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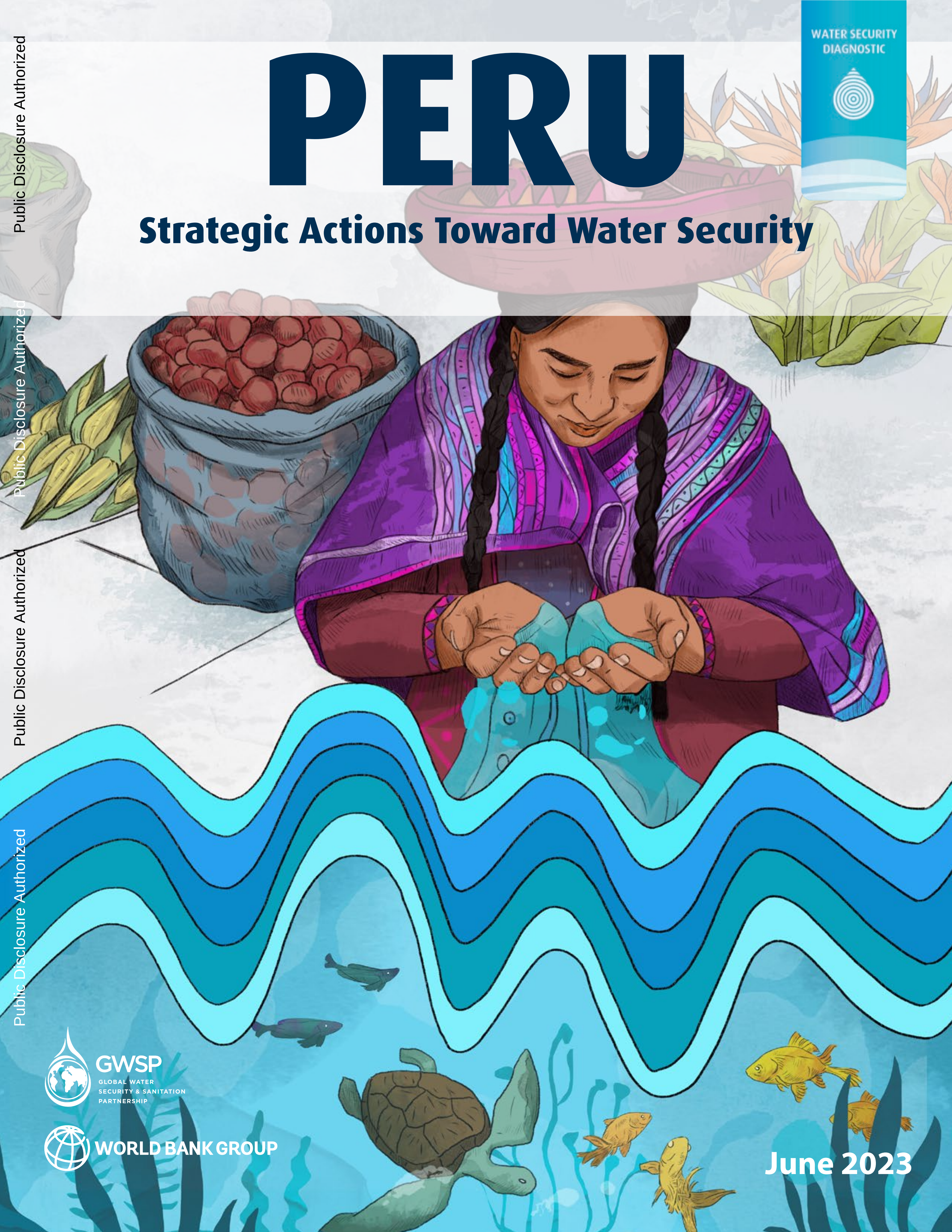
PERU

Strategic Actions Toward Water Security



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GLOBAL WATER SECURITY & SANITATION PARTNERSHIP

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Welcome to the Water Security Diagnostic for Peru

This report is part of the World Bank's water security series—a collection of reports analyzing water-related challenges and opportunities that could affect a country's economy, people, and natural environment.

These reports are designed to help countries position water at the center of their national development agendas through evidence-based analytics and multi-stakeholder dialogues. To date, several comprehensive studies have been undertaken around the world, including studies for Argentina and Colombia. The Bank has also conducted regional water security studies for the Middle East and North Africa, and Latin America and the Caribbean.

For more information on the Water Security Initiative, please go to:

https://www.worldbank.org/en/topic/water/publication/water-security-diagnostic-initiative

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Executive Summary

Water security—the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies (Grey and Sadoff 2007)—is crucial to Peru's path to shared prosperity while addressing climate risks. Access to this precious resource, however, is increasingly threatened by climate change, pollution, and uncontrolled and inefficient use of existing water resources and infrastructure. Taking strategic action now is critical to ensuring that Peru can sustain its water resource base, continue to deliver water to people and productive sectors of the economy, and build resilience to climatic and non-climatic events.

This Water Security Diagnostic (WSD) provides concrete, strategic actions to strengthen Peru's water security that complement the government's ongoing initiatives. The recommendations are based on the World Bank's knowledge of and experience in the Peruvian water sector, several government studies, as well as specific assessments carried out as part of the WSD to close knowledge gaps. The brief begins by providing an overview of Peru's water systems, then outlines the impact of water on economic and social development, continues with a detailed analysis of the key challenges to achieving water security, and culminates with a list of recommendations to accelerate Peru's path to water security.

Water Security Is at the Heart of Peru's Path toward Sustainable Development

Water is a key driver of economic and social development, and sustainable ecosystems in Peru. Water-intensive sectors account for nearly two-fifths of Peru's gross domestic product (GDP), with about 13 percent from manufacturing, 12 percent from mining and hydrocarbons, 7 percent from construction, 6 percent from agriculture, and 2 percent from water and electricity (BCRP 2022). The mining and agriculture sectors account for 63 percent and 16 percent of Peru's total exports, respectively. The agriculture sector alone employs almost a quarter of the total labor force, and more than half in rural areas (INEI 2020a). This is significant for rural development, given that 46 percent of rural populations remain poor and about 14 percent are mired in extreme poverty (INEI 2021). Water's contribution to Peru's economy and overall livelihoods is further highlighted when considering the impact of electricity— about 57 percent of which is produced through hydropower—on all GDP-contributing sectors (COES 2021). Water is also essential for sustaining Peru's highly diverse ecosystems, which include about 8 million hectares of wetlands and a vast network of rivers and lakes. These in turn contribute to Peru's tourism industry, which accounts for 4.5 percent of its GDP in 2020.

Access to water for efficient irrigation contributes to poverty alleviation, food security, agricultural income, and resilience to climate change. Irrigation has positive impacts on productivity and profitability. The World Bank–financed Sierra Irrigation Project reported yield increases of 30 to 70 percent, and net household income per hectare increases of 25 to 100 percent because of improvements in water availability and irrigation techniques.[1] Irrigated yields in Peru are double those of rainfed (dryland) yields (FAO 2022). Nevertheless, only 22 percent of agricultural land—2.6 million hectares—is under irrigation. Most of the agricultural land in Peru's Costa region (along the Pacific coast) is irrigated to sustain commercial agriculture. However, in the Sierra (Andes Mountains) and Alta Selva (high-altitude Amazon), where 50 percent of the rural population lives in poverty, only about 20 percent of the cultivated land is under irrigation. This leaves agricultural production exposed to shifts in rainfall patterns linked to climate variability and climate change. Utilizing irrigation in these areas would improve productivity, encourage farmers to harvest higher-value crops, and build resilience to climate variability.

Access to safe water supply and sanitation (WSS) services is essential for a healthy and productive population. Millions of Peruvians face water insecurity daily. Only 50 percent of the population have access to safely managed water and 43 percent to safely managed sanitation (WHO/UNICEF JMP 2021). Two million Peruvians lack basic drinking water services, and a million rural Peruvians still have no alternative but to defecate in the open. Regional disparities are acute. Sanitation coverage, for example, is particularly poor in the Sierra (65 percent) and Selva, or Amazon, (51 percent), relative to the Costa (90 percent). The people of the Amazon rainforest shoulder the biggest share of the burden associated with unimproved WSS services, reporting double the number of related deaths (14.3 deaths per million people) as those in the Costa (7.4 per million) (Garcia-Morales 2021).

Women and children are disproportionately affected by inadequate access to water and sanitation. In rural areas, women, responsible for overseeing, fetching, storing, and purifying water, work on average 10 hours more than men per week. This often limits their access to education, paid jobs, and decision-making spaces. Women and children's lack of access to adequate sanitary facilities exposes them to risks not only to their health, but also risks to their security, because they become vulnerable to harassment, attacks, and violence. The lack of a hygienic environment for girls and women during their menstrual period or pregnancy can also perpetuate both health and safety risks.

The quality of education is also negatively affected by Peru's coverage gap. Only two-thirds of public schools have adequate toilet facilities, and only 20 percent have access to adequate drinking water (UNICEF 2020). Each year about 900,000 Peruvian children under the age of five develop acute diarrhea directly related to inadequate WSS services, negatively affecting their health and cognitive capacities as well as their future productivity.[2]

Climate change and climate variability are linked to extreme water-related weather events that affect vast swathes of population, with grave implications for the economy and human capital accumulation. Almost half of Peru (46 percent) is highly to very highly vulnerable to natural disasters associated with the El Niño phenomenon and long-term climate change. The country already faces severe water scarcity in the Pacific region, floods and mudslides in the highlands and along the coastline, extreme rainfall events triggered by the El Niño phenomenon, and intense rainfall and floods in the Amazon. Water shocks linked to extreme rainfall and droughts are expected to increase given the continuous deterioration of watersheds, increased precipitation variability, and the acceleration of glacial retraction in the Andes. During the period 1990–2020, 1 percent of the total population was affected by water shocks, causing US$4.2 billion in accumulative economic damages (in 2020 constant prices), equivalent to 2 percent of 2020 GDP (EMDAT 2022). Furthermore, damage caused by floods and droughts have direct impacts on educational outcomes, morbidity and mortality rates, and labor productivity, hampering human capital accumulation (Barron and Moromizato 2020; Garcia-Morales 2021).

Water shocks and limited WSS services cost Peru between 1.3 and 3.5 percent of GDP per year.[3] The cost of water shocks is linked to floods, droughts and restrictions in water supply affecting agriculture, mining, manufacturing, health, and household income. The costs due to limited WSS services are linked to the burden of disease. When production shocks and losses and higher economic costs due to water pollution are also considered, the economic impact ranges from 4.0 to 6.4 percent of GDP per year. This estimate is conservative as it does not consider the spillover effects of water shocks on local economies or losses in value added. Water shocks disproportionally affect the poor, who experience higher rates of water-borne diseases, in part due to lower coverage of WSS services compared to the nonpoor. By 2030 the impacts of water shocks will be exacerbated by climate change, resulting in an income reduction among the bottom 40 percent of the country's income distribution by 5.2 percent. This could push an additional 0.6 percent of the population into extreme poverty (Hallegatte et al. 2016).

Peru is facing a growing gap between its development demands and the quantity and quality of its water resource endowment

Peru's growth is dependent on water, yet the country faces the highest climate variability in the Latin America and Caribbean region and significant rainfall spatial distribution. In terms of freshwater volume, Peru is the eighth-most water-rich country in the world and the third in Latin America. But these water resources are unevenly distributed among Peru's three major hydrographic regions. Watersheds in the Pacific region (the Costa) experience the greatest water deficit yet are positioned in Peru's most populous and productive area. For example, the Rimac Basin, which serves Lima's 11 million residents, provides less than 100 cubic meters of water per person per year. This is the lowest level of water resources per person in the country and classifies as absolute water scarcity. Peru also faces rainfall distribution challenges in much of the Andes and parts of the Amazon. Most precipitation occurs between November and March, resulting in a large dry period with water deficits. Irregular rainfall further complicates Peru's situation; historical data indicate that annual precipitation can vary from a 40 percent decrease to a 50 percent increase between years in key productive basins.

Natural storage in glaciers and groundwater, a key factor to attenuate mismatch between supply and demand and climate variability, is under increasing threat. Glaciers have lost about 43 percent of their surface area since 1970, severely reducing water supply in areas already suffering from water scarcity (ANA 2014). Groundwater, another important form of natural storage, is poorly understood and unsustainably used. Of the country's 95 aquifers, the National Water Authority (Autoridad Nacional del Agua, ANA) monitors only 47, representing less than 1 percent of total groundwater. Several aquifers face depletion, indicating the need for effective water rights regulation enforcement, monitoring, and management.

Climate change will further reduce water availability and increase uncertainty, threatening economic growth and development. By the end of the century, the northwest region of South America, where Peru is located, is expected to experience an increase in the number of days per year of extreme heat and cold, an additional loss of glacier volume and permafrost in the Andean mountains (causing reductions in river flows), and high-magnitude glacial lake outburst floods (IPCC 2021). The lack of a comprehensive and local response increases the vulnerability of Peru's storage systems to these increasingly frequent climatic events.

Pollution is further limiting the water endowment available to the people, the environment, and the economy. Only 25 percent of monitored water bodies in Peru have "good" ambient water quality, meaning they are not harmful to people or ecosystems. The main cause of water pollution in urban areas is the discharge of domestic wastewater into waterways. Only about 60 percent of wastewater generated by urban households is treated at wastewater facilities before being released into the environment (WHO/UNICEF JMP 2021). The impact of untreated wastewater is especially acute along the Pacific coast, where high population densities and low-flow rivers have resulted in a concentration of pollution hotspots. Other sources of pollution include mining effluents, use of agrochemicals in intensive agriculture, and oil production. In inland areas, agricultural pollution has had the most substantial impact on water quality due to the runoff of nitrogen, sediments, and pesticides in large, upstream areas.

Peru's aging water infrastructure and limited implementation of its water management framework have amplified water security risks

Hydraulic infrastructure is essential to tackle the mismatch between water availability and demand and the challenge of high climate variability. But current solutions are not sufficient. Peru has among the lowest dam storage capacity levels in Latin America and the Caribbean, leaving it susceptible to system failures amid rising climate risks. In addition, limited capacity to monitor and manage large hydraulic infrastructure poses access and safety risks. Hydraulic infrastructure, for the most part, was not designed to withstand the forces exerted by floods due to climate change and the El Niño weather phenomenon. Despite Peru's dam safety regulations, very few operators have implemented early warning mechanisms, or safety and emergency protocols for disasters affecting hydraulic infrastructure, to prevent potentially fatal floods or power interruptions. Also, Peru does not legally mandate that the regional governments and private entities that manage most of its hydraulic infrastructure ensure dam safety or follow standards for the construction and operation of large hydraulic infrastructure.

Although Peru has a comprehensive water management legal framework, it has not reaped the benefits of the framework, given low levels of implementation. Over the past two decades, the Government of Peru (GoP) has demonstrated its commitment to strengthening the water sector by developing policies on water resources management, water and sanitation services delivery, irrigation, and disaster risk mitigation. Although the reforms are comprehensive, implementation is lagging due to wider governance challenges pertaining to bias in the allocation of water usage rights, low levels of decentralization, the need for greater collaboration across sectors in water management and disaster management approaches, and limited gender equity in water resources management.

Efforts to close water and sanitation supply gaps have been slower in rural and peri-urban areas than in cities. Peru has made remarkable progress in closing water and sanitation coverage gaps over the past 20 years, yet progress has been much slower in rural and peri-urban areas, where technical and management solutions are more complex due to geographic, sociocultural, and political conditions, as well as low population density and logistical difficulties. The use of traditional solutions in these areas that do not consider territorial and social differences has been a lead cause of stalled water and sanitation investment projects. This is mainly due to high capital and operating costs, lack of ownership from beneficiaries, and limited implementation capacity.

