendixes

Appendix A. RISE Benchmarking Methodology

Countries are benchmarked against the maximum value in their peer group. There are two different formulas employed, depending on the variable:

1. **Standard case:** Higher value is better performance.

   Benchmarking score = [Country Score—worst performing country] / [Peer Group Maximum—worst performing country]

   Example: Control of Corruption

   - Country Score= –0.115
   - LMI Max= 1.65 (Bhutan)
   - Worst performing country: –1.80 (Somalia)
   - **Benchmarking score = [–0.115+1.8]/[1.65+1.8]=1.685/3.45=0.49**

2. **Inverted case:** Higher value is worse performance, strictly non-negative.

   Benchmarking score = [Worst Performer–Country Score] / [Worst Performer–Peer Group Best performer]

   Example: Gini Index

   - Country Score= 43.5
   - Worst Performer = 57.1 (Zambia)
   - LMI Best Performer = 25.7 (Moldova)
   - **Benchmarking score = [57.1 – 43.5]/[57.1 – 25.7]= 13.6/31.4=43%**

How to Read the Flower Diagrams

Example: Fisheries index measures the health and sustainability of a country's fisheries. So higher values imply a better performance.

- **Country A has a value of 14.6** for this indicator.
- **Worst performer in the world has a score of 3.2.** This is assumed to be the worst possible score that this indicator can take and would result in a score of zero percent (that is, there would be no petal for this country's graph for this indicator).
- **Best performer in the peer group has a score of 19.6.** This represents the peer group's frontier and would result in a score of 100 percent (that is, the petal would be completely full for the country in this indicator).
- Score for Country A shows where the country lies on the spectrum from the worst possible score to the peer group frontier.
- **Country A's score of 14.6 is *70 percent*** of the way from 3.2 to 19.6.
- **Thus, the petal extends 70 percent of the way from the origin to the frontier.**

Example: Risk to asset measures destruction of assets due to natural disasters. **So lower values imply a better performance.**

- **Country A** has a value of **1.5 percent of GDP destroyed** for this indicator.
- **Worst performer in the world has a score of 4.336 percent.** This is assumed to be the worst possible score that this indicator can take and would result in a score of zero percent (that is, there would be no petal for this country's graph for this indicator).
- **Best performer in the peer group has a score of 0.003 percent.** This represents the peer group's frontier and would result in a score of 100 percent (that is, the petal would be completely full for the country in this indicator).
- Score for Country A shows where the country lies on the spectrum from the worst possible score to the peer group frontier.
- **Country A's score of 1.5 is *66 percent*** of the way from 4.336 to 0.003.
- **Thus, the petal extends 66 percent of the way from the origin to the frontier.**
- **But it is still the case that longer (larger) petals show better performance.**

FIGURE A1.1

Source: Exclusive economic zone (EEZ) data from the Sea Around Us data tool, https://www.seaaroundus.org/data/#/eez.

Appendix B. RISE Indicator Definitions and Sources

a. Resilience Indicators			
Natural disaster risk to assets (% of GDP): The average value of the damage disasters causes to asset (expressed in repair or replacement value).	2017	124	*Unbreakable* report (Hallegatte et al. 2017)
Natural disaster risk to well-being (% of GDP): The decrease in GDP that would have the same impact on people's well-being as the disasters that occur in the country (that is, people's willingness to pay to prevent all disasters).	2017	126	*Unbreakable* report (Hallegatte et al. 2017)
Population exposure from disasters (% of total population exposed): The average share of population affected by geophysical, meteorological, hydrological, or climatological natural disasters over a 20-year period (2000–19).	2000–19	151	EM-DAT database
Urban slum population (% of urban population): The proportion of the urban population living in slum households. A slum household is defined as a group of individuals living under the same roof lacking one or more of the following conditions: access to improved water, access to improved sanitation, sufficient living area, and durability of housing.	2018	103	World Development Indicators
Population exposure from dry rainfall shocks (% of total population exposed): The average share of the population exposed to a dry rainfall shock (rainfall <1 st. dev. below average) over a 5-year period (2009–2013).	2009–13	146	Willmott and Matsuura (2014), as calculated in *Uncharted Waters* (Damania et al. 2017)
Food Security Index: Measures three factors related to food security in countries—affordability of food, availability of food, and quality and safety of food. Data are for the year 2019.	2020	110	Economist Intelligence Unit: https://foodsecurityindex.eiu.com/Index
Population exposure from epidemics (% of total population exposed): The average share of population affected by epidemiological disasters over a 20-year period (2000–19). *Note: The variable was upwardly censored at 0.045% to prevent extreme outliers from biasing the benchmarking.*	2000–19	108	EM-DAT database
Population covered by social protection (% of total population): Per SDG 1.3.1, the share of population covered by at least one social protection benefit.	Latest year available	86	ILOSTAT

