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Peru

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

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Acronyms

AFOLU	agriculture, forestry and other land use
ANA	National Water Authority, *Autoridad Nacional del Agua*
BAM	Bosques Amazónicos
BAU	business as usual/business-as-usual
BRT	bus rapid transit
CANCC	High-level Commission on Climate Change, *Comisión de Alto Nivel de Cambio Climático*
CBAM	Carbon Border Adjustment Mechanism
CCDR	Country Climate and Development Report
CENEPRED	National Center for the Assessment, Prevention and Reduction of Disaster Risks, *Centro Nacional de Estimación, Prevención y Reducción del Riesgo de Desastres*
COES	electricity system operator, *Comité de Operación Económica del Sistema Interconectado Nacional*
CPSD	Country Private Sector Diagnostic
DFP	deforestation-free product
DRM	disaster risk management
EG	environmental goods
EHS	environmentally harmful subsidies
ENAHO	National Household Survey, *Encuesta Nacional de Hogares*
EU	European Union
ETS	Emissions Trading System
FEF	Fiscal Stabilization Fund, *Fondo de Estabilización Fiscal*
FISE	Energy Social Inclusion Fund, *Fondo de Inclusión Social Energético*
GCI	Green Complexity Index
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
GWh	gigawatt-hours
IDB	Inter-American Development Bank
INEI	National Institute of Statistics and Information, Peru
INFOCARBONO	Institutional arrangement for the elaboration of National Inventories of Greenhouse Gases
ISC	fuel excise tax, *impuesto selectivo al consumo*
kWh/m^2	kilowatt hours per square meter
LEZ	low-emission zone
LNG	liquified natural gas
LPG	liquified petroleum gas
LULUCF	land use, land-use change and forestry
MEF	Ministry of Economy and Finance, *Ministerio de Economía y Finanzas*
MERESE	Remuneration Mechanisms for Ecosystem Services, *Mecanismos de Retribución por Servicios Ecosistémicos*
MFMod	The World Bank's Macro-Fiscal Model
MINAM	Ministry of Environment, *Ministerio del Ambiente*
MRIO	Multi Regional Input Output
MTC	Ministry of Transport and Communication, *Ministerio de Transportes y Comunicaciones*

$MtCO_2e$	million tonnes of carbon dioxide equivalent
MW	megawatts
NAP	National Adaptation Plan
NCRE	nonconventional renewable energy sources
NDC	nationally determined contribution
NMT	nonmotorized transport
NPV	net present value
OECD	Organisation for Economic Co-operation and Development
PIRCC	Comprehensive Plan for Reconstruction with Changes, *Plan Integral para la Reconstrucción con Cambios*
PPP	public-private partnership
SAC	agricultural insurance scheme, *Seguro Agricola Catastrofico*
SEDAPAL	Lima's Potable Water and Sewerage Service, *Servicio de Agua Potable y Alcantarillado de Lima*
SEIN	National Interconnected Power System, *Sistema Eléctrico Interconectado Nacional*
SERFOR	National Forest and Wildlife Service, *Servicio Nacional Forestal y de Fauna Silvestre*
SIAF	Financial Management Information System, *Sistema Integrado de Administración Financiera*
SINAGERD	National Disaster Risk Management System, *Sistema Nacional de Gestión del Riesgo de Desastres*
tCO_2e	tonnes of carbon dioxide equivalent
WHO	World Health Organization
WITS	World Integrated Trade Solutions
ZEV	zero-emission vehicle

All dollar amounts are U.S. dollars unless otherwise indicated

1. Development and climate-related risks

Main messages

Peru has achieved fast economic growth and poverty reduction over the last two decades, but future development goals could be threatened by climate change if it does not strengthen its foundations for resilience.
Informal jobs and illegal activities are costly in terms of gross domestic product (GDP) growth, natural resource overuse, vulnerability to shocks, and greenhouse gas (GHG) emissions.

GHG emissions are mostly due to deforestation, but increasing rapidly in other sectors, particularly transport.

1.1. Gains from fast economic growth and poverty reduction are threatened by natural hazards and climate change

Before COVID-19, Peru had achieved high economic growth and poverty reduction for two decades. With a per capita GDP of $6,692 in 2021 (dropping from a historical high of $7,023 in 2019 due to the COVID-19 pandemic),[1] its economy is one of the largest and fastest-growing in Latin America and the Caribbean, averaging 4.8 percent of annual growth between 2000 and 2019. The success of its growth strategy was heavily anchored in external and internal factors: coupled with a friendly international environment, its comparative advantage in commodities helped boost exports and incomes, while solid macroeconomic management and well-targeted programs fostered inclusive economic growth. This prolonged, stable period of high growth reduced poverty by more than half, falling from 59 percent in 2004 to 20 percent in 2019. At the same time, inequality also fell substantially. Rural poverty declined more than in urban areas, partly because of a lack of social protection for urban populations.[2] Peru's Gini Index[3] declined from 0.50 to 0.44 over the same period, and the middle class expanded from 15 to 34 percent of the population. After increasing to 30 percent in 2020 due to COVID-19 pandemic, poverty decreased again to 26 percent in 2021, according to recent estimates.[4]

Peru's growth is largely driven by natural capital, which creates vulnerability to climate change and risks and opportunities linked to the global low-carbon transition. Peru holds the second largest area of Amazon jungle after Brazil and is in the world's top 10 most biodiverse countries. Its large ore reserves include copper, gold, silver, zinc, lead, iron, and tin. With copper accounting for

[1] World Bank national accounts data and OECD National Accounts data.

[2] https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/AM2020/Global_POVEQ_PER.pdf.

[3] The Gini index measures inequality in income distribution. A Gini coefficient of 0 expresses perfect equality, where all values are the same, while a Gini coefficient of 1 (or 100%) expresses maximal inequality among values.

[4] Data from INEI, https://www.inei.gob.pe/prensa/noticias/pobreza-afecto-al-259-de-la-poblacion-del-pais-en-el-ano-2021–13572/

about one-third of its total exports,[5] Peru has become the world's second largest copper exporter, after Chile.[6] It also has oil and gas reserves, is the world's third largest fish producer (the largest exporter of anchovy fishmeal),[7] and has become a leading exporter of fruits and vegetables.[8] The country's high reliance on agriculture and fisheries exports makes it particularly vulnerable to climate change impacts. Oil and gas reserves are under threat to become stranded assets, while the agriculture sector can no longer rely on deforestation to stay competitive in a decarbonizing world. If powered by clean energy, however, its mineral resources can be an asset in the global low-carbon transition.

1.1.1. Geography, climate, and socioeconomics: high exposure and vulnerability to natural hazards and climate change

Peru is more exposed and vulnerable to natural hazards than most of its structural peers,[9] scoring higher on 10 out of 15 indicators representing drivers of risk (figure 1.1). This is partly due to the high frequency of hazards (mostly earthquakes, floods, landslides and droughts), and spatial concentration of people and assets in high-risk areas. The country lies in a highly seismic region called the Pacific Ring of Fire, where about 80 percent of the world's earthquakes occur. Notably, Peru is one of the countries most affected by the climatic phenomenon known as El Niño, which is associated with increased incidence of flood and drought events in the Costa and Sierra regions, respectively (World Bank Group 2016). The relatively high share of agriculture and fisheries in both GDP and employment also increases the country's vulnerability to natural hazards and climate change impacts.

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[5] In 2019, copper ores accounted for 26% of Peru's exports and copper products for 4% (The Observatory of Economic Complexity 2022).

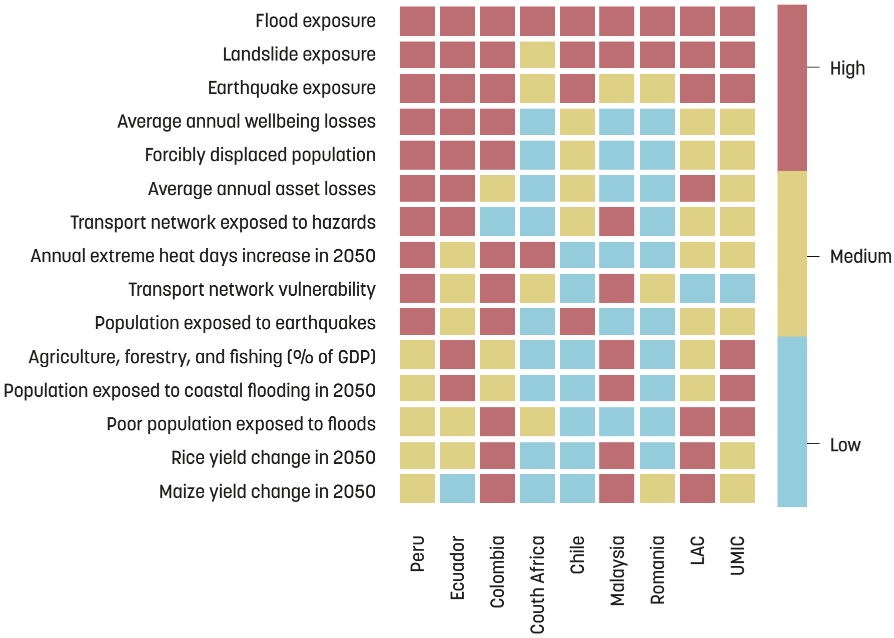
[6] World Bank. Copper ores and concentrates exports by country in 2018. https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2018/tradeflow/Exports/partner/WLD/product/260300;

[7] Fish products account for 25 to 30% of total exports.

[8] Agricultural exports increased in value from $758 million in 2000 to more than $5.78 billion in 2016, growing at an average annual rate of 12.5%. During the same period, exports of nontraditional products—including grapes, asparagus, avocado, and other fruits—grew at an even faster rate. Coffee remains the most economically important agricultural export, increasing in real terms from $223 million in 2000 to $756 million in 2016, despite its share in total agricultural exports dropping from 28.5 to 13% over the same period (World Bank 2017).

[9] Selected economies include some that share a similar level of hazard exposure and/or are structural peers (Ecuador, Colombia, South Africa), aspirational peers (Chile, Malaysia, Romania) and other typical comparators, such as Latin American, Caribbean, or upper-middle income countries (UMICs).

FIGURE 1.1. Drivers of risk, Peru vs. selected economies



Sources: World Bank staff calculations, based on Climate Analytics n.d.; Kulp and Strauss 2019; Rentschler and Salhab 2020; UNISDR 2015; UNHCR 2018; WDI 2022; World Bank n.d.; World Bank Climate Knowledge Portal (https://climateknowledgeportal.worldbank.org/, accessed August 24, 2022).
Notes: The indicators presented are a selection of drivers of risk in a country. Countries in red (high-risk) are in the upper third; those in yellow (medium risk) are in the middle third; and those in blue (low-risk) are in the lowest third. LAC = Latin America and the Caribbean; UMIC = upper middle-income countries.

As a result, the country regularly suffers high damages and losses from natural hazards. During the 2003–19 period, Peru was affected by 61,708 emergencies caused by natural phenomena (intense rains, floods, droughts, earthquakes, landslides, and frost). Each year on average, disasters cause more than $40 million in losses, with some individual events—such as the Pisco earthquake in 2007—causing damage in excess of $2 billion (Tolmos et al. 2011). Earthquakes can have long-lasting effects, even affecting future generations; for example, Caruso and Miller (2015) show that the 1970 earthquake in Ancash had adverse intergenerational effects on welfare, while the severe episodes of El Niño in 1982–83 and 1997–98 caused an estimated $6.8 billion in losses. More recently, the 2017 coastal El Niño event resulted in economic losses estimated at $3.1 billion, equivalent to 1.6 percent of national GDP, damaging roads, houses, bridges, farming areas, educational institutions, irrigation canals, rural roads, and health facilities.[10,11] When adding the burden of disease to flood events, water shock events cost 3.4–6.4 percent of GDP per year (World Bank 2022). It is estimated that almost half of Peru's road network was damaged during the last El Niño event, and 18 percent was destroyed (INDECI 2017).

Climate variability has affected economic growth in Peru. Contemporary (1990–2019) deviations in temperature compared to historical levels (1960–90) have already reduced economic growth. Recent estimates suggest that, on average, each degree increase in temperature leads to a percentage point loss in per-capita growth rate (Chirinos 2021). Impacts are concentrated in the agriculture and fishing

[10] RPP Noticias. 2017. "El Niño costero: Daños ya suman $3,124 millones según Macroconsult" (March 24). https://rpp.pe/economia/economia/el-nino-costero-danos-ya-suman-s--noticia-1039319.

[11] https://www.indeci.gob.pe/wp-content/uploads/2019/01/201802271714541.pdf.

sectors. By region, Lima and Tumbes, Huancavelica, and Madre de Dios were the most affected areas of the Costa, Sierra, and Selva regions, respectively. Extrapolating to 2050, the increase in temperature would reduce per capita income by 9 percent, and by 22 percent as of 2100.

Socioeconomic vulnerability, and particularly labor informality, further increases welfare risk. High informality, high inequality, prevailing low access to basic services such as safe water and sanitation, and unequal financial inclusion all increase people's vulnerability to climate change impacts and decrease socioeconomic resilience (de Vries Robbé 2022). Labor informality is a key determinant of poverty and informal jobs can be more susceptible to economic shocks. Although Peru experienced a significant decrease in informal labor over the last two decades—until 2016, after which it increased slightly—it remains high. In 2019, 73 percent of the employed had an informal job. Poverty rates among informal workers are more than four times higher than their formal counterparts, and their vulnerability to shocks is higher since they lack government support.

This vulnerability is exacerbated by one of the most unequal distributions of infrastructure in Latin America and the Caribbean, and there are stark differences in access and connectivity between Lima and secondary cities. The vast Sierra and Selva regions are difficult to traverse, resulting in large development gaps between the country's regions. Good connectivity and high access to electricity and other infrastructure services is geographically concentrated around Lima and other coastal urban centers. Secondary cities and regions, which are high producers of exported goods—such as mining and agriculture products, which represent 13 and 6 percent of GDP respectively—have some of the lowest connectivity in the country, resulting in high transport costs to reach international markets and high disruption costs in case of natural hazard (Rozenberg et al. 2017). It takes approximately twice as long to reach a healthcare facility in rural regions as in urban ones, and travel times strongly correlate with the percentage of population with at least one unsatisfied basic need (Carrasco-Escobar et al. 2020). One in 10 Peruvians lack access to basic water services, five in ten have no safely managed water, one in four has no access to basic sanitation services, and half of the population does not have safely managed sanitation. Sanitation coverage is particularly poor in the Sierra (65 percent) and Selva regions (51 percent), relative to the Costa (90 percent). The people of the Amazon rainforest shoulder the biggest share of the burden associated with unimproved services, reporting double the number of related deaths (14.3 deaths per million people) as those in the Costa (7.4 per million) (World Bank 2022).

These disparities in access to basic services are a consequence of infrastructure spending gaps. According to the most recent estimates (Government of Peru 2019), the country needs to invest $36 billion to reach the basic infrastructure access levels a country of its socioeconomic and geographical characteristics should have. Of this, 31 percent is required in the transport sector, followed by sanitation (25 percent), health (24 percent), telecommunications (10 percent), as well as the irrigation, electricity, water, and education sectors. The long-term basic infrastructure gap, which represents the investment needed to close the gap between Peru and developed countries, amounts to $110 billion.

The challenges in access to services are exacerbated by patterns of territorial development, inadequate housing, and disorderly urbanization, which all increase vulnerability. Almost 80 percent of Peru's population lives in cities, with 30 percent in Lima alone.[12] Unplanned occupation of space is leading to environmental degradation—for example, of riverbed or wetland ecosystems around Lima—and increased exposure to natural hazards such as floods and landslides.[13] According to the National Household Survey, *Encuesta Nacional de Hogares (ENAHO)* (INEI 2019b), almost half of the country's urban population (45.5 percent) lives in slums or inadequate housing. These populations are disproportionately vulnerable to the effects of climate change due to settlement location, precarious construction, and a lack of access to basic services, such as water and sanitation, adequate transport, and social protection.[14] The high-vulnerability areas are concentrated in the periphery of large and medium-sized cities, as a result of informal settlements.

1.1.2. Future climate change impacts could slow down development gains

Studies have highlighted economically meaningful impacts related to climate change, particularly in agriculture and fisheries. In the Sierra region, projections indicate that the negative impacts of climate change have resulted in lower yields of main crops such as potatoes, lima beans, green peas, barley, soft corn, wheat, and beans (FAO 2015). An increased frequency of droughts, floods, frost, and cold waves will heavily impact the agriculture sector, especially in rain-fed systems, which represent 64 percent of Peru's cultivated land (World Bank 2017). The agricultural sector could face losses between 1.4–3.1 percent of sectoral GDP for 2010–2040 and 3.8–14.2 percent of sectoral GDP for 2010–2070 (ECLAC 2014). Projections show that climate change will lead to lower production of almost every crop and in all scenarios. The only exception is coffee, which will slightly increase in the first 10 years before decreasing. Rice will be the most affected crop (Gianella, Chavez-Tafur and Thomas 2019).

Fish resources could be affected by changes in water temperature, shifts in current flow, and acidification. Livestock will also be affected, especially by higher temperatures. The impact of climate change on the Peruvian fishing sector is concentrated in a decline in anchovies, which would affect fishmeal production. Due to a lack of data, it is difficult to quantify potential losses in the livestock sector. But some rules of thumb indicate that, as the temperature in tropical and subtropical areas rises, livestock production will be hindered in two main ways. First, higher temperatures can stress the animals, leading to lower weight gain and increased mortality rates. Second, higher temperatures tend to increase the prevalence and range of livestock diseases, increasing mortality rates. Climate change impacts could lead to a loss of up to 90 percent of livestock GDP by 2100 compared with 2011 (Gianella, Chavez-Tafur and Thomas 2019).

Together, Peru's unequal spatial distribution of water resources, unbalanced development patterns, and climate change increase the risks of water scarcity. Higher glacial melt and changes in precipitation will significantly impact the timing and availability of water for agriculture, drinking, and energy production, increasing the frequency and severity of droughts with significant economic consequences. One-third of the country's population lives in the Lima metropolitan area, which relies

[12] More than 1.2 million Venezuelan migrants and refugees have also migrated to Peru since 2017, concentrating mainly in urban and peri-urban areas.

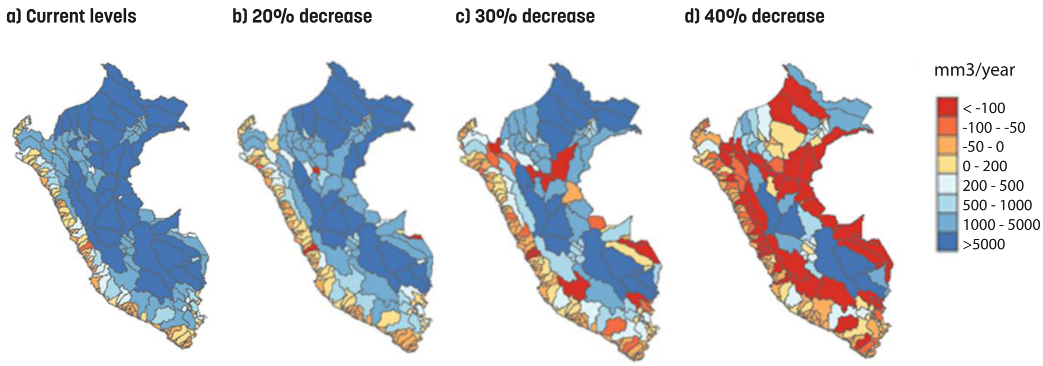
[13] For example, 134,000 households were affected by a 2017 flood event in the Rimac—one of Lima's most prominent rivers—due to families living in vulnerable areas near the river.

[14] https://data.worldbank.org/indicator/EN.POP.SLUM.UR.ZS?locations=PE.

heavily on water from glacial melt. And, as Peru has lost about 43 percent of its surface glacial area since 1970, it is likely to experience significant reduction in water flow as early as 2030. Lima's Potable Water and Sewerage Service, *Servicio de Agua Potable y Alcantarillado de Lima* (SEDAPAL) already struggles to cope with regular water shortages, which will become more severe as the population grows and demand for water increases. Hydropower, which makes up two-thirds of Peru's electricity production, is uniquely vulnerable to these changes. Reducing the availability of hydroelectric resources could drive a shift to a higher emissions energy mix in the future, although the timing, scale of impact, cost, and GHG emissions are not fully understood.[15] Groundwater, another important form of natural storage, is poorly understood, due to a lack of monitoring, and unsustainably used, with several aquifers facing depletion.

Climate change could stress water balances and many watersheds could experience net water losses. Figure 1.2 presents the effect of different changes in precipitation (from 0–40 percent) on the water balance. This range is consistent with existing records for dry years, and therefore considered feasible. In extreme cases, many Pacific basins would be subject to net stress (shown as orange and red in figure 1.2). Although Atlantic basins could suffer similar stress, the hypothesis that precipitation falls by 40 percent and real evapotranspiration is maintained is not supported by historical events.

FIGURE 1.2. Effect of the fall in precipitation on the water balance



Source: World Bank 2022

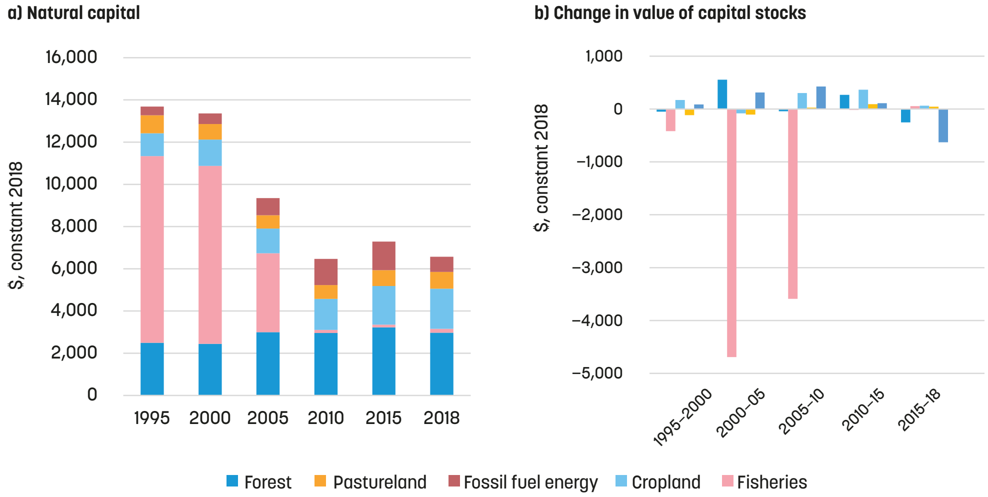
Climate change threatens the most vulnerable populations in Peru. Direct impacts include increased disease prevalence and extreme heat, or material losses due to natural hazards or water stress. Indirect effects include higher food prices, and impacts on labor productivity or macroeconomic stability (Hallegatte et al. 2016). Considering all the impacts of climate change, by 2030, the income of Peru's poorest 40 percent could be reduced by 5.2 percent, and another 0.6 percent of the population could be pushed into extreme poverty (Hallegatte et al. 2016). Future climate change impacts on poverty will mostly be felt in the health sector, with increased prevalence of vector- and water-borne diseases, and heat stress. Health impacts could account for 53 percent of total income reduction in the bottom 40 percent and 73 percent of additional people pushed into extreme poverty. That said, increased disaster losses and climate change impacts on labor productivity and food prices will also impact on poverty, as we discuss and quantify in chapter 4.