Most of Peru's water and sanitation utilities are locked in a negative cycle in which low revenues weaken the utilities' skills base and operational performance, resulting in water supply outages that further reduce revenues. At the heart of this cycle are low tariffs that do not cover the cost of adequate service, resulting in utilities that are not financially sustainable. On average, utilities apply a tariff of US$0.62 per cubic meter, which is well below the Latin America and Caribbean regional average of US$1.44 (GWI 2020). These tariffs often include large subsidies to users that are not necessarily in need of this financial support. The effect of low tariffs is compounded by frequent water service outages, which cost utilities more than US$500 million each year, equivalent to about 10 percent of the total health budget for 2020. High levels of commercial and physical water losses, and the impact of COVID-19 on household and business finances have further strained water utilities' financial performance. Other issues contributing to utilities' limited operational and financial performance are the highly fragmented nature of service provision that limits economies of scale, and the unplanned urban settlements on the outskirts of cities, which increase the capital and operational costs of service provision.

Deteriorating irrigation and drainage systems and low irrigation coverage are contributing to low agricultural and water productivity. The agriculture sector is Peru's biggest water user, accounting for 89 percent of water withdrawals in the country (the average across Latin America and the Caribbean is 70 percent) (INEI 2020b). The physical efficiency of agricultural water use, however, is between 30 and 45 percent. Approximately 57 percent of Peru's existing irrigation and drainage infrastructure is in poor condition. Only 70 percent of the 2.6 million hectares of agricultural land under irrigation are used to produce crops, and 25 percent of the coastal irrigated areas suffer from salinization. In addition, Peru has only reached 41 percent of its irrigation potential. Irrigation coverage is not expanding at the same pace that agricultural land is expanding. This can be attributed to several factors, including the variability of local conditions, insufficient coordination between various levels of government, limited execution of public investment for the rollout of irrigation (over the past decade, only 60 percent of the assigned budget was executed), and limited performance-based incentives for the entire institutional chain to deliver irrigation efficiently and equitable.

Low budget execution and funding gaps are hindering Peru's achievement of national targets and the Sustainable Development Goals (SDGs) by 2030. In the past five years, Peru allocated about S/. 6.2 billion (US$1.6 billion) per year to the WSS sector (predominantly in basic water and sanitation services) with a budget execution rate between 50 and 60 percent. The 2022–26 National Sanitation Plan estimates that additional annual funding of S/. 10 billion (US$2.6 billion) per year will be needed to achieve universal access to safely managed WSS services as envisaged in SDG targets 6.1 and 6.2 by 2030. In addition, other sources suggest different levels of funding gaps. For instance, the UNICEF-SWA JMP[4] estimates that Peru will need additional investments on the order of US$1.3 billion per year from 2021 to 2030 to deliver universal, safely managed WSS services, whereas a recent study of the Inter-American Development Bank (IDB 2021) estimates that Peru needs to enhance and additional US$2.2 billion to reach this goal.[5] Therefore, when compared with the current budget execution, the funding gap to reach universal access to safely managed WSS services by 2030 is between US$1.9 billion and US$3.2 billion per year. To reach these levels of financing, Peru needs to enhance and accelerate its various financing options and mechanisms and, more importantly, improve budget execution by spending better with cost-effective, innovative solutions.

Strategic action now can fortify and accelerate Peru's path to water security

The GoP has begun laying the groundwork for water security

Ensuring universal and continuous access to water security is high on Peru's political agenda. To accelerate progress and develop a comprehensive understanding of water issues, the GoP has engaged in three key activities to build water security. First, it engaged in a water policy dialogue with the Organisation for Economic Co-operation and Development (OECD) that elevated the discussion around water security and facilitated high-level stakeholder engagement. The dialogue culminated in a report, *Water Governance in Peru* (OECD 2021), which contained specific recommendations centered on the following three key areas: (i) strengthening multilevel governance to improve water resources management, especially risk management linked to pollution, floods, and droughts; (ii) effectively implementing economic instruments for water risk management, including water abstraction and pollution charges and payment for environmental services; and (iii) strengthening the regulatory framework toward universal coverage of WSS services. Second, ANA is updating the water resources policy to include water security objectives in Peru's national development plans and investment system. Third, the Ministry of Housing, Construction, and Sanitation (Ministerio de Vivienda, Construcción y Saneamiento, MVCS) recently approved the National Sanitation Plan (2022–26), which includes the goal of reaching universal access to water and sanitation by 2040. In addition, the GoP is aligning water-related programs to its Nationally Determined Contribution (climate action plan).

The GoP has further signaled strong commitment to water-related issues in its General Government Policy (2021–26). The policy prioritizes (i) increasing access to water and sanitation services in rural and vulnerable urban areas to ensure social protection; (ii) promoting water security in agriculture through water storage solutions (infrastructure and nature based), water-efficient irrigation systems, and sustainable water approaches that consider social, productive, and environmental uses; and (iii) strengthening environmental protection and disaster risk management and promoting climate change adaptation and mitigation.

Recommendations to accelerate Peru's path to water security

Achieving the sustainability, efficiency, and resiliency that water security requires entails shifting the sector's focus away from infrastructure building and toward service delivery and risk management. Although the GoP has begun developing policies that promote this shift, critical gaps remain. The key to fortifying Peru's approach, however, does not rely solely on ensuring the existence of robust and effective policies and planning material but on their consolidation and implementation. As highlighted in the challenges section, implementation of sector policies is lagging as a result of the need for greater high-level commitment among other factors. Moreover, despite the vast funding needs of the sector (see box ES.1), only a fraction of the budget allocated for water supply, sanitation, and irrigation infrastructure is executed each year. This low level of execution can be attributed to weak implementation capacity within key sector agencies, limited monitoring and evaluation, as well as the use of approaches that do not reflect territorial realities. Therefore, the country needs to optimize its budget execution and implement the cost-effective solutions most appropriate to the sector.

The following nine recommendations, which are derived from the findings of the WSD and dialogues with key stakeholders, focus on shifting Peru's approach to tackling water security issues and ensuring that resources are used in an effective and efficient way. The recommendations respond to the key sector challenges (see figures ES.1 and ES.2) and are grouped around the three pillars of water security: (i) sustaining water resources, (ii) efficiently delivering services for people and production, and (iii) building resilience.

Each recommendation centers on a concrete first step to strengthen Peru's water security, identifies the entity responsible for carrying it out, and specifies the timeline (immediate, short term, or medium term) for implementation. Immediate actions, which can be carried out within the next six months, are not administratively or politically costly. Short-term actions, which can be carried out within six to twelve months, are at the center of dialogue, but may require investment in awareness raising to gain consensus and political support. Medium-term actions, which can be carried out over the course of one to two years, still require significant discussion to determine the next steps to reach their objective.

Box ES.1 Key Investment Needs and Associated Costs of Addressing Water Security Challenges

This box summarizes the estimated costs and infrastructure requirements of addressing the water security challenges identified in the Water Security Diagnostic. Key steps include the:

1) Expansion of safely managed water supply and sanitation (WSS) works to improve public health and contribute to human capital development.
2) Expansion of wastewater management works to improve water quality in main water bodies.
3) Modernization and expansion of irrigation infrastructure to reduce the impact of water shocks on agriculture production and to contribute to rural development.
4) Expansion of integrated water storage solutions to increase resilience to climate variability.

Expansion of flood control measures and early warning systems to reduce water-related disasters.

Building on national studies—such as the 2021 Climate Change Adaptation National Plan, the 2019 Infrastructure for Competitiveness National Plan, and the 2022–26 National Sanitation Plan—the Water Security Diagnostic provides a more comprehensive estimate of investment costs (in 2021 prices) based on the targets presented in these studies. However, the cost estimate should be considered nominal in nature and should not be used for budgeting purposes. It is important to mention that only key infrastructure investments (not all investments needed to move toward water security) have been costed. The total investment costs for Peru to move toward water security have been estimated at US$32 billion to US$52 billion (in 2021 prices). The estimated ranges of investment costs for water storage, water supply and sanitation, irrigation and drainage, and water-related disasters are shown in table B.ES.1.

Table ES.1 Cumulative Investment Cost Estimate for Priority Infrastructure Measures, 2021–30 *(US$ Millions)*

Component	Low estimate	High estimate
Water supply and sanitation (including wastewater treatment)	22,000	33,000
Irrigation and drainage	4,300	7,560
Water storage	5,107	11,138
Reduction of water-related disasters	219	639
Total	**31,600**	**52,300**

Investments in water supply and sanitation assume that the country will **reach universal access to safely managed water and sanitation (SDG targets 6.1 and SDG 6.2)** and will **reach full wastewater treatment coverage in urban areas**.[7]

Investments in irrigation, which are aligned with SDG 2 to end hunger and achieve food security, assume that the country will (i) **increase irrigated land between 330,000 and 490,000 hectares** and (ii) increase the efficiency of irrigation water use through off- and on-farm interventions covering **between 250,000 and 280,000 hectares**.[8]

Investments in water storage assume that the country will (i) **develop additional storage capacity** of multipurpose dams ranging **between 1,800 million cubic meters (MCM) and 2,300 MCM**; (ii) **improve the** productivity and safety of existing storage capacity of nonenergy dams estimated at 4,500 MCM; and (iii) protect and conserve between 130,000 and 170,000 hectares to serve as nature-based water storage solutions.[9]

Investments in reducing risks of water-related disasters assume that the country will invest in: (i) establishing **200 early warning systems** and (ii) **undertaking 60 interventions to protect agriculture production against floods**.[10] Investments in both water storage and disaster risk reduction are also aligned to SDG 13 to strengthen resilience and adaptive capacity.

Figure ES.1 Recommended Actions to Achieve Water Security for All

Water security key element	Recommendations	Key actions (first step)	Responsible	Timeline
Sustain water resources management and improve water quality	1 Consolidate and implement integrated water resources governance at the national and basin levels.	Reinstate the interagency water commission to complete the water governance implementation plan.	PCM	Immediate
	2 Improve the ANA's technical capacity to pro-actively build water security.	Finalize and approve updates to the 2015 Water Resources Policy and begin updating the 2015 Water Resources National Plan.	ANA CEPLAN	Short-term
	3 Improve and expand wastewater management to address water quality in critical basins.	Develop a wastewater management strategy.	MVCS	Short-term
Deliver services for people and agricultural production	4 Utilize differentiated, territorial approaches to increase access to safely managed water and sanitation services for Peru's most vulnerable.	Prepare and implement a comprehensive water and sanitation policy and strategy for rural and peri-urban areas.	MVCS	Medium-term
	5 Establish financial incentives to improve the efficiency, service quality, and sustainability of WSS service providers	Prepare and adopt a performance-based financing policy for water-related capital investments.	MVCS	Short-term
	6 Implement a comprehensive approach to deliver sustainable, efficient, and equitable irrigation and drainage services.	Develop a detailed national irrigation strategy and plan.	MIDAGRI	Medium-term
	7 Strengthen capacity to effectively utilize budget allocation for WSS and irrigation services.	Provide capacity building and technical assistance for government implementation units.	MVCS MIDAGRI	Short-term
Build resilience to ever-increasing climate extremes	8 Invest in integrated water storage solutions to increase productivity and resilience.	Develop an integrated water storage strategy.	ANA	Medium-term
	9 Integrate DRM policies in existing sectoral planning instrument.	Develop a pilot program for local water organizations to incorporate DRM measures into sectoral instruments.	ANA, MIDAGRI, and MVCS	Medium-term

Note: ANA = National Water Authority (*Autoridad Nacional del Agua*); CEPLAN = National Center for Strategic Planning *(Centro Nacional de Planeamiento Estratégico)*; MIDAGRI = Ministry of Agricultural Development and Irrigation (*Ministerio de Desarrollo Agrario y Riego*); MVCS = Ministry of Housing, Construction, and Sanitation (*Ministerio de Vivienda, Construcción y Saneamiento*); PCM = Presidency of the Council of Ministers (*Presidencia del Consejo de Ministros*).

Figure ES.2 Linking Challenges with Recommendations

	Challenges	Linkage with recommendations
Water resources endowment challenges	Demand outpaces supply in key economic regions.	1 2 3 8 9
	Groundwater is poorly understood and unsustainably used.	2
	Climate change will further reduce water availability, threatening economic growth, development, and stability.	2 8 9
	Pollution is further limiting the water endowment available to people, the environment, and the economy.	3
Infrastructure and water management challenges	Limited storage capacity and insufficient attention to securing the safety of existing large hydraulic infrastructure are compromising efforts to boost water security.	8
	Centralized and inadequately managed water governance is hindering policy rollout.	1 9
	Efforts to close supply gaps have been slower in rural and peri-urban areas.	4
	Water and sanitation utilities are in operational and financial distress.	5
	Deteriorating irrigation and drainage systems and low irrigation coverage are contributing to low agricultural and water productivity.	6
	Budget execution and funding gaps are hindering the achievement of national argets and SDGs.	7

These action-oriented first steps lay the necessary groundwork for efficient, effective, and sustainable infrastructure investments. Key infrastructure improvements center on reaching universal access to safely managed WSS services, expanding wastewater treatment to improve water quality, expanding access to efficient irrigation solutions, and increasing integrated water storage solutions to build resilience to water security challenges. The level of financing required to achieve these improvements, however, depends on many variables, including the actual goals and targets the GoP establishes. For instance, the GoP may decide to provide only basic water and sanitation services or may decide to utilize high-cost technology. Box ES.1 provides greater detail on infrastructure needs and costs.

Sustain water resources

To sustain water resources, Peru must accelerate its capacity to respond to growing threats from climate change, pollution, and increasing demand through proactive water resources management.

Recommendation 1. Consolidate and implement integrated water resources governance at the national and basin levels.

To overcome its many water resources endowment challenges (high climate variability, water pollution, and a mismatch between demands and water availability among others), Peru will need to employ strong water governance, adopt integrated water resources management strategies at the local and basin levels, and ensure that there is coordination and harmonization across water-related agencies. Although Peru has a comprehensive legal framework for water resources management, it has not reaped the benefits of the framework given low levels of implementation. Through implementing the existing legal framework, Peru will be better positioned to safeguard its water resources endowment from both controllable (i.e., pollution, degradation, and water overexploitation) and uncontrollable (i.e., climatic change, climate variability, and natural disasters) factors.

Implementing the legal framework will require shifting from centralized governance to inclusive, properly decentralized, responsive governance. In particular, ANA requires greater independence to fulfill its role and employ a comprehensive and multisectoral approach to water. The authority's current position under the Ministry of Agricultural Development and Irrigation (Ministerio de Desarrollo Agrario y Riego, MIDAGRI) limits its capacity to operate independently with the full recognition from all water users and all government institutions. To overcome these challenges, the GoP formed an interagency water commission in 2019 as part of an OECD water governance dialogue and was tasked with drafting an implementation plan based on the OECD's recommendations. The process, however, stalled due to political instability. Strong political will and commitment are needed to overcome this core challenge.

First step: Reinstate the interagency water commission to complete the water governance implementation plan based on the findings from the OECD water governance report and this WSD (see additional guidance below). Once complete, the interagency commission may submit the implementation plan to the Presidency of the Council of Ministers (Presidencia del Consejo de Ministros, PCM) and the National Water Resources Management System (Sistema Nacional de Gestión de Recursos Hídricos, SNGRH) for high-level approval. After approval, the PCM might want to establish a monitoring system to track progress.

Responsible entity: PCM
Timeline: Immediate

The implementation plan would do well to:

- Ensure that ANA is a neutral, institutionally autonomous entity. ANA's irrigation functions should also be transferred to MIDAGRI.
- Improve the SNGRH's ability to coordinate water-related policies and programs efficiently across sectors and government levels by systematically involving high-level officials in meetings, ensuring adequate staffing and financial resources for water resources management, and strengthening coordination between river basin management plans and regional and local development plans.
- Strengthen local water resources management by increasing the effectiveness of ANA's decentralized entities to: (i) implement regulation policies linked to water abstraction and pollution discharge permits; (ii) facilitate cross-sectoral and stakeholder participation and water conflict resolution mechanisms; and (iii) design and implement river basin management plans. The GoP could also further the decentralization process by accelerating the formation of the 17 remaining (out of 29 planned) river basin councils.

Recommendation 2. Improve the National Water Authority's technical and planning capacity to integrate risk management, improved information systems, and efforts to address climate change into water resources management.

Although ANA has made progress toward setting up a system for managing information on national water resources, developing six river basin management plans, and creating a technical dam safety unit, it needs to scale up these efforts to sustain water resources for current and future generations. ANA would do well to continue strengthening its knowledge base and analytical capacity on water security at the national and basin levels.