b. Inclusion Indicators			
Poverty headcount US$1.90/day (% of total population): The percentage of the population living on less than US$1.90 a day at 2011 international prices. As a result of revisions in PPP exchange rates, poverty rates for individual countries cannot be compared with poverty rates reported in earlier editions.	2010–16	115	World Development Indicators
Female labor force participation rate (% of female population): Labor force participation rate is the proportion of the population ages 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period.	2018	158	World Development Indicators
Safely managed drinking water (% of total population): The percentage of people using drinking water from an improved source that is accessible on premises, available when needed, and free from fecal and priority chemical contamination. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.	2017	101	World Development Indicators
Safely managed sanitation (percent of total population): The percentage of people using improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated off-site. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks, or pit latrines, ventilated improved pit latrines, compositing toilets, or pit latrines with slabs.	2017	90	World Development Indicators
Human Capital Index: The index measures the amount of human capital that a child born today can expect to attain by age 18, given the risks of poor health and poor education that prevail in the country where he or she lives. It is designed to highlight how improvements in current health and education outcomes shape the productivity of the next generation of workers, assuming that children born today experience over the next 18 years the educational opportunities and health risks that children in this age range currently face.	2017	141	World Bank's Human Capital Index
Gini Index (World Bank estimate): Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. Thus a Gini index of zero represents perfect equality, while an index of 100 implies perfect inequality.	2015–19	100	World Development Indicators

Secondary school enrollment rate (% of total population): The ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education completes the provision of basic education that began at the primary level and aims at laying the foundations for lifelong learning and human development by offering more subject- or skill-oriented instruction using more specialized teachers.	2015–19	129	World Development Indicators
Universal health service coverage (UHC) index: Per SDG 3.8.1, the coverage of essential health services (based on tracer interventions that include reproductive, maternal, newborn and child health, infectious diseases, noncommunicable diseases, and service capacity and access). It is presented on a scale of0 to 100.	2017	152	*2019 Global Monitoring Report* (WHO 2019)
Rural Access Index: The Rural Access Index (RAI) measures the proportion of the rural population who live within 2 km of an all-season road. It is included in the SDGs as indicator 9.1.1., providing a way of measuring progress toward SDG 9 and Target 9.1.	2020	132	World Bank
Financial inclusion, bottom 40% (% with financial account): Denotes the percentage of respondents in the poorest 40% of households, age 15+, who report having an account (by themselves or together with someone else) at a bank or another type of financial institution or personally using a mobile money service in the past 12 months.	2017	138	Global Findex database: http://datatopics.worldbank.org/financialinclusion/
LGBT global acceptance index: The index measures the relative level of social acceptance of LGBT people and rights in each country. Acceptance is the extent to which LGBT people are seen in ways that are positive and inclusive, both with respect to an individual's opinions about LGBT people and with regard to an individual's position on LGBT policy.	2014–17	150	Williams Institute, UCLA School of Law: https://williamsinstitute.law.ucla.edu/publications/global-acceptance-index-lgbt/
Women, Business, and the Law Index: The index measures gender inequality in the law. It identifies barriers to women's economic participation and encourages the reform of discriminatory laws. The index is based on scores across the following eight topics: mobility, workplace, pay, marriage, parenthood, entrepreneurship, assets, and pension.	2020	167	World Bank: https://wbl.worldbank.org/en/wbl-data
Access to electricity (% of total population): Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys, and international sources.	2018	165	World Development Indicators