[15] Recent research suggests that most Peruvian hydropower stations will experience a slight increase in capacity, albeit with higher variability, by 2100 (Caceres et al. 2021).

1.2. Economic growth, natural capital degradation, and growing GHG emissions

High growth in Peru came at the cost of natural capital degradation, expressed as high deforestation rates and exhausted fishing resources (figure 1.3). Between 2001 and 2017, 2.1 million hectares of forested land—an area approximately the size of El Salvador—was cleared in the Peruvian Amazon at a rate of approximately 150,000 hectares a year (Finer and Mamani 2018). Estimates of fish biomass in the Southwest Pacific have also declined, and approximately 50 percent of fish stocks in the region are overexploited (Melnychuk et al. 2020). Stocks of Peruvian anchoveta, however, have increased recently, following a decline in 2014 (IMARPE 2019).

FIGURE 1.3. Natural capital and change in stock value, per capita



Source: World Bank staff calculations, based on World Bank 2021b.
Note: Mineral estimates are not included.

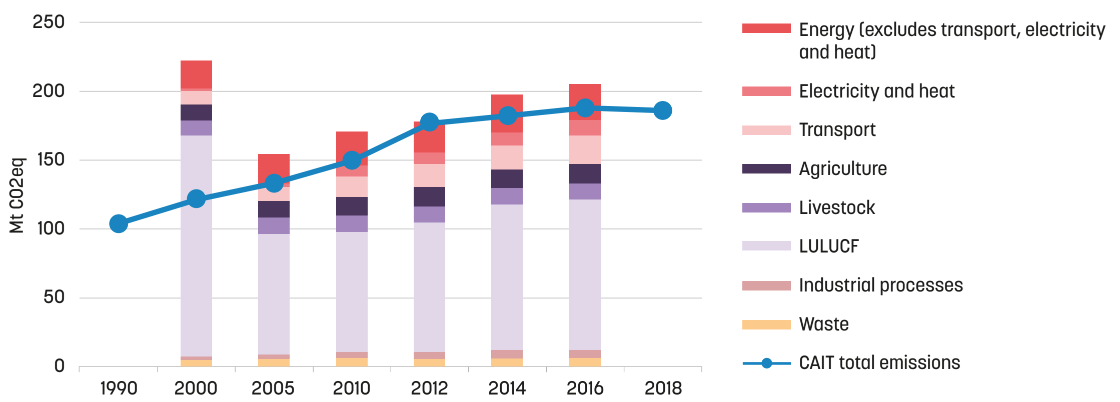
Informal, small-scale, and illegal activities often over-exploit fishing resources and lead to deforestation. Informality in land tenure and small-scale production drive environmental degradation outside of cities. Illegal and artisanal fishing threaten fish stocks while illegal and small-scale mining and logging and smallholder agriculture all contribute to deforestation high rates. Illegal mining has transformed large areas of forest into desert-like landscapes and released large amounts of mercury into the environment, causing health risks (Diringer et al. 2020). Agricultural activities are responsible for 76 percent of illegal deforestation. This is partly related to the low state presence in Loreto, San Martin, Huánuco, Ucayali, and Madre de Dios in the Selva region. Coffee and cacao are the two largest contributors to deforestation, grown mostly by small farmers in the Peruvian Amazon (Pokorny et al. 2021). Informal and small-scale producers also play a role in fish stock depletion, as uncontrolled fleet growth is directly reducing fishing efficiency and fishers' well-being. This is especially relevant for poverty considerations, since most small-scale fishers live in relative poverty (De la Puente et al. 2020; Pauly 2009). This growth in fishing effort is unsustainable over time.[16]

[16] The main sources of unreported catches over the last two decades are small-scale fleet targeting anchoveta for illegal fishmeal and fish oil production and jumbo flying squids with manual jigs (De la Puente et al. 2020).

Econometric analysis suggests that there is a strong and significant link between informal, small-scale agricultural activities and deforestation in Peru. Using ENAHO data, we estimate that forest cover decreases by 0.48 percent for each percent increase in share of informality in agriculture in a district. In the Amazon districts, this translates into 6.24 million square meters of forest cover lost each year. Perhaps unsurprisingly, we also find that informal mining activities also have a negative relationship with forest cover.[17]

Land use change and forestry are the main source of emissions in Peru. According to the latest National GHG Inventory, the country's 2016 emissions were distributed as follows: land use, land-use change and forestry (LULUCF) (53 percent); energy (28 percent); agriculture and livestock (13 percent); waste (3 percent); and industrial processes (3 percent).[18] Emissions growth in the energy sector is concerning, rising 84 percent between 2000 and 2016 (figure 1.4). Of total LULUCF emissions, 85 percent correspond to emissions from land converted to farmland or grassland. Between 2001 and 2019, Peru lost more than 4 million hectares of tree cover, representing 4 percent of its forest cover. Although the loss of the natural forest from expanding the agricultural frontier, commercial mining, and illegal logging are some of the main environmental issues Peru faces today, agriculture is firmly established as the main driver of deforestation.

FIGURE 1.4. Total GHG emissions, by sector (1990–2018)



Sources: World Bank staff calculations, based on data from Ministerio del Ambiente 2021b and World Resources Institute, CAIT Climate Data Explorer (http://cait.wri.org/, accessed February 18, 2022).
Notes: In the LULUCF sector, the methodology applied for 2014 and 2016 differs from that applied for 2000, 2005, 2010, and 2012. For the former, method 3 was applied for land representation in the Selva biome, and method 2 for the Costa and Sierra biomes. For the latter, method 3 has been applied in the Selva biome, and method 1 in the Costa and Sierra biomes. LULUCF emissions are higher in 2000 due to a deforestation peak. $MtCO_2e$ = million tonnes of carbon dioxide equivalent.

[17] This analysis combines main economic activity and informality measures from the ENAHO survey, and forest cover estimations gathered through Global Forest Watch. Our empirical strategy consisted of a panel data estimation at district level for 2011–20. Agriculture is the most important activity, reported by 25% of individuals in the sample. Extra covariates included in our analysis are: average household members per district, average income per district, and squared terms of informality, agriculture and mining.

[18] The distribution of emissions by sector and total changes when considering global inventories. According to CAIT Climate Data Explorer, Peru accounts for 0.39% of global emissions (including LULUCF) and the main sources of emissions are LULUCF (48 %), energy (29 %), and agriculture (11 %).

Transport is the fastest-growing sector in terms of emissions due to a 44 percent growth in the vehicle fleet,[19] and 123 percent growth in emissions, between 2000 and 2016. Transport emissions represented 10 percent of Peru's total emissions in 2016, growing 123 percent since the turn of the century. Of total transport emissions in 2016, 92 percent came from road transport, 5 percent from civil aviation, 2 percent from sea transport, and 1 percent from rail transport. Within road transport, emissions are mostly generated by light- and heavy-duty trucks and buses. Transport emissions are caused by the combustion of fossil fuels used to transport cargo and passengers at national level, and are therefore intrinsically related to the country's economic growth.

Electricity and heat production represent 5.4 percent of Peru's total GHG emissions, with the electricity mix dominated by hydropower and natural gas. Electricity and heat are the second largest GHG emitters of Peru's energy intensive sectors (19 percent of energy emissions). Hydropower is the largest source of electricity, with 55 percent of the total electricity mix, followed by natural gas (38 percent). Nonconventional renewable energy accounts for less than 5 percent of electricity generated.

[19] Based in data from Ministry of Transport and Communications – General Office of Budget and Planning. Data do not include motorcycles.

2. Country climate commitments, policies, and capacities

Main messages

Despite substantial progress in developing and advancing a solid legal framework for environmental sustainability, considerable challenges remain in terms of enforceability, capacity, and policy alignment.
Peru could make its public financial instruments environment- and climate-sensitive, further align its public investments with climate and social objectives, and ensure public procurement incorporates and enforces climate variables.
Peru has made advances in developing and disseminating emissions inventories, but public access to climate information is limited. Key sectors can develop information systems—such as a National Forestry Information System—to make information publicly available.

The government could also engage the private sector to mobilize the resources needed to bridge the climate finance gap. Concrete opportunities exist in the forestry sector but will require a change in existing incentives. The national Climate Financing Strategy is expected to strengthen private sector participation in climate action financing.

2.1. Policy commitments and institutional arrangements

2.1.1. Legal framework developments

In 2015, the country adopted its National Strategy on Climate Change,[20] **followed by the Framework Law on Climate Change, *Ley Marco sobre Cambio Climático*, of 2018.**[21] The latter defined the principles and approaches for Peruvian climate policy, established a structure of institutional arrangements for its development, coordination, articulation, execution, and incorporated instruments for its implementation. The country has made important efforts in the last 20 years to regulate the forestry sector, considering its impact in achieving the decarbonization goals set forth in its nationally determined contribution (NDC). The Forest and Wildlife Law, *Ley Forestal y de Fauna Silvestre*,[22] provides the country with a modern legal framework for implementing sustainable forest management, with participation from private actors and native communities and most importantly, recognizing the value of managing rather than extracting resources.[23]

[20] Through Supreme Decree N°. ENCC-011-2015, approved in March 2015. https://www.minam.gob.pe/wp-content/uploads/2015/09/ENCC-FINAL-250915-web.pdf.

[21] https://sinia.minam.gob.pe/normas/ley-marco-cambio-climatico#:~:text=La%20Ley%20Marco%20sobre%20Cambio,las%20medidas%20de%20adaptaci%C3%B3n%20y (April 18, 2018)

[22] Law N° 29763. https://www.minam.gob.pe/wp-content/uploads/2017/04/Ley-N%C2%B0-29763.pdf.

[23] It helped moving from extracting wood in small annual contracts (1,000 hectares) to managing forests in larger contracts (5,000–50,000 hectares) with a duration of 40 renewable years.

Its latest NDC, submitted in December 2020, increases the ambition of Peru's mitigation efforts. Additionally, the country committed to net zero CO_2 emissions by 2050. The latest NDC increases Peru's unconditional GHG reduction target from 20 to 30 percent by 2030, and its conditional goal from 30 to 40 percent, compared with the business-as-usual (BAU) scenario. President Castillo confirmed the latter when he announced the country's commitment to achieving net zero CO_2 emissions by 2050 and the country's 2022–25 Multiannual Macroeconomic Framework includes specific fiscal forecasts for climate change for the first time.

Released in June 2021, the country's National Adaptation Plan (NAP)[24] **reinforces the NDC adaptation measures.** The NAP prioritizes the agriculture, water, forestry, fisheries and aquaculture, and health sectors, and identifies two new areas: tourism and transport. The NAP proposes and sets strategies to implement 13 strategic actions, 46 products, and 92 adaptation actions in prioritized areas. It also has a monitoring and evaluation scheme to track progress and a cost analysis of the proposed measures.

As part of its Framework Law on Climate Change, Peru established the High-level Commission on Climate Change, *Comisión de Alto Nivel de Cambio Climático* (CANCC).[25] The law creates the foundation to articulate climate change policy by clarifying competencies and setting mandates for sectoral, regional, and local actors. It also appointed the Ministry of Environment, *Ministerio del Ambiente* (MINAM) as the national authority on climate change and designated the CANCC as a coordination body that proposes adaptation and mitigation measures and leads the country's NDC. The commission remains in its initial stages and will be primarily determined by the technical secretariat's ability to provide effective support.

2.1.2. Challenges remain

The fragmentation of natural resource management hampers the operation of climate policy. MINAM has the formal mandate to lead the climate policy, but lacks key functions in territorial planning (also referred to as territorial ordering) and natural (water, forest) resource management, which are led by other entities. This sectorial fragmentation creates a challenge for MINAM as climate policy lead. Strengthening institutional coordination and alignment between key institutions such as the National Forest and Wildlife Service, *Servicio Nacional Forestal y de Fauna Silvestre* (SERFOR) and National Water Authority, *Autoridad Nacional del Agua* (ANA) would help achieve climate goals.

Sectoral planning and horizontal coordination to advance climate action are not fully aligned. The Framework Law on Climate Change requires all sectors to incorporate climate change mitigation and adaptation measures in their planning and budgeting, but only a few sectors had developed the required plans in practice (CENEPRED 2017). This implementation gap raises concerns about the feasibility of integrating climate policy into sectoral policies and remains one of the main challenges in a forestry sector characterized by weak alignment of policies with climate change efforts and a lack of real incentives to promote sustainable resource management. There are no real incentives to stop deforestation, promote standing forest management, or change the culture that promotes change of

[24] Ministerial Resolution N° 096–2021-MINAM (June 9, 2021). https://www.gob.pe/institucion/minam/noticias/499597-peru-ya-cuenta-con-su-plan-nacional-de-adaptacion-al-cambio-climatico-hacia-el-2050.

[25] The CANCC was approved in 2020 by Ministerial Decree 006/020, MINAM. https://sinia.minam.gob.pe/normas/decreto-supremo-que-crea-comision-multisectorial-caracter-permanente July 4, 2020

use. At the same time, the few incentives provided by the government to the private sector and local communities struggle to compete with the "extra forestry" incentives that continue to be focusing mainly on promoting more "productive" forest activities generally associated with agriculture, given that the economic benefits of sustainable forest management are not sufficiently recognized.

Vertical coordination between different government levels remains a challenge. The coordination and steering mechanisms to align regional government efforts with national objectives are limited, and only a few have the required capacity for implementation. Regional administrations have several tools for planning climate action and incorporating national climate objectives into development and territorial planning. However, coordination between national and regional levels of government is weak because keeps a strong sectoral and nonterritorial component.

Subnational governments have limited participation in disaster risk management (DRM), reducing their resilience and capacity to respond to climate shocks, and emergency responses usually fall to central authorities. At regional and local levels, presidents of regional government and mayors are the highest authorities responsible for DRM processes and actions within their respective areas of competence.[26] But only 13 regions (52 percent of the total), 28 provinces (14 percent) and 39 districts (2 percent) have a disaster prevention plans. As a result, central authorities tend to practice risk management outside of the legal DRM framework. For example, during the 2017 El Niño episode that caused one of the country's biggest natural disasters on record, the government declared a state of emergency in affected areas and formed a ministerial committee. Ministers of state supervised the safety of the affected populations, acting outside the DRM framework.

Improving vertical coordination and building capacity across all levels of government and using monitoring and evaluation results to inform improvements are priorities to increase resilience. Peru has a strong institutional framework for adaptation and resilience, with appropriate stakeholder involvement, but the lack of coordination and strong enforcement mechanisms, as well as significant capacity gaps at regional and local levels, are major obstacles to mainstreaming DRM and climate change policies in Peru. One consequence is institutional weakness and inefficiency, characterized by a low execution public investment rate (on average 60 percent in recent years), together with delays along the public investment management chain.[27] The National Center for the Assessment, Prevention and Reduction of Disaster Risks, *Centro Nacional de Estimación, Prevención y Reducción del Riesgo de Desastres* (CENEPRED) conducts a yearly survey on DRM policy implementation, but there is limited evidence on how their results are used in practice to address challenges and adjust actions and reviews of disaster-related expenses are only performed on an ad-hoc basis.

[26] In accordance with article 14 of Law N°. 29664.

[27] An ongoing World Bank study finds large delays at different stages of the public investment cycle: between approval of investment projects and preparation of technical specifications (735 days on average); between preparation and approval of technical dossiers (229 days); between bidding and procurement (299 days); and for overall project execution (536 days), with large differences between government levels and sectors.

2.2. Public financial management and climate finance

Peru is gradually coordinating climate policy with public financial instruments to make them environment- and climate-sensitive, but can do more. The Climate Change Law and the recently adopted Climate Emergency Declaration, *Declaración de Emergencia Climática*, both mandate the Ministry of Economy and Finance, *Ministerio de Economía y Finanzas* (MEF) to develop and incorporate climate-related provisions in the budget regulations and directives, and to monitor and report on climate financing based on the information generated by the government financial management information system, *Sistema Integrado de Administración Financiera* (SIAF). But, to date, only a few climate-related provisions have been issued, mostly related to the DRM agenda. The Vulnerability Reduction and Disaster Response budgetary program (PN 0068) is dedicated to finance DRM activities across sectors and levels of governments.

Peru has a set of tools and guidelines that seek to align public investment with climate and social objectives. Existing regulations establish the need to link risk management and adaptation in public investment, and to integrate climate objectives into the national environmental impact assessment system. MEF has also developed guidelines for green public investment projects,[28] which require public investments to consider current and future impacts of climate change, as well as both adaptation and mitigation measures. Other regulations also establish the need to link risk management and adaptation in public investment, and to integrate climate objectives into the national environmental impact assessment system. There are opportunities to improve these tools and explicitly incorporate climate policy in project prioritization, within the framework of the National Infrastructure Plan for Competitiveness. A stronger mechanism would provide information to the public how public investments perform with respect to policy objectives.

Peru is working on its climate finance strategy, but can take further actions and mobilize more resources to meet its investment needs. MINAM and MEF have led several efforts to develop instruments that allow resources to be channeled to the climate agenda, including:

1. Approving the Peru Sustainable Bond Framework, which connects financing to environmental and social objectives
2. Modifying the regulation of the law on Remuneration Mechanisms for Ecosystem Services, *Mecanismos de Retribución por Servicios Ecosistémicos* (MERESE) to promote the implementation of hydrological MERESEs to help close the gap of 4.1 million hectares of degraded ecosystems that require financing.
3. Developing the Operations Manual of the Green Climate Fund, prepared and published in October 2020 by MEF
4. Developing the Green Finance Roadmap,[29] which seeks to articulate public and private actors to incorporate environmental and climate aspects in the operations of Peruvian financial entities.

[28] The "Guidelines for the formulation of public investment projects in biological diversity and ecosystem services" were designed to implement Ministerial Resolution N°. 199–2015-MINAM.

[29] https://www.gob.pe/institucion/minam/noticias/343020-conoce-la-hoja-de-ruta-de-las-finanzas-verdes-en-nuestro-pais.

International funding for DRM efforts has also been regulated. The General Law on the National System of Indebtedness, *Ley de Endeudamiento del Sector Público*, allows the government to contract contingent loans to address major natural disasters. The country also has a contingency reserve for responding to emergencies and providing rehabilitation after a disaster, and a Fiscal Stabilization Fund, *Fondo de Estabilización Fiscal* (FEF), which can also be used in case of disasters.

Climate finance is a crucial tool to achieve medium- and long-term goals, as public spending does not cover the country's needs. Despite the progress seen in the institutional framework for green financing, several gaps still affect climate financing in Peru, including:

1. The dispersion of projects, themes, and resources allocated to green finance
2. A lack of homogeneity in the relational terms used, with different institutions referring to sustainable finance, green finance, climate finance, and so on
3. A lack of coordination and collaboration mechanisms to involve regulators, policy makers and private sector entities to agree and enforce related green finance regulations.

2.3. Accountability and access to climate information

Peru has developed emission inventories and shares information with the public, although access to climate information is limited. The Institutional arrangement for the elaboration of National Inventories of Greenhouse Gases (INFOCARBONO) contributes to the formulation of policies, strategies, and development plans to reduce emissions and to fulfill Peru's commitments under the United Nations Framework Convention on Climate Change. The country has prepared and presented two biennial update reports, which contain national GHG inventory updates (Ministerio del Ambiente 2014; 2019). Although MINAM has developed a Communication Strategy on Climate Change Challenges for 2019–25 (Ministerio del Ambiente 2021a) to raise awareness on these issues among the population, these efforts have yet to permeate all sectors and levels of government. Although there is broad legal recognition of the right to access environmental information, the lack of effective mechanisms for generating, managing, and disclosing information limits the exercise of this right.

Improving access to climate data will empower people and firms and increase community awareness. There has been good progress in assessing disaster risks and making the information available, but more can be done to ensure private actors have the climate-related information they need to make informed decisions. For example, nearly 90 percent of municipalities do not have local-scale hazard maps that are fundamental for land use planning. Having access to more granular information and improved access to climate data and tools would help producers and other value chain actors better understand changing climate conditions and adjust their farm management decisions accordingly and increase community awareness. Likewise, strengthening surveillance and traceability is important in the health and agriculture sectors to monitor and mitigate vector and disease spread.

Strengthening climate action oversight mechanisms can help the government deliver on its climate targets and policies. The Peruvian state's main external advisory space on climate matters is the CNCC, and Congress has created two committees to institutionalize the process of monitoring the government's climate policy commitments. But technical capacities are limited. To enhance the new committee's capacities to fulfill its functions and deliver on the many tasks included it its 2021–26 work plan,[30] it could develop specialized areas of expertise, establish mechanisms for interinstitutional coordination and automatic information and data exchange, and expand its internal analytical capacity by leveraging national and international expertise.

2.4. Private sector preparedness

Peruvian export companies will need to adapt to new international environmental regulations and clients' efforts to reduce carbon emissions in their supply chain. As high income countries establish climate-related requirements on imported products—such as the European Union's (EU's) Carbon Border Adjustment Mechanism (CBAM) and deforestation-free product (DFP) proposals—and private companies, such as supermarket chains, commit to reducing their carbon footprint, Peruvian firms will have to account for their production processes to comply with new trade requirements. Larger firms (especially those on the coast and those working in agriculture and fishing), are experienced in dealing with a range of quality demands, but a many small or medium companies will have challenges ahead.

Working closely with the private sector will help the government measure the country's carbon footprint as well as its progress on NDC implementation and other sustainable practices. Public companies are working on mitigation and adaptation efforts, and in February 2020, the Round Table on Climate Action, *Mesa de Acción Climática*,[31] started working with the private sector on carbon footprint measurement, creating an online platform, Carbon Footprint Peru, *Huella de Carbono Perú*,[32] to support this task. The table also promotes clean production and sustainability actions. Other government initiatives to engage the private and financial sector in NDCs fulfillment, include the 2019 roadmap for involving the private and finance sectors, *La Hoja de Ruta para el involucramiento del Sector Privado y Financiero en Nuestro Desafío Climático o NDC al 2030*,[33] and the 2021 Green Finance Roadmap, *La Hoja de Ruta de las Finanzas Verdes*.[34]

[30] https://www.congreso.gob.pe/comisiones2021/CE-seguimiento-cambio-climatico/sobrelacomision/plan-trabajo/.

[31] More information on the Climate Action Table is available https://www.gob.pe/institucion/minam/noticias/81265-viceministro-quijandria-el-estado-y-el-sector-privado-deben-embarcarse-en-la-misma-direccion-para-fortalecer-la-accion-climatica-del-peru

[32] https://huellacarbonoperu.minam.gob.pe/huellaperu/#/inicio.

[33] https://www.gob.pe/institucion/minam/informes-publicaciones/2458192-hoja-de-ruta-para-el-involucramiento-del-sector-privado-y-financiero-en-nuestro-desafio-climatico-o-ndc.

[34] https://www.gob.pe/institucion/minam/noticias/343020-conoce-la-hoja-de-ruta-de-las-finanzas-verdes-en-nuestro-pais.

3. Pathways toward resilience and decarbonization

Main messages

Peru has made good progress toward building resilience to natural disasters and future climate impacts, but gaps remain. Priorities include: improving the resilience of critical infrastructure and public services (mainly transport, health and water); advancing resilient urban planning; developing the insurance sector; and building a social protection system that can adapt to shocks.

Peru has the option to get to net zero emissions by 2050, by transforming the forestry sector into a carbon sink, using renewable energy for all new capacity in electricity generation, reducing emissions from agriculture, and completely transforming its transport sector. All these actions will require large investments but could generate even larger benefits.