First step: Finalize and approve updates to the 2015 Water Resources Policy and begin updating the 2015 Water Resources National Plan to integrate water security and climate change elements. These steps will facilitate resource allocation and the prioritization of activities related to water security in ANA and in water-dependent sectors.

Responsible entity: ANA
Timeline: Short term

The Water Resources Policy and Plan might include measures to:

- Ensure that information regarding water security gaps and related indicators linked to social, environmental, and economic outcomes are included in the national strategy development plan, the concerted regional development plans, and the national budgeting and public investment system (invierte.pe) through strong coordination with sectoral agencies, the Ministry of Finance, and the National Center for Strategic Planning.
- Put in place a monitoring and evaluation process to track the implementation of water security measures under three pillars (sustaining water resources, delivering efficient and equitable water services, and building resilience) in coordination with the Ministry of Economy and Finance (MEF) and the National Center for Strategic Planning.
- Strengthen knowledge of groundwater to inform regulations for its management, with an initial focus on overexploited aquifers, and to identify potential areas for groundwater development. This will help promote the use of both surface water and groundwater in regions with water stress.
- Establish a regulatory framework for dam safety, modernize dam safety instruments, and implement dam safety plans and their respective emergency action plans in key dams. The capacity of ANA's Dam Safety Technical Unit should also be strengthened.
- Strengthen existing information management systems and planning tools by integrating remote sensing technologies, using drones to complement information systems, and using water balance modeling (and other planning methodologies that take a risk management approach) to better understand system uncertainties and to support robust decision-making.

Recommendation 3. Improve and expand wastewater management to address water quality and quantity in critical basins.

Pollution due to economic growth and rapid urbanization has decreased the quality and availability of water resources, affected public health, and is posing serious threats to the environment. Given the complexity of the problem, this diagnostic recommends that ANA and the Ministry of Environment (Ministerio de Ambiente, MINAM) work together to: (i) identify pollution hotspots, point sources (domestic, mining, and other industrial wastewater discharges), and nonpoint sources (agricultural runoff) of pollution; (ii) implement targeted source control measures in the identified hotspots; and (iii) enforce adequate treatment solutions where pollution cannot be prevented at the source. Given that the main cause of water pollution is the discharge of domestic wastewater into surface water bodies, this diagnostic proposes the development of a wastewater management strategy led by the MVCS as a first step to overcome this challenge.

First step: Develop a wastewater management strategy and pilot, at the basin level, sustainable programs for wastewater treatment that utilize circular economy approaches.

Responsible entity: The MVCS in close collaboration with MINAM and ANA
Timeline: Short term

The strategy could aim to:

- Rehabilitate and optimize existing wastewater treatment plants to ensure effective and efficient wastewater treatment.
- Align financing and investment programs for new wastewater treatment systems with public health and water quality objectives at the basin level. Including successive targets and standards that are realistic given investment needs and operation and maintenance costs will be central to achieving this objective.
- Utilize non-networked solutions in accordance with SDG target 6.2 in areas of low population density that do not have sewerage networks.
- Strengthen the regulatory and incentives framework for circular economy approaches through establishing (i) methodological guidelines to study reuse alternatives; (ii) market demand and reference prices for the commercialization of water reuse and biosolids; and (iii) incentive programs and technical assistance for service providers.

Deliver services for people and agriculture

To ensure secure water for human consumption and agriculture use, Peru must improve the efficiency of water services; employ differentiated, territorial approaches for service delivery; and ensure the financial sustainability of operations.

Recommendation 4. Utilize differentiated, territorial approaches to increase access to safely managed water and sanitation services for Peru's most vulnerable.

Peru still has significant work to do to improve water and sanitation services in rural and peri-urban areas, especially in regard to achieving drinking water quality standards and providing access to basic sanitation. Tackling such challenges will improve the health and capacity of citizens and promote opportunities for social mobility. Reaching these areas, however, requires a differentiated, territorial approach that considers geographic, sociocultural, and political conditions and takes into account population density and logistical difficulties.

First step: Prepare and begin implementation of a comprehensive water and sanitation policy and strategy for vulnerable populations in rural and peri-urban areas that includes strong community participation in the selection of technical and management solutions, promotes handwashing and hygiene, and utilizes innovative financial strategies.

Responsible entity: MVCS
Timeline: Medium term

The policy would do well to:

- Improve the existing public sector investment approach to ensure poverty and low human capital indicators are used when selecting project interventions.
- Include guidelines and incentives for cost-effective, innovative technical solutions and management models that reflect Peru's geographical and cultural differences. To ensure that the solutions are adequate, the process will require community participation, close coordination with local officials, and knowledge of urban plans and risk management regulations.
- Coordinate across sectors to prioritize and plan access to water and sanitation services for health care facilities and schools, initially focusing on areas most vulnerable to COVID-19 (in other words, areas with high population densities and limited access to safe water and adequate toilet facilities).

Recommendation 5. Establish financial incentives to improve the efficiency, service quality, and sustainability of water and sanitation service providers.

To ensure continued WSS access and to improve overall service quality, service providers must improve their efficiency and achieve financial sustainability. Despite several water and sanitation policies directed at improving performance and efficiency of water service providers, including tariff regulations that allow for cost recovery and aggregation of service providers, overall performance has not improved given low adoption and implementation of the policies at the local level. To ensure more sustainable WSS service delivery, the WSD recommends aligning existing policies with financing incentives.

First step: Prepare, adopt, and begin implementation of a performance-based financing policy for water-related capital investments.

Responsible entity: MVCS, in close coordination with service providers and local governments
Timeline: Short term

The proposed policy might:

- Allocate investment funds based on operational and commercial efficiency, application of adequate tariffs, aggregation of service providers, and improvements in service quality.
- Ensure transparency and the efficient allocation of resources for investments through simple procedures accompanied by technical assistance.
- Ensure that internal renumeration policies attract qualified, experienced professionals who are capable of leading efficient and sustainable utilities. Human resources must be equitable and promote gender equity in utilities given the low representation of women in senior and key decision-making positions.

Recommendation 6. Implement a comprehensive approach to deliver sustainable, efficient, and equitable irrigation and drainage services.

Investing in modernizing and developing irrigation and drainage systems and developing the technical and institutional capacity to improve service delivery will increase agricultural efficiency and productivity. Irrigated agriculture is critical to achieving better food security, producing higher-value crops, and increasing resilience of agriculture to climate change, especially in drought seasons. Irrigation-related investments, however, have not kept pace with the expansion of agricultural land in Peru. The country requires a comprehensive approach to enable irrigation expansion to the most vulnerable and improve the efficiency, reliability, flexibility, adequacy, and equity of irrigation and drainage services following performance-based mechanisms.

First step: Develop a detailed national irrigation strategy and plan that considers water storage, equitable water allocation, modernization of irrigation systems, and differentiated irrigation approaches to allow for the expansion of irrigation systems in undeveloped areas with irrigation potential.

Responsible entity: MIDAGRI, in close coordination with ANA
Timeline: Medium term

In addition, the irrigation strategy and plan would do well to:

- Prioritize the upgrade and expansion of efficient irrigation and drainage systems, especially for small- and medium-sized family farms in areas with high seasonal water variability.
- Couple irrigation and drainage projects with complementary activities linked to cropping systems, innovation and technical assistance, and the production and marketing stage of produced crops to support agricultural productivity and rural development.
- Strengthen MIDAGRI's information management system by integrating water resources, climate, agricultural, and land use information in a single knowledge management center.
- Develop capacity and financial incentives programs linked to public investments for regional and local governments to improve the design, implementation, and performance of irrigation and drainage projects.
- Develop technical assistance programs to strengthen the ability of water user organizations to improve the quality, efficiency, and sustainability of irrigation and drainage services and to access local and international markets.
- Encourage private sector investment in irrigation through farmers' and water user organizations. In addition to technical assistance programs, MIDAGRI could support land titling and registration of water use rights to encourage investment and create incentives for public-private partnerships in small- and medium-sized farms.

Recommendation 7. Strengthen capacity to effectively utilize budget allocation for water, sanitation, and irrigation services.

Strengthening the technical and project management capacity of national, local, and regional agencies to implement public investments in the water, sanitation, and irrigation sectors is key to accelerating efforts to close service gaps and expand access to irrigated agriculture. As detailed in the challenges section, the budget execution for the water and agriculture sectors is low despite the high need for financing.

First step: Provide capacity building and technical assistance to strengthen project implementation units to support the design and implementation of water and sanitation and irrigation projects and to enhance the capacity of government staff.

Responsible entity: MVCS and MIDAGRI
Timeline: Short term

Technical support might be needed to:

- Conduct a systematic audit of investment bottlenecks and develop and standardize processes and tools to assist with overall project management activities.
- Provide targeted assistance to local, regional, and national agencies in the preparation and approval of feasibility studies, following social and environmental safeguards.
- Prepare a capacity-building action plan that includes activities such as virtual learning, certification programs with accredited local institutions, and twining and internship arrangements.
- Accompany new hydraulic infrastructure with reliable water resources studies and environmental and social assessments.

Build resilience

To build resilience to ever-increasing climatic extremes, Peru must focus on improving the productivity and safety of existing dams, developing additional multipurpose and integrated water storage capacity, and strengthening disaster risk governance at the national and local levels.

Recommendation 8. Invest in integrated water storage solutions and improve resilience of existing hydraulic systems.

Peru faces water stress in the Costa region and significant interannual and seasonal variability of surface runoff in the Selva and Sierra regions. Regulation of surface runoff is even more critical in the context of climate change and impacts on the frequency and severity of floods and droughts. To build resilience to extreme droughts and floods, Peru must invest in integrated water storage measures and improve management of existing hydraulic infrastructure. To respond to this challenge, the GoP needs to employ an integrated approach that goes beyond infrastructure.

First step: Develop an integrated water storage strategy focused on ensuring risk-based management of existing hydraulic infrastructure, increasing water storage capacity, and facilitating multipurpose arrangements.[6]

Responsible entity: ANA, in close collaboration with water users
Timeline: Medium term

It is advisable that the water storage strategy:

- Prioritize rehabilitation of aging hydraulic infrastructure and strengthen risk management measures—including dam safety protocols, sediment management, operation and maintenance systems, and catchment management programs—to reduce vulnerability and increase the longevity of infrastructure.
- Promote investment in water storage systems that utilize nature-based solutions, use groundwater during drought periods, and optimize multipurpose water storage and regulation of river flows.
- Develop institutional arrangements and flexible water allocation mechanisms to facilitate and optimize multipurpose water storage, particularly for the energy and agricultural sectors.
- Support the development of capacities to improve information management systems for long-term planning, and monitoring resilience of water systems and services in an integrated platform.

Recommendation 9. Build resilience, in the face of an uncertain future, into existing sector planning instruments.

Peru has a national disaster risk management (DRM) legal framework that focuses on improving prevention of and building resilience to disasters, but adoption by water-related agencies at the local level has been slow. A concerted, multisectoral effort to develop harmonized guidelines, provide technical assistance, and offer incentives is needed to ensure that local governments, service providers, and river basin counsels incorporate DRM policies into their existing sectoral planning instruments and operational procedures. Given that several studies have been conducted to include DRM in river basin plans, to accelerate adoption of nature-based solutions for climate resilience and incorporate decision-making under deep uncertainty in water master plans, the WSD recommends working with ANA, MVCS, and MIDAGRI to develop a targeted pilot program to include DRM practices within local water organizations' planning instruments.

First step: Develop a pilot program for local water organizations, including river basin councils, water and sanitation service providers, and water user organizations (irrigation) to incorporate DRM measures into existing sectoral planning instruments and operational procedures.

Responsible entities: ANA, MIDAGRI, and MVCS
Timeline: Medium term

The pilot program could focus on the following:

- Drought and flood preparedness and emergency plans in selected water user organizations (irrigation) and asset inventory and management programs in selected urban water utilities.
- Natured-based solutions for water source protection in selected water user organizations (irrigation) and water service providers.
- Application of decision-making under deep uncertainty in water supply master plans and in river basin management plans to support short- and long-term investment planning and project design to manage water-related risks in select water utilities and river basin councils, taking into account the interconnected water uses and sources at the local level.

The results of the pilot program should be documented and used to inform the development of policies and programs to scale up these resilience-related practices across the water sector. To incentivize these practices, public funds for investments could be subject to specific DRM and resilience-building requirements (refer to Recommendation 5).

Notes

1. The Sierra Irrigation Project closed in 2017: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/595941505485032273/peru-sierra-irrigation-project.
2. Data calculated from the Institute of Health Metrics and Evaluation's Global Burden of Disease Results Tool (http://ghdx.healthdata.org/gbd-results-tool) and from Peru's 2018 Demographic and Family Health Survey (Encuesta Demográfica y de Salud Familar).
3. Includes losses due to water pollution and production shocks.
4. The Water Supply, Sanitation, and Hygiene (WASH) SDG Costing Tool uses data from the Joint Monitoring Programme (JMP) and is a joint publication of the United Nations Children's Fund (UNICEF) and Sanitation and Water for All (SWA). The data by country can be accessed at: https://www.sanitationandwaterforall.org/tools-portal/tool/sdg-costing-tool.
5. The range of additional investments required come from different sources. The JMP estimates US$1.3 billion based on a narrow set of least-cost sanitation technologies. The highest estimate of US$2.6 billion comes from the National Sanitation Plan (2022–26), which incorporates all sanitation projects with a larger set of technologies and options. The UNICEF-SWA JMP estimates (US$1.3 billion)

represent 16 percent of the trade balance of the country in 2020, whereas the IDB estimates (US$2.2 billion) represent one-quarter of all 2020 imports of consumer goods in the country. Calculated based on data from: https://www.bcrp.gob.pe/eng-docs/Statistics/quarterly-indicators.pdf.

6. Operational and legal arrangements so that storage can serve multiple functions and provide multiple services and uses.
7. The cost estimate for WSS services is based on the 2022–26 National Sanitation Plan, and the cost range to reach safely managed WSS services is based on the data estimates of the UNICEF-SWA JMP (lowest) and IDB's 2021 study (highest). The cost range estimated in the 2019 Infrastructure Plan for Peru is close to US$25 billion.
8. Irrigated land targets are based on MIDAGRI's Multiannual Plan for the period 2015–21 (40.8 percent of the cultivated land in 2012) and the long-term target under the National Infrastructure Plan is 490,000 hectares at a unit cost ranging between US$10,000 and US$12,000 per hectare (expert estimates). The target established under the National Climate Change Adaptation Plan for increasing efficiency of irrigated land with on-farm irrigation equipment (such as sprinkler or drip irrigation) is between 250,000 and 280,000 hectares (equivalent to 20.1 percent of total irrigated land) at a unit cost ranging between US$4,000 and US$6,000 per hectare (expert estimates).
9. Development of water storage is estimated based on the water deficits data obtained from the 2015 National Water Resources Plan and from the water balance study conducted for this diagnostic. A unit cost between US$2.2 and US$4.2 per cubic meter was used to determine the investment cost based on the recent Chancay-Lambayeque River Basin Plan. Improving the productivity and safety of existing storage capacity of nonenergy dams is estimated at 4,500 MCM. Hectares and unit cost for nature-based solutions are estimated based on information provided by the National Climate Change Adaptation Plan.
10. The target of early warning systems and the number of interventions to protect agricultural production against floods, as well as unit costs, are calculated based on information in the National Climate Change Adaptation Plan for the period 2021–30.