Refugees and Internally Displaced Persons Index: An input into the Fragile States Index, this indicator measures the pressure upon states caused by the forced displacement of large communities as a result of social, political, environmental, or other causes, measuring displacement within countries as well as refugee flows into others.	2020	152	Fragile States Index: https://fragilestatesindex.org/indicators/s2/
Belief that "most people can be trusted" (% agreeing): Survey question from the World Values Survey, which conducts nationally representative surveys in 77 countries and societies. Respondents are asked if most people can be trusted, and the indicator is the share of those who respond, "Most people can be trusted," with the other option being "Need to be very careful."	2020	76	World Values Survey Association: http://www.worldvaluessurvey.org/wvs.jsp
Homicide rate (victims of intentional homicide per 100,000): Per SDG 16.1.1, the number of victims of intentional homicide per 100,000 population, by sex and age. *Note: The variable was upwardly censored at 13.5 to prevent extreme outliers from biasing the benchmarking.*	2019–18	127	UN SDG database
Personal rights index: This index is one of the components used in social progress index. Personal rights are defined as political rights, freedom of expression, freedom of religion, access to justice, and property rights for women.	2020	146	Social Progress Imperative: https://www.socialprogress.org/index/global/results
c. Sustainability Indicators			
Mortality rate attributed to household and ambient air pollution, age-standardized (per 100,000 population): Number of deaths attributable to the joint effects of household and ambient air pollution in a year per 100,000 population. The rates are age-standardized. The following diseases are taken into account: acute respiratory infections (estimated for all ages); cerebrovascular diseases in adults (estimated above 25 years); ischemic heart diseases in adults (estimated above 25 years); chronic obstructive pulmonary disease in adults (estimated above 25 years); and lung cancer in adults (estimated above 25 years).	2016	152	World Health Organization
Water quality, nutrients, salts, chemicals (SDG 6.3.2): A water quality index that covers the pollutants tracked by SDG 6.3.2, namely nutrients, salts, and chemical pollutants. It is an index of three water quality parameters: nitrates, electrical conductivity, and biological oxygen demand. The dataset was generated for the report Quality Unknown: The Invisible Water Crisis using a machine learning model using data from 2000–13. The resolution is the 0.5 x 0.5 degree gridcell. The country value here is calculated by taking a population weighted average of all gridcells where the centroid falls within the country.	2020	148	World Bank: www.worldbank.org/qualityunknown

Total renewable freshwater resources per capita (cubic meters): Renewable resources (internal and external river flows and groundwater from rainfall) in the country. Total renewable freshwater resources per capita are calculated using the World Bank's population estimates.	2017	152	World Development Indicators
Forest loss, short term (% of forest loss since 2000): "Tree cover" is defined as all vegetation greater than 5 meters in height and may take the form of natural forests or plantations across a range of canopy densities. Tree cover loss is defined as "stand replacement disturbance," or the complete removal of tree cover canopy at the Landsat pixel scale. Tree cover loss may be the result of human activities, including forestry practices such as timber harvesting or deforestation (the conversion of natural forest to other land uses) as well as natural causes such as disease or storm damage. Fire is another widespread cause of tree cover loss, and can be either natural or human-induced. Forest loss percentage is calculated as aggregate tree cover loss during 2001–19 as a percentage of tree cover in 2000.	2001–19	146	Global Forest Watch
Forest loss, long term (% of forest loss since 1900): Historical land cover data for the years 1900–2005 are based on HYDE 3.1. These data represent fractional land use and land cover patterns annually for the globe at 0.5-degree (~50-km) spatial resolution. Land use categories of forest, cropland, pasture, primary land, secondary (recovering) land, and urban land, and underlying annual land use transitions, are included. National shares of land use devoted to forests are calculated for the year 1900 and again in 2005, and the percentage change is calculated over this time period.	1900–2010	128	HYDE version 3.1: https://hyde.earth/mod/mod/hyde31
Renewable energy consumption (% of total energy consumption): Renewable energy consumption is the share of renewable energy in total final energy consumption.	2017	161	World Development Indicators
Wastewater treatment capacity (% of wastewater produced): The percentage of collected, generated, or produced wastewater that is treated, normalized by the population connected to centralized wastewater treatment facilities.	2020	147	Yale Environmental Performance Index
Mortality rate attributed to unsafe water, unsafe sanitation, and lack of hygiene (per 100,000 population): Death rates are calculated by dividing the number of deaths by the total population. In this estimate, only the impact of diarrheal diseases, intestinal nematode infections, and protein-energy malnutrition are taken into account.	2016	152	World Health Organization
Land degradation (degraded land as share of total land area): Per SDG 15.3.1, the proportion of land that is degraded over total land area. Land degradation is defined as the reduction or loss of the biological or economic productivity and complexity of rainfed cropland; irrigated cropland; or range, pasture, forest, and woodlands resulting from a combination of pressures, including land use and management practices.	2000–15	113	UN SDG database