3.1. Priorities to boost economywide resilience and adaptation

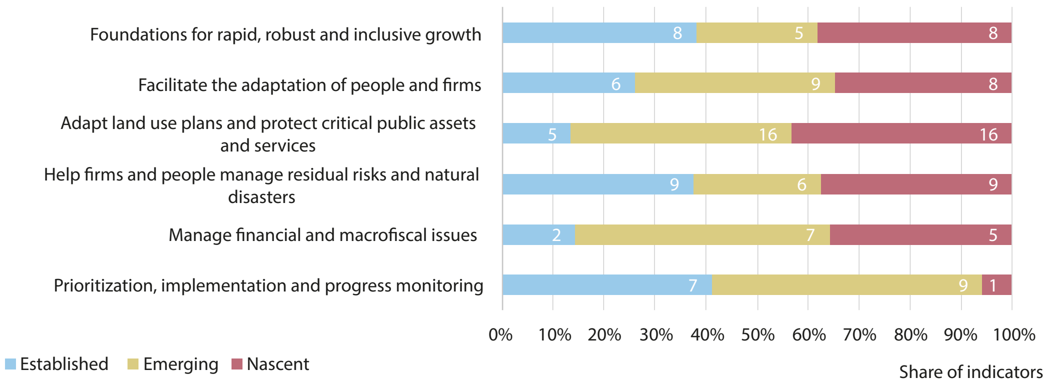
Identifying priorities to increase resilience and adaptation capacity forms a central piece in this Country Climate Development Report (CCDR). Its geographic, climatic, and socioeconomic conditions make Peru particularly vulnerable to disasters (chapter 1). To identify priorities for adaptation, this CCDR builds on the conceptual framework proposed by Hallegatte, Rentschler and Rozenberg (2020), organized around six pillars that reflect universal principles for effective climate change adaptation. Under each pillar lie several actions with indicators that are tailored toward Peru's priorities for adaptation.[35] The framework defines three maturity levels—nascent, emerging, and established—to measure progress, and classifies indicators according to preset criteria (for qualitative indicators) or using a benchmarking approach[36] (for quantitative indicators). Figure 3.1 provides a summary overview of the six main pillars of the framework and Peru's performance for each.

Note that this analysis includes geophysical risks in its resilience assessment. While earthquakes are not a climate hazard, most policies and measures to manage risks—from construction standards to disaster risk finance instruments—have to consider the full range of threats in their design.

[35] These include agriculture, health, transport, and water, as identified in Peru's National Climate Change Adaptation Strategy and Action Plan.

[36] For the benchmarking exercise, we chose comparator countries that have similar (Ecuador, Colombia and South Africa) or aspirational (Chile, Malaysia and Romania) hazard levels and socioeconomic characteristics, and the averages of typical country aggregates (Latin America and the Caribbean and upper-middle-income countries).

FIGURE 3.1. The state of adaptation and resilience in Peru



Sources: World Bank staff calculation, based on a combination of quantitative data, review of government, World Bank and other publicly available documents, and input from World Bank sector teams.
Note: The number in each bar indicates the number of indicators per category.

3.1.1. Facilitate the adaptation of people and firms

Private actors (firms and households) need government support to take actions to adapt to a changing climate. Private actors have an incentive to increase their resilience and adapt to climate change. However, they face a range of obstacles, from the lack of information and behavioral biases to imperfect markets and financial constraints. To facilitate adaptation by private actors, there are many actions that the government of Peru can take to provide the right information and financing instruments, and to facilitate structure change toward sectors with lower vulnerabilities.[37]

Addressing the factor and product market rigidities that hamper formalization is a priority to increase the resilience of the population. As we discussed in chapter 1, Peru's labor market is characterized by a relatively rigid regulatory environment,[38] which tends to foster informality (IFC 2022). According to Loayza and Wada (2010), 75 percent of the gap in labor informality levels between Peru and Chile is due to factors linked to poor governance, while the remaining 25 percent has to do with low productivity. The government could implement reforms to remove the barriers from labor and tax regulations that hamper formalization like promoting greater flexibility for job separation, facilitating temporary hiring (for example, seasonal agricultural workers), and extending its maximum duration, and unifying the tax regime for small and medium-sized enterprises (SME), facilitating transition to the general regime.

Facilitating structural economic change will help seize the opportunities of climate change and manage economic sectors that are in decline. Peru is not very well diversified for its income level,[39] and its export growth has been driven by minerals, while other sectors have not taken off. To facilitate structural transformation, it could identify sectors with high productivity that might benefit from the physical and transition impacts of climate change (discussed in chapter 4) and develop a strategy to maximize its benefits. To hedge against climate risk, it could develop a strategy to help sectors that are expected to be negatively affected by climate change, particularly those most affected, such as agriculture and fisheries.

[37] For more details on the progress made in adaptation, refer to (de Vries Robbé 2022).
[38] Peru's index of labor market rigidity is higher than in its neighbors, advanced economies, and other middle income regions.
[39] https://atlas.cid.harvard.edu/countries/173.

Solutions that support productivity growth and innovation and help farmers cope with shocks would allow the country adapt to changes in weather patterns and new pests and diseases. The agriculture sector is a cornerstone of Peru's economy, contributing 6 percent of GDP in 2021, 24 percent of exports and 27 percent of employment, but it is exposed and vulnerable to climate change (section 1.1.2). Estimates suggest an average projected productivity decline of 5 percent in 2050 (IFC 2022). Recognizing these risks, the Ministry of Agriculture developed a comprehensive national climate adaptation strategy for the agriculture sector,[40] which it has partially implemented. It also requires updating. Measures that would build resilience and maintain productivity include (but are not limited to):

» Developing an early warning system that produces and disseminates trend and forecast information on crop and livestock price information, weather and climate forecasts, and pests/diseases information (under construction but not fully operational)
» Expanding the agricultural insurance scheme, *Seguro Agrícola Catastrófico* (SAC)
» Investing in irrigation infrastructure, conservation of water recharge areas, water-efficient crop varieties and site-specific land-use planning to mitigate water scarcity
» Productive alliances—contractual arrangements that link smallholder associations to larger exporters—to promote stronger inclusion of smallholders in export value chains, minimizing the risk for both small producers and large firms, and maximizing value addition and productivity.

Going forward, using geospatial technologies and integrated territorial planning can help identify and strengthen the climate resilience of clusters and smallholder associations that can be linked to exporters (or more directly to consumers), leveraging public-private dialogues or productive alliance mechanisms.

Strengthening water resource management and investing in multipurpose water storage is crucial for adapting to changing rainfall patterns and can deliver significant productivity gains. With climate change, producers are confronting greater intra- and inter-annual variability in the distribution, quantity, and timing of precipitation. Drought has become more persistent and widespread and the capacity to manage scarce water resources is deficient. Particularly along the coast—where agriculture is the most productive and contributes the most to exports—investing in irrigation infrastructure, conservation of water recharge areas, water-efficient crop varieties, and site-specific land-use planning would improve water-use efficiency and resilience of agriculture systems. In the short run, measures such as multipurpose water storage, irrigation, nature-based solutions, and adaptive and flexible water allocation mechanisms could increase GDP. On its own, irrigation could increase GDP by 0.8 percent each year through productivity gains in the agriculture sector (World Bank 2022).

Sustainable construction represents another opportunity to adapt to climate change, reducing both operational costs and GHG emissions. Buildings are vulnerable to climate change-related events and might face a risk of severe damage or collapse when facing extreme climate events. Changes in weather could also lead to changes in energy demand, affecting heating and cooling expenses, with the net effect depending on whether the increase in cooling expenditures outweighs

[40] *Plan de Gestión de Riesgos y Adaptación al Cambio Climático en el Sector Agrario 2012–2021 (PLANGRACC-A).*

the decrease in heating expenditures, or vice versa (Clarke et al. 2018). Implementing passive design techniques, deep energy renovations, efficient technologies, and resilient structure design are vital for tackling the impact of extreme weather conditions, mitigating emissions, and adapting to climate change. Peru already has public policies in place to incentivize green construction practices[41] and there are examples of positive local experiences,[42] but scaling up the adoption of certification and financial and nonfinancial incentives would boost green buildings.

3.1.2. Adapt land use plans and protect critical public assets and services

The government has an important role to play in ensuring the adaptation of vital public assets and infrastructure systems, such as power systems, roads, water and sanitation, and essential services such as health care, education, and safety and security. Urban and territorial land use plans also influence massive private investments in housing and productive assets, so adapting these would evolve long-term climate risks and avoid locking people into high-risk areas (de Vries Robbé 2022).

Adopting a whole-of-a-government approach to manage and protect public assets will increase public infrastructure resilience and lead to more resilient growth. Despite progress in identifying critical vulnerable public assets and services, disruptions in power and water supply and transport persist and cost the economy 0.82 percent of GDP every year, mainly driven by transport disruptions (Hallegatte, Rentschler and Rozenberg 2019). Without action to adapt infrastructure systems, these costs are bound to rise. Necessary actions to future-proof Peru's critical assets and services include updating the National Infrastructure Plan[43] to cover the cost of increasing infrastructure resilience, and establishing a dedicated resilience agency and asset management system to track maintenance. Making infrastructure resilient by 2030 would increase required annual investments by 4 percent of baseline needs and reduce annual repair costs by a factor of 2.3 (figure 3.2). Based on known critical points[44] for climate adaptation action, the resilience of the road network can be increased in a targeted way, saving hundreds of millions of dollars to users every year (Rozenberg et al. 2017), improving rural connectivity, and contributing to more resilient growth.

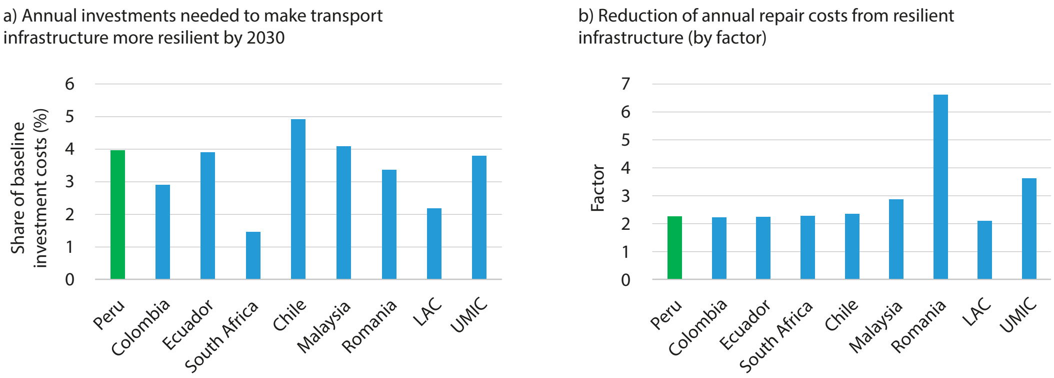
[41] Such as *Fondo mi Vivienda* (FMV) through the *Bono Verde* program.

[42] For example, in Lima's San Borja district, the municipality has incentivized green building construction by providing "height bonuses" that allow the construction of up to two additional levels in green buildings.

[43] https://www.mef.gob.pe/contenidos/inv_privada/planes/PNIC_2019.pdf.

[44] These are distributed around Carretera Central near Lima, Piura in the north, and a southern part of the Pan-American Highway.

FIGURE 3.2. Resilient infrastructure investment needs and cost-efficiency



Source: World Bank staff calculations, based on Hallegatte, Rentschler and Rozenberg 2019
Notes: Annual investment needs are compared to a situation without resilience considerations. LAC = Latin America and Caribbean; UMIC = upper-middle-income countries.

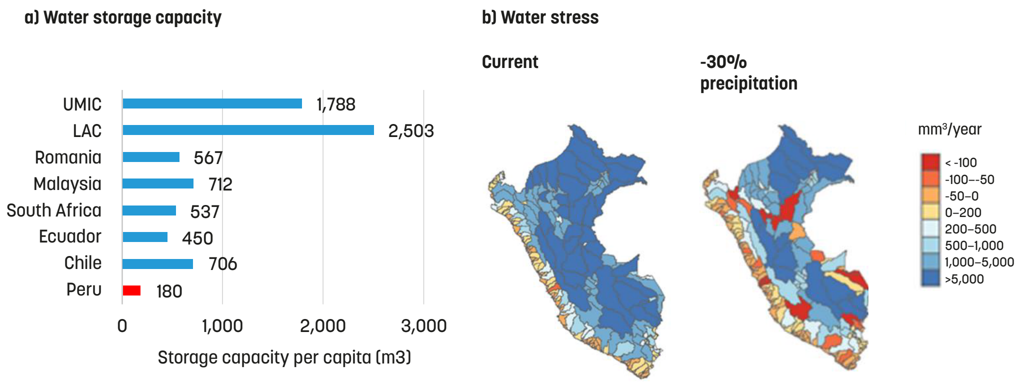
Strengthening the institutional and regulatory framework for urban and land use planning and building capacity to include disaster risk considerations in planning are necessary to enable resilient urban planning. A few key aspects that hinder resilient urban planning. First, while the recently enacted Sustainable Urban Development Law[45] mandates that DRM and climate should play an integral role in urban planning, there is no clear institutional and regulatory framework for planning. Second, the lack of laws or multisectoral policy on territorial organization hinders the involvement of, and coordination between, the different sectors and levels of government, as well as the provision of technical assistance to the municipalities. Third, there is a lack of clarity between the roles played by MINAM and the Presidency of the Council of Ministers. Existing regulations do not clarify how territorial organization relates to territorial conditioning and urban development, which are regulated by the Ministry of Housing, Construction and Sanitation, *Ministerio de Vivienda, Construcción y Saneamiento* (MVCS). Local governments oversee urban management, but they lack the data on housing and urban assets (such as an updated cadaster) and local hazards, human capacity, expertise, and financial resources they need to prepare the complex planning instruments required by law.

Strengthening water resource management and investing in multipurpose water storage and adaptive and flexible water allocation mechanisms will be crucial. Peru's water law, the *Ley de Recursos Hídricos*,[46] integrates the principles of integrated water resource management, but there are major implementation challenges (WWAP 2020). Strong water resource institutions and policies, reliable data and information for decision making, and adequate mechanisms for operating and maintaining strategic water infrastructure are vital to adapt to climate change impacts. Peru's water storage capacity is modest, at only 18 percent of the Latin American and Caribbean average (figure 3.3). Increasing its storage capacity (both surface and groundwater) and taking steps to foster a sustainable water culture would help Peru cope with future climate variability and extreme drought. It has already taken some promising steps, such as implementing demand-oriented approaches that

[45] Law N° 31313, 2021.
[46] Law N° 29338.

focus on incentives for reducing water use by changing people's habits, increasing efficiency, smart water management, and considering Indigenous and local knowledge for evaluating water scarcity and glacier lake outburst flood risks (Castellanos et al. 2022).

FIGURE 3.3. Water storage capacity and stress in Peru



Source: World Bank 2022
Notes: LAC = Latin America and the Caribbean; UMIC = upper middle-income countries.

With water scarcity and higher temperatures expected to increase the burden of disease, adapting the health sector to evolving needs would help it respond to sudden increases in demand for care. Simulations indicate that in the event of a magnitude 8 earthquake affecting Lima's metropolitan area, hospitals would be able to attend only 1–15 percent of the "golden hour" demand for care—that is, the trauma and emergency care that must be given within 60 minutes from the time of injury (GFDRR 2021). Health service delivery is already overwhelmed as the burden of disease has transitioned to chronic and noncommunicable diseases while infectious and maternal-infant conditions remain prevalent. Climate change is expected to increase the burden of disease (IPCC 2022), and the health sector will not be able to meet demand. On top of that, direct damage to infrastructure delays service delivery. Priorities for the health sector include improving capacity by increasing the share of doctors and nurses to the ratio advised by the World Health Organization (WHO),[47] training medical personnel, and enhancing emergency planning.

Adapting the road sector is crucial to support the government's priority of improving rural connectivity. Climate adaptation is a critical component to develop the rural road network and guarantee access to economic opportunities for people from poor rural areas, enhancing local markets and increasing trade. The type of intervention needed varies by region and road segment, but recent studies find that the most robust option along the Piura and Pan-American Highway clusters is to flood-proof critical roads by improving drainage capacity and performing frequent maintenance work to reduce disruption related to disasters. Upgrading an existing alternative road along the Carretera Central region is another robust climate adaptation strategy. Regarding natural disaster risk, it is important to continue developing a sectoral DRM plan.

[47] The WHO advises at least 2.5 doctors and nurses per 1,000 people; Peru has 1.7 doctors and 2.2 nurses (INEI 2019a).

Adapting roads to climate change calls for a life-cycle approach with a specific focus on asset maintenance and preservation. This approach includes:

- **Systems planning:** considering integration and redundancy of critical infrastructure to offer alternatives
- **Engineering and design:** using innovative materials and design specifications that enhance the robustness and flexibility of infrastructure
- **Asset management:** improving institutional and financial arrangements for infrastructure maintenance, integrating climate and disaster risk considerations when prioritizing new infrastructure, rehabilitation, and restoration investments
- **Contingency programming:** policy and institutional frameworks, communication protocols, investments in emergency preparedness and response, and alignment of transport systems and flows with local and regional evacuation, response, and recovery needs.

3.1.3. Help firms and people manage residual risks and climate change impacts

While effective risk mitigation can go a long way in reducing loss and damage, some natural shocks are too extreme and intense to be prevented. The government of Peru can develop strategies to ensure that when disasters occur, people and firms can cope without devastating long-term consequences, and can recover quickly (de Vries Robbé 2022).

Although Peru has strengthened its capacity to respond to emergencies, improving early warning systems could reduce vulnerability to climatic events. Effective climate services and an established DRM system have strengthened the country's capacity to respond to emergencies, but it could expand its early warning systems to include fires, droughts, torrential rain, and rising rivers, and to increase access rates, which are currently below 45 percent. The country has formal training programs for emergency response actors, but capacity to respond to events remains a problem.

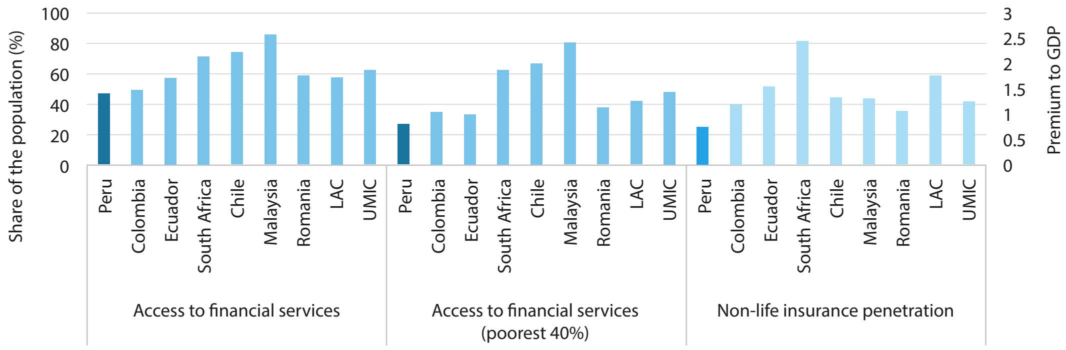
Increasing uptake of insurance and other financial instruments can improve firms' and households' capacity to manage residual risks and boost productivity.[48] However, uptake among households and firms is very low. Non-life insurance penetration is 0.76 percent, well below other countries (figure 3.4), and of the 18 active insurance companies in Peru, only five offer catastrophic insurance.[49] To increase uptake, developing the sector to supply affordable insurance is important. Although there have been efforts to establish subsidized agricultural insurance, penetration and geographical coverage remain limited. The SAC, a catastrophic insurance instrument that insures low-income growers (mostly subsistence farmers) against all relevant hazards,[50] covers only 8 of 25 regions and about 8.9 percent of small and medium-sized farmers on average (World Bank 2019a). Other instruments that help people cope with shocks—such as formal savings (8.4 percent of the population) and access to emergency borrowing—also have low coverage. When scaling up access to finance and insurance, it is important to develop instruments that are adequate for poor households and agriculture and forestry smallholders.

[48] One study shows that using insurance boosts agricultural producers' efficiency by 22 percent in the Selva region, and by 26 percent among subsistence farmers (World Bank 2017).

[49] https://www.sbs.gob.pe/.

[50] Implemented in 2009, the SAC's coverage is extended when farmers suffer a reduction of approximately 50% of expected yield.

FIGURE 3.4. Access to instruments to cope with shocks in Peru and peer countries



Source: World Bank staff calculations, based on data from World Development Indicators (accessed December 2021)
Notes: UMIC = upper-middle-income countries; LAC = Latin America and the Caribbean.

Peru's social protection system is progressive and could be leveraged for adaptation if improved to better respond to shocks. Its well-established system has advanced social assistance programs and delivery systems as well as solid financing arrangements, but these have traditionally been focused on rural areas and are not designed to adapt to natural disasters. Developing clear regulations, guidelines, and triggers would allow the social protection system to activate the expansion of benefits (greater coverage) before and/or during a crisis. Improving the interoperability of social protection and DRM data, increasing the coverage and capillarity of digital payments, and incorporating vulnerability criteria would allow they system to identify and support households in transitionary poverty, including economically vulnerable households that have suffered the consequences of a disaster and vulnerable groups such as refugees and displaced people. Incorporating lessons from past disasters would also help improve important components of the social protection system. For example, when leveraging the national social registry during the COVID-19 pandemic, around 20 percent of the data were outdated, especially among vulnerable urban populations.

3.1.4. Manage financial and macrofiscal issues

The impact of climate change on the economy will affect activity and tax revenues, and strong impacts on major sectors (especially exporting ones such as agriculture and fisheries) can affect Peru's trade balance and capital flows. The combination of these factors may result in new risks for macroeconomic stability, public finances, and debt sustainability, and the broader financial sector (de Vries Robbé 2022). This section gives an overview of Peru's management of macrofiscal and financial issues, while chapter 4 goes into more depth on some of these aspects.

Mainstreaming adaptation, resilience, and disaster risk financing in macrofiscal policies can help Peru anticipate and mitigate the long-term impacts of climate change. Peru has a layered financial protection strategy for natural disasters, the *Estrategia Integral de Protección Financiera ante el Riesgo de Desastres Asociados a Fenómenos Naturales*, in place since 2016, which consists of different risk retention instruments such as budget allocations, contingency reserves, a fiscal stabilization fund, and exclusive contingent credit lines, but its array of risk transfer instruments can be expanded to respond to different types of disasters. And although the country has clear institutional arrangements for public financial management during emergencies, it has yet to comprehensively assess the physical risks to the country's fiscal sustainability and public finances. To date, it has only done so for the agriculture sector, estimating them at 30.8 percent of the sector's tax revenue.[51] Expanding risk transfer instruments and quantifying risks to fiscal sustainability can contribute to anticipating and mitigating the long-term macroeconomic impacts of physical risks.

The credit portfolio of banks in Peru is significantly exposed to physical risks, and around 23 percent of the credit portfolio is tilted toward transition-sensitive industries. Physical risks are derived from the impact of climate change on the incidence and severity of natural disasters—including floods (coastal and inland), droughts, landslides, and wildfires—which can lead to economic costs and financial losses affecting the stability of the financial system. An analysis of provincial-level credit portfolio data from December 2021 with data from Thinkhazard![52] reveals that 15 percent of Peru's total credit portfolio is concentrated in provinces with exposure to inland flooding, 12 percent is in provinces exposed to coastal flooding, 6.2 percent in provinces exposed to landslides, and 3.8 percent in provinces exposed to droughts, with the severity of these risks varying by exposure risk level (table 3.1). Previous large-scale natural disasters in Peru have induced a deterioration in banks asset quality: damage caused by the flood of the 2017 El Niño event led to a cumulative increase of around one percentage point of nonperforming loans three fiscal quarters after its occurrence, and around three percentage points in the most affected sectors.[53] The banking sector is also vulnerable to a disorderly adjustment during the transition toward a greener, carbon-neutral economy. Overall, 22.9 percent of the credit portfolio of Peruvian banks is held by corporations that operate in sectors or industries that are intensive in carbon emissions and other polluting practices. The highest exposure is towards heavy industry, at 9.70 percent, followed by transport (6.2 percent), agriculture (4.2 percent), and energy generation (2.6 percent). To manage financial and macrofiscal issues, Peru can assess physical and transition risks to public finances and include them in fiscal planning and debt management. The government could also require banks, insurers, and large investors to systematically quantify and include risks in their business processes and portfolios.