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Abbreviations

ANA	National Water Authority (*Autoridad Nacional del Agua*)
BCM	billion cubic meters
BOT	build, operate, transfer
BOD	biological oxygen demand
DRM	disaster risk management
DSGE	Dynamic Stochastic General Equilibrium
DTF	Decision Tree Framework
EPS	urban water utility
FAO	Food and Agriculture Organization
GDP	gross domestic product
GoP	Government of Peru
IDB	Inter-American Development Bank
INEI	National Institute of Statistics and Computing (*Instituto Nacional de Estadística e Informática*)
JMP	Joint Monitoring Programme of WHO/UNICEF
LAC	Latin America and the Caribbean
m^3	cubic meter
MCM	million cubic meters
MERESE	Mechanisms of Compensation for Ecosystem Services (*Mecanismos de Retribución por Servicios Ecosistémicos*)
MIDAGRI	Ministry of Agricultural Development and Irrigation (*Ministerio de Desarrollo Agrario y Riego*)
MINAM	Ministry of Environment (*Ministerio de Ambiente*)
MVCS	Ministry of Housing, Construction, and Sanitation (*Ministerio de Vivienda, Construcción y Saneamiento*)
MW	megawatt
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development
PCM	Presidency of the Council of Ministers (*Presidencia del Consejo de Ministros*)
PPP	purchase power parity
UNICEF	United Nations Children's Fund
S/.	The Peruvian sol (code PEN) is the currency of Peru; it is subdivided into 100 céntimos (cents)
SEDAPAL	Lima's water and sanitation utility (*Servicio de Agua Potable y Alcantarillado de Lima*)
SEDAPAR	Arequipa Water and Sanitation Utility (*Servicio de Agua Potable y Alcantarillado de Arequipa*)
SDG	Sustainable Development Goal

SNGRH	National Water Resources Management System (*Sistema Nacional de Gestión de Recursos Hídricos*)
SUNASS	National Superintendence of Sanitation Services (*Superintendencia Nacional de Servicios de Saneamiento*)
WASH	water supply, sanitation, and hygiene
WHO	World Health Organization
WSD	Water Security Diagnostic
WSS	water supply and sanitation
WUA	water user association

CHAPTER 1

About This Report

The World Bank defines water security as the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies.

This Water Security Diagnostic (WSD) report adds to the evidence base that water security matters for Peru's economic, social, and environmental development pathways, and presents recommendations on how the Government of Peru (GoP) could further strengthen its ability to address water challenges in the face of a changing climate to achieve water security objectives. It is informed by the World Bank's firsthand experience in the Latin America and the Caribbean (LAC) region and in Peru itself, where water security challenges stemming from growing demand and climate change are on the rise.

This report was also inspired by the country's commitment to achieving the 2030 Sustainable Development Goals (SDGs), in which water plays a central role. This commitment is reflected in Peru's Nationally Determined Contributions as well as its 2021–26 General Government Policy, which prioritizes universal access to safe water and sanitation for all, water storage solutions, expansion of sustainable irrigation systems to improve rural livelihoods, and climate change adaptation and mitigation.

Information Sources and Research Methodology

This diagnostic draws on the wide range of knowledge and experiences of the World Bank's Water Global Practice in Peru, together with strong engagement with the national government. It also draws on existing studies, supplemented by additional data and analysis to fill knowledge gaps. Deep dives conducted in preparation for this diagnostic are available as background papers (refer to box 1.1). Topics include the burden of disease associated with unimproved water and sanitation services; a quantitative model to determine how the water balance (supply and demand) at the basin level might shift in response to climate change; a public expenditure review of water supply and sanitation (WSS) services and irrigation services; a hydroeconomic model for Peru to estimate the impacts of water shocks on key economic sectors; and a water quality diagnostic of Peru.

For the purposes of this report, the World Bank drew on national and global datasets to develop a set of water-security-related indicators. These indicators provided information on various water-related variables over time, most notably water endowments; water use; water's contribution to people and ecosystems; and the impacts of floods and droughts on people, the economy, and ecosystems.

A wide range of studies and assessments cover different aspects of water security in Peru. This knowledge has been critical in the development of this diagnostic. References that have been especially useful include *Water Governance in Peru* (OECD 2021); the *National Water Resources Plan* (ANA 2013); the *Water Resources Policy and Strategy* (GoP 2015); the *Investment and Financing Policy Proposal for the Sanitation Sector* (World Bank 2016); *The Future of Irrigation in Peru* (World Bank 2013); and *Repensar el Futuro del Perú [Rethinking the Future of Peru]* (World Bank 2021).

Although the scope of the diagnostic was national, this report also reflects geographical and social differences across Peru's three main geographic regions—the coast (Costa), the highlands (Sierra), and the Amazon rainforest (Selva)—to support social inclusion in future measures to improve water security.

Report Structure

The report begins by providing an overview of Peru's key institutions and stakeholders in the water sector, then analyzes why water is important for Peru's socioeconomic development and continues with a detailed analysis of the key challenges to achieving water security. The challenges are broadly grouped into those that pertain to the quantity and quality of the country's water resource endowment, and those that pertain to the performance of the country's water sector institutions and infrastructure. The report concludes with nine priority recommendations and concrete actions to improve water security in Peru.

Before proceeding, it is helpful to understand the water cycle of use, as explained in box 1.2 and depicted in figure B1.2.1.

Box 1.1 Technical Deep Dives Conducted for the Water Security Diagnostic (WSD)

The information and analysis summarized in this report are the results of deep dives presented as technical studies conducted between 2019 and 2021. Below is a list of the key studies commissioned for the WSD:

- Countrywide hydrological water balance modeling at the macrobasin level, with climate change projections.
- A hydroeconomic model to estimate the economic impacts of various types of water shocks on the sectoral and aggregate economy through an input-output matrix (2017) and a dynamic, stochastic general equilibrium model.
- Burden of disease: An in-depth analysis of the economic cost of lack of access to water and sanitation using a burden of disease methodology that pays close attention to health impacts on children and women.
- A public expenditure review of water, sanitation, and irrigation subsectors between 2010 and 2020.
- A water quality study to identify pollution hotspots and relate them to known sources of pollution and impacts on human health and development.
- A gender analysis identifying opportunities and good practices for gender-sensitive water resources management and water supply and sanitation services.
- Nine actions to improve water security in the country proposed by high-level private sector stakeholders.
- Additional background papers on microeconomic impacts of water shocks on human capital and development outcomes.

Box 1.2 An Overview of the Water Cycle of Use

The water cycle starts with a water endowment, that is, the rivers, glaciers, lakes, aquifers, and various other freshwater resources that are available for a country to tap to serve its economic and demographic needs. Additional aspects to consider include rainfall volumes and patterns, and also water pollution, which wield significant influence on a country's economy and people, especially through their effects on public health, agricultural productivity, and the occurrence of extreme events such as droughts and floods.

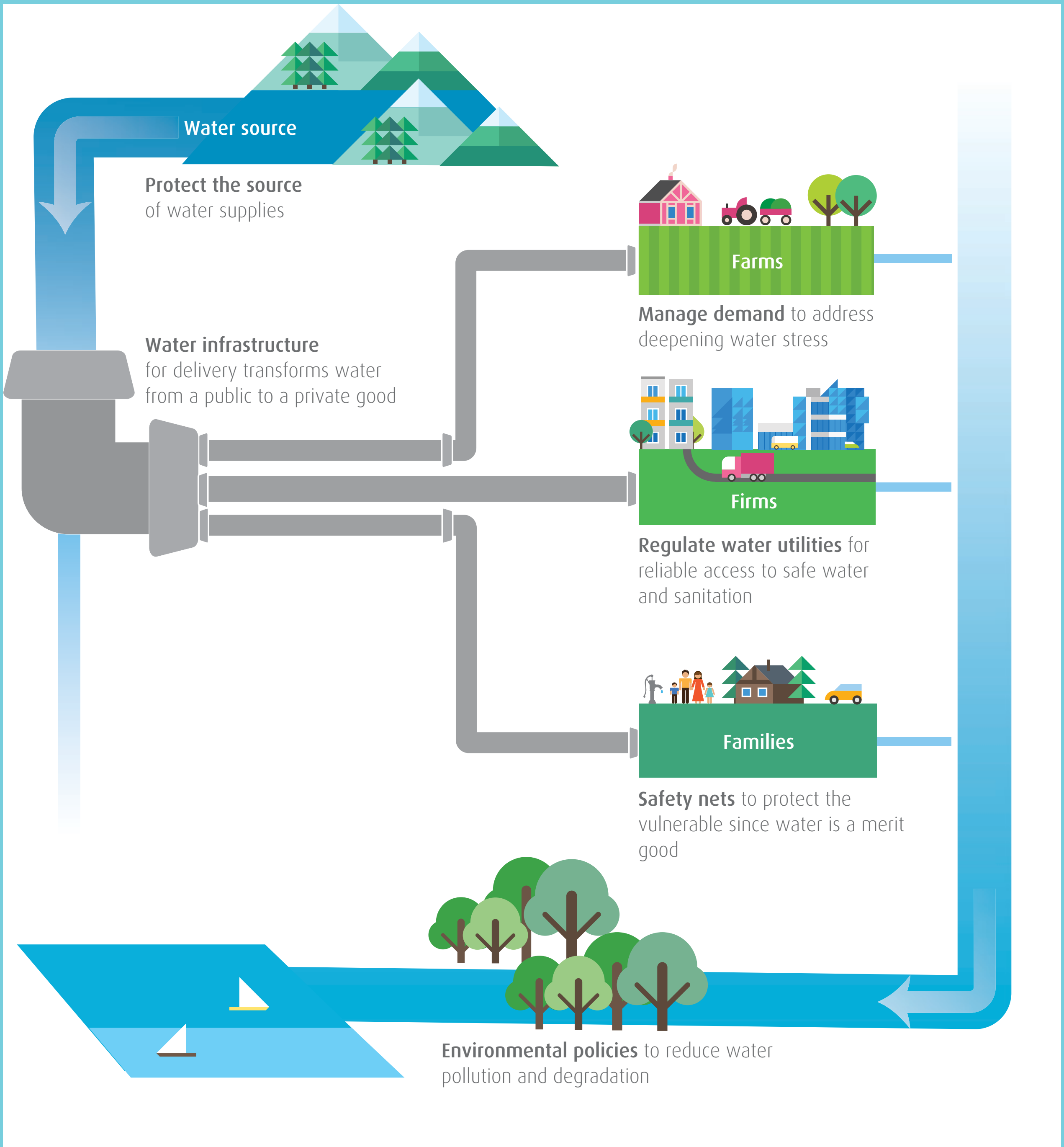
Water resources need to be tapped and managed in a sustainable manner. This second stage of the cycle centers on the institutions and policies governing the use of water resources, as well as the physical infrastructure in place to store water, transport it to its end users, and to dispose of waste in a manner that does not compromise the quality and quantity of water at its source. The present Water Security Diagnostic aims to assess the performance

Box 1.2 Continued

of the Peruvian water sector, by gauging its effectiveness in the delivery of services, mitigation of risks, and the management of resources.

Last in the cycle of use come the end users—the "farms, firms, and families" that utilize water for subsistence, recreation, and production, before returning it to the earth in one form or another. Looking at the entire cycle helps assess a country's water security and its ramifications for the economy, environment, and people.

Figure B1.2.1 Water Use Cycle



Source: Damania et al. 2017

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CHAPTER 2

Mapping Peru's Key Water Institutions and Stakeholders

This chapter outlines the key institutions and stakeholders involved in Peru's water sector.

This diagnostic focuses on the activities and challenges of the institutions linked to water resources management and the delivery of WSS and irrigation and drainage services, as well as the multisectoral platform that ensures interagency coordination of water policies.

Overall, the core institutional challenge is to improve governance, which in turn would enhance the sector's efficacy and effectiveness. The first step is to align management practices with sustainability, quality, and performance objectives. Also, building resilience can help adapt water resources use to population demands and a changing climate. Gaps in the administrative and technical capacities of local institutions need to be filled so they can implement national policies and regulations. Considerable financial investment is needed to meet the sector's objectives for access, availability, and quality, and prepare it to cope with the increasing risks and vulnerabilities of climate change.

Water Resources Management

Peru's water resources sector is headed by the National Water Authority (Autoridad Nacional del Agua, ANA), created by the Water Resources Law approved by Congress in 2009. ANA is ascribed to the Ministry of Agricultural Development and Irrigation (Ministerio de Desarrollo Agrario y Riego, MIDAGRI). Therefore, MIDAGRI issues supreme decrees proposed by ANA in order to regulate the integrated and multisectoral management of water resources (OECD 2021).

ANA has a deconcentrated administration responsible for local water resource policy, through administrative water authorities, with hydrographic regional scope; local water authorities at the basin/multibasin level; and river basin councils (established at the initiative of regional governments). ANA's main functions include: (i) developing national water resource policy and supervising its execution; (ii) determining the value of fees for water usage rights and for the discharge of wastewater in natural water sources; and (iii) granting, amending, and terminating water usage rights. ANA generated the National Policy and Strategy for Water Resources Management 2013 and the National Water Resources Plan 2015. Their main feature is a focus on the basin level as the main unit for integrated water resources management. Regional governments are responsible for the operation and maintenance (O&M) of major public hydraulic infrastructure, and regional and local governments participate in basin-scale planning and undertake water quality and discharge monitoring and control actions in their areas of jurisdiction. A tribunal for conflict resolution was also created by the Water Resources Law to address conflicts between water users.

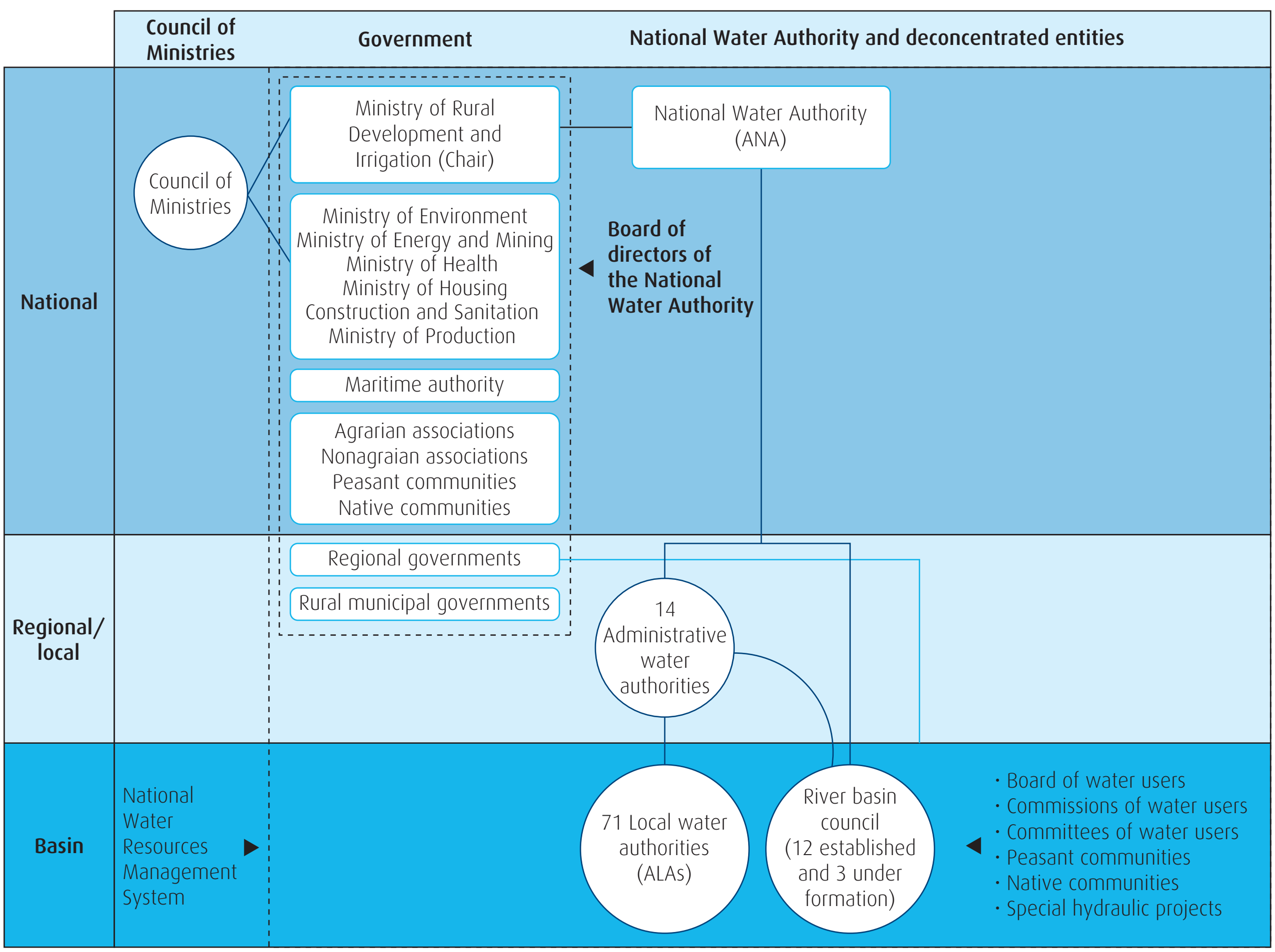
These deconcentrated entities work with water user associations (WUAs) to plan, distribute water, and operate the hydraulic infrastructure. To date, of the 29 such councils originally envisioned, 17 river basin councils are outstanding, only 12 having been established (ANA n.d.), and the corresponding basin management plans are under development or completed. WUAs provide services to the agricultural sector but were envisioned in the Water Resources Law as multisectoral organizations that would address a wider variety of water-related issues.