Biodiversity and habitat index: The index is calculated from remote sensing data and other studies of ecological diversity. A score of 100 indicates that a country has experienced no habitat loss or degradation, and a score of 0 indicates complete habitat loss.	2020	147	Yale Environmental Performance Index
Fisheries sustainability index: The fisheries issue category measures the health and sustainability of the world's fisheries. It is made up of three indicators: fish stock status, marine trophic index, and fish caught by trawling.	2020	102	Yale Environmental Performance Index
Change in GHG emissions per capita (% change 2008 to 2017): Percentage change of GHG emissions per capita from 2008 to 2017.	2008–17	151	CAIT Climate Data Explorer via Climate Watch
d. Efficiency Indicators			
Efficiency of carbon use (GNI per kt of CO2e): The ratio of GNI (current US$) to total GHG emission (kt of CO2 equivalent). Total GHG emissions in kt of CO2e are composed of CO2 totals excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires, and decay of drained peatlands); all anthropogenic CH4 sources; N2O sources; and F-gases (HFCs, PFCs, and SF6).	2012	138	World Development Indicator
Agricultural value added per worker ($ per agricultural worker): Computation based on data from FAOSTAT and ILOSTAT, downloaded in March 2020. This indicator provides information on the output of the agricultural sector by worker engaged. It is a measure of agricultural productivity (US$, 2010 prices).	2017	98	Food and Agriculture Organization (FAO)
Agricultural land productivity ($ per hectare of agricultural land): Gross production value as a share of total agricultural land.	2016	156	Food and Agriculture Organization (FAO)
Governance effectiveness: Reflects perceptions of the quality of public services; the quality of the civil service and the degree of its independence from political pressures; the quality of policy formulation and implementation; and the credibility of the government's commitment to such policies.	2018	158	Worldwide Governance Indicators: http://info.worldbank.org/governance/wgi/#home
Control of corruption: Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	2018	158	Worldwide Governance Indicators: http://info.worldbank.org/governance/wgi/#home

Logistics performance index: The LPI is based on a worldwide survey of operators on the ground (global freight forwarders and express carriers), providing feedback on the logistics "friendliness" of the countries in which they operate and those with which they trade. It provides an index based on six areas: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness.	2012–18	151	Logistics Performance Index: https://lpi.worldbank.org/about
Tenure security (% of population reporting insecure property rights): Percentage of people who believe it is somewhat or very likely that they could lose the right to use their property or part of it against their will in the next five years. Based on nationally representative surveys.	2020	132	Prindex: https://www.prindex.net/data/
Population using the internet (% of total population): The percentage of the population who used the internet from any location in the last three months. Access could be via a fixed or mobile network.	2020	156	International Telecommunication Union: https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
Productivity of water use ($ per m³ water withdrawals): The value added in US$ per volume of water withdrawn in cubic meters, by a given economic activity over time. It considers water use by all economic activities, with a focus on agriculture, industry, and the service sector.	Latest year available	147	Food and Agriculture Organization (FAO), as tracked by SDG 6.4.1
Air pollution regulation economic efficiency: Measures the share of the budget spent on reducing air pollution that is spent efficiently—that is, the share of the actual budget that could have been spent to achieve the same air pollution related morbidity. A value of 100 percent means it would not be possible to spend less and achieve the same level of efficiency. Ninety percent means a country could have spent 10 percent less to mitigate air pollution and achieved the same morbidity outcomes, if it had spent those funds more efficiently.	2020	52	World Bank, Resource Efficiency Index: https://govdata360.worldbank.org/indicators/h62ef0757?country=BRA&indicator=28773&viz=line_chart&years=2006,2020
Change in energy intensity (% change in MJ energy/GDP 2008–2017): Percentage change in energy intensity level of primary energy (MJ/$2011 PPP GDP) from 2005 to 2015. Energy intensity level of primary energy is the ratio between energy supply and gross domestic product measured at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output. Lower ratio indicates that less energy is used to produce one unit of output.	2008–17	151	World Development Indicators

Digital penetration index: It is also called digital adoption index. The DAI is a worldwide index that measures countries' digital adoption across three dimensions of the economy: people, government, and business. The index covers 180 countries on a 0–1 scale and emphasizes the "supply side" of digital adoption to maximize coverage and simplify theoretical linkages. The overall DAI is the simple average of three subindexes. Each subindex comprises technologies necessary for the respective agent to promote development in the digital era: increasing productivity and accelerating broad-based growth for business, expanding opportunities and improving welfare for people, and increasing the efficiency and accountability of service delivery for government.	2016	149	World Bank
Rapid transit urban availability (km of rapid transit per million urban residents): km of rapid transit / million urban residents (in cities with populations above 500,000). Rapid transit is defined as any of the following: bus rapid transit, light rail transit, and metro.	2018	65	Rapid Transit Database, Institute for Transportation and Development Policy (ITDP)

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