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[51] MINAM calculations; physical risks included floods, El Niño, landslides, and frosts.

[52] https://www.thinkhazard.org/en/.

[53] These estimates are based on a difference-in-difference methodology that follows Calice and Miguel (2021).

TABLE 3.1. Potential exposure of Peru's banking sector to physical risks and their potential impact

Region	Flooding				Coastal flooding			Landslide			Drought	
	Very low	Low	Medium	High	Very low	Medium	High	Low	Medium	High	Very low	Low
Lima	10.90	0.03				0.04	10.85			4.24		2.29
Arequipa	0.52				0.02		0.03		0.33	0.01	0.17	
Ica	0.50					0.01	0.02			0.08	0.24	0.15
La Libertad	0.04	0.43					0.45		0.24	0.02	0.00	0.18
Piura	0.03	0.31	0.01				0.03	0.12	0.01	0.01	0.15	
Cusco	0.26	0.03	0.02					0.00	0.00	0.18	0.07	
Junin	0.21	0.05		0.02					0.03	0.12	0.04	0.04
Lambayeque	0.00	0.23					0.23		0.11		0.02	0.07
Cajamarca	0.15	0.07							0.01	0.06	0.06	0.01
Puno	0.01	0.08	0.08	0.01				0.09	0.01	0.00	0.04	
Other regions	0.66	0.07	0.05	0.26		0.11	0.11	0.11	0.13	0.27	0.20	0.04
All Regions	13.29	1.28	0.17	0.30	0.02	0.16	11.71	0.33	0.86	4.99	0.99	2.79
	15.04				**11.89**			**6.18**			**3.78**	

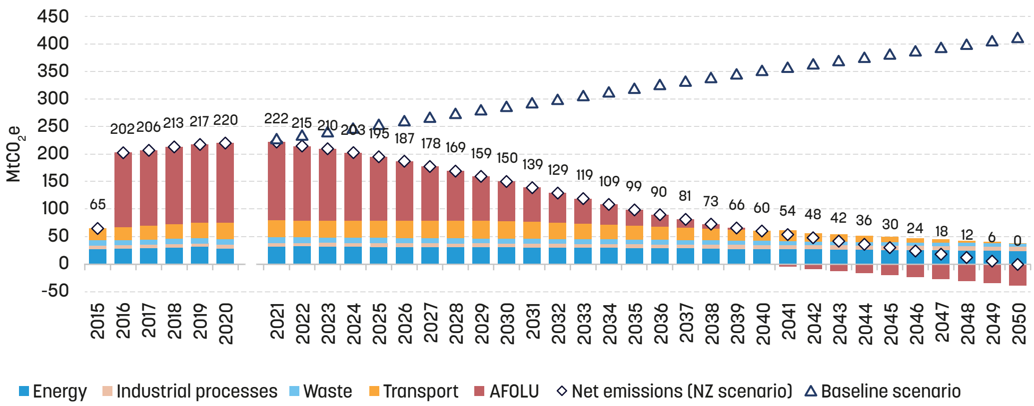
Source: World Bank staff calculations, based on Calice and Miguel 2021

3.2. GHG emissions, mitigation, and development goals

3.2.1. An illustrative pathway to long-term decarbonization

Peru's current NDC commitments are not enough to meet its commitments under the Paris Agreement, but the country is committed to achieving net zero CO_2 emissions by 2050. Peru still lacks a long-term strategy to fulfill its climate commitments, but this CCDR proposes a low carbon and resilient pathway based on the analysis carried out for the report, combined with a recent Inter-American Development Bank (IDB) study (IDB 2021).[54] To reach net zero, all sectors would have to undertake significant transformations, as described in figure 3.5 and table 3.2.

FIGURE 3.5. Emissions in Peru: from 2015 to a net zero scenario



Note: N = net zero

[54] Notice that costs are borne early (2021–25), while benefits kick in later.

TABLE 3.2. Sectoral transformations required to meet net zero by 2050

Sector	Transformation required	Emission reductions in 2050, compared to baseline
AFOLU	Almost complete ending of deforestation; escalating agroforestry, silviculture systems, and forest plantations; substituting rice cultivation; decreasing red meat consumption	282 $MtCO_2e$, equivalent to a 116% reduction (net carbon sink)
Transport	Total electrification of the vehicle fleet; small increase in the use of public transit; modal shift to nonmotorized vehicles; movement to remote working	76 $MtCO_2e$, equivalent to a 100% reduction
Energy	Almost complete transition to renewables by 2050 (90% of grid), supported by smart grid technologies and increased energy efficiency	46 $MtCO_2e$, equivalent to a 65% reduction
Waste	Decreased volume of solid waste through separation and recycling; increased treatment of wastewater and industrial runoff	8 $MtCO_2e$, equivalent to a 57% reduction
Industrial processes	Move away from certain cement production practices	1 $MtCO_2e$, equivalent to a 57% reduction

Source: World Bank staff calculations, based on data from IDB (2021)

The illustrative decarbonization strategy outlined in this CCDR would yield positive net benefits, especially for the transport and AFOLU sectors.[55] Achieving net zero CO_2 emissions by 2050 would yield net benefits for Peru,[56] largely due to decarbonizing the transport and AFOLU sectors, with 66 and 21 percent of net benefits, respectively. Decarbonizing the transport sector would yield the highest net benefit, reducing operative and maintenance costs, providing health co-benefits, increasing productivity, and reducing road accidents. Decarbonizing the transport sector would yield $135 billion in net benefits[57] and reduce emissions by 76 $MtCO_2e$ compared to the business-as-usual scenario in 2050. Decarbonizing the AFOLU sector would yield $42 billion in net benefits,[58] due to income from the sale of wood products and ecosystem services, and would capture 38 $MtCO_2e$ in 2025 (compared to emitting 145 $MtCO_2e$ in 2020). Decarbonizing transport and electricity generation would also positively impact competitiveness in the mining sector (box 3.1).

55 Net benefits are highest for transport and AFOLU, with a wider range of uncertainty in transport.

56 Costs and benefits consider the 2021–50 period and have been discounted to 2021, using a discount rate of 6%.

57 Over the 2021–50 period, at a discount rate of 6%. Using an 8% discount rate (as in the original study) gives net benefits of $92 billion.

58 Using an 8% discount, net benefits in the AFOLU sector would be $29 billion.

Box 3.1. Green mining in Peru

The mining sector presents an opportunity to decarbonize and build trust with local communities. Peru is home to several of the world's largest mines, and is the second biggest producer of copper, silver, and zinc. Driven by increasing demand for low-carbon energy and transport, the global value of metal production is likely to rise more than fourfold from 2021 to 2040, rivaling the global value of crude oil production. The copper market could see a deficit of 1.5 million to 9.9 million mega tonnes by 2035 depending on the supply scenario (S&P Global Market Intelligence 2022). Another study finds that copper prices could increase 60 percent in the next decade (Boer, Pescatori and Stuermer 2021)a. To take advantage of this opportunity and become a cornerstone of Peru's green growth, the mining sector can act on three pillars:

- **Energy:** renewable energy projects to power the mines and decarbonized transport
- **Water:** although it consumes a small fraction of water resources, the sector's contribution to water pollution is an issue to address
- **A social license to operate:** multiple large-scale projects remain undeveloped due to community conflicts, while a recent analysis (Ballon and Cuesta 2022) finds that departments that receive higher royalties from mining draw greater multidimensional exclusion than other departments, mostly due to a lack of empowerment, voice and accountability.

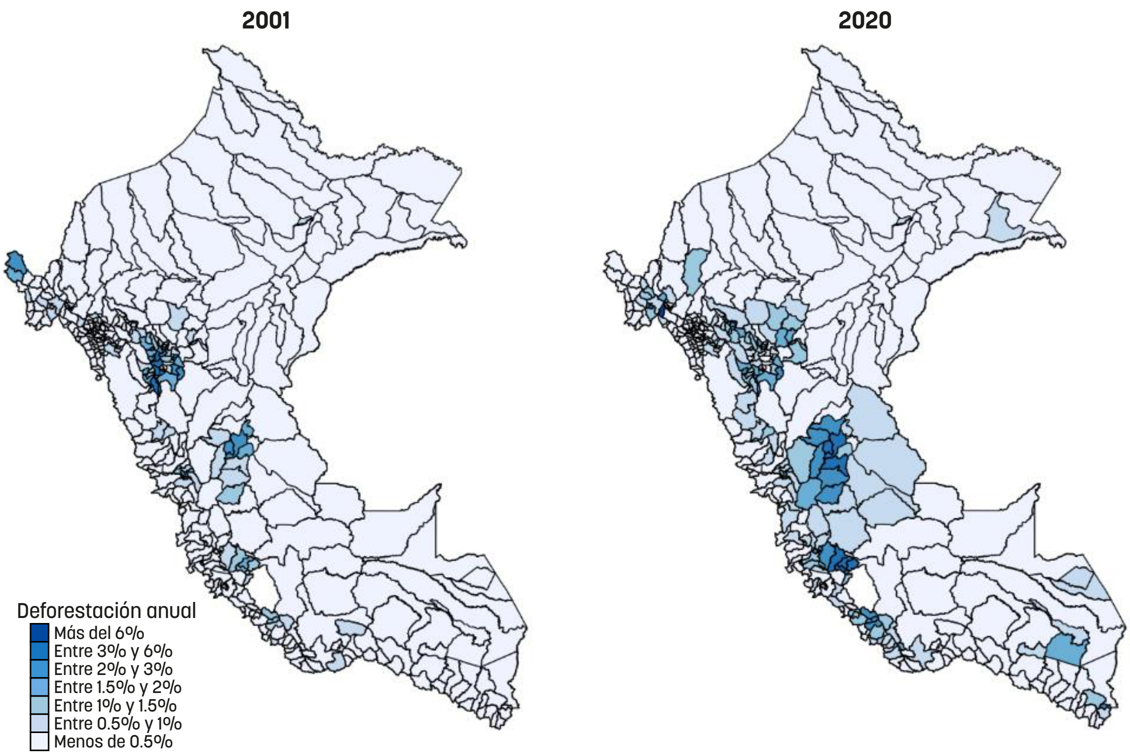
Mining companies operating in Peru are taking initiatives to decarbonize their operations through renewable energy. Mining is energy- and transport-intensive, and markets increasingly scrutinize the global mining value chain with an eye for decarbonization. Companies operating in Peru are reaching power purchase agreements for renewable energy supply for the operating mines in a similar way as neighboring countries such as Chile have done. Another area to address is reducing emissions from freight transport, the sector's largest source of emissions.

[a] See chapter 4 for more discussion on Peru's comparative advantage in green mining.

3.2.2. Forests and landscapes: eliminating deforestation[59]

The Peruvian Amazon covers 57 percent of the country's territory, expanding over 68 million hectares, but forests are disappearing at alarming rates. Between 2001 and 2020, 2.6 million hectares were deforested, reaching 203,000 hectares in 2020, the highest level in the last 20 years and equaling one hectare lost every three minutes. There are concerns that the Amazon region may be approaching a tipping point (Dourojeanni 2020; Bastos Lima et al. 2021). Deforestation has been concentrated in the northwestern and central-western regions of the Amazon Region (figure 3.6) in areas with uncategorized land use (Ministerio del Ambiente 2020). Crops grown in these regions are rice, corn, coffee, and cocoa (with the latter two expanding), but there is also a high incidence of illegal coca crops, concentrated mainly in the valley of the Apurímac, Ene and Mantaro rivers, and surrounding areas. Since 2003, deforestation has also increased in some southeastern districts, mainly driven by (illegal) mining activities.

FIGURE 3.6. Deforestation rates by district, 2001 and 2020



Source: World Bank staff calculations, based on data from GEOBOSQUES 2021
Note: Deforestation is measured as share of forest cover loss.

Crops and livestock are the main drivers of deforestation, representing 90 percent of the total deforested forest cover. Amazonian soil is not directly suitable for agriculture, and unsustainable farming practices, caused by a lack of human and financial capital, degrade the soil, forcing farmers to encroach into forests in search of new, productive soils (IDB 2021; De La Torre Ugarte et al. 2021). Institutional weaknesses—mainly expressed in the prevalence of informal and illegal activities, the

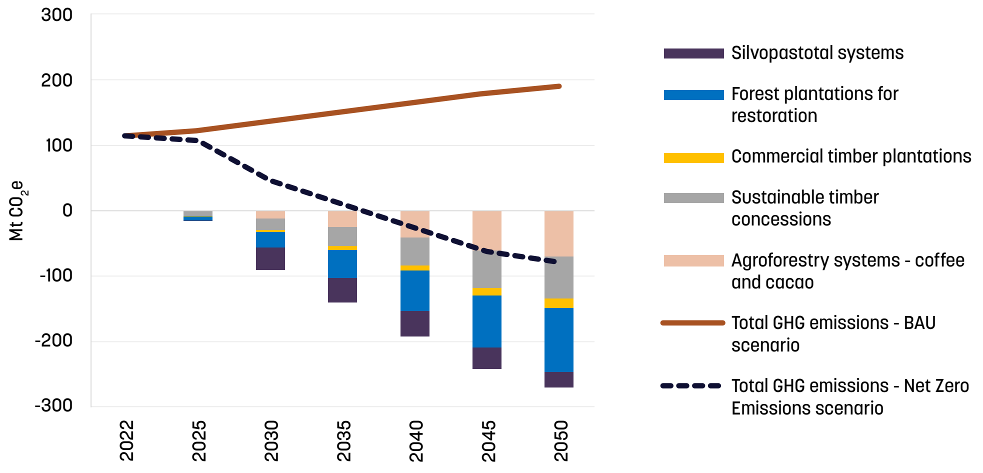
[59] For a more detailed analysis of the forestry and agroforestry assessment, see De La Torre and Heros (2022). A more detailed analysis of the forestry and agroforestry assessment is available in the forestry background note (De La Torre and Heros 2022).

absence of an integrated planning system, and a transport system that promotes deforestation—alongside a general lack of awareness of the potential value of forest goods and services, are additional enablers of deforestation (Muñoz 2015).

Deforestation patterns are a threat to reducing emissions, biodiversity, and ecosystem services, and current gains contribute little to development. At the current pace, deforestation would lead to a significant increase in GHG emissions. In a BAU scenario, AFOLU sector emissions would reach 200 $MtCO_2e$ by 2050. Current economic use of the forest contributes little to economic development; the extractive forestry sector contributed 0.15 percent to GDP in 2019 (SERFOR 2021). Peru therefore faces two challenges: first, how to generate economic growth and social development through the sustainable forest landscape use, and second, how to operationalize its development objectives and climate commitments into instruments that induce private and public investments to work consistently in the same direction.

The proposed net zero CO_2 emissions scenario reverses the deforestation trend and turns the forest into a carbon sink. This CCDR proposes seven interventions to reverse deforestation, increase the value of forestry operations, and ensure the sector becomes a net carbon sink (table 3.2). The proposed measures make standing forests more attractive than converting the land to agricultural use. Implementing them would have a substantial impact on deforestation, reversing the historical trend from about 200,000 to almost 15,000 hectares by 2050. This is mainly driven by a significant reduction in deforestation from agriculture and grazing due to increased productivity in these sectors. Reducing deforestation reduces emissions by 266 $MtCO_2e$ by 2050, allowing the forest to become a net carbon sink that would sequester 74 $MtCO_2e$ by 2050 (figure 3.7).[60]

FIGURE 3.7. GHG emissions from the Peruvian Amazon, in BAU and net zero CO_2 emissions scenarios

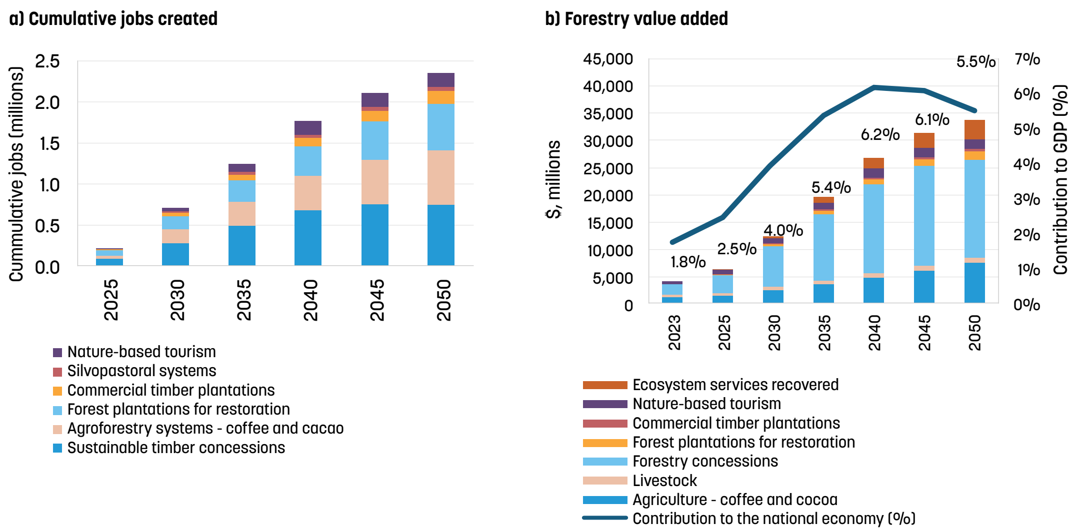


Sources: World Bank staff calculations, based on IBD 2021

[60] The forest deep dive (De La Torre and Heros 2022) includes a second scenario, named the *moderated ambition scenario*, based on the same interventions but with less ambitious targets.

Moving to a zero-carbon forest sector could generate jobs, bring $3.5 billion in benefits from recovered ecosystem services, and increase the sector's value-added seven times by 2050. Interventions in the sustainable pathway could generate 85,000 new jobs every year by 2050 (figure 3.8a). And because completing the rights allocation in uncategorized forests will be a strong element of reducing the expansion of economic activities into forests, these are expected to be largely formal jobs. The proposed interventions increase productivity of crops and livestock and enhance the forest value chain, while participating in modest carbon markets generates revenue opportunities for indigenous communities. This increases the sector's contribution to the economy by seven times and raises its (real term) GDP contribution from 1.9 percent in 2023 to 5.5 percent in 2050 (figure 3.8b). Allowing for the recovering ecosystem services, new forest plantations would also contribute $3.5 billion in ecosystem services by 2050.

FIGURE 3.8. Jobs created and value added in the forestry sector, under a sustainable growth scenario



Sources: World Bank staff calculations, based on data from: (a) IDB 2021; SERFOR 2021; INEI 2021; and (b) IBD 2021; 2019 Input-Output Matrix

Achieving this land use sector shift will require a total investment of $6 billion and a set of enabling conditions at institutional level. These include allocating use and/or property rights to protect the forest and promote private investment; developing extension services to improve the technical capacity of agricultural, livestock and forestry producers; undertaking research to develop quality seeds for timber plantations; developing logistics and transportation infrastructure that supports production processes and does not promote deforestation; financing adapted to the agents and activities of the region; and strengthening sustainable electricity supply. Sustainable timber concessions would produce the highest GDP contribution per dollar invested, while silvopastoral systems offer the highest reduction in emissions per dollar invested (table 3.3).

Payment for conservation is an alternative for low-income families, which monetizes recovered ecosystem services. This approach pays small-scale landowners to protect their land to ensure it continues to provide a service rendered by nature, such as clean water, habitat for wildlife, or carbon storage. It also encourages people to maintain natural ecosystems through environmentally friendly practices that avoid damage to other natural resource users. This can be done by placing bonds in the carbon market or through payments made by the government. The Bosques Amazónicos (BAM) reforestation model in Ucayali has been internationally recognized as one of the most successful experiences in recovering degraded areas. To date, BAM has restored and fertilized 1,000 hectares of degraded pastures and soils, planting over 850,000 native trees and helping protect more than 24,000 hectares. BAM has successfully used sustainable bonds to expand its efforts.

TABLE 3.3. Proposed AFOLU interventions and their economic and environmental benefits

	Investment ($, millions)				Ratio			
	Total *2023–50*	Short-term *2023–30*	Medium-term *2031–40*	Long-term *2041–50*	GDP increase / investment	(GDP increase + ecosystem services recuperated)/ investment	Emissions reduction/ investment *tCO_2e * $*	Cumulated jobs / Investment *$, millions*
Agroforestry systems (coffee and cacao)	1,160	603	381	176	16.26	18.39	-0.76	574
Silvopastoral systems	57	30	19	9	1.64	39.66	-13.61	838
Sustainable timber concessions	1,595	385	714	496	56.68	58.36	-0.60	472
Commercial timber plantations	326	129	120	76	17.14	17.14	-0.57	479
Plantations for restoration proposes	2,500	1,300	820	380	0.80	1.56	-0.54	224
Rights allocation in uncategorized forest	350	321	25	3				
Nature-based tourism	n.a.	n.a.	n.a.	n.a.				
Total investment	**5,988**	**2,769**	**2,079**	**1,140**				

Sources: World Bank staff calculations, based on IBD 2021; SERFOR 2021; INEI 2021
Note: tCO_2e = tonnes of carbon dioxide equivalent

3.2.3. Agriculture: reducing emissions

Agriculture is the leading driver of deforestation but providing incentives to farmers to invest in sustainable intensification would reduce deforestation while increasing productivity. Smallholder farmers with low productivity rely on extensification strategies to increase production, encroaching into marginal areas in the Sierra region and leading to accelerated deforestation in the Selva region.[61] These trends can be reversed by promoting intensification and integrating smallholders and communal organizations from the Sierra and Selva regions into agriculture value chains in the Costa region. Investing in sustainable intensification would improve land tenure security and strengthen incentives to make productivity-enhancing investments with long-term payoffs. Exporters on the coast can source from farmers in the Sierra and Selva regions. Governments can leverage geospatial technologies and integrated territorial planning to identify smallholders with strong potential to participate in export value chains and improve their access to adequate infrastructure (such as irrigation and rural roads) and services, accelerating their access to technology, know-how, market intelligence, and climate-smart practices (IFC 2022).

[61] In the Selva region, for each 1 % increase in the share of informality in agriculture in a district, forest cover decreases 0.48%.

The agriculture sector also can implement measures to reduce emissions and reap net benefits while decarbonizing. The sector could reduce more than 12 $MtCO_2e$ in 2050, compared to the BAU, equivalent to 25 percent of total emissions reductions that year (IDB 2021). And although emissions would still grow in the net zero CO_2 emissions scenario, this would be at a slower pace than the BAU scenario. Lower capital requirements and lower operating costs would also lead to net negative costs from decarbonization compared to the BAU, with savings derived from a lower beef inventory. There would also be additional income from agriculture products due to changes in prices and productivity within the sector.