The National Water Resources Management System

ANA is responsible for overseeing the National Water Resources Management System (Sistema Nacional de Gestión de Recursos Hídricos, SNGRH), an integrated water management platform established in 2009 under the Water Resources Law. The platform brings together public sector institutions and water users at the national and subnational levels—including grassroots and indigenous communities—to collectively contribute their competencies and sensibly designate functions. It is strategically important because it offers a vehicle to integrate, articulate, and coordinate aspects of water management that are carried out by multiple public entities.

The SNGRH develops its policies in coordination with the Ministry of Environment (Ministerio de Ambiente, MINAM); MIDAGRI; the Ministry of Energy and Mines; the Ministry of Health; the Ministry of Production; the Ministry of Housing, Construction, and Sanitation (Ministerio de Vivienda, Construcción y Saneamiento, MVCS); and the regional and local governments, within the framework of the national water resources policy and strategy (figure 2.1).

Figure 2.1 Organization of the National Water Resources Management System's Water Integration Platform



Service Providers—Water Supply and Sanitation, and Irrigation and Drainage

Various national and subnational institutions are responsible for regulating and providing water and sanitation services in Peru (see figure 2.2). At the national level:

The MVCS oversees policy development and national planning, including prioritizing and allocating public investments at the national level.

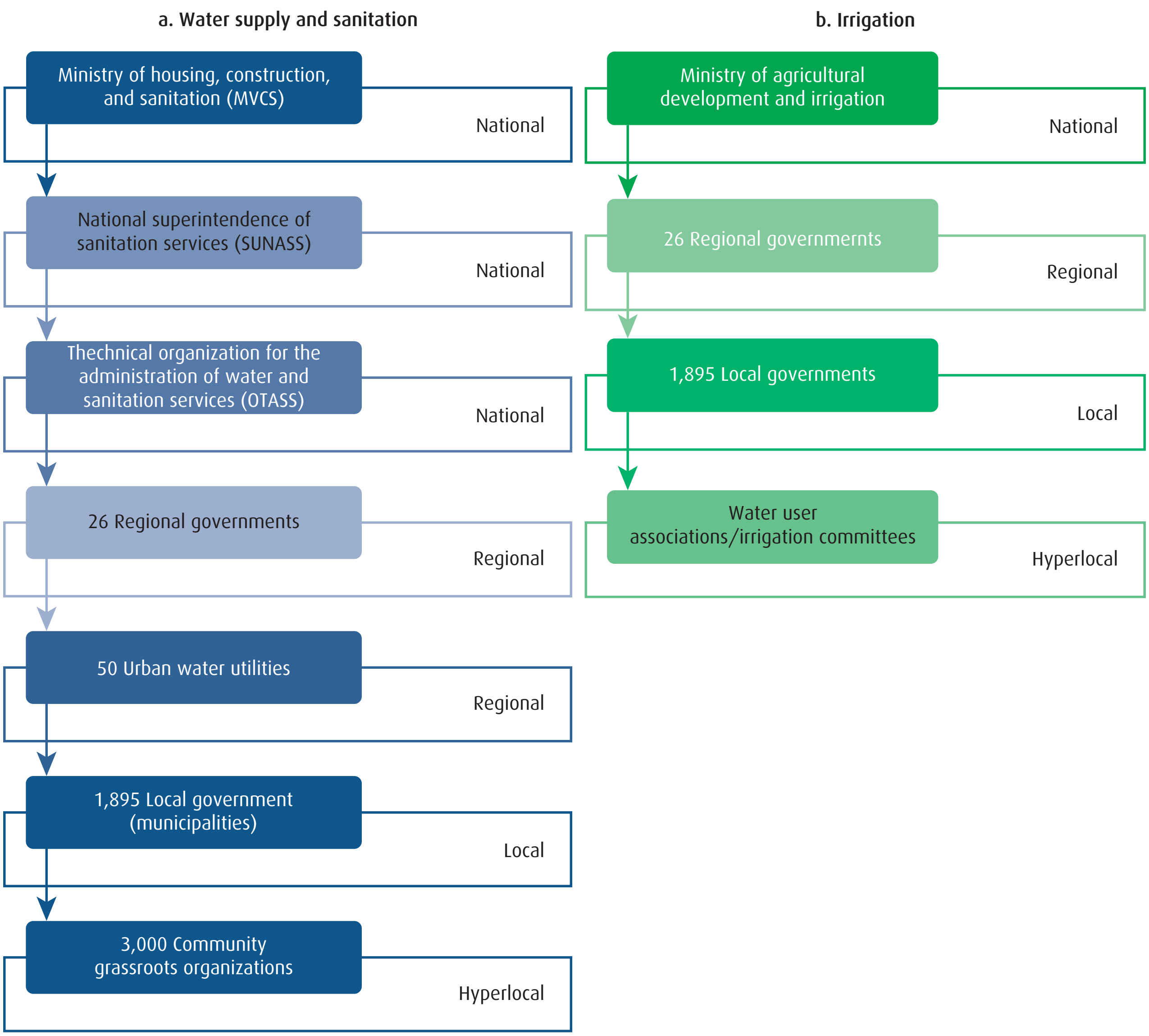
The Technical Organization for the Administration of Water and Sanitation Services (Organismo Técnico de la Administración de los Servicios de Saneamiento, OTASS), which falls under the MVCS, is primarily responsible for providing technical assistance to urban water utilities in order to execute the national government's policy on administration and management of these entities.

The National Superintendence of Sanitation Services (Superintendencia Nacional de Servicios de Saneamiento, SUNASS) is an independent entity responsible for economic regulation of water and sanitation services, including the resolution of customer service complaints to the regulator.

Regional and local governments are responsible for applying MVCS standards and policies to sector investments within their jurisdictions. The regional governments are also mandated by law with the role of providing technical assistance to local governments and to service providers.

A variety of service providers are responsible for the delivery of water and sanitation services. Lima's water and sanitation utility (Servicio de Agua

Figure 2.2 Key Entities Responsible for Water Supply and Sanitation and Irrigation



Potable y Alcantarillado de Lima, SEDAPAL) serves the country's metropolitan capital, while another 49 water and sanitation utilities provide services to other urban areas. Small municipalities and community grassroots organizations are responsible for small towns and rural areas.

Various national and subnational institutions are responsible for regulating and providing irrigation services in Peru (see figure 2.2).

At the national level, MIDAGRI's main function is to regulate the agrarian sector. To this end, it oversees national policy development and planning, including prioritizing and allocating public investments in irrigation. MIDAGRI implements a number of financing mechanisms for irrigation through institutions including Agrorural, the Sierra Azul, and the Irrigation Subsectoral Program, which implements infrastructure irrigation systems.

Regional and local governments are responsible for applying MIDAGRI's standards and policies to sector investments within their jurisdictions. The regional governments are also mandated by law to provide technical assistance to local governments and to service providers.

Local WUAs are groups of private water users, such as irrigators, who pool their financial, technical, material, and human resources for the O&M of a water system. Following a period of strong intervention from the public administration in the management of irrigation systems in Peru, responsibility for the operational management of systems was transferred to these WUAs in 1989. There are 64 WUAs in the coastal area and 34 in the highlands or Sierra region. These coexist with more traditional organizations (irrigation committees and farming communities), sometimes creating confusion regarding their roles and responsibilities.

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CHAPTER 3

Why Water Matters to Peru's Development

Water security is at the heart of Peru's path toward sustainable development. The country needs to act now to safeguard its water resources and, ultimately, protect its ecosystems, economy, and people from the negative impacts of water stress and excess. This chapter outlines why water security is important for Peru's economy, industry, food security, energy, natural environment, and public health.

Water is a Key Driver of Economic and Human Capital Development

Water-intensive sectors account for two-fifths of Peru's gross domestic product (GDP), with about 6 percent coming from agriculture, 12 percent from mining and hydrocarbons, 13 percent from manufacturing, 7 percent from construction, and 2 percent from water and electricity (BCRP 2022). Metals and ore are especially important to Peru's economy, accounting for 63 percent of total exports in 2020. Copper alone accounts for 50 percent of all exports; other important export minerals are gold and refined petroleum.

Agriculture is also a key economic sector, with exports of tropical fruits, grapes, blueberries, avocado, coffee, and other high-value produce accounting for 16 percent of total exports. The agricultural sector also accounts for 22 percent of employment on the national scale; in rural areas, this increases to 54 percent (INEI 2020). Nearly two-thirds of the 300,000 new formal jobs created in 2018 and 2019 combined were related to the agricultural sector. Without water, these exports and jobs would not be possible. This is significant for rural development given that 46 percent of the population in rural areas remains poor and about 14 percent is mired in extreme poverty (INEI 2021).

As the agriculture sector demonstrates, water and jobs are intimately linked. As many as 2.4 million jobs are in water-intensive sectors such as mining, construction, and manufacturing. Manufacturing alone employs 1.3 million people, or 5 percent of Peru's workforce. The high production value of manufacturing, combined with the number of people it employs, means that it is highly exposed to water risks. The yearly water shocks generate impacts on the mining and manufacturing industries in the order of US$395 million on average, an amount that is comparable to 45.8 percent of the total budget for health infrastructure in 2021 (US$874 million) (MEF 2021).

Water is key for industrial production. The interruptions in water services halt production processes and increase production costs in industries such as manufacturing. For many manufactured products, water is essential to clean, cool, or transform raw materials or inputs used for production. Moreover, strong consumption and investments have driven solid growth rates in Peru over the last two decades, but when the provision of water or energy is not continuous, investments are delayed and their impact on growth is diminished. Further, water interruptions also have impacts on firm productivity. According to the World Bank Enterprise Survey, about 13 percent of firms in 2017 experienced insufficient water supply for production (with interruptions amounting to 30 hours per month on average). Water shortages are estimated to translate into an 18 percent reduction in total factor productivity (box 3.1). Similar burdens resulting from water shortages are also felt by informal firms in Peru. A 24-hour increase of water shortage in a month leads to a 3.7 percent loss in monthly sales per worker (Islam 2018).

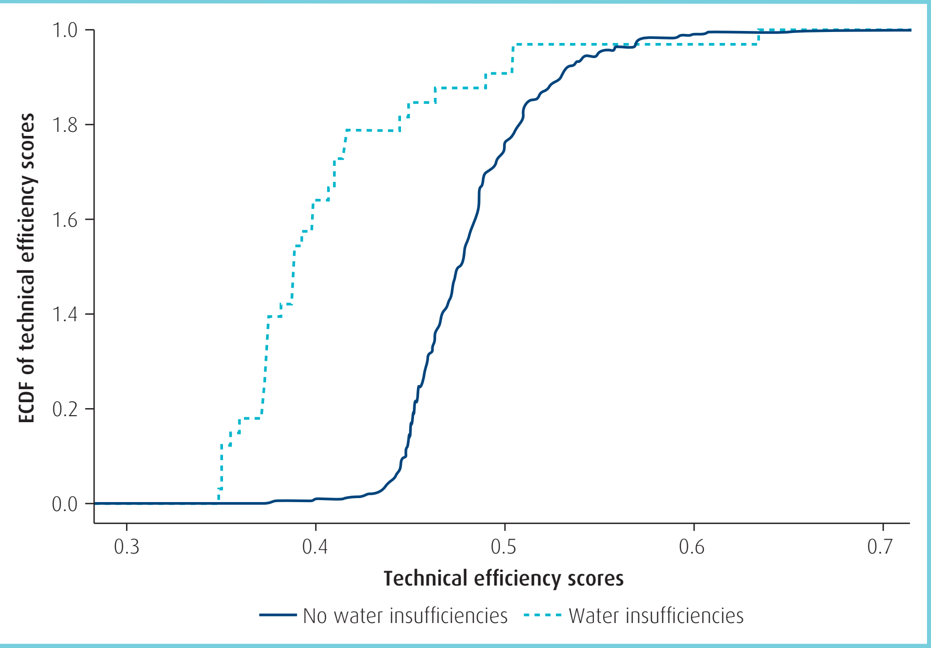
Unreliable water services also affect the competitiveness of firms and have direct impacts on households. It has been estimated that a substantial improvement in the reliability of water supply services (from the current rate of 4.5 to 6.0 on a scale of 1 to 7) will generate an increase of 1 percent in Peru's Global Competitiveness Index. Water disruptions are estimated to cost households between 0.11 percent and 0.19 percent of GDP every year (Hallegatte, Rentschler, and Rozenberg 2019), which in the case of Peru corresponds to US$222–384 million. This underpins the importance of improving the reliability of water and sanitation systems.

Water shocks linked to extreme rainfall and droughts, which are commonplace in Peru, affect vast populations causing severe economic damages and impacts on human capital accumulation (Barron and Moromizato 2020).

Box 3.1 Water Shortages Lower Firm Productivity in Peru

A stochastic frontier analysis based on the World Bank Enterprise Survey (2017) was conducted to assess the impacts of water shortages on firm productivity. The results indicate an 18 percent reduction in total factor productivity. Figure B3.1.1 shows the cumulative distribution of technical efficiency scores of firms experiencing water insufficiencies and firms experiencing no water insufficiencies. A higher technical efficiency score indicates a higher technical efficiency.

Figure B3.1.1 Firms Experiencing Water Shortages in Peru



Note: Empirical cumulative distribution function (ECDF) is an empirical cumulative distribution function that plots continuous data points of a sample from lowest to highest against their percentiles or percent contribution to total in cumulative terms.

The 1990 and 1992 droughts affected 10 percent and 5 percent of the population in the country and generated economic losses that represented 0.14 and 0.7 percent of the country's GDP, respectively. The water shocks from the El Niño events of 1982/83 and 1997/98 caused the greatest economic losses of any natural event to date (about 11 percent and 6 percent of GDP, respectively).The 2017 floods associated with El Niño Costero offer another example of the substantial impacts of water shocks: nearly 2.2 million people, representing 7 percent of the population, were affected; and US$3.2 billion of economic damages were inflicted, equivalent to 1.5 percent of GDP. During the period 1990–2020, 1 percent of the total population was affected by water shocks causing US$4.2 billion in accumulative economic damages (in 2020 constant prices), equivalent to 2 percent of 2020 GDP (EMDAT 2022). Furthermore, damage caused by floods and droughts have direct impacts on educational outcomes, morbidity and mortality rates, and labor productivity, hampering human capital accumulation.

According to the economic analysis conducted for this diagnostic (refer to box 3.1), water security gaps cost Peru between 1.3 and 3.5 percent of GDP per year (table 3.1); 4.1 percent of jobs are lost as a result of water-related losses in agriculture, mining, manufacturing, health, and households' income.[1] When production shocks and losses due to water pollution are also considered (and concomitant benefits are excluded), the economic impact could range between 4.0 percent and 6.4 percent of GDP per year. These losses do not consider spillover effects on local economies or losses in value added, so they largely underestimate the impacts of water shocks and pollution.

Table 3.1 Summary of Economic Impact of Climate-Related Water Shocks, by Economic Sector

Impact area	Agriculture	Manufacturing / mining	Industry	Energy	Households	Total
Restrictions in water supply						
Total value (US$, billions 2020 PPP)	1.08	2.90	0.99	0.24	0.28	**5.49**
% of sector's GDP	9.46	10.24	8.41	6.22	1.50	
% of GDP	0.51	1.36	0.46	0.11	0.13	**2.57**
Floods						
Total value (US$, billions 2020)	0.22	0.08	0.14	0.01	0.15	**0.60**
% of sector's GDP	1.93	0.29	1.18	0.29	1.10	
% of GDP	0.10	0.04	0.15	0.01	0.07	**0.37**
Droughts						
Total value (US$, billions 2020)	0.48	0.09	0.03	0.01	0.06	**0.67**
% of sector's GDP	4.20	0.32	0.28	0.25	0.9	
% of GDP	0.22	0.1	0.04	0.01	0.03	**0.40**
Limited water and sanitation services linked to burden of disease						
Total value (US$, billions 2020)					**0.25**	**0.25**
% of sector's GDP					1.4	
% of GDP					0.12	**0.12**
Range of economic cost						
% of GDP (low)—Climate-related impacts only (floods and droughts)	0.70	0.17	0.17	0.02	0.21	**1.27**
% of GDP (high)—All impacts	0.83	1.50	0.65	0.13	0.35	**3.46**

Source: Estimates based on the Input-Output Matrix and DSGE model 2021.
Note: Data are in PPP (purchasing power parity) 2020 prices, expressed in billion US dollars. Dollar figures for gross domestic product (GDP) are converted from domestic currencies using 2020 official exchange rates of Peru's Central Bank (BCP). Underlying GDP in local currency unit is annualized with time series of PPP conversion factors for GDP, which are extrapolated with linked GDP deflators. GDP is expressed in current international dollars, converted by the PPP conversion factor. GDP is the sum of gross value added by all resident producers in the country plus any product taxes and minus any subsidies not included in the value of the products. The PPP conversion factor is a spatial price deflator and currency converter that eliminates the effects of the differences in price levels between countries. The sectors' gross production values are taken from INEI's GDP series 2007–20 (https://m.inei.gob.pe/estadisticas/indice-tematico/pbi-de-los-departamentos-segun-actividades-economicas-9110/).

By contrast, Peru generates between 21,000 and 36,000 indirect and direct jobs when it invests US$1 billion to close water security gaps.[2] This shows the potential that investments in the water sector have to maximize job generation in Peru. In fact, the GoP has prioritized water-related investment projects as a key strategy of its post–COVID-19 economic recovery while benefitting from building a green and inclusive economy. For instance, in irrigation, the GoP is using a short-term response strategy, as public funding for deferred maintenance and cleaning of irrigation and drainage canals has generated 100,000 temporary jobs, while increasing access to water and preparedness for flood events (World Bank 2021a).

Water's contribution to Peru's economy is further amplified when the impact of hydropower is considered. Water is required to produce electricity and is critical for energy security and green energy. Hydropower accounts for 57 percent of total electricity generation in the country and is the enabler of other energy renewables (solar and wind) by providing the storage needed to manage variability. Peru's Regulatory Agency for Investment in Energy and Mining (Osinergmin) has estimated that a 60 percent reduction of the electricity generated by the Mantaro hydropower system, equivalent to 10 percent of electricity generation in Peru, could reduce GDP by 0.23 percent and the balance of payments by 0.22 percent. Fortunately, at present, Peru has a good electricity reserve, which allows the country to avoid negative impacts in case of electricity disruptions. Nonetheless, this exemplifies the economic contribution of hydropower.

People need access to adequate and safe water and sanitation services if they are to be healthy and productive enough to contribute to the economy

The World Bank defines human capital as the knowledge, skills, and health that people accumulate throughout their lives, enabling them to realize their potential as productive members of society (World Bank 2022). It is possible to end extreme poverty and create more inclusive societies by developing this human capital, which requires access to public services such as health care, education, and safe water and sanitation.

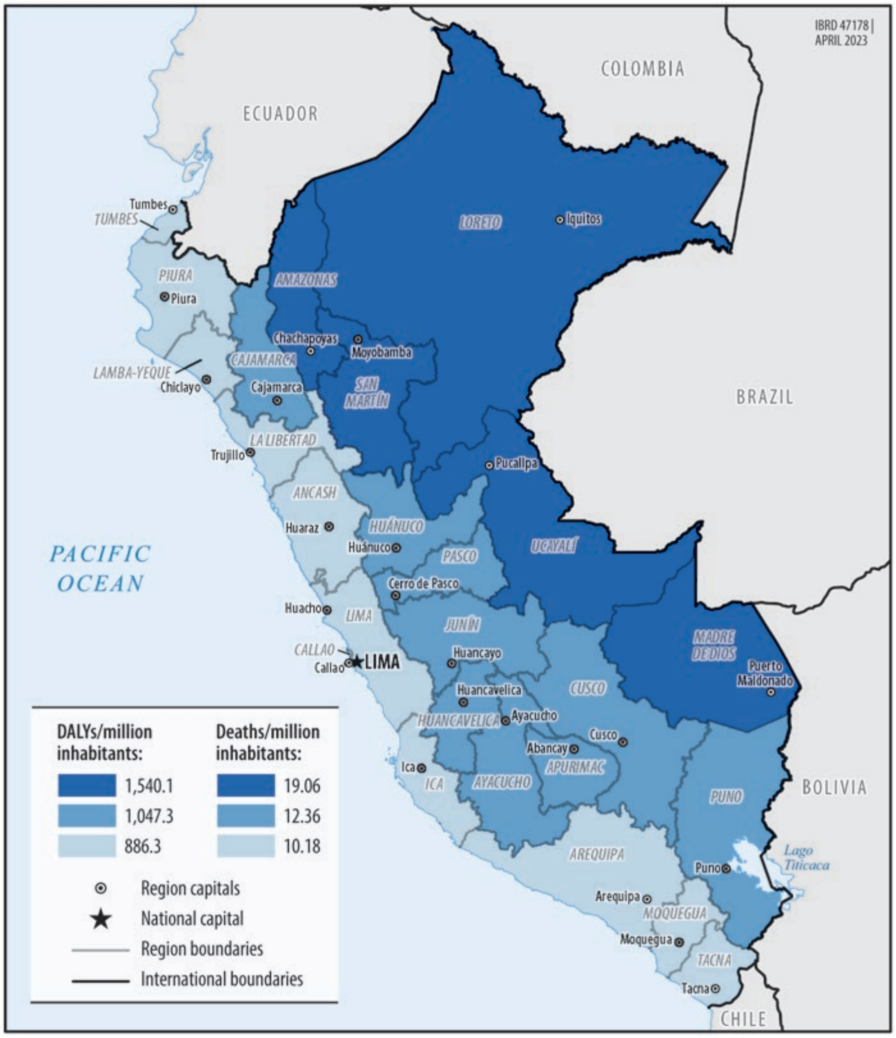
Each year, about 900,000 Peruvian children under the age of five develop acute diarrhea directly related to inadequate water and sanitation services. Empirical studies show that recurrent infections could result in gut dysfunction in children, leading to malnutrition. In turn, this could lead to negative outcomes in school performance and physical growth, with long-term consequences for both society as a whole and individuals, who might struggle to find well-paying work due to their short stature or poor academic record. A study conducted in Peru indicates that the odds of children developing acute diarrhea is 2.5 times higher in rural areas without improved sanitation, with the highest prevalence among children 22 months to 6 years of age (Ballard 2017).

A study of the economic burden of diseases associated with unimproved WSS services found that the number of years of life lost resulting from inadequate access to water and sanitation is costing the country about US$246 million per year. Of this, US$138 million was due to illnesses, US$82 million due to hospitalizations, and US$26 million due to the cost of caregiving, most of which is done by women.[3] In addition, an economic analysis conducted for this study indicates that closing the gap in access to water and sanitation services would increase GDP by 1.6 percent each year through reducing the burden of disease and limiting the impact of climate change on health.

The people of the Amazon rainforest region shoulder most of the burden associated with unimproved water and sanitation, recording double the number of deaths related to inadequate WSS services (14.3 deaths per million people, compared with 7.4 deaths per million for the Costa) and double the number of years lost due to disability linked to WSS-related diseases (1,328.2 years, compared with 684.8 years on the Costa) (map 3.1). This geographical disparity is closely linked to economic and public health conditions, which are better in the Costa region.

Investments in nutrition-specific interventions aiming at reducing child stunting that include access to water supply, sanitation, and hygiene are estimated to yield substantial returns. Economic costs of childhood stunting to the private sector are very high. Childhood stunting reduces cognitive development, causing delays in starting school (by five months), losses of schooling (by more than half a year), and reductions in lifetime earnings; and, in women, poor reproductive performance, including smaller babies (Barron 2018; Molina and Saldarriaga 2017). In the case of Peru, it is estimated that total median annual income losses associated with stunting in childhood are US$3.7 billion (representing 8 percent of national income). The benefit-cost ratio of investments to

Map 3.1 Number of Deaths and Disability-Adjusted Life Years Lost per Million Inhabitants Attributable to Inadequate Water and Sanitation Services, by Region, 2018



Note: DALY = disability-adjusted life year.

improve nutritional outcomes and prevent stunting is very high: there is a return of 15 dollars for every dollar invested annually (at a 5 percent discount rate) (Akseer et al. 2022). Since in utero exposure to nitrate pollution in water bodies lowers the height-for-age scores and increases the likelihood of stunting for children younger than five; and women born during rainfall deficiencies are more likely to grow up stunted, investments to improve water quality and increase food security will also prevent stunting (see box 3.2 on the impacts of increased temperature and associated food insecurity on birth outcomes). The performance levels of water and sanitation utilities amplify these impacts, as do improved institutional and governance frameworks.

Water Security Strengthens Food Security, Promotes a Thriving Agricultural Sector, and Contributes to Rural Development

A quarter of Peru's agricultural land is unused, partly due to lack of water. In 2018, there were 11.7 million hectares of agricultural land in Peru, most of which are in the Sierra (table 3.2). However, a quarter of this land was unused, with 18 percent of farmers on unproductive land citing lack of water as the main reason for this.

Agriculture is the sector most threatened by water scarcity, especially in the Costa region (where it is the most productive and contributes

Box 3.2 The Perils of Climate Change: In Utero Exposure to Temperature Variability and Birth Outcomes in the Andean Region

A study conducted by Molina and Saldarriaga (2016) in the Andean region of Bolivia, Colombia, and Peru looked at how in utero exposure to temperature variability affects birth outcomes. When dividing the effects according to gestational period, the results indicate that the effect of temperature variability on birth weight is concentrated during the six to eight months before birth, corresponding to the first trimester of pregnancy or the embryonic period. In particular, a one standard deviation increase in the temperature relative to the local long-term meandering rates for six to eight months before birth, reduces birth weight by 16.5 grams (roughly 84 percent of the overall effect). The results therefore suggest that the effects of temperature variability on birth outcomes may not be driven by the effects in a particular gestational period but are likely to represent the overall temperature variability experienced during the full gestational period.

The results of the effects of temperature variability during the nine months before birth (entire pregnancy period) on birth weight indicate that birth weight is more affected when the distributional changes in the temperature levels are positive rather than negative. In addition, this study found some evidence that these results might be explained by food insecurity and insufficiencies in health care during pregnancy that arise due to increased temperature variability. These results are more likely to mirror the actual effects of climate change on birth outcomes, since the use of adaptation technologies is not widespread in developing countries.

Source: Molina and Saldarriaga 2016.

Box 3.3 Use of an Input-Output Matrix and a Dynamic Stochastic General Equilibrium Model to Estimate the Economic Impacts of Water Insecurity

The Water Security Diagnostic estimates the economic impacts of water insecurity in Peru. The results are summarized in this report. The estimates are based on a quantitative evaluation of different water scenarios or shocks, conducted using a Dynamic Stochastic General Equilibrium (DSGE) model. The model incorporates information from an Input-Output Matrix (in monetary value units) for Peru for the year 2017 representing 54 sectors, and the sectoral composition of gross domestic product. The DSGE model captures the water-intense economic sectors (namely, agriculture, mining, manufacturing, and energy) and services, representing the rest of the economy; and takes into account capital, labor, water, energy, and (imported) oil. The model makes the following simplifications regarding the factors of production: capital is only used in the production of mining, manufacturing, services, and energy; labor is an input for manufacturing, services, and agriculture; energy is required in the mining, manufacturing, and services sectors; oil is only used in the energy sector as an alternative to water; and water is used in all sectors. Energy is an intermediate good, and is produced using capital, water, and oil.

The different scenarios or water shocks simulated with the DSGE model include: (i) decline of production across several sectors resulting from water scarcity under future climate change; (ii) reduction in agriculture production because of droughts; and (iii) capital and assets shocks resulting from floods.

The Input-Output Matrix was also used to analyze adjustments in supply, demand, value-added, and production in the presence of the above water shocks. The results were then used to calibrate the DSGE model.

For the analysis of increasing water scarcity, sectoral impacts calculated with a Computable General Equilibrium model that incorporates water based on the Global Trade Analysis Project (GTAP 9) database (featuring the reference year 2011, 140 regions, and 57 commodities) were considered.

For the analysis of drought, the elasticity of agriculture production at the department level (defined as the ratio of percentage change in agricultural value added to the percentage change of precipitation, when the precipitation is one standard deviation below the 1981–2019 average) was used to estimate the reduction in agricultural production resulting from a 25 percent reduction in precipitation.

Flood risk assessments for a 1-in-100-year return period fluvial flood hazard were carried out for Peru using three Global Flood Models (CMA-UNEP, GLOFRIS, and IRC); five datasets of global population (GHS-POP, GPW4, HRSI, LandScan, and WorldPop); and two approaches for calculating vulnerability based on global depth-damage functions using GlobCover and Global Human Settlement Layer landcover maps. The resulting averages of minimum and maximum economic damages were used to represent capital and asset shocks associated with floods.

the most to exports) but also in the Selva and Sierra regions, given the high levels of climate variability. Multipurpose water storage, irrigation, nature-based solutions, and adaptive and flexible water allocation mechanisms will be critical to sustain economic growth. In the short run these measures could increase GDP by 0.8 percent each year through productivity gains in the agriculture sector.[4]

Agriculture water productivity—the value of agricultural output to the economy per unit of water withdrawn—is low compared to other sectors (figure 3.1). Opportunities for improving agricultural water productivity mainly lie in choosing adapted, water-efficient crops; reducing unproductive water losses with modernized irrigation systems; and ensuring ideal agronomic conditions for crop production. Crops with high water consumption can still be part of water-productive systems if their multiple uses are taken into consideration. For example, a high-value crop that also provides residues for livestock feed has both economic and agricultural benefits that counterbalance its relatively high rate of water consumption. The Sierra region in particular shows potential for export-oriented crops, which require a substantial investment in irrigation infrastructure.

Table 3.2 Cultivated Land in Peru, 2018 *(hectares)*

Region	Agricultural land	Irrigated land
Sierra	5,172,954	1,257,032
Costa	1,654,258	1,156,923
Selva high altitude	1,741,767	198,108
Selva low areas	3,080,737	7,704
Total	11,649,716	2,619,667

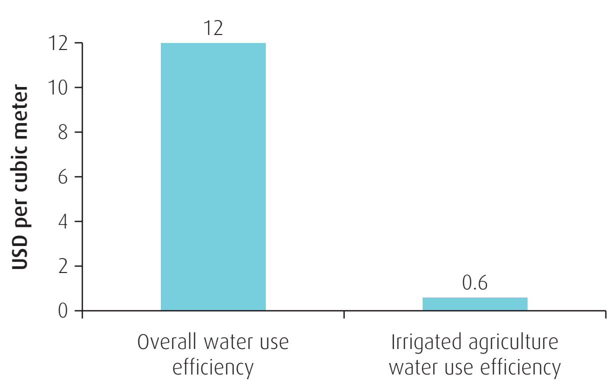
Access to irrigation increases agricultural productivity

Access to irrigation contributes to better food security, better agricultural incomes by enabling farmers to grow higher-value crops, and the increased resilience of agriculture to climate change, especially in drought seasons. Yet currently only 22 percent of agricultural land—2.6 million hectares—is under irrigation. About 44 percent of this is along the water-stressed Pacific coast and covers about 70 percent of the agricultural land. Only 24 percent of agricultural land in the highlands and 11 percent of agricultural land in the rainforests (Selva high altitude) are irrigated. In these areas, subsistence farming dominates.