The agriculture sector can reduce emissions by changing irrigation practices, substituting fertilizers, managing pastures and through diet changes in the population. The scenario used in this CCDR and developed by (IDB 2021) uses the following measures:

- In rice production, replacing flood irrigation, characteristic of the Costa region, with an intermittent dry system, allowing for higher yields and decreasing methane emissions
- Implementing silvopastoral systems and rotating feed in the Amazon, increasing carbon sequestration and the weight of cattle by up to 20 percent, reducing emissions per kilogram of meat produced
- Promoting a change in the composition of carbohydrate consumption by replacing rice with less emission-intensive crops, such as tubers, cereals, grains, and legumes
- Changing meat consumption patterns, substituting red meat with pork. In the net zero CO_2 emissions scenario, per capita meat consumption is reduced by 4 percent by 2050.

3.2.4. Decarbonizing transport to reduce emissions

Decarbonizing transport is central to the success of Peru's NDC. Transport is the fastest-growing sector in terms of emissions. Increasing multimodality, improving freight transport efficiency, developing mass transit systems, and promoting nonmotorized transport (NMT) will help Peru meet its NDC targets, Strengthening the coordinating role of the Urban Transport Authority for Lima and Callao, *Autoridad del Transport Urbano* (ATU)'s coordinating role would enable it to effectively implement e-mobility, cycle logistics, and public transportation systems, while also tackling informal transport sources that may not implement low-carbon policies. A detailed assessment of the transport sector and the policies proposed is available in (Portabales Gonzalez et al. 2022).

The government of Peru is committed to decarbonizing the transport sector, but its reduction commitments are not enough to reach its NDCs targets. The Ministry of Transport and Communication, *Ministerio de Transportes y Comunicaciones* (MTC) proposes nine measures framed by three development challenges—sustainable transport, improvement of railway infrastructure, and energy efficiency in transport—which should reduce emissions by 1.08 $MtCO_2e$ by 2030. MINEM also proposes five mitigation measures for the sector framed by the energy efficiency development challenge, which would reduce emissions by 5.85 MtC02e by 2030 (Government of Peru 2018). Together, the MTC and MINEM measures would reduce emissions by 6.9 $MtCO_2e$ by 2030. This falls short of the government's commitment in its latest NDC that should translate to at least a reduction of emissions in the transport sector of 12.23 $MtCO_2e$ by 2030. Here, we propose another six additional mitigation measures that could reduce emissions to 8.72 $MtCO_2e$. These proposed measures represent a step toward achieving the government's goals, with feasible activities based on benchmark scenarios of countries of the region. But it requires more ambitious implementation program to fill the existing gap (of 3.51 $MtCO_2e$) and get a higher reduction.

Our analysis identifies six feasible, short- and medium-term policies (P1–6) that would help close the emission reduction gap in the transport sector (table 3.4). We selected these policies because of their feasibility by 2030, in terms of costs and environmental benefits, as a first step toward the net zero CO_2 emissions by 2050. We defined the design of scenarios and targets used in each policy with regional benchmarking and the ability to implement by 2030. For the freight sector, we propose three policies: reducing truck travel distance, improving cargo fuel efficiency, and shifting to cleaner modes of freight transport. Our four proposals in the urban context—expanding bus rapid transit (BRT) operations promoting NMT in six cities, implementing traffic management solutions, and promoting cycle logistics for urban freight and parcel delivery—would develop efficient and reliable urban mobility systems to guarantee sustainable cities, emphasizing their role in providing primary access to job and educational opportunities.

P1. Promote the development of 10 cargo service or truck centers: Developing these centers in key strategic points of the logistics network would help transport companies reduce the kilometers traveled per vehicle unit, better distribute goods, and avoid extra truck trips.[62] This would increase efficiency in goods distribution by road—a government priority and focal intervention point in past years. Annually, this policy would result in an average distance traveled per vehicle between 30 to 34,000 kilometers, reducing GHG emissions in relation to BAU by 0.11–0.57 $MtCO_2e$ by 2030.

P2. Expand the scrapping program to reduce the age of the cargo transport vehicle fleet: Reducing the number of vehicles that are more than 15 years old would improve emissions efficiency. Encouraging the renewal of the cargo transport fleet through economic incentives, scrapping programs for older vehicles, and offering financing for the purchase of vehicles by medium and small carriers would reduce diesel fuel consumption and GHG emissions. The MTC's proposal, in the NDC mitigation measures, is to scrap vehicles that can no longer circulate by law, those that are obsolete, and older public transportation units by 2030, reducing their numbers by 50, 70, and 100 percent, respectively. The resulting fleet renewals and lower fuel consumption would reduce emissions by 0.18 $MtCO_2e$ by 2030.

P3. Promote the intermodal exchange from land cargo to cabotage: The shift approach aims to encourage alternative modes of transport for freight, reducing the reliance on road freight. Peruvian geographical conditions (including more than 2,400 kilometers of coastline between Tacna and Tumbes) open the door to intermodal land and sea freight. Maritime cargo transportation is a viable alternative to quickly connect different regions of the country when road infrastructure services are interrupted due to natural disasters, blockades, and other events. To estimate the GHG emissions reduction this policy would create, we consider three scenarios, shifting 20, 40, and 60 percent, respectively, of the total tonnes currently transported via the Pan-American Highway to cabotage. Compared to BAU, implementing this policy would reduce GHGs by 0.02–0.07 $MtCO_2e$ by 2030, and 0.06–0.19 $MtCO_2e$ by 2050.

[62] Framed in the avoid-shift-improve approach to sustainability.

P4. Promote NMT in Lima and Callao and implement it in the main intermediate cities (Arequipa, Trujillo, Ica, Piura, and Cusco): Developing NMT infrastructure for short distances and to increase access to mass public transport systems is an essential part of an efficient public transport network. Expanding the NMT network in Lima and implementing one in the main intermediate cities—could reduce emissions by 0.27 $MtCO_2e$ by 2030 and 1.08 $MtCO_2e$ by 2050. The majority of the reduction comes from the development of the NMT infrastructure plan for Lima and Callao that considers a 1,383-kilometer bike network for 2041, creating a fully reachable city with safe infrastructure. This shifts the modal share for bikes from 0.39 percent in 2020 to 11.58 percent by 2050. A model developed to study this infrastructure plan estimates that in Lima metropolitan area, this project could reduce emissions by 0.64 $MtCO_2e$ for 2030 and 1.03 $MtCO_2e$ for 2050. This measure could be extrapolated to the country's main intermediate cities.

P5. Expand the BRT system in Lima and Callao and implement it in the main intermediate cities (Cusco, Ica, Arequipa, Trujillo, Piura): Expanding the BRT kilometers operating in Peru's major cities could help to significantly reduce emissions, improve accessibility, and reduce fuel consumption. A 400-kilometer BRT construction program could save 0.22 $MtCO_2e$ by 2030 and 0.69 $MtCO_2e$ by 2050. Transportation plans of six Peruvian cities, including Lima and Callao, aim to achieve a total of 130 kilometers of BRT operating by 2030, with reducing emissions by 0.22 $MtCO_2e$ a year. However, increasing this to 400 kilometers would triple Peru's emissions savings for 2030. The model developed for this study takes as a reference the emissions reduction achieved for the 10.2-kilometer extension of the Lima BRT, which estimates 0.18 $MtCO_2e$ on average per year (World Bank 2019b).

P6. Implement the last-mile freight system based on bikes in the Lima metropolitan area: Around 25 percent of urban transport GHG emissions are related to freight movement. With the emergence of new business models and the rise of e-commerce, cycle-logistics is an effective solution for achieving net zero CO_2 emissions in urban freight and parcel delivery. Policies related to incentives for buying cargo bikes and investing in necessary infrastructure consider that 25 percent of cargo motorcycle trips and 50 percent of light commercial truck trips could shift to cargo bikes in Lima metropolitan area (based on Wrighton and Reiter 2016). This could reduce emissions by up to 0.8 $MtCO_2e$ in 2030 and 3.6 $MtCO_2e$ in 2050.

Traffic management measures that discourage the use of private vehicles—such as vehicle restrictions, congestion charge and low-emission zones (LEZs)[63]—are also effective in reducing emissions in major urban centers. The World Bank is in the preparation stage of a traffic management project in Lima that represents an opportunity to implement high-impact measures. For example, in São Paulo, Brazil, a city with similar characteristics to Lima in terms of population and mobility,[64] a program including these measures would be expected to reduce up to 5.97 $MtCO_2e$ by 2030.

[63] *Vehicle restriction* is a forbidding circulation policy for vehicles according to their plate numbers. *Congestion charge* involves a cordon pricing system where vehicles are charged for entering these zones. *LEZs* are zones restricted to pollutant vehicles.

[64] Motorized mobility index for Lima is 12.1 millions of trips per day, and for São Paulo, 16.7 millions of trips per day. The average distance of each trip is 5.1 and 7.1 kilometers, respectively.

TABLE 3.4. Summary of additional recommendations to close emission reduction gap in transport sector

GHG reduction policies 2030	*Cost by 2050 $, billions*	Emission reductions by 2030 *$MtCO_2e$*	Emission reductions by 2050 *$MtCO_2e$*	Benefits by 2050 *$, billions*
1. Freight transport				
P1: Promote the development of 10 cargo service centers or truck centers	0.24	0.34	0.45	5.96
P2: Expand the scrapping program to reduce the age of the cargo transport vehicle fleet	0.21	0.18	0.50	1.67
P3: Promote the intermodal exchange from land cargo to cabotage	0.12	0.05	0.13	2.98
2. Urban context				
P4: Promote NMT in Lima and main intermediate cities (Cusco, Ica, Arequipa, Trujillo, Puno)	0.68	0.27	1.08	2.07
P5: Expand the BRT system in Lima and implement it in the main intermediate cities (Cusco, Ica, Arequipa, Trujillo, Piura)	0.55	0.22	0.69	3.76
3. Urban logistics				
P6: Implement the last-mile freight system based on bikes in the Lima metropolitan area	0.32	0.83	3.6	6.74
TOTAL	**2.12**	**1.89**	**6.45**	**23.18**

Source: World Bank staff calculations, based on data from Ministerio del Ambiente 2021b and Government of Peru 2018
Notes: Benefits include health co-benefits from reduced air pollution, reduced congestion, reduced road accidents, fuel savings and road maintenance savings. Present value, using a 6% discount rate.

In the long term, a net zero CO_2 emissions scenario to 2050 would require reducing emissions from the transport sector by 76 $MtCO_2e$ with respect to the BAU value by 2050. That would only be possible with aggressive vehicle electrification, densifying cities through transit-oriented development,[65] and adopting new habits such as digitalization and remote work (IDB 2021). The net zero CO_2 emissions scenario considers a modal shift away from private cars toward walking and cycling while also digitizing services and promoting teleworking to reduce passenger demand by 30 percent by 2050. Investing in infrastructure, densifying cities along transport corridors, and improving logistics would further reduce passenger demand by 15 percent and freight demand by 20 percent. An accelerated penetration of electrification in the medium term due to competitive prices for low-emissions vehicles across the board—private, public, passenger, and freight transport—would allow Peru to achieve zero emissions by 2050. But this process would require strong coordination between public authorities and private actors due to the estimated $64 billion investment required. These investments are related to modernizing the transportation fleet, improving infrastructure for both freight and passenger transport, and embracing electric technologies.

These proposed policies would be aligned with national development goals, significantly reducing externalities such as local air pollution, congestion, and road accidents. Air pollution is a major health issue in Peru, responsible for than 11,000 deaths each year (Global Burden of Disease Collaborative

[65] Transit-oriented development is an urban model that seeks to shift away from the unsustainable growth of cities dependent on private cars by building cities with amenities within walking distance of the primary means of public transport, promoting high density.

Network 2020)[66] and even impacting on labor productivity (Aragón, Miranda and Oliva 2017). Major transport corridors are also severely congested and have slower travel speeds and higher negative externalities such as productive time loss, more expensive vehicle operating costs, increased local and GHG pollutant emissions, and road safety issues. Congestion costs are estimated as 1.8 percent of GDP (Villar 2019), while road traffic injury and fatality costs are estimated as 4.5 percent of GDP. The proposed policies are estimated to bring $23 billion in potential economic benefits for 2022–50, by reducing externalities in air pollution, congestion, road accidents, road maintenance, and savings on fuel use. An ambitious net zero scenario to 2050 could bring even larger benefits, estimated at $135 billion by 2050.

3.2.5. Power: facilitating the energy transition and decarbonizing the system

Peru's power generation is dominated by hydropower and natural gas, but there is great potential to increase the share of renewable energy in the mix and facilitate the energy transition and overall decarbonization of the economy. In 2021, hydropower generation accounted for 56.7 percent of total electricity generated, followed by natural gas with 37.6 percent and 5.5 percent of nonconventional renewable energy sources (NCRE). Diesel and coal power generation accounted for only and 0.2 percent. But Peru is endowed with world-class hydro and solar resources and wind power potential. Its technical hydropower potential is about 70 gigawatts (GW), which could produce 400,000 gigawatt-hours (GWh) per year, 10 times 2015 consumption levels. Solar technical potential is 25 GW with daily irradiation over 5.5 kilowatt hours per square meter (kWh/m^2) in most coastal areas, and over 7 kWh/m^2 in the south, among the highest in the world. The estimated national wind power potential is 22.5 GW.

Although Peru was a regional leader in promoting renewable energy in the electricity sector through energy auctions more than a decade ago, integrating its national interconnected power system, the *Sistema Eléctrico Interconectado Nacional* (SEIN), has stalled. Four renewable energy auctions took place between 2009 and 2015 with a total capacity awarded of 1,305 megawatts (MW)—44 percent small hydro, 30 percent wind, 21 percent solar, and 5 percent biomass—in 66 projects. Although these auctions brought renewables to the market, they were more expensive than conventional energy, so the auction included a premium to be paid by regulated customers during the 20 years of the contract duration.[67] In the last five years, renewable energy plants have increased their capacity by 518 MW (4 percent of total installed capacity)—66 percent from solar and wind power plants, and 33 percent from small hydropower (with capacity < 20 MW).

Taking advantage of Peru's solar and wind potential could improve the performance and resilience of the power system, contribute to local economic growth, and help meet energy demand needs. Given the geographic distribution of Peru's solar and wind potential, investments in new renewable capacity could contribute to local economic growth in lagging regions, at least in the short run through infrastructure construction. Up to 2025, generation projects that are already committed or under construction need to increase efficient capacity by about 855 MW to meet expected demand (COES 2021). The electricity system operator, *Comité de Operación Económica del Sistema Interconectado Nacional* (COES) estimates that the country will need to increase generation capacity by 1,600 MW

[66] The population-weighted average of fine particulate matter (PM2.5) is above 30 µg/m^3 (IHME 2020), well above the 5 µg/m^3 limit proposed by the WHO. Air pollution is estimated to be the fifth highest health risk in Peru, causing more deaths and disabilities (combined) than dietary risks, alcohol use, unsafe sex, and tobacco consumption (Global Burden of Disease Collaborative Network 2020).

[67] It is estimated that the cost of renewable energy auctions to the regulated customers who bore the cost of the premium was about $1.7 billion over the 20 years of the contracts.

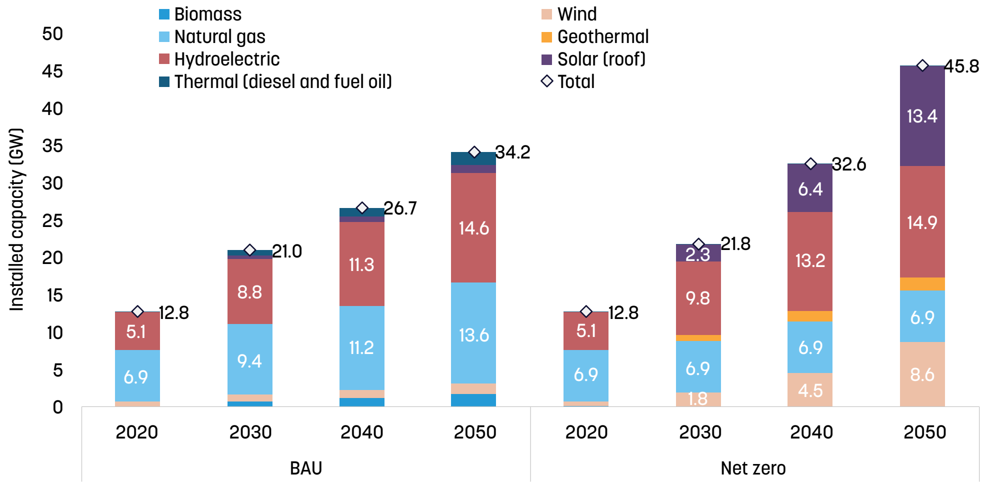
for a conservative demand growth during 2026–30, considering there is a generation deficit in the south. To meet this demand, Peru has developed 2,000 MW of thermal generation (natural gas/diesel), assuming that the gas pipeline from Camisea to the south would be constructed. But this has not been the case and short-term solution is now needed, and renewable energy could be a much cheaper and cleaner source than diesel-based generation. Investment lags by public distribution companies have also undermined the resilience of many electricity subtransmission systems to reliably meet demand and withstand the risks of natural climate shocks. As a result, polluting and costly diesel generators have been installed to avoid emergency situations and outages in various parts of the country and will be required elsewhere unless urgent distribution system investments are made by 2023, increasing GHG emissions and operating costs.

Considering Peru's energy potential, a prudent long-term energy policy up to 2050 could rest on the efficient use of the three main native energy sources: hydro, natural gas, and renewables. This includes: reorienting the development of hydroelectricity toward medium and small power plants (<50 MW), which would have relatively minor socioenvironmental impact and be easier to implement; have an orderly phase-out of natural gas infrastructure, based on their end-of-life decommissioning calendar, as combined cycle power plants are less than 10 years, techno-economically viable and adjusted to local demand; and developing renewable energy, mainly solar and wind and eventually, depending on costs, geothermal. The energy transition toward decarbonization can take advantage of the existing local conventional energy sources (hydropower and natural gas), which are flexible sources of electricity. They can act as an energy storage buffer to facilitate the rapid expansion of variable renewable electricity from local NCRE (solar and wind). The sustained drop in the costs of solar panels and wind turbines is increasing the competitiveness of nonconventional renewable electricity. If implemented efficiently, an expansion of wind and solar power can lead to lower electricity and health costs in the long term (especially if replacing diesel generators). This aligns with long-term economic development plans, under a framework of energy supply security and system resilience.

A power sector net zero emissions scenario (IDB 2021) identifies policy and investment priorities to decarbonize Peru's power system. Under this pathway, Peru's emissions will be 46 $MtCO_2e$ lower in 2050 compared to the BAU scenario. Both pathways are illustrated in figure 3.9 and assume the following:

- **BAU scenario:** annual 2.8 percent increases in current energy mix production to meet growing energy demand; relative increase in biomass and natural gas in 2050; relative decrease in hydro; limited development of renewable energy sources; development and operationalization of already committed power plants in national planning.
- **Net zero CO_2 emissions scenario:** phased increase of renewables to 90 percent of the energy mix in 2050; natural gas capacity remains constant at 6.9 GW; increase of energy efficiency (transmission, distribution, buildings) that translates into a relative reduction of energy demand; investments in smart grids and battery storage to facilitate electrification of important sectors, especially transport.

FIGURE 3.9. Peru's power system capacity in a BAU and net zero CO_2 emissions scenario



Source: IDB 2021

Under the net zero scenario, decarbonizing the energy sector requires an additional capital investment of $33 billion; it also yields $38 billion in net benefits,[68] increases installed capacity, contributes to the competitiveness of key sectors, and brings co-benefits. The main investment needs are for developing hydropower, nonconventional renewable plants, smart grids, and electricity infrastructure (transmission and distribution). With these investments, installed capacity increases by 11.6 GW compared to the BAU scenario. Reduced operating costs and health benefits outweigh required investments to decarbonize the energy sector and yield $6 billion in net benefits between 2021 and 2050. Investments in clean energy (renewables, distributed generation, energy efficiency, electromobility, smart grids, and green hydrogen development) would help build resilience in the sector by complementing hydroelectricity, displacing thermal generation, creating green jobs, and bringing economic development to areas outside of Lima. Other benefits for the most vulnerable citizens include better air quality, health benefits associated with the reduced burning of fossil fuels, and improved livelihoods.

Regulatory changes to integrate renewable energy more prominently into the power matrix would help decarbonize the economy. The country has committed to generating 15 percent of its energy from NCRE by 2030. Achieving this target and mobilizing the private sector—which has an important role to play given the liberalized market in the country—will require regulatory change in the wholesale market, transmission sector, and distribution and retail market. Most urgently, the government could go ahead with the changes it is considering in the electricity auction law. These include recognizing firm capacity for variable renewable energy beyond peak hours and changing instead to hourly, daily, or seasonal blocks that are better aligned with daily solar and wind power generation, as Colombia and Chile have done. Removing the requirement for energy supply to be linked to firm capacity would allow firms to contract energy and capacity separately.[69] Further investments in the transmission

[68] Values from IDB (2021), adjusted to use a 6% discount rate. Flows from 2021 to 2050.

[69] These changes in the electricity supply auctions for regulated customers would enable NCRE to participate in technology-neutral auctions. The increase in renewable intermittency will require regulation related with ancillary services to ensure the system is flexible and the power grid well balanced. for variable renewable energy beyond of peak hours (17.00–00.00); and (ii) change from peak and off-peak blocks to hourly blocks that are better aligned with daily solar and wind power generation, as Colombia and Chile have done..

system will also be needed to address congestion in the network and ensure delivery of electricity generated by the new renewable capacity in the south to other parts of the country.

This CCDR has identified the following priorities for the power sector:

1. **Implement a long-term energy planning process that involves co-optimizing electricity and gas sectors to ensure better coordination among energy subsectors.** Developing a comprehensive plan that synchronizes COES and Osinergmin's separate transmission and transmission investment plans[70] into a single transmission planning process will optimize electricity use and create opportunities for connecting clean energy sources.

2. **Allow public distribution companies to raise long-term debt to finance needed investments.** When substations and subtransmission lines face capacity constraints, they cannot transport electricity from the grid and distribution companies have to use on-site diesel generation, which is polluting and more costly. The higher cost is ultimately paid by end customers. Allowing public distribution companies to raise long-term debt would help overcome delays in investments that would increase capacity and mitigate emergency diesel generation.

3. **Enable NCRE suppliers to participate in technology-neutral electricity supply auctions by introducing hourly blocks and separating energy sales and capacity.** Given the overcapacity in the country's electricity system and the drop in NCRE costs globally, a logical step is to follow the example of neighboring countries such as Chile and Colombia and allow NCRE suppliers to compete in technology-neutral electricity auctions. Enabling hourly or seasonal blocks could help open space for NCRE to enter the electricity auctions, while separating energy supply and capacity would enable solar energy to compete in the electricity auctions (wind energy is already allowed). These reforms would increase NCRE competitiveness and bring new players into the regulated market.

4. **Separate distribution and retail to enable the participation of new players that offer new technologies, such as distributed energy resources, smart meter data management, storage capacity, and flexibility market maps.** The distribution activities framework currently includes retail sale of services and does not foster the development of new clean technological advances to the distribution grid. This includes, for example, being able to absorb solar rooftop energy or increase electric vehicle storage capacity at retail level. Separating distribution activities—such as wiring and cabling—from retail sales would encourage new players to enter the market and provide clean and more resilient distribution services.