Agriculture becomes a more productive activity where utilized land parcels have access to irrigation. Thanks to increased access to irrigation, in 2021 there was a significant increase in agro-exports (of cocoa, coffee, and Andean berries as well as avocados) from the Selva and Sierra subregions. A recent study reported yield increases of about 30 to 70 percent, and net household income per hectare increases of 25 to 100 percent as a result of improvements in water availability and irrigation techniques in agricultural parcels in the Sierra (World Bank 2017b). But in both the Sierra and Selva, competitiveness is based not only on providing water efficiently. Amid these subregions' difficult climatic conditions, technical assistance in logistics and access will help producers increase crops' quantity and quality for more competitive markets.

The 22 percent of land that is under irrigation produces about two-thirds of the country's agricultural outputs, demonstrating the effect irrigation has on productivity. On average, irrigated yields are twice as much as rainfed yields in Peru. Indeed, the irrigated

Figure 3.1 Agricultural Water Productivity Compared To Overall Water Productivity



Note: This includes the sum of water usage in the services, industrial, and irrigated agriculture sectors. Industrial use is the highest at US$115 per cubic meter.

regions of Arequipa and Ica yield on average 33.5 and 32.2 tons per hectare, respectively, while the rainfed regions of Piura and Lambayeque barely produce 9.5 and 6.6 tons per hectare (MIDAGRI 2017). Crop management, local climate, and market access also contribute to these differences.

About 82 percent of Peruvian farmers, mostly located in the Sierra and Selva, practice subsistence farming on less than 5 hectares of land (USAID 2017). **Much of this land—about 63.8 percent of Peru's total agricultural area—is rainfed (drylands), with low productivity. In addition, rainfed agriculture leaves agricultural production exposed to shifts in rainfall patterns linked to climate change and variability.** This vulnerability undermines national food security and reduces farmers' economic resilience to the effects of climate change, potentially driving migration to urban and peri-urban areas. Such migration has already been observed in Ancash, Cusco, Junín, and Piura, where glacial recession and rainfall changes are driving water scarcity and droughts (Bergmann et al. 2021). Very high food insecurity is already affecting Huancavelica, Apurimac, Huánuco, Puno, Amazonas, and Ayacucho.

Access to irrigation, especially when paired with access to roads and markets, makes it possible for small holders to rise above subsistence agriculture by enabling them to produce higher-value export crops, which are generally more sensitive to water stress. These crops have the potential to boost farmer incomes and so improve their economic resilience to climate change, especially in times of drought. They also strengthen the agriculture sector, which is becoming increasingly important to the country's export economy.

Water Sustains the Thirsty Hydropower Sector, Which Is Important for Peru's Clean Energy Transition

Fifty-seven percent of Peru's electricity (30,664 gigawatt-hours, with 5,286 megawatts [MW] of installed capacity at the end of 2021) came from hydroelectric energy in 2021 (COES 2021). By October 2021, the GoP had issued concessions and authorizations for the development of an additional 4,150 MW of hydropower generation capacity involving 50 hydropower projects, many of which have a capacity of under 20 MW (considered nonconventional renewable energy resources). Of these 50 projects, 6 are under construction, totaling 391 MW. Even with these additional projects, Peru is accessing only a small fraction of the nearly 70,000 MW that it could potentially derive from hydroelectric sources (MINEM 2011).

Hydropower plants are important for Peru's clean energy transition. Hydropower is the enabler of other energy renewables by providing the storage needed to manage variability. However, building new hydropower plants can be challenging. Since 86 percent of potential hydropower is located in river basins in the Amazon rainforest region, construction of new reservoirs could generate opposition from local communities due to potential social and environmental concerns (Gestión 2021). Environmental concerns stem from the carbon dioxide and methane that are emitted when new hydropower dams are filled, flooding large areas that contain plants and other organic materials.

Potential measures to improve the environmental performance of both new and existing hydropower plants include installing solar floating panels to supplement generation capacity and reduce evaporation and eutrophication (by reducing exposure of the water body to the sun), which are expected to increase with climate change. **Ensuring that hydropower reservoirs provide for other water uses and benefit local communities while generating electricity could help to address social concerns.** So far, however, limited consideration has been given to multipurpose dams.

Peru's Vulnerability to Climate Change Could Erode These Economic, Human, and Natural Benefits

Almost half of Peru's area (46 percent) is highly to very highly vulnerable to natural disasters associated with the El Niño phenomenon and long-term climate change (MINAM 2016). In some regions climate change may already be increasing the frequency and intensity of floods and droughts in some basins. The agricultural lands of Cajamarca, Pasco, and Huánuco face the highest risk of droughts, while Tumbes, Piura, Lambayeque, Loreto, Ica, Ancash, Cajamarca, Huancavelica, and the metropolitan provinces of Lima are the most vulnerable to human and material losses from floods (ANA 2019).

Farmland is especially sensitive to both droughts and flooding due to its dependence on rain. In Candarave in Tacna district, only 10 percent of crops grew in areas where the 100-year flooding mark was greater than 50 centimeters. Areas where the flooding mark was 25 centimeters accounted for 55 percent of crops (World Bank 2021b).

Climate change is expected to increase average national temperatures, which in turn will drive up demand for water (by increasing evapotranspiration, which is the loss of water from soils and the entire ecosystem), increase the variability of rainfall patterns, and accelerate glacial melt. Glaciers in Peru have lost about 43 percent of their surface area since 1970, severely reducing water supply in areas already suffering from water scarcity (ANA 2014). This represents 7 billion cubic meters (BCM) of water, or the equivalent of 10 years of drinking water for the capital city of Lima.

Water is Essential for Living Ecosystems

Water resources are essential for sustaining healthy ecosystems, which provide key services that benefit humans. Peru's highly biodiverse ecosystems are the result of its diverse geography, which ranges from high-level mountains in the Andes to the dry Pacific coastline to the jungles in the Amazon. The country is blessed with close to 72 million hectares of forested land, 8 million hectares of wetlands, and a vast network of rivers and lakes.

There are 14 Ramsar sites (wetlands of international importance) covering 6.8 million hectares within Peru's borders (Ramsar 2013). The three largest Ramsar sites are Lake Titicaca, the Paracas National Reserve, and the Pacaya-Samiria National Reserve. These ecosystems contribute to food security and support the livelihoods of rural populations, especially indigenous people and local communities who live along major rivers and lakes and depend on them to meet their basic needs. These ecosystems also provide nature-based solutions by providing key services, including flood protection, climate regulation, water storage, and water quality improvement.

Water resources and freshwater ecosystems are also fundamental elements for Peru's sustainable tourism. Tourism generates 1.4 million jobs (OECD 2020) and accounts for 4.5 percent of the GDP, which increases to about 10 percent when travel-related services and business activities are included (MVCS 2021). Before the pandemic, tourism was the third-largest exporting sector (8.5 percent of exports) generating US$4.9 billion in foreign currency revenues (OECD 2020). Since tourism activities rely heavily on natural resources, preserving water bodies and freshwater ecosystems for recreational activities, as well as ensuring adequate access to drinking water and sanitation, are critical conditions for spurring tourism that will fuel the country's economy.

Environmental degradation is costly in economic, social, and natural resources terms. Changes in land cover and pollution pose serious threats to ecosystems and the country's natural resources. Between 2001 and 2017, Peru lost about 2.1 million hectares of Amazon rainforest due to agricultural expansion. Land use and forestry already accounts for 48 percent of greenhouse gas emissions in Peru; now these activities are accelerating soil erosion and land degradation while reducing water availability.

Wetland integrity continues to be threatened. Despite efforts to improve regulatory oversight, Peru's wetland loss score on the Environmental Performance Index is 43 (out of a possible 100), which falls below the South American average of 50 and the upper-middle-income country average of 56.5 (Wendling et al. 2020). In addition, pollution has caused significant water quality deterioration in Peru's water bodies. Only 25 percent of Peru's water resources have good ambient water quality based on global standards. This is significantly lower than the LAC average of 60 percent.

Notes

1 The economic analysis is based on hydroeconomic analysis commissioned for this water security diagnostic that modeled various water shocks and their impacts in the economy using an Input-Output Matrix and a Dynamic Stochastic General Equilibrium (DSGE) model.

2 This is based on estimates from the International Monetary Fund (IMF 2019) and the Center of Distributive, Labor and Social Studies (CEDLAS 2020) of the impacts on employment of public spending on infrastructure.

3 Based on background paper on burden of disease: an in-depth analysis of the economic cost of lack of access to water and sanitation using a burden of disease methodology that pays close attention to health impacts on children and women, Garcia-Morales (2021).

4 This figure comes from the Input-Output Matrix and DSGE model 2021. Agriculture is the highest-water-consumptive sector of the economy, and water scarcity affects its economic outcomes such as labor, investment, consumption, wages, and productivity. In the World Bank's Global Trade Analysis Project analysis, the loss in total factor productivity due to water scarcity is 12.03 percent. Since the GDP of Peru is US$220 billion (2020), the loss in productivity is US$27.06 million. Additionally, the shock in the agricultural sector estimated with the DSGE model is 6.7 percent, so the GDP decline would be 0.81 percent (6.7%*27060/220000). Also, 80 percent of this shock persists throughout three-quarters of a year.

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CHAPTER 4

Challenges to Peru's Water Security

This chapter outlines the most pressing water-related concerns that Peru faces in achieving water security. The challenges can be broadly grouped into those that are related to the quality and quantity of Peru's water resource endowment and those that are related to Peru's institutions and infrastructure. The second set of challenges presents an opportunity for Peru to strengthen water security in the short term.

The following challenges relate to the quality and quantity of Peru's water endowment.

Demand Outpaces Supply in Key Economic Regions

Peru is blessed with ample renewable water resources, but this volume is unevenly distributed away from the country's most populated and economically active areas. The country's renewable water resources are estimated at 1,800 BCM/year with around 30 percent of this coming from renewable groundwater (540 BCM/year), and the balance from surface water (1,260 BCM/year). Consequently, water availability per person in Peru is 54,563 cubic meters (m^3) per year, three times the LAC average. Due to the geographic position of the Andes highlands, the vast majority of the country's rainfall accumulates to the east, in the Atlantic hydrographic region whereas the Pacific hydrographic region—home to 65 percent of the population and where most economic activities and exports take place—receives just under 4 percent of the country's water resources endowment (map 4.1).

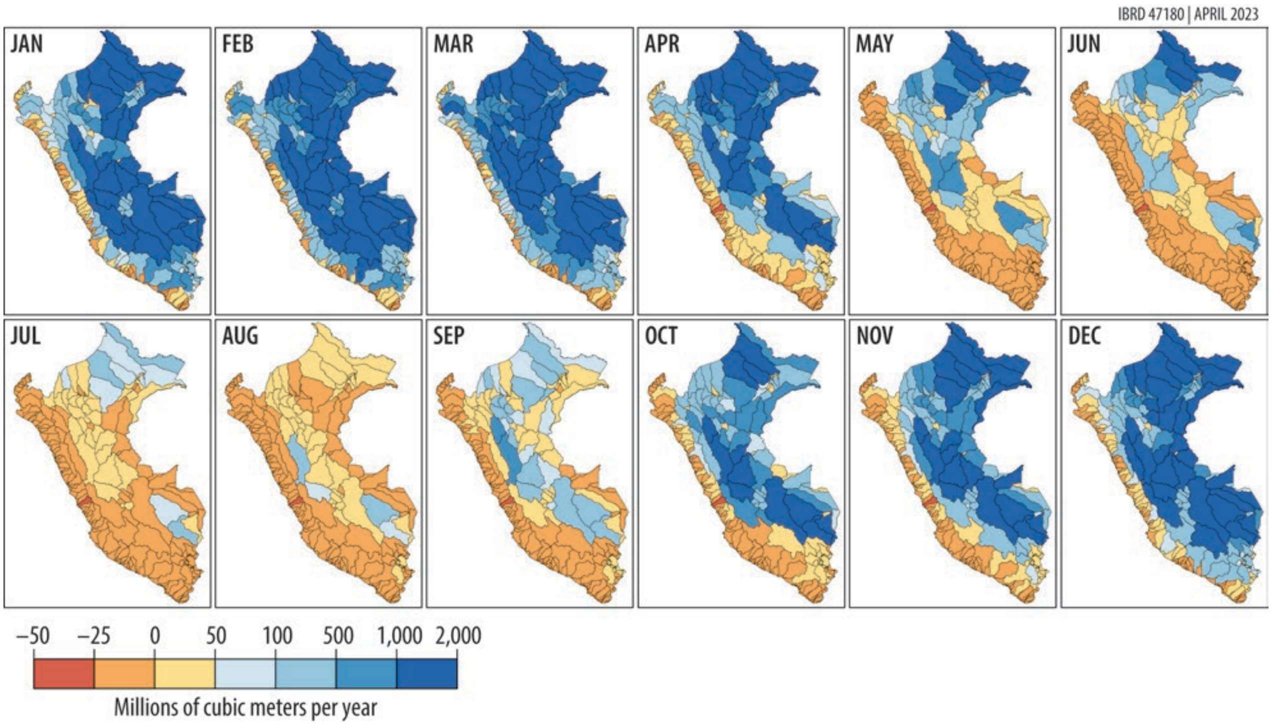
Peru has significant seasonal[1] and interannual[2] variability, challenging inclusive and sustainable development. Rainfall distribution is very irregular during the year in most areas of the country, including the Atlantic hydrographic region. Overall, most precipitation occurs between November and March, resulting in large areas with water deficits lasting more than half of the year (map 4.2). Peru has a seasonal variability of 2.9 and an interannual variability of 4.20, which equates to 20 percent and 115 percent greater than the LAC averages, respectively. Historical data indicate that annual precipitation can vary significantly in key productive basins, ranging from a 40 percent decrease to a 50 percent increase between years.

Peru has built dams, reservoirs, and interbasin transfer systems in an attempt to address the high climate variability and uneven distribution of water resources; provide a more stable water supply to households, industry, and agriculture; generate electricity; and control floods. The overall storage capacity in dams is about 5.77 BCM/year or 0.5 percent of surface renewable resources, and interbasin transfer systems divert 950 million cubic meters per year (MCM/year) from water-abundant

Map 4.1 The Pacific, the Atlantic, and the Titicaca Hydrographic Regions and Their River Basins

Source: National Water Authority (*Autoridad Nacional del Agua*). https://snirh.ana.gob.pe/observatoriosnirh/.

Map 4.2 Peru's Water Balance, by Month



Note: Red and orange areas show water deficits, whereas blue areas signify a water surplus. This figure captures seasonal and regional variability in the country, where the Sierra and Selva regions also experienced water deficits.

to water-scarce regions. However, amid the country's limited water storage capacity and water governance challenges, sustaining future growth will be constrained.

Growing water demands and key water users

In the past three decades, water withdrawal has doubled in Peru, placing mounting pressure on Peru's water endowment as demands from competing users grow. The agricultural sector (specifically irrigated agriculture) uses most of the water, accounting for 89 percent of withdrawals (higher than the LAC average of 70 percent). This is followed by withdrawals for domestic use, which amount to 9 percent, and for the industry, mining, and other sectors that total 2.3 percent.

Demand is highest in the dry Pacific basin—and will intensify with climate change

High demand meets low precipitation levels in the Pacific hydrographic region. Peru withdraws about 26,000 MCM of freshwater a year for consumptive uses. While this is just 1.4 percent of the national renewable water resources, about 81 percent of water abstraction occurs in the dry Pacific hydrographic region. When considering evapotranspiration and human demands, the water availability per person in the Pacific results in a little over 1,000 m^3/person/year. This contributes to the Pacific region being on the threshold of being classified as water scarce in terms of the Falkenmark water stress indicator.[3] In Lima, with a population of 10 million people, the water availability drops to 90–100 m^3/person/year, which is classified as absolute water scarcity according to the Falkenmark water stress indicator.[4]

The current number of water basins in deficit are expected to increase amid climate change and future increases in demand, affecting key economic regions. Applying the water balance conducted for this diagnostic, today Peru has 72 river basins that are experiencing a net water deficit (total demand exceeds supply in annual terms), of which most are in the Pacific region (map 4.3). Climate change is expected to increase temperatures, which would also drive up water demand by increasing evapotranspiration, resulting in new water-deficit basins and further deficits from climate variability (refer to box 4.1). While water storage and transfers are being used to counter these deficits at the moment, current developed capacity will not be sufficient to support economic growth and development.