5. **Regulate energy storage to provide flexibility in the power system.** Only generators can provide and withdraw from the system, and therefore they are the only ones who can provide storage services. Modifying regulation to allow new players to offer storage services and eventually create a storage market will help generate competitive conditions for storage. Thinking through storage, especially in the southern energy node that is likely to be developed with solar energy

[70] Osingermin is the supervising agency for investment in energy and mining. https://www.osinergmin.gob.pe/Paginas/en/what-is-osinergmin.html.

sources, will be important to ensure clean—rather than fossil fuel-powered—supply when solar is not available. Concentrated solar power, which produces and stores electricity, has significantly fallen in cost and could be an alternative to ensure security of clean supply.

3.2.6. Natural gas: rethinking residential mass gasification programs

Since the discovery of Camisea natural gas fields in the Cusco region, the consumption of natural gas has been rising steadily in Peru, from a daily average of 368 million cubic feet per day in 2010 to 604 in 2019. The Camisea fields are the country's largest natural gas fields, with proven reserves of 9.7 trillion cubic feet (95 percent of national proven reserves) as of 2019. Considering liquified natural gas (LNG) exports and domestic consumption, these reserves are expected to last about 30 years. Electricity generation consumes 63.4 percent of the gas, followed by the industrial sector (21.4 percent), the transport sector (11.6 percent), and the residential and commercial sectors (4.3 percent). During the COVID-19 pandemic, natural gas consumption dropped by 17.4 percent in 2020 compared to 2019, given the lower demand especially in electricity generation, which consumed hydropower more prominently. See Franco, Zolezzi and Pérez (2022) for more details about the gas sector in Peru.

Peru's natural gas industry is privately driven and, unlike other countries, its pricing system is decoupled from the international market, making it highly competitive with other energy sources, including renewables. Internal regulations consider differentiated prices for use in electricity generation, industry, transport, and the residential sector. In the short- to medium-term, natural gas could continue to have an important share of the power generation mix, given that many of the combined cycle power plants are less than 10 years old, and provide the necessary flexibility in the transition toward integrating more renewables.

Although natural gas infrastructure exists to supply electricity generators, the network does not extend throughout the country. Ten of the country's regions—Lima and Callao, Ica, Áncash, La Libertad, Lambayeque, Cajamarca, Arequipa, Moquegua, Tacna, and Piura—have natural gas supply. But only three are connected through natural gas pipelines; the rest connect through LNG trucks or "virtual pipelines". A lack of demand to make the natural gas pipelines profitable has been the main reason for such limited infrastructure investment.

The government's strategy includes increasing demand for natural gas in the residential sector. The cities of Lima, Callao and Ica had programs for expanding the distribution network expansion financed by the private sector with government support for the financing of residential connections through the Bonogas program.[71] This program is financed by the Energy Social Inclusion Fund, the *Fondo de Inclusión Social Energético* (FISE) and has been the government's main tool for increasing gas connections in the residential sector. In 2020, nearly 92,000 residential connections were made through Bonogas, accounting for 97 percent of total connections made that year. There are now about 1.4 million residential natural gas connections across the country, and these are expected to rise to around 2.6 million by 2025 in the regions that already have natural gas connections.

[71] Bonogas is a state contribution that finances new natural gas installations for users living in of medium, medium-low and low socioeconomic neighborhoods (according to INEI classification), covering 100, 75, or 50% of installation costs, depending on household's socioeconomic level.

The government supports a natural gas massification program, with the goal of reaching 3 million homes in 20 regions by 2032. According to the MINEM, a new natural gas massification program could expand to Puno, Cusco, Junín, Huancavelica, Ayacucho, Apurímac and Ucayali, connecting some 400,000 new households by 2032, for an estimated investment of $780 million. This is four times higher than the previous Seven Region Project,[72] which aimed to connect 114,000 users in eight years. The new natural gas massification project would be carried out under a special orders model (to state companies) and developed in three stages: Phase 1: Ayacucho and Ucayali,[73] from 2021; Phase 2: Cusco; and Phase 3: Huancavelica, Junín, Apurímac and Puno. FISE would partially finance the new gas distribution networks and promote natural gas massification in the north and south.

This new natural gas massification program represents a significant financing and management challenge and alternative technologies could be used in the residential sector. The implementation of previous natural gas promotion public policies has been slow, partly due to a delayed network expansion by natural gas distribution companies. Demand for gas consumption in the residential sector is low, as it is used mainly for cooking and heating water. Residential liquified petroleum gas (LPG) consumption (using 10-kilogram cylinders, on average) is subsidized, indirectly promoting LPG use and dissuading residential natural gas consumption. Given the global shift toward low-carbon technologies, the government could rethink the natural gas massification program and assess its cost-effectiveness against alternative technologies, such as electrifying the residential sector, powered by low-cost renewable electricity generation. It also needs to consider how to finance the new infrastructure, subsidy contributions, financial and tariff schemes, and the type of business management required for implementation.

3.2.7. Water and waste management: other mitigation opportunities

Although it only represents 3 percent of Peru's total GHG emissions, decarbonizing the waste sector—including disposal of solid waste on land, domestic and municipal wastewater treatment, and industrial effluents treatment—would have large benefits. The IDB's proposed decarbonization strategy is based on reducing the volume of solid waste through separation and recycling, and increasing the treatment of wastewater and industrial effluents (IDB 2021). By 2030, this could reduce waste emissions by 57 percent, at a negative net cost. When all benefits are considered, this is the sector with the highest net benefits per tCO_2e avoided, although the reductions would account only for 1.8 percent of cumulative GHG emission reductions in the country. The economic benefits of decarbonizing this sector arise from waste valorization, water recovery, and health benefits. The costs are due to waste collection, separation and recycling, and water treatment investments.

[72] Launched by Proinversión, this initiative aimed to provide natural gas to Sierra and Selva households through a combination of virtual and physical gas pipelines. According to Proinversión, none of the three qualified bidders—Cálidda, YPFB, and the NG Holding SAC (China Gezhouba Group Company Limited) Consortium—submitted an offer in the tender scheduled for June 2021. As a result, the MINEM has taken charge of the project.

[73] Both Ucayali and Ayacucho have gas pipelines that allow natural gas to be transported more economically than by virtual gas pipelines (tanker trucks). Ucayali also has its own natural gas reserves, exploited and marketed by Aguaytía Energy (Kallpa).

4. Macroeconomic costs, obstacles, and implications

Main messages

The case for climate change action in Peru is strong. Climate change is expected to have significant impact on Peru's economy, especially on the poor. And as the country's economy grows, its GHG emissions will also grow, putting its climate action commitments at risk.

The transition to a resilient and low-carbon economy presents challenges; but it also presents opportunities for the country to meet its development objectives and climate goals. Peru does not have to choose between climate action and economic growth. This CCDR identifies a range of climate change actions that support both climate adaptation and mitigation, and economic development.

Implementing the climate transformation will require mobilizing significant, but feasible, public and private sector financing. Increasing the efficiency of public investment and providing the right incentives for private sector investment will be key.

To encourage private investments into climate mitigation, a carbon tax can play a key role, complemented by other measures.

Peru has limited exposure to transition risks through exports and could benefit from decarbonization.

4.1. Short and long-term macroeconomic implications of climate change in Peru

Global climate change is projected to have significant macroeconomic implications for Peru and, without adaptation actions, could hold back economic development. To estimate the impact of climate change on the country's economy, this CCDR has developed a general equilibrium macroeconomic model of Peru, augmented with core climate change variables.[74] The lack of reliable data and estimates limits our assessment of the total impacts of climate change on Peru's GDP. But modeling estimates of the partial impacts of climate change on GDP—that is, more intense and frequent flood events, heat, and reduced average yields in agriculture and fisheries[75]—show that Peru could face cumulative losses close to $15 billion[76] by 2050.

[74] This model builds on the World Bank's MFMod framework (used to make the forecasts during the Spring and Annual meetings). The technical description of the framework can be found in Burns et al. (2019).

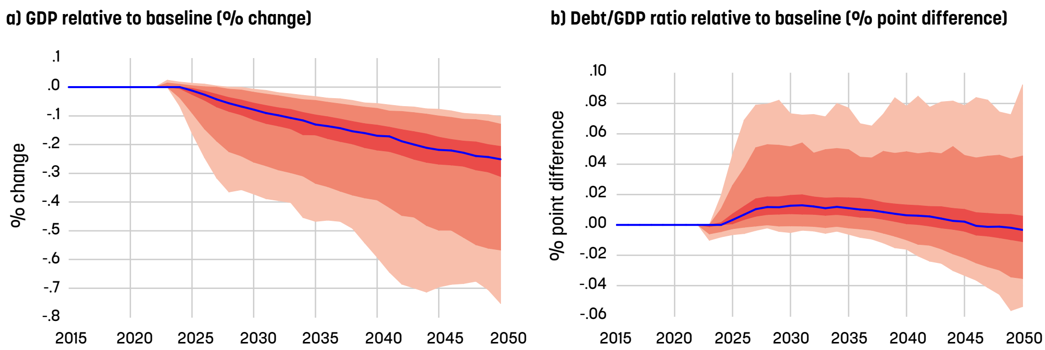
[75] These impacts, taken from BID and CEPAL (2014), only model the impact of average climate change on average yields and therefore miss the potentially bigger impacts of cumulated individual shocks.

[76] World Bank staff calculations using MFMod with climate change module, based on economic impacts data from BID and CEPAL (2014); flood impacts are estimated from historical exceedance probability curves estimated by World Bank GFDRR staff, based on climate change impacts from Hirabayashi et al. (2013; 2021); Daniell et al. (2011); Risklayer (n.d.). RCP8.5 scenario is used which is a worst-case scenario, where emissions continue to rise throughout the 21st century. A net present value with a 6 % discount rate between 2022 and 2050.

As highlighted in figure 4.1, in a BAU scenario in which global GHG emissions are not significantly cut and Peru does not take significant action to adapt to climate change, the estimated GDP loss due to these selected climate change impacts could reach close to 0.8 percent of annual GDP by 2050.

Natural hazards expose Peru to economic and welfare losses. Peru is highly exposed to earthquakes, landslides, droughts, and floods. The 2017 El Niño event damaged crops, roads, bridges, homes, schools, and health posts. Figure 4.1 shows the distribution of economic impacts that would result from damages caused by flooding and earthquake events relative to a baseline without these natural hazards. On average, floods and earthquakes destroy capital worth 0.1 percent of GDP every year. The lower capital stock subsequently results in lower levels of GDP and consumption, while debt-to-GDP ratio increases slightly as GDP falls. By 2050, the median loss in GDP reaches 0.25 percent. But the risk is skewed downward, and GDP loss could increase up to 0.75 percent. Adaptation investments—such as more resilient infrastructure systems and early warning systems—can protect against this downside risk, reducing the impact of the worst scenarios.

FIGURE 4.1. Economic impacts of damage from natural hazards

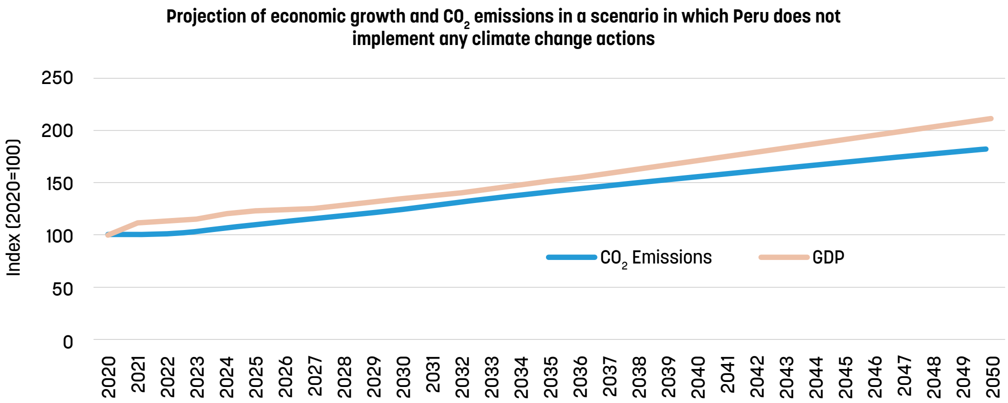


Source: MFMod using flood data from FATHOM
Notes: These panels display the results of a Monte Carlo analysis based on scenario runs with probabilistic draws of event intensities based on historical loss-exceedance curves. The fan charts show possible economic impacts compared to a baseline which is set as a counter-factual scenario without disasters. The blue line is the median outcome, and the progressively lighter red areas cover the scenarios between the 25th and 75th percentile, the 10th and 90th percentile, and the 5th and 95th, respectively.

In the absence of climate change mitigation action, Peru's development will significantly increase its contribution to global GG emissions until 2050. Growth will come with a significant increase in emissions, reflecting increased economic activity. According to the CCDR macroeconomic model, without climate mitigation actions, net emissions from the energy, transport and LULUCF sectors could increase by 83 percent over the next 30 years (figure 4.2). Another scenario by IDB (2021), suggests that emissions could grow 86 percent in the same period, from 220 $MtCO_2e$ in 2020 to 412 $MtCO_2e$ in 2050. In both scenarios, emissions are higher than Peru's NDC commitments,[77] despite emissions growth being lower than GDP growth in the same period (relative decoupling of emissions and GDP).

[77] Peru's NDC commits to total emissions not exceeding 202.8 $MtCO_2e$ by 2030, unconditionally, and not exceeding 179 $MtCO_2e$ by 2030, conditional on international support. The country has committed to reach net zero CO_2 emissions scenario by 2050.

FIGURE 4.2. Projected economic growth and CO_2 emissions in a BAU scenario (2020–50)



Source: World Bank staff calculations, using MFMod with climate change module
Note: GDP growth does not include climate impacts in the BAU scenario.

Peru's financial sector has significant exposure to climate change risks, making it a key transmission channel to the economy. Climate change poses physical and transition risks to Peru's financial sector. Physical risks are derived from the impact of climate change on the incidence and severity of natural hazards—including coastal and inland floods, droughts, landslides, and wildfires—which can lead to economic costs and financial losses that affect financial institutions. Transition risks are derived from the economic adjustment costs associated with the transition toward a greener, carbon-neutral economy and can materialize in credit exposures of financial institutions to carbon-intensive industries and other polluting sectors. Overall, 22.9 percent of the credit portfolio of Peruvian banks is held by corporations that operate in transition-sensitive industries. The highest exposure is related to heavy industry (9.7 percent), followed by transport (6.2 percent), agriculture (4.2 percent), and energy generation (2.6 percent).

Climate change risks setting back the fight for poverty, through impacts on economic development and household welfare. These will be unevenly distributed, exacerbating poverty and inequality. Poor people are more exposed to higher temperatures and river floods in urban areas. Half of Peruvian territory is exposed to recurring hazards and one-third of the population uses these exposed spaces. Moreover, an estimated 9 million people are exposed to heavy rain, floods, flash floods, and landslides, 7 million to low and very low temperatures, and 3.5 million to droughts (Bergmann et al. 2021).

Climate change will likely affect welfare in Peru via agricultural earnings and food prices. Forty percent of the poorest households' income comes from agricultural labor. Among the rural poor, this share rises to 45 percent (20 percent for urban poor). Across the bulk of the income distribution, households in Lima and the Costa provinces spend a greater fraction of consumption on food. In all regions, food burdens appear to increase among the near poor, though this may be due to systematic underestimation of food expenditure among the poor. These income and consumption concentrations signal widespread vulnerability to volatility in domestic and international food production systems.

Moderate simultaneous food price and agricultural earning shocks could increase poverty by nearly one percentage point by 2030. We find that a 2–5 percent food price increase for consumers in Lima and the Costa region, alongside a 2–5 percent decrease in per capita agricultural earnings for farmers in the Sierra and Selva regions (disconnected from international markets) could increase extreme poverty by nearly one percentage point, or over 300,000 individuals (Walsh et al. 2022). This is relative to business-as-usual forecasts of poverty incidence in 2030 and subject to associated uncertainties. In the best-case scenario, the same shocks could move 70,000 people into extreme poverty, depending on developments in the interim (Walsh et al. 2022). Vulnerabilities are not uniformly distributed among households as poverty in coastal and urban areas is more sensitive to food price increases than agricultural earnings shocks.[78] Climate resilience strategies in Peru can exploit regional differences like these to hedge against the largest threats to welfare in each location.

4.2. Transition abroad: limited risk and rising opportunities

Peru has limited exposure to transition risks through exports, and can develop green competitiveness and benefit from the shift toward a greener economy. With a growing number of countries making net zero emission pledges, global demand is beginning to shift away from fossil fuel-based production toward cleaner technologies and more environmentally friendly products. As new growth opportunities in green product markets open, cultivating competitiveness in these areas will help Peru achieve greater economic benefits from the transition to the green economy.

4.2.1. Low-carbon regulations abroad: impact on trade and competitiveness in Peru

Regulations abroad will have limited impact on Peru's exports. A ban on DFP products, as proposed by Europe and the United States,[79] would only affect around 1 percent of Peru's total exports. This is mainly in cocoa and coffee, where more than 60 and 50 percent are exposed (figure 4.3a), as the expansion of their cultivation of these two products is one of the main causes of deforestation in the Peruvian Amazon. The CBAM proposed under a European regulation[80] would also have limited impact, since trade on the regulated products with the EU is minimal (figure 4.3b). However, the EU could expand the CBAM to products on the Product Environmental Footprint (PEF)and EU Emissions Trading System (ETS) carbon leakage lists, including minerals, agriculture products, and textiles. This would increase the impact to almost 6 percent of Peru's exports, with raw metals and metal products being most at risk.

[78] For more details, see Walsh et al. (2022).

[79] The EU published its Proposal for a regulation on deforestation-free products (EU-DFP) in November 2021. The United States introduced the Fostering Overseas Rule of Law and Environmentally Sound Trade Act of 2021 (FOREST Act, S. 2950 and H. R. 5508) bill to the Senate in June 2021 and to the House of Representatives in August 2021.

[80] In July 2021, the European Commission proposed the CBAM to attach carbon leakage risk, replacing the EU-ETS free emissions distribution. In the same month, a similar bill—the Fair, Affordable, Innovative and Resilient Transition and Competition Act (FAIR Transition and Competition Act, S.2378)— was introduced to the United States Congress. Both policies charge importers for the carbon content of some highly mobile and high-emitting industrial sectors, net of carbon taxes already paid in their home country, to avoid carbon leakage.

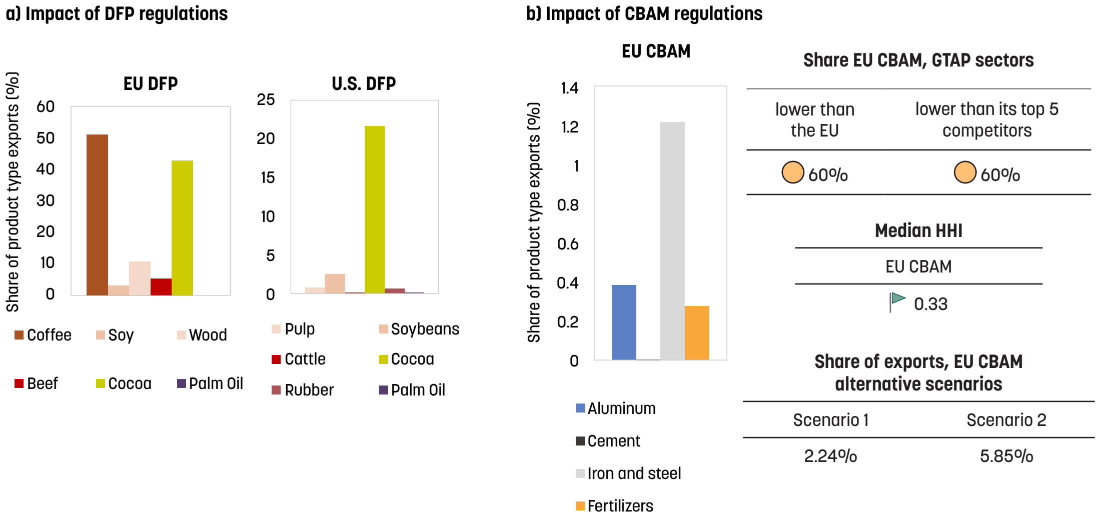
Box 4.1. Vulnerability to climate shocks

Poor people always lose more, relative to their income or wealth, when affected by climate shocks for two main reasons. First, they do not save in financial institutions, instead holding most of their wealth in housing or livestock, and second, the quality of these assets is often lower than average. So, sociodemographic characteristics are useful to predict who will be most affected by a natural hazard. In this analysis, we combine district-level data on housing and living standards from the 2017 population census with extreme temperature and precipitations data from the National Service of Meteorology and Hydrology (SENAMHI)'s climate stations for 2016 to: identify: (i) the districts with the highest percentage of households that are vulnerable to climate shocks and (ii) whether the districts most exposed to climate shocks are also the poorer districts, according to the 2018 poverty map.

Dwellings in the most exposed districts lack access to decent housing and adequate sanitation facilities. We find that only 10.2 percent of houses in the 90 frost-prone districts (where the temperature falls below 0°C for at least half of the year) are built with high-quality materials, such as concrete and bricks. In the 573 most heat-prone districts (where the temperature rises above 28°C for at least half of the year), that proportion amounts to only 32.7 percent. Homes with poorly insulated roofs and walls are likely to reach extreme temperatures inside, exacerbating vulnerability to heat- and frost-related illnesses. In districts exposed to extreme heat, nearly half of all households have no access to piped water and improved sanitation facilities, greatly reducing people's ability to mitigate heat stress. Finally, in the 432 districts exposed to heavy precipitation (where annual rainfall rises above 750 millimeters), only 30.6 percent of homes have access to improved sanitation facilities and 16.8 percent are built with concrete or brick.

The districts that are most exposed to frost and heavy rainfall also register higher rates of poverty. In the frost-prone districts, 37.5 percent of the population is poor (above the national average of 34 percent). In those exposed to extreme heat, poverty amounts to 26.5 percent (below the national average, but quite still high) and, in districts exposed to heavy precipitation, 37 percent of the population is poor.

FIGURE 4.3. Trade exposed to regulations abroad



Source: World Bank staff calculations, based on World Integrated Trade Solutions data for 2019 (https://wits.worldbank.org/) and GTAP 11 Data Base (https://www.gtap.agecon.purdue.edu/databases/v11/index.aspx, accessed August 25, 2022)

Notes: HHI = Herfindhal-Hirschman Index (for measuring market concentration). *Emissions intensity calculations* include Scope 1 emissions under GTAP11. The *EU CBAM base scenario* includes aluminum, cement, fertilizers, iron and steel, and electricity; *Scenario 1* includes sectors with installations within the EU ETS; *Scenario 2* includes additional goods under EU-PEF. DFP regulations cover six agricultural sectors: palm oil, soy, cocoa, cattle/beef, and wood, which are common to both the EU and U.S. proposals, with coffee in the EU and rubber in the United States.

4.2.2. Global and domestic low-carbon transitions: economic opportunities for Peru

Peru's existing competitiveness in green products and participation in green value chains are limited. Its exports are concentrated in low-complexity products, mainly related to minerals. Environmental goods (EG) trade in Peru is premature, representing only 0.74 percent of total merchandise trade. The country ranks 160th in the Green Complexity Index (GCI),[81] falling from the 138th in 1995–99. Similarly, it scores 0.07 out of 3.5 in the International Monetary Fund's Comparative Advantage in Low Carbon Technology Products Indicator, effectively ranking among the world's worst performing countries.[82] In Latin America and the Caribbean, Peru's environmental goods (EG) exports ranked 8th in 2020, below Colombia and significantly behind Mexico and Brazil. The United States is the main export destination and supplier of EG goods to Peru, accounting for a quarter of Peru's EG exports and imports.