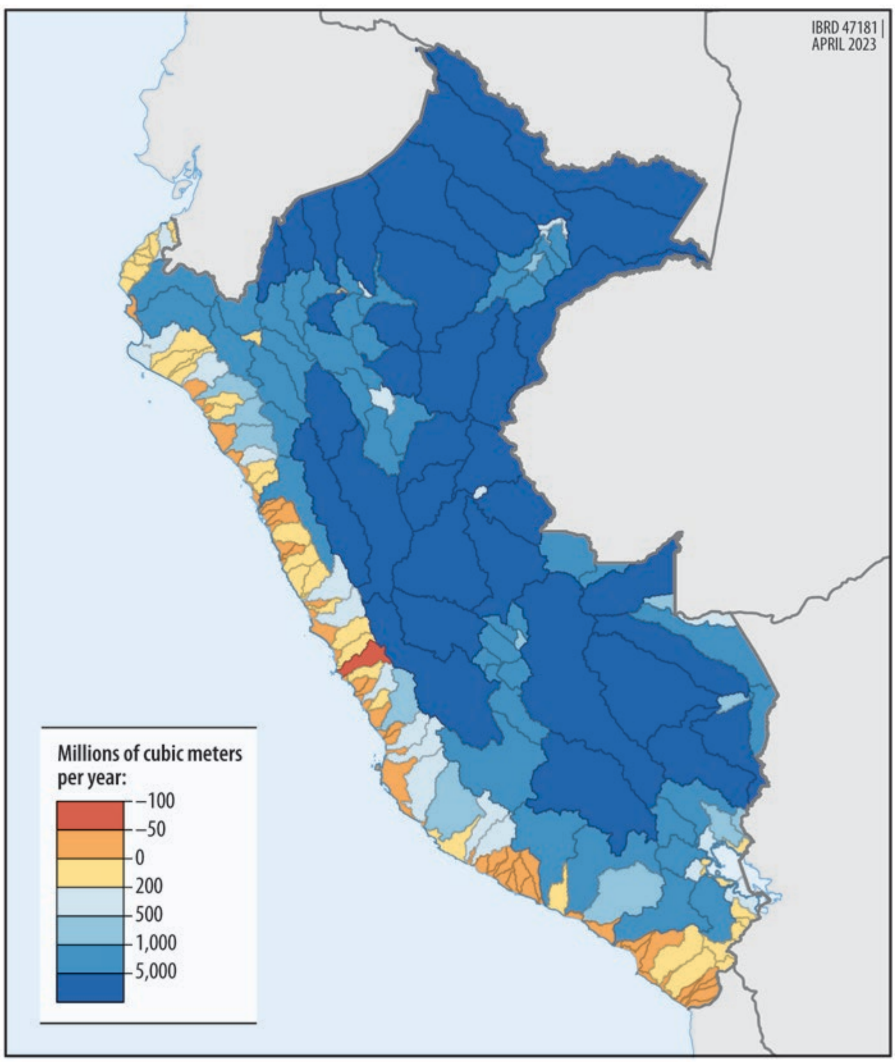
Watersheds that experience the greatest water deficits are also those that are the most populous and productive (map 4.3). The water deficit is most pronounced in the Rimac Basin, which is home to the capital city, Lima, and its 11 million residents. For several months of the year, Lima relies on water transfers from the water-secure Atlantic hydrological region to meet

Table 4.1 Consumptive Use of Surface Water by Sector and Watershed *(MCM/year)*

Hydrographic region	Total	Agriculture	Domestic	Industrial	Mining	Others
Total	**26,081**	**23,166**	**2,320**	**249**	**273**	**73.3**
Pacific	21,154	19,042	1,779	171	156	6.6
Atlantic	3,767	3,017	494	78	111	66.7
Titicaca	1,160	1,107	47	0.08	6.0	—

Source: Plan Nacional de Recursos Hidricos, 2015.
Note: "Others" includes livestock, recreation, and tourism.

Map 4.3 Watersheds with Current Surpluses and Deficits



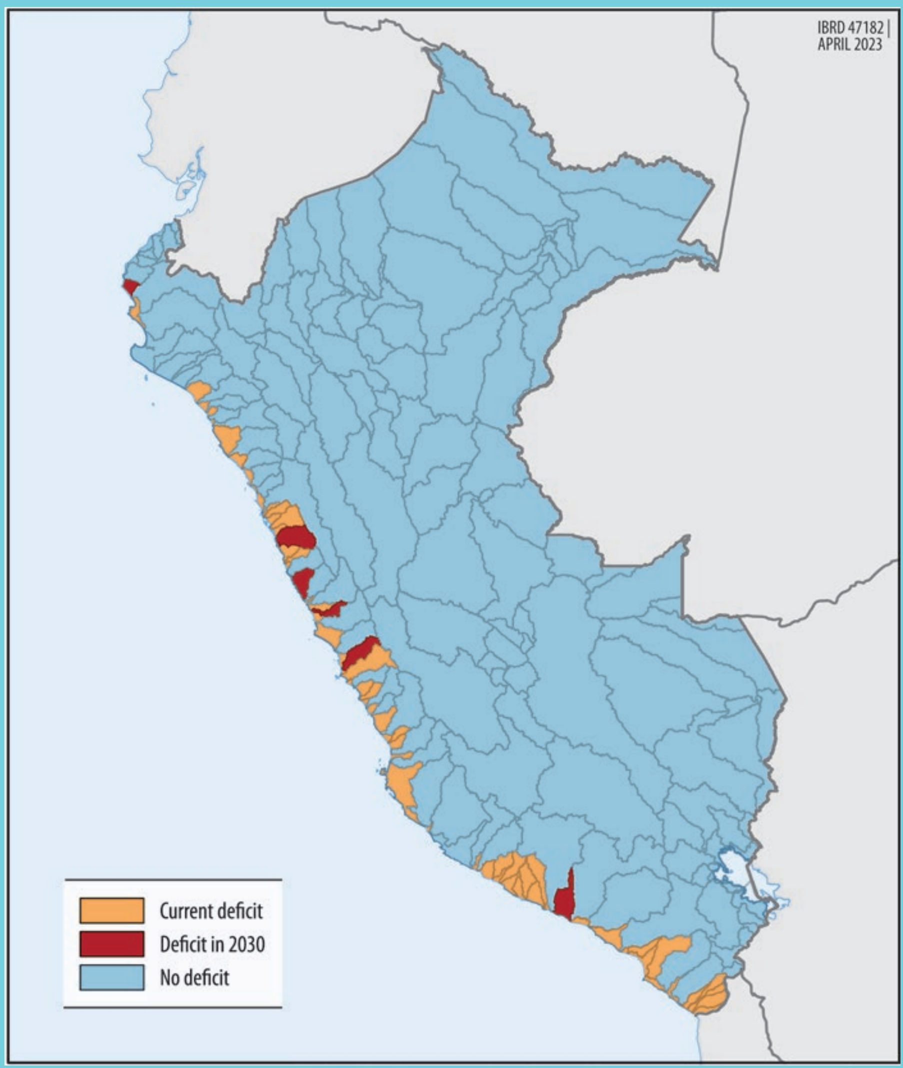
Note: Red and orange areas show water deficits, whereas blue areas signify a water surplus. This map captures seasonal and regional variability in the country, where the Sierra and Selva regions also experienced water deficits.

Box 4.1 Water Balance Assessment through the Lens of Climate Change and Climate Variability

The water balance assessment conducted for this Water Security Diagnostic considers local precipitation data and existing storage capacity, counterbalanced by evapotranspiration data (obtained from satellite images) and water demand for drinking, industry, agriculture, and livestock, calculated from various local databases. This analysis considered three types of water balances: (i) the natural water balance (including precipitation and real evapotranspiration), (ii) the natural water balance (applying water demands); and (iii) water balance projections for 2030 and 2050 with climate change projections obtained from the National Meteorology and Hydrology Service (SENAMHI) and climate variability. Applying a spatial disaggregation (pixel) of about 5 kilometers allowed the model to cover all the basins in Peru. Maps B4.1.1 and B4.1.2 capture the water deficit changes once climate change and climate projections are applied to the water balance model. Currently, 72 basins out of 231 are experiencing water deficits.

Overall, climate change will lead to a net increase in temperatures and demand (evapotranspiration). This directly impacts water balances with nearly all basins likely to lose net resources and experience increased deficits

Map B4.1.1 Representative Concentration Pathway 8.5 Scenario in 2030



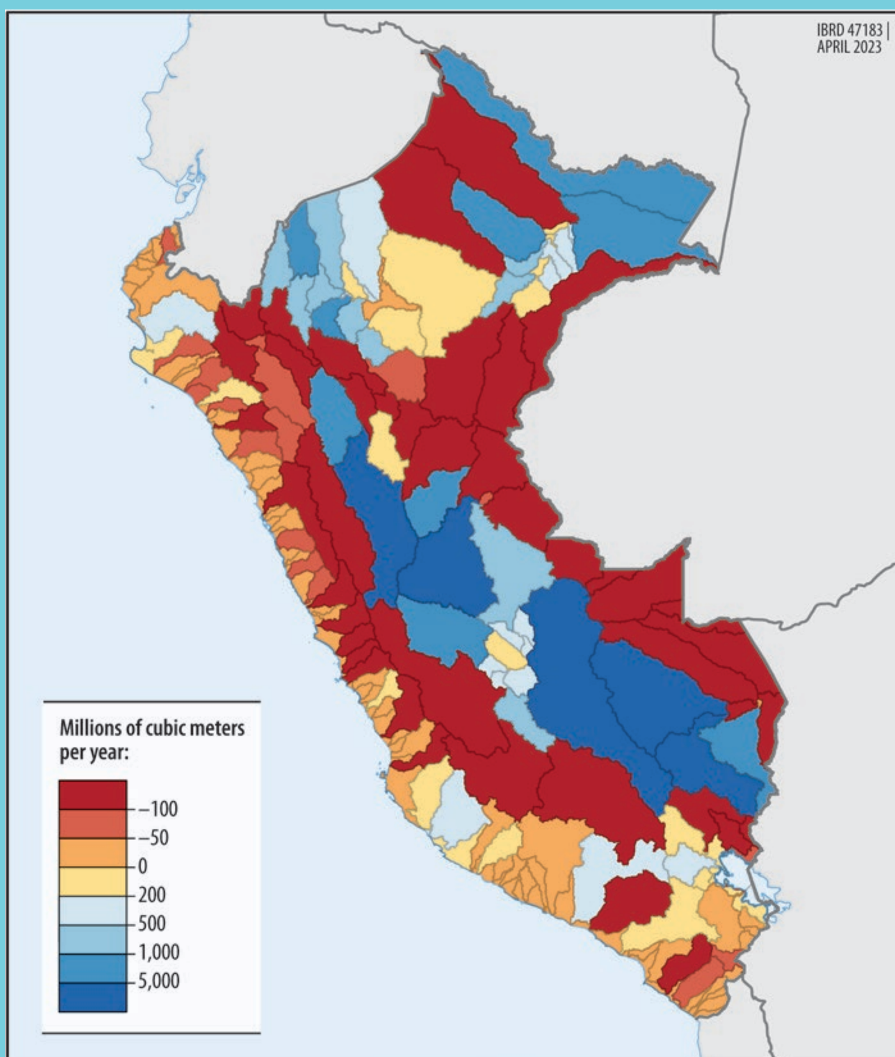
Box 4.1 Continued

in the dry months. This suggests that less-well-endowed areas are likely to experience increased water stress and risk, which Peru will need to prioritize, ensuring that water does not become a serious impediment to economic growth or poverty alleviation.

Peru's water balance indicates that six additional basins could experience water deficits when applying the Representative Concentration Pathway (RCP) 8.5 projections (map B4.1.1).

If there is a 40 percent decrease in precipitation in a given year across the country due to increased interannual variability, only 60 out of the 231 basins will maintain a water surplus (map B4.1.2). Historical data indicate that a precipitation reduction of 40 percent is a realistic scenario.

Map B4.1.2 Interannual Variability in 2030



its water needs. As a result, the agriculture sector is the most threatened by water scarcity, especially along the north coast, where it is the most productive and contributes the most to exports.

Agriculture, manufacturing, mining, and municipal (domestic) sectors' inefficient water use places additional stress on decreasing water resources

Agriculture, the biggest water consumer, productively uses only about 35 percent of its water to grow food, while the rest is lost to runoff and percolation. Mining wastes about 75 percent of the water that is drawn (and this figure could be higher, given the prevalence of illegal mining in the country), causing significant water pollution. Industry loses about 50 percent of water from its operations, whereas the municipal sector loses about 30–50 percent of water due to ruptures and leaks in the water network and reservoirs.

Achieving water savings provides a great opportunity to increase water availability to sustain future demands. As water shortages have become more and more severe due to the increasing population, climate change, and other factors, increasing water efficiency and minimizing losses could represent cost-effective and readily available solutions compared to the complexities of developing new water supplies. In the case of irrigation, technological improvements, while beneficial and indispensable, do not always translate into real water savings. They need to be linked to reductions in water consumption.

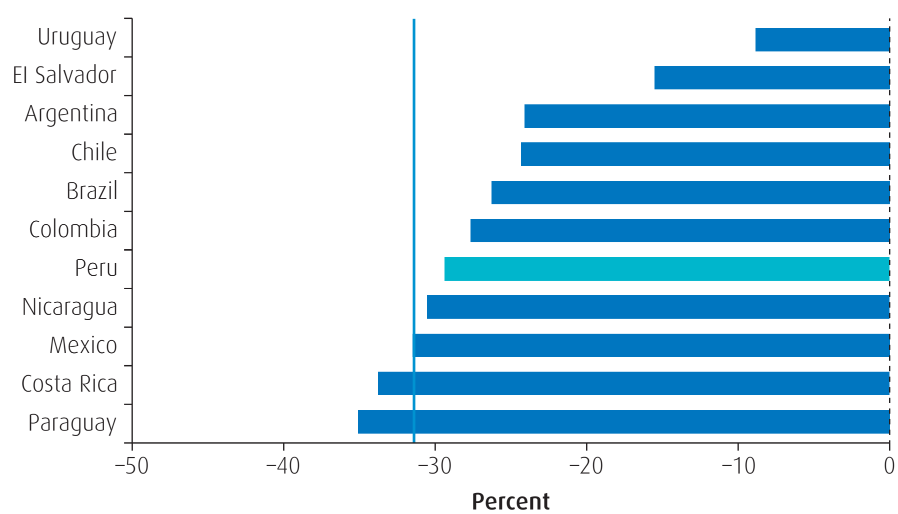
Reducing water losses provides an opportunity to increase water economic efficiency (also known as water productivity or water use efficiency by the SDGs). Changes in water use efficiency over time (US$/$m^3$) is tracked through SDG indicator 6.4.1 as a proxy to assess sustainable withdrawals from economic activities (agriculture, industry, and services) and supply of freshwater to address water scarcity. Increasing water use efficiency over time means decoupling a country's economic growth from its water use; in other words, the economy can continue to grow without needing more water (FAO and UN Water 2021). Peru improved its overall water use efficiency or water productivity from US$10.0/$m^3$ in 2012 to US$11.7/$m^3$ in 2017. However, this value is lower than the LAC regional average of US$21.3/$m^3$.

The growing population is another stressor on available water resources

Although the rate of Peru's population growth has slowed, the population is nonetheless growing in number, directly driving an increase in demand for domestic supply and indirectly driving demand for industrial and agricultural uses. The inefficiency of Peru's irrigation and drinking water systems is intensifying this stress, resulting in overexploitation of water resources. In many areas, underground aquifers are being depleted at a rate faster than they can recharge. Overall, the decline of total renewable resources per capita over the period 1992–2017 is below the regional average (figure 4.1).

Demand is growing precisely where water resources are already scarce. The peri-urban areas around Lima have experienced exponential growth as a result of internal migration. Internal migration has been primarily driven by rural poverty, political conflict, and the effects of climate change (see box 4.2). Peru has