But there are some green products where Peru is competitive, largely relating to solid waste treatment or recycling and environmental measuring instruments. These products have registered the highest compound annual growth rates over the last four years, with export volumes for grinding machines used in solid waste treatment or recycling; survey instruments; hydrographic, oceanographic, hydrological, meteorological or geophysical instruments; and appliances for measuring ozone layers or natural disasters growing between 38 and 95 percent from 2016 to 2020.[83] More complex products—such as waste incinerator, vacuum pump or air or gas compressor parts—are also strategic bets, which involve higher risks in developing competitiveness but could generate economic rewards if successful.

[81] The GCI tracks countries' capacity to competitively export products that are green (have environmental benefits) and complex (involve more technologically sophisticated capabilities).

[82] International Monetary Fund, Climate Change Indicators Dashboard: Peru, https://climatedata.imf.org/.

[83] WITS. 2022. "Data on Export, Import, Tariff, NTM." https://wits.worldbank.org/

The clean trade regulatory landscape is favorable, although the green product industry could benefit from more open markets for services trade. Peru imposes almost zero tariffs and a relatively small number of non-tariff measures on environmental goods. But its regulatory framework for environmental services is generally restrictive. Peru's Organisation of Economic Co-operation and Development (OECD) Services Trade Restrictiveness Index score is slightly lower than the OECD average (OECD 2020). Considering that environmental services are critical for environmental goods usage and functionality, Peru could benefit from further liberalizing services such as information and communications technology, engineering, architecture, construction, legal services, accounting services, waste management services, and environmental consulting services, which provide environmental services (Sauvage and Timiliotis 2017).

EU demand for organic agricultural exports could increase and Peru has competitive advantages in the sector. Studies show that the EU "Farm to Fork" Strategy—a key component of the Green Deal through the pursuit of quantified environmental targets and related targets—will result in reduced agricultural production in Europe (Dekeyser and Woolfrey 2021; Beckman et al. 2020; Fellmann et al. 2018). European agricultural imports are expected to increase, and exports to decline. Lower European agricultural production could stimulate increased agricultural production elsewhere, shifting production to Africa, Asia, and Latin America. Peru has a competitive advantage in the agriculture because, it has restricted genetically modified or engineered crops and foods.[84] It is also gaining a higher comparative advantage in the production of maize, bananas, and other crops, buoyed by climate change shocks.

The energy transition will boost the demand for Peru's minerals, including copper, nickel, cobalt, and lithium. Global demand for minerals has been growing due to increased demand for construction and infrastructure, and the energy transition will boost demand further. The low-carbon energy strategies envisioned across the world for environmental goods to realize climate change adaptation and mitigation will depend on critical raw material inputs for clean energy and technologies. For example, an electric car requires five times as much of these metals than a conventional car. It is estimated that the total value of metal production will rise more than fourfold between 2021 and 2040, rivaling the total value of crude oil production. Cobalt, lithium, and nickel prices are projected to rise several hundred percent from 2020 average levels in a net zero CO_2 emissions scenario (Aguilar 2022).

Higher copper demand and prices represent a significant opportunity for Peru, the world's second largest producer, especially if it can expand copper production. Its mining portfolio has 46 projects totaling more than $56 billion, a figure that could increase further. There is, however, a challenging mix of complicated permissions and community conflicts; addressing these would allow the sector to fulfil its potential. Peru could also benefit from creating new higher-value byproducts in the mining and hydrocarbon sectors, particularly those that are critical for the global green transition, such as copper, lead, molybdenum, silver, and zinc, as well as decarbonized natural gas.

[84] Between 2013 and 2018, World Trade Organization members raised trade concerns regarding Peruvian technical regulations in relation to: the 2012 Implementing Regulations for the Moratorium on Planting Genetically Engineered Crops, and the Draft Supreme Decree Approving the Regulations Governing the Labelling 120 of Genetically Modified Foods (Peru WTO Trade Policy Review – WTO Secretariat 2019, page 80).

4.3. Comprehensive policy action to enable structural transformation to a greener and more resilient economy

With a fundamental transformation of its economy, Peru can rise to the climate change challenge. Beyond sectoral interventions, economywide incentives that increase the cost of inaction and lower the cost of action could encourage the private sector to act. Deeper public finance reform would ensure the resilience of the government budget. This CCDR details a multilayer fiscal response to climate change covering spending, revenue, and appropriate financing tools and contingencies.

4.3.1. Investment needs and public spending efficiency

A net zero resilient pathway for Peru would require substantial public and private sector investments by 2030, as well as maintaining existing strong macrofiscal foundations. Priority actions to reduce GHG emissions and adapt to climate change were described in detailed in chapter 3 and accompanying additional investment needs are summarized in table 4.1. Priorities include combining land use and transport planning, improving water and transport asset management and maintenance, reforming the power sector, increasing land tenure security to reduce deforestation, developing and implementing green and resilient building regulations, and improving early warning systems for water resource management. Figure 4.4 shows the breakdown of private/public sector investment needs, with 55 percent of the proposed reforms—including, for example, vehicle electrification—carried out by the private sector. The public sector would play a predominant role in water storage investments. Box 4.2 explains the quantification of costs and benefits of investments.

Although public investment needs for climate action are high in terms of additional annual infrastructure expenditure, over time, they would bring significant benefits beyond climate change. The government's annual spending on climate change has been below $300 million for the past decade (MEF 2022). Public Investment on infrastructure, on the other hand, has averaged $5.4 billion over the past five years,[85] and total public investment $10.6 billion.[86] Additional public investment needs displayed in table 4.1 would average $3.3 billion per year, but benefits would be high (box 4.2).[87] Big ticket items are in the transport, energy and water sectors (figures 4.4. and 4.5a), and include decarbonizing transport through electrification, increasing renewables in the electricity and energy mix, improving water supply and sanitation, and developing smart grids, energy storage solutions, and fast recharging infrastructure for electric mobility. Agriculture and fishing, on the other hand, require relatively smaller investments. Notably, the forestry sector reforms—including developing silvopastoral systems, sustainable forest concessions, commercial forest plantations, and restoring forest plantations, are notably the ones that contribute most to emissions reductions by 2030 and provide the lowest average cost per reduced tonne of emissions (figure 4.5b).

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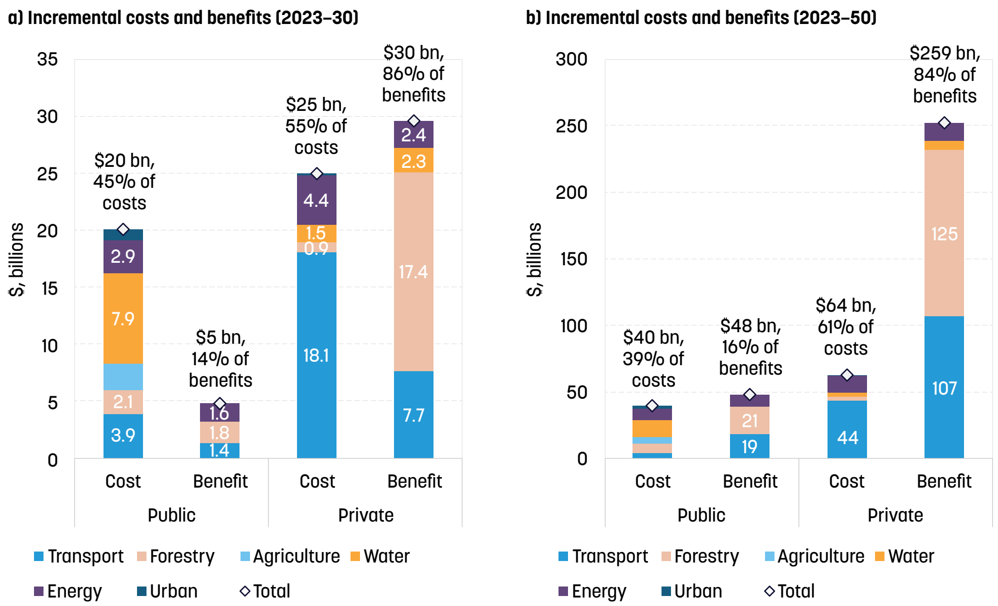
[85] Infralatam. 2021. "Data on Public Investment in Economic Infrastructure in Latin America and the Caribbean." January 29, 2021. http://infralatam.info/en/home/.

[86] National fiscal accounts.

[87] In this CCDR, we have prioritized additional investment needs to address climate change needs, rather than alongside other necessary development objectives and critical investments that would address the country's structural challenges. Dealing with the broader structural challenges that increase vulnerability to climate change—such as inequality and informality—will also be costly, and is already part of the development agenda. Considering these objectives together will help Peru prioritize reform and spending. This could be the scope of a public expenditure review.

FIGURE 4.4. Net present value (NPV) of total investment needs and benefits, by sector and investment type



Source: World Bank staff calculations, based on data from IDB 2021
Notes: Discount rate 6%; benefits in transport and energy correspond to operational expenditure savings, in forestry, to value added of production and in water, to efficiency improvements and damage reduction from droughts and flooding.

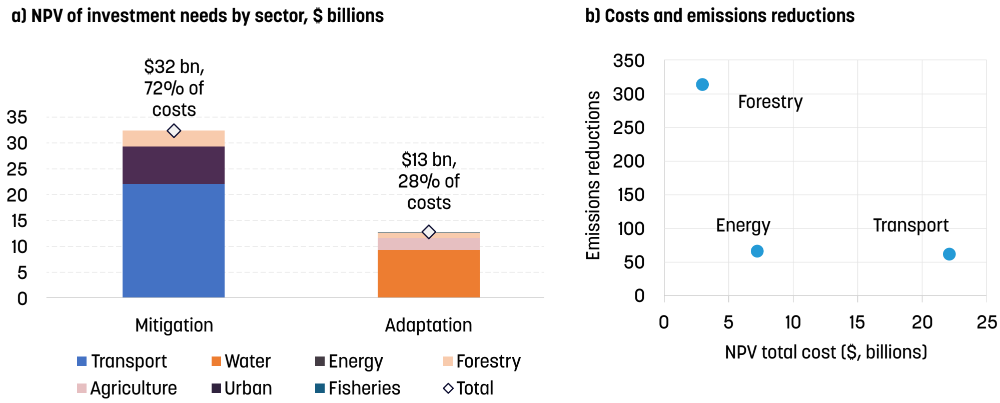
TABLE 4.1. Peru's adaptation and mitigation investment needs by 2030 and 2050

Sector/action	Emissions reductions by 2030	Adaptation benefits	Annual cost	Cost	Benefits and GDP impacts	Cost	Benefits (included in MFMod)	Co-benefits (not included in MFMod)
				2023–30		2023–50		
	$MtCO_2e$		*% GDP*	*$, billions*				
Total	118.3		3.8	45.2	34.6	103.9	307.3	
Transport: Develop truck centers, expand scrapping program, promote intermodal exchange from land cargo to cabotage, non-motorized transport in Lima and intermediate cities, expanding the bus rapid transit system, last-mile freight system based on bikes for Lima. Decarbonization scenario of the sector through electrification and habits change	14.8	++	2.4	22.1	9[a]	49.4	125.9[a]	36.97[d]
Forestry: Develop agroforestry systems and sustainable forest concessions; restore forest plantations, silvopastoral systems, and commercial forest plantations	90	+	0.19	3	19.25[b]	7.4	145.59[b]	
Agriculture: Pest management, resistant genetic resources, agricultural risk transfer systems, crop and livestock diversification, cultivated pasture conservation, soil erosion management and control technologies, soil fertilization	+	++	0.15	2.3		4.9		

Sector/action	Emissions reductions by 2030	Adaptation benefits	Annual cost	Cost	Benefits and GDP impacts	Cost	Benefits (included in MFMod)	Co-benefits (not included in MFMod)
				2023–30		2023–50		
	$MtCO_2e$		*% GDP*	*$, billions*				
Water: Water supply and sanitation, multipurpose water storage and support technified irrigation, drainage systems	0.02	++	0.41	9.39	2.32[c]	15.8	13.7[c]	
Fishing: Adapt landing sites for artisanal fishing, strengthen early warning systems, aquaculture management	+	++	0.001	0.01		0.01		
Energy: Increased renewables in the electricity and energy matrix, smart grids, storage and fast recharging infrastructure for electric mobility, limiting additional fossil-fueled capacity, reduced energy consumption in productive sectors	13.5	++	0.60	7.25	4a	23.9	22.15[a]	9.01[e]
Urban: Land use planning and sustainable urban development	+	+	0.07	1.1		2.4		

Source: World Bank staff estimates, based on sector analyses presented in chapter 3.
Note: Costs are NPV, discount rate 6%; ++ = large positive impact; + = small positive impact; a = reduced operational expenditure; b = forestry value added of production; c = water efficiency management, reduced droughts and flooding damage (conservative estimates); d = reduction in accidents, increased productivity, improved health and congestion; e = health benefits.

FIGURE 4.5. Investment needs and emission reductions (2023–30)

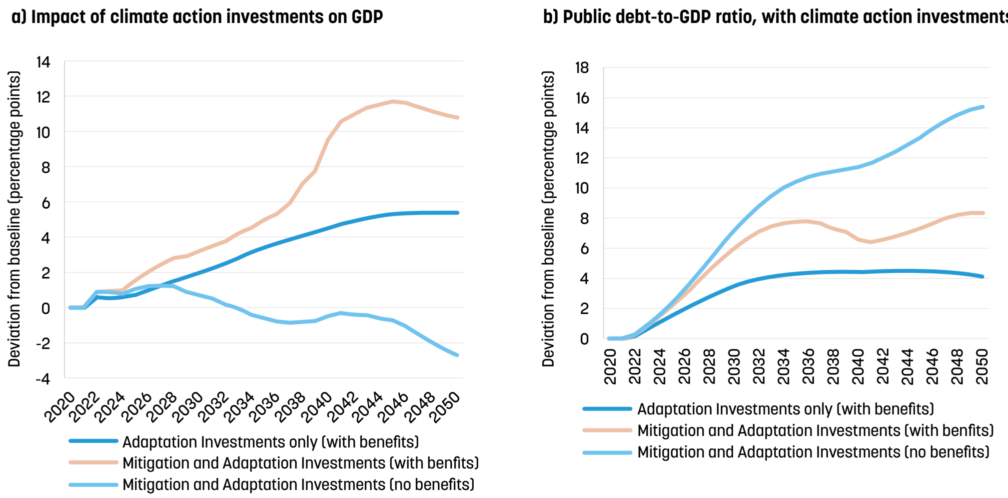


Source: World Bank staff calculations, based on data from IDB 2021

Financing investment needs in mitigation and adaptation will have an economic cost but also bring economic benefits. The main mechanism that impacts GDP negatively is that fewer resources go to accumulating physical capital (if it is more expensive than in BAU) and fewer resources are

available for conventional productive investments,[88] causing GDP to decline (figure 4.6a, light blue line).[89] As shown in table 4.1, the main adaptation investment needs or costs are in the water sector; for mitigation, they are in energy and transport. After adding on the estimated benefits, we find they outweigh the costs, turning the net impact positive (figure 4.6a, dark blue line).[90] If we consider the costs and benefits of both mitigation and adaptation, GDP could be up to 10 percent higher compared to the BAU scenario, by 2050 (figure 4.6a, orange line). The main benefits from adaptation investments come from the water sector, driven by: the increase in human capital productivity; water efficiency management, which increases productivity in agriculture, mining, and industry; and avoiding damage from drought and floods. Apart from reducing emissions, mitigation investments bring benefits that result mostly from reduced operational expenditures in the transport sector due to savings on fuel use (box 4.2) and in the energy sector. Investments would also bring a significant boost to forestry output, driven by the increase in wood extraction, manufacturing of wood products, and higher coffee and cocoa productivity due to agroforestry systems.[91] While implementing these investments will increase debt over the long run, it also increases growth over time, so the net impact on the debt-to-GDP ratio is negligible (figure 4.6b).

FIGURE 4.6. The GDP impacts of mitigation and adaptation investments



Source: World Bank staff calculations using MFMod, with climate change module based on data from sectoral teams
Note: This scenario assumes all additional investments are debt-financed.

Peru will need to design a financing strategy for climate-related investments. Some of the investments proposed in table 4.1. are "conventional" investments that have climate benefits (for example, water supply and sanitation, public transportation) and could be funded and financed through conventional instruments. These could be prioritized by the government over other conventional

[88] Either directly, because other investments are delayed, or indirectly, because domestic borrowing displaces financing available for conventional investments.

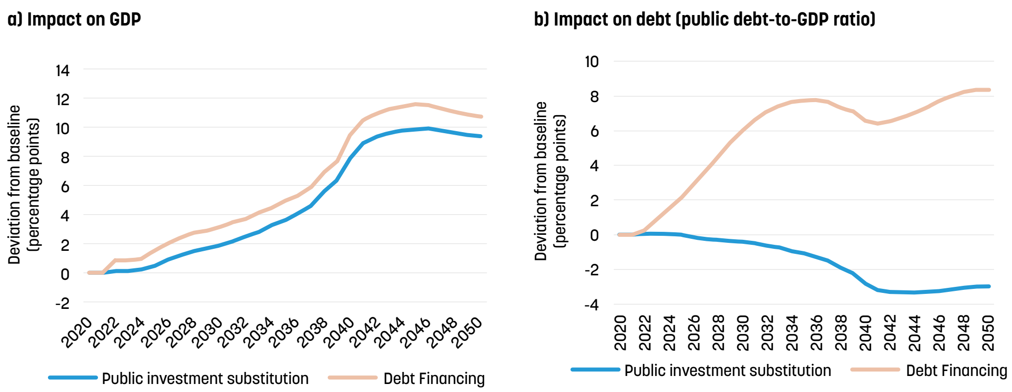
[89] We also consider a different approach to dealing with investment costs, thinking of investment and operational costs as symmetrical, as the rise in the former increases the cost of goods, while a drop in the latter decreases the cost of goods. In this approach, we simply net out the two costs and alter unit costs by the resulting difference. Since the overall costs remain the same, this approach results in very similar outcomes.

[90] See Box 4.2 for a detailed explanation of how the investment needs and benefits are collected and modeled.

[91] The model can endogenize investment needs/costs, but benefits are mostly exogenously provided by sector teams, who collected investment needs and GDP benefits (plus co-benefits, not included here). Box 4.2 provides methodological guidance and details on how we collected and modeled investment needs/costs and benefits.

investments, thereby keeping total public investment spending unchanged. Others, on the other hand, are purely related to climate issues (for example, charging infrastructure for electric vehicles, or additional water storage). These investments could be implemented in addition to the current public investment envelope, and in the absence of additional domestic revenue mobilization, this will require increasing public debt. Debt-financing climate investments could stimulate GDP growth through the demand effect, as other growth-enhancing public investments would not be neglected (figure 4.7a). But the model used in this CCDR finds that debt-financing climate change action could come involve a substantial (10 percentage point) increase in the public debt-to-GDP ratio by 2050 (figure 4.7b). A more realistic scenario would involve prioritizing urgent public adaptation and decarbonization investment needs that bring large development benefits (funding these investments from the budget or through domestic or foreign borrowing) while increasing concessional finance for climate-specific investments with high upfront costs and lower benefits, and incentivizing the private sector to invest in sectors with high cost recovery (section 4.3.4).[92]

FIGURE 4.7. Financing climate action: impacts of debt-financing and public investment on GDP and debt



Source: World Bank staff calculations using MFMod with climate change module, based on data from sectoral teams
Notes: Assumes recommended mitigation and adaptation investments are undertaken. In the *debt-financing scenario*, there is an immediate increase in GDP. In the first projection periods, there is no quantified efficiency gain from such investments. Instead, the GDP increase stems from the additional (debt-funded) demand generated by expanding the government balance sheet. This Keynesian effect is eventually inflated away as prices adjust to additional demand, leaving its permanent mark as an increased debt-to-GDP ratio.

Significantly improving the efficiency of its spending would help the government meet its large share (45 percent) of required additional climate-related investments. Institutional efficiency is low in Peru, and public investment has a low execution rate. The country has recently carried out reforms to improve its public investment system and create an enabling environment for a more agile project investment cycle and climate-sensitive investment pipeline. Given the need to increase spending for climate action, being more selective in the project prioritization process would ensure it only executes the projects that are necessary. This CCDR aims to provide guidance on the most pressing investment needs that would set Peru on a net zero CO_2 emissions pathway.

[92] Public investment in Peru is close to 5% of GDP, compared to an average of around 3.6% for seven big Latin American countries and 3% for OECD. But there is still room to improve prioritization and efficiency at the local level.

Box 4.2. Quantification of costs and benefits of climate specific investments

For this CCDR, we collected investment needs, GDP benefits, and co-benefits from sector teams, including forestry, agriculture, fisheries, water, urban, energy, and transport. The teams provided a flow of investment costs that would put Peru on a path to net zero emissions and more resilient development between 2023 to 2050, classifying them as mitigation or adaptation investments and public or private sector. These flows are incremental compared to what Peru has planned so far. Inputs from the forestry, energy, and transport sectors were based on IDB (2021) but updated for this study. The flow of costs obtained from agriculture, fisheries, water and transport sectors were spread out throughout the period using a five-year moving average to smooth out significant discrete jumps in the data. In addition, the data received from agriculture, fisheries and urban sectors only reached 2030 and were extended to 2050. Sector teams exogenously provided co-benefits and GDP impacts; these include a reduction in operational expenditures for the energy and transport sectors—reflecting, for example, fuel savings as individuals shift to electric cars—benefits from better water efficiency management, and an expected increase in forestry output.

The investment cost and benefit scenarios depart from the model baseline scenario by assuming that the proposed investment requirements are additional to existing capital formation, and that reductions in operational costs are efficiency increases. This approach implies that funds need to be directed to these additional investments without affecting the baseline's productive capital stock. The private component of these investments is funded by assuming an equivalent decrease in regular private investment, which would result in lower capital formation (because, for example, electric cars are more expensive than gasoline cars). For the public component we consider two alternative approaches. The first, analogous to the approach for private funds, assumes that the government decreases public investment by the required amount, similarly reducing capital formation (this is the public investment scenario). The second approach leaves the government's regular expenditure unaltered and finances the additional spending by raising funds on international capital markets (debt financing). The two approaches, diametrically opposed in their implications on capital accumulation capture the range of intermediate possibilities.

For operational cost reductions, we assume that the unit cost of economic output falls by the estimated amount. So, if the prior investments imply that at a future date operational costs are lower by 1 percent of GDP, we assume a technological improvement that makes it possible to produce the same amount of GDP with 1 percent fewer inputs. This amounts to an increase in total factor productivity.

In addition to the changes in cost structure, some interventions foresee increases in future GDP. The forestry sector interventions, for example, are projected to result in a 2.5 percent increase in GDP by 2030. In an analogous approach to the reductions in operational costs, we model such improvements as efficiency gains affecting total factor productivity.

4.3.2. A comprehensive tax reform package to address climate change

Despite decades of impressive economic growth, tax revenues in Peru remain relatively low compared to the regional average. In 2020, environmental tax revenues were 0.5 percent of GDP, well below the OECD average, and lower than other countries in the region. Most of these revenues were derived from taxes on energy—that is fuel excises—and with the remainder were from motor vehicle and transport services. As Peru transitions to an electric transport system, some of these revenues will need to be compensated by other taxes (box 4.3). Peru also has several subsidies and incentives that could qualify as environmentally harmful subsidies (EHS). Despite some being designed mainly to reduce inequality and poverty, most of them generate an irrecoverable loss of efficiency, sometimes greater than the loss derived from taxes.

Box 4.3. Assessing the fiscal impact of transport decarbonization in Peru

For this CCDR, we investigated the fiscal impact of decarbonizing Peru's road transport over 2022–50—that is, unrealized tax revenue, relative to the BAU scenario—and contrast this with the financial impacts (or avoided expenses) of decarbonization. Building on a cost-benefit analysis of a net zero transport sector (Quirós-Tortós et al. 2021), we find that, without changes in the tax structure, decarbonizing road transport would have a moderate fiscal impact, mainly in the 2031–50 period, which is lower than the financial benefits of decarbonization).

We estimate that the yearly average fiscal impact of decarbonizing the sector is -0.8 percent of GDP during the 2022–50 but financial benefits would average at +3.3 percent of GDP a year. Under a BAU scenario, the yearly average fiscal impact is estimated at -0.3 percent of GDP in the midterm, growing to -1 percent in the long term. Most of this would occur in the long term, when electrification becomes predominant, but the impact analysis also includes reduced fuel consumption due

Note: For more details on assessing the fiscal impact of transport decarbonization in Peru, see Portabales Gonzalez et al. (2022).

to an increased use of mass public and nonmotorized transport. Electrifying the fleet would lower the consumption of fossil fuels but reduce revenue from fuel excise tax, *impuesto selectivo al consumo* (ISC), gasoline sales tax (*impuesto al rodaje*), and general value-added tax or VAT (*impuesto general a las ventas*) on fuels. The fiscal impact of VAT is the largest among fuel-related taxes. Its yearly average is -0.1 percent of GDP in the midterm, increasing to -0.4 percent in the long term. Vehicle-related fiscal impacts (import, excise, VAT, and property taxes) represent -0.2 and -0.5 percent of GDP in the mid and long term, respectively. Revenue loss may be partially compensated by increased revenue from electricity for transport. While the fiscal impact is practically null in the midterm, due to limited electrification, the yearly average fiscal impact accounts for +0.3 percent of GDP in the long term.

Decarbonizing the transport sector would bring a net benefit, as the positive financial impact is larger than the fiscal impact. Transforming the transport sector from fossil fuel-based to zero-emission requires higher capital investments—for example, in electric buses and hydrogen trucks. But using zero-emission vehicles (ZEVs) reduces operational costs. In the midterm, additional yearly average investments are estimated at -0.5 percent of GDP. These are compensated by reduced operation and maintenance costs for ZEVs (+1.1 percent of GDP), which result in a yearly average midterm net benefit of +0.6 percent of GDP. The benefits of decarbonizing are larger if we also consider the economic benefits of fewer accidents, better air quality, and greater productivity.

Fiscal instruments—including feebates, certification-based feebates, and taxation—could help reduce emissions from LULUCF, the main source of GHG emissions in Peru. Feebate schemes are a potentially promising instrument for reducing net emissions from deforestation. A carbon sequestration feebate applies a sliding scale of fees to landowners who reduce their carbon storage relative to a BAU level and rebates to landowners who increase their carbon storage (Parry 2020; World Bank 2021a). Feebate certification can also be used for deforestation-driving commodities in contexts where robust monitoring may be lacking. It taxes commodities on a sliding scale according to production method, with a preferential rate given to producers who obtain a third-party sustainability certification, for example, for timber. This system can be combined with a credit, with sustainable producers getting preferential credit (Parry 2020; World Bank 2021a). Forest-related export taxes can be redesigned to implement variable tax rates based on the sustainability of production. Using export forestry taxes at chokepoints—border crossings, international shipping ports, and other places where the informally sourced goods enter a formal market structure—can minimize challenges related to informality. Carbon taxes, however, have limited applicability in the forestry sector,[93] but

[93] Carbon taxes generally cover GHG emissions from the energy sector, such as transport, industry, and power. No carbon tax directly covers the forestry sector to date.

they can be linked to carbon credits. For example, Colombia's carbon tax allows taxpayers to use carbon credits from forestry to offset 100 percent of their carbon tax liability. However, it is important to balance the risks of this approach against the potential benefits (see Wang-Helmreich and Kreibich 2019 for a discussion).

Payments for environmental services (PES) are another cost-effective option for reducing forestry emissions. PES, which offer incentives to farmers or landowners conditional on evidence that the managed land has delivered an environmental service (Engel, Pagiola and Wunder 2008), require adequate, reliable, and stable sources of funding and a good focalization scheme (see, for example (Muñoz-Piña et al. 2011). Although PES programs can have important impacts on environmental outcomes, they require strong governance structures to monitor and ensure compliance and behavioral change.

To incentivize the private sector to invest in climate mitigation actions in the energy sector, a carbon tax could be a crucial element of the overall climate policy mix. The previous sections and simulations assume that Peru's private sector will undertake a large share (55 percent) of the investments needed for climate mitigation, and that the government can create the right incentives to make this happen. Here, we explore the role that carbon taxes can play in incentivizing the private sector to act, in addition to raising revenues for public investment. Both carbon taxes and emissions trading systems can provide cost-effective means to reduce GHG emissions. Cap-and-trade sets the quantity of emissions reductions and lets the market determine the price. Despite the certainty about the aggregate CO_2 emissions, the market is left to choose the price of the permits, which could discourage firm investment as well as the development of green technologies (Aldy and Armitage 2022). The introduction of a carbon tax[94] sets the price of carbon dioxide emissions and allows the market to determine the quantity of emission reductions. By setting a pre-defined tax trajectory (for example, with yearly increases for the next 5–10 years), a carbon tax signals future carbon prices long in advance, providing certainty to firms and allowing them to plan investments (Aldy and Armitage 2022) well in advance and avoid stranded assets. As a carbon tax allows companies to anticipate the price of carbon, it creates an environment of greater certainty for investment planning (WSJ 2019).

Key features of carbon taxes make them useful in developing countries and can help standardize excise taxes in all industries. When applied upstream on the carbon content of fuels,[95] carbon taxes have important fiscal co-benefits related to covering the informal sector, whereas conventional taxes struggle at covering the informal sector. Upstream carbon taxes can be applied on choke points, where they are not easily evaded. Not only are they highly environmentally effective in highly informal settings; they also help reduce the formal-informal tax wedge.[96] When applied upstream, where the point of regulation applies to a few importers, refiners and/or distributors, their ease of administration can help reduce costs.[97] They also generate stable and predictable public revenue streams, which

[94] Examples of such externalities are damage to infrastructure from floods, loss of crops from droughts, ecosystem degradation from increasing rainfall variability, or health care costs from heat waves. Putting a price on carbon would help shift the burden for the damage back to those who are responsible for it and, importantly, those who can act to reduce it.

[95] Since carbon content is proportional to fuel quantities, fuel sales and emissions factors are enough to estimate carbon tax rates for fuels.

[96] ETS are generally applied downstream—where the emissions are released to the atmosphere—limiting applicability to firms and/or formal sector installations.

[97] For example, an upstream carbon tax does not require the creation of a monitoring, reporting and verification system, which can involve important use of public funds. The number of regulated entities upstream is also generally smaller, which helps reduce administrative costs.

can be used to finance other sustainable development priorities. Although an important part of the total carbon price signal, excise taxes on transportation fuels effectively create different levels of carbon prices for different fuels and sectors. Expanding coverage of such excises to other fuels outside the transport sector and aligning the tax rates to the social cost of carbon can help improve their environmental and cost-effectiveness. This is where a carbon tax can be useful, as it generally is applied to most fuels.

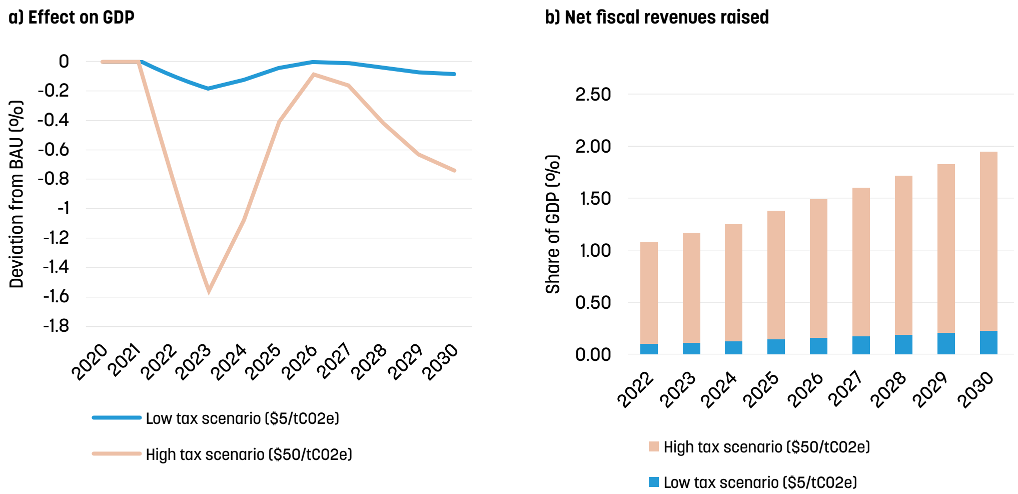
In Peru, a carbon tax can help raise fiscal revenues and redirect economic activity toward a lower-emitting path. Although the full design of the appropriate package of possible policies is beyond the scope of this CCDR and requires consultations and political processes, our analysis of carbon pricing options and the implication of a carbon tax finds that a $5 per tCO_2e tax implemented in 2022, progressively increasing to $9 per tCO_2e by 2030 (the low-tax scenario), would not hurt economic growth in the long term and would slow down the increase of emissions (figure 4.8a). A more ambitious $50 per tCO_2e, increasing to $93 by 2030 (the high-tax scenario), would have a small negative impact on GDP in the short term but bring GDP to about 1 percent below the BAU scenario by 2030.[98] It would also bring in significant revenue—around 1.7 percent of GDP per year by 2030 (figure 4.8b)—, which could be partly used to ensure compensation and progress on development goals, or to fund the investments identified in section 4.3.1.

Although price changes from a carbon tax can initially have negative impacts on consumers and producers, it is possible to compensate for poverty impacts. Introducing a carbon tax would lead to higher fuel prices. According to CPAT estimates for Peru, in the high-tax scenario, gasoline, diesel, LPG, and natural gas prices would increase between 8 and 14 percent in the fist year of the policy. In time, fossil fuel prices would continue to grow, and by 2030, gasoline, diesel, and LPG prices would increase between 15–26 percent. After initially jumping by 5.7 percent, electricity prices would stabilize in time, and by 2030, prices would be 2.9 percent higher.[99] Since a carbon tax increases fuel prices and general consumer goods, it would inevitably increase poverty, so a compensation system is needed (Ansuategi and Galarraga 2012). If 50 percent of the fiscal revenue collected through such a tax goes to public investment and 50 percent to cash transfers, the poorest 40 percent would be better off under the carbon tax scenario. A carbon tax in Peru would be progressive or neutral since in relative terms, as a share of consumption, the two poorest income deciles would be less affected than the richest decile.

[98] We show a simple carbon tax scenario here for illustration purposes. But depending on the situation, a carbon tax could be accompanied by a reduction of other types of tax, and part of the revenue generated could be spent to ensure vulnerable segments of the population are not worse off.

[99] For additional results and graphs regarding the introduction of a carbon tax, refer to the macro chapter background note (Dorband and Schulz-Antipa 2022).

FIGURE 4.8. Effect of carbon tax on GDP and fiscal revenues under two scenarios



Source: World Bank staff calculations, using MFMod with climate change module

Depending on how the government uses the revenues, carbon tax reforms could also have a positive impact on employment. The net-positive short-term effect on labor demand (two to four years after reform) is driven by the growth of low-carbon and service sectors. Overall, job creation in low-carbon sectors outweighs jobs lost in higher-carbon sectors, despite the net negative GDP effect. This is because low-carbon sectors generally tend to be more labor-intensive than carbon-intensive ones. Overall, total labor demand could increase by 0.05 percent in the low ($5) tax scenario and by 0.7 percent in the high ($50) tax scenario. Most jobs would be created in the service, public administration, health, and education sectors (because in this example, we assume 50 percent of revenues raised go to government expenditure). In relative terms, those sectors would increase their labor demand by around 1 percent. Negative output effects in more capital-intensive sectors, such as the extractive industries, would create negative job effects along their value chains—in construction, for example. In terms of skill levels, in this example, 75 percent of net gained jobs will require high-skilled workers and 25 percent low-skilled workers. Jobs created in the services sectors tend to be higher-skilled, providing opportunities for tailored reskilling and upskilling in active labor market support policies.[100]

Reforming EHS could also create fiscal space and encourage more sustainable consumption and production patterns. The potential benefits of such an approach include helping to balance the public budgets; promoting more efficient resource use and reducing unintended negative impacts; increasing competitiveness; stimulating innovation—for example, through cleaner energy sources—to move toward a circular and green economy; and improving long-term economic and employment prospects. However, it is important to pay particular attention to the political economy and communication of any planned reforms.

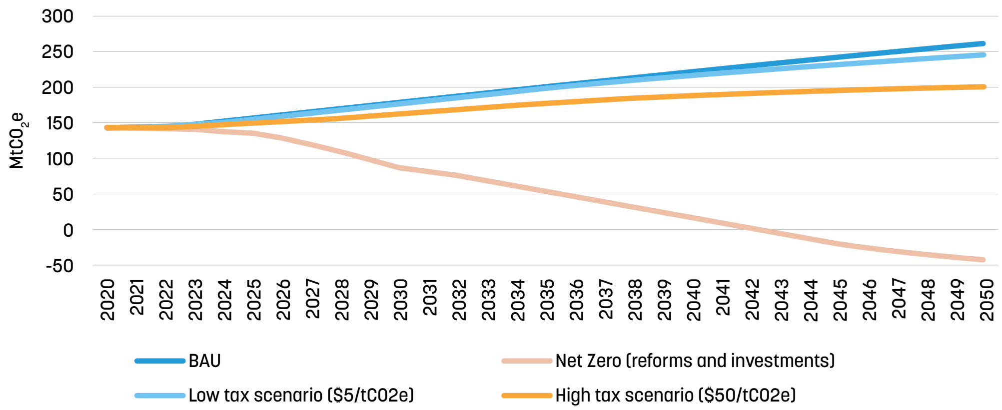
Evaluating the effectiveness of some EHS can also ensure a positive contribution to distributional equity. For example, the VAT and oil and natural gas excise tax exemptions in Loreto, Ucayali, and Madre de Dios, in the Selva region were aimed at promoting growth and economic development. But several

[100] For more details on jobs impacts, see Dorband and Schulz-Antipa (2022).

studies have found that, as well as not yielding the expected results, they have generated a high fiscal cost (approximately 0.3 percent of GDP in 2019[101]) and misaligned environmental incentives (APEC Secretariat 2015). The argument that they promote growth and economic development was also questioned when growth in another Selva department, San Martín, was higher after it renounced the tax exemptions in exchange for and equivalent amount in direct government transfers. Undertaking a cost-benefit assessment of tax exemptions, incentives, and subsidies with respect to their policy objectives may offer guiding principles to prioritize reforms going forward.

If it implements the investment package detailed in this CCDR (table 4.1), Peru can achieve net zero emissions by 2050. Fiscal measures that incentivize the transition in the private sector and households can help with implementation and bring additional revenues to the economy without hurting long-term growth. Estimates show that a carbon tax at $50 per tCO_2e would substantially reduce the emissions increase projected in the BAU scenario and contribute 23 percent of the funds needed to get to net zero by 2050 (in terms of emissions reduction) (figure 4.9).

FIGURE 4.9. Emissions under BAU, carbon tax, and net zero (reform and investments) scenarios



Note: Scenarios only cover the energy, transport and forestry sectors, but the forestry sector is not impacted by the carbon tax.

4.3.3. Managing the fiscal and debt impacts of natural hazards

Widening its range of risk management instruments will help the government better manage fiscal and debt impacts of disasters. Peru's layered financial protection strategy, in place since 2016, consists of different risk retention instruments such as resources from budget allocations, contingency reserves, a fiscal stabilization fund and exclusive contingent credit lines, but has yet to comprehensively assess the physical risks to the country's fiscal sustainability and public finances. Extending the National Disaster Risk Financing Strategy to include more instruments could better insure public assets and ensure natural disasters and climate change impacts are included in fiscal planning and debt management.

[101] Based on MEF (2019).

4.3.4. A conducive regulatory environment to facilitate private sector action

Unleashing private sector investment in more inclusive and climate-smart economic activities would boost climate-resilient economic growth. Given the current high concentration of employment in primary sector activities, a large share of jobs in Peru are in occupations or sectors that are not focused on the green transition. Correcting land market failures, by establishing cadasters and property rights, improving territorial planning and related investment, and enhancing labor market regulations and local government capacity to attract investment and deliver services can increase private sector investment in greener activities and sectors of the economy where the country has a comparative advantage. Addressing such cross-cutting constraints could, for example, increase investment in climate-smart agricultural practices, decrease illegal and artisanal fishing, which threatens fish stocks, and curtail small-scale mining and logging, which contribute to high deforestation rates (World Bank 2022).

Private investment in agriculture can play a crucial role in adapting value chains to the growing imperatives of market-side consumer trends and supply-side social pressure. The current production structure in the Costa region poses serious environmental concerns, particularly around water and land use and soil pollution. Meanwhile, good environmental management is a surging competitiveness parameter in global food exports. To harness the momentum created by the "coastal boom" while bringing crops to a more environmentally sustainable, conducive microclimate and increasing inclusive growth and regional convergence, Peru could improve Sierra smallholders' access to export markets, or increase the link between them and large exporting firms on the coast, capitalizing on the more successful experiences in market-driven productive alliances.

In aquaculture, the private sector can support the adoption of modern technologies and skills to adapt to a changing climate and control for external environmental factors that lead to significant losses. For example, aquaculture yields have been highly volatile in recent years due to climate change-induced volatility in oceanic conditions and disease. The supply of seeds for scallops also depends on natural conditions that are threatened by climate change, so Peru has depended on imports from Ecuador. Private sector investments in research can genetically improve local seed production and capture more value locally. Regulatory and investment support for research into better practices and technologies that are adapted to local geographical and climate conditions make the sector more sustainable, while adopting circular waste management practices in the transformation stage can create synergies with other sectors, such as agriculture.

4.3.5. Mobilizing green finance: providing the right financing and insurance tools for the private sector

The government and private sector both recognize that effective disaster risk finance measures are necessary to manage fiscal risks resulting from natural disasters. The government has taken a layered approach, composed of risk retention instruments such as the FEF, while also gaining experience with risk transfer instruments, such as Catastrophe Bonds (CAT). In the private sector, efforts are under way to strengthen the financial capacity of insurance companies, to enable them to deal with claims produced by large-scale events. In 2019, MEF published its guidelines for the design of public-private partnership (PPP) contracts, which include an insurance regime that incorporates good practice for proper insurance of PPPs.

A more inclusive financial sector can also help households and firms build their resilience to climate change-related risks. Access to digital financial services can make households more resilient to economic shocks, including those resulting from climate change. For example, evidence from Kenya has shown that access to mobile money strengthened households' adaptive capacity to negative shocks, including droughts and floods, enabling them to receive timely and affordable remittances from their social networks, and allows governments to provide emergency financial support in the wake of climate-related or public health crises (Jack and Suri 2014). In Peru, Banco de la Nación's *Cuenta DNI* initiative, which aims to provide transaction accounts to all Peruvians, holds promise to help improve the resilience of households facing climate change-induced natural disasters.

There are significant opportunities to develop Peru's green financing ecosystem, with an emphasis on supporting strategic real sector investments linked to climate change. In particular, the investor base has untapped potential as financier of sustainable assets, but lacks incentive and information. The government could develop a strategy for issuers and investors of financial products to strengthen and standardize disclosures related to climate change. Peru's initial efforts to develop a green financing roadmap hold promise for channeling financial resources to support the implementation of climate mitigation and adaptation measures. Under the recently approved Peru Sustainable Bond Framework, the government has already issued two sustainable and one social bond for more than $4 billion equivalent; but the challenge is now implementing the framework, including allocating funds to green or sustainable projects and preparing allocation and impact reports. Implementing the roadmap will require sustained prioritization and close coordination across stakeholders, including developing green taxonomy and green portfolio options.

5. Conclusion: prioritized actions

Peru has many opportunities to develop and implement comprehensive climate policies that also increase productivity and reduce poverty. It can achieve low-carbon and resilient development if it can implement the right reforms and fund critical investments for water security and decarbonization (table 5.1). While public investments must cover critical investments, the right regulations, information systems, social services and fiscal incentives can also ensure households and the private sector plays a large role. The resulting productivity and efficiency gains could increase GDP by 2 percent by 2030 and potentially much more by 2050, and create many jobs. While the overall impacts of climate reforms and investments are positive on growth and job creation, policies need to be carefully designed to be politically acceptable. Fiscal reforms to reduce emissions can be designed to ensure increased support to the poorest and reduction of inequality. Technical support to the agriculture sector can target smallholder farmers and ensure informal subsistence farmers can be either integrated in more formal value chains or to the forestry sector. Social protection can be scaled up to support the poorest households after climate shocks and to support job transitions away from the most vulnerable or emitting sectors. Finally, the mining sector can be transformed to ensure that local populations benefit from revenues and participate in decisionmaking.

TABLE 5.1. Priority reforms to complement the investments identified in table 4.1.

Broad priorities	Benefits for adaptation	Benefits for mitigation
Planning and regulations		
1. Finalize and implement the Green Finance Roadmap, including components on disclosures related to climate change; implementation of Peru's Sustainable Bond Framework; and the development of a green taxonomy		+
2. Further incorporate climate risks into financial sector regulatory and supervisory frameworks	+	
3. Promote green products production and trade		+
4. Improve access to export markets by smallholders (in the Sierra) by linking them to large exporting firms on the Coast , and improving the efficiency of the agriculture innovation system to promote development of climate-smart technologies and practices	++	+
5. Improving land tenure security and real time monitoring of deforestation through increased law enforcement		++
6. Reform power sector regulations, including implementing a long-term energy planning process that involves co-optimization of electricity and gas sectors; reforms to the electricity auctions law to enable non-conventional renewable energy to enter the market and compete; improving transmission planning and reducing delays of transmission infrastructure; developing long-term capacity expansion that incorporates renewables, the potential for distributed energy sources, and energy efficiency		++
7. Deliver technical assistance to farmers, and enhance systems for monitoring and mitigating vector and disease spread	++	
People-centric policies		
8. Implement the *Cuenta DNI* initiative to facilitate digital delivery of government-to-person emergency payments in the event of natural disasters	++	
9. Re- and upskill natural gas, mining and agriculture workers	+	+
10. Adapt service delivery in the health sector to evolving health needs and increase capacity to respond to sudden surges in demand for care	++	
Macrofiscal reforms and price incentives		
11. Establish a feebate system or taxation with output-based rebates for reduced emissions from forestry		++
12. Establish carbon pricing and remove environmentally harmful subsidies while also supportitng vulnerable groups		++
13. Improve the execution rate of public spending and reduce delays in the public investment management chain	+	+
14. Unify the tax regime for SMEsmall and medium-sized enterprises and facilitating their transition to the general tax regime, to reduce informality	++	+
Public investments		
15. Invest in water supply and sanitation; multipurpose water storage; irrigation support; drainage systems	++	
16. Invest in public transport including NMT in Lima and intermediate cities, and expanding the BRT system; last-mile bike-based freight system in Lima		++
17. Investments in the electricity transmission system to ensure renewable electricity generated in the south can be delivered to other parts of the country		+

Notes: Costs are NPV, discount rate 6%; ++ = large positive impact; + = small positive impact.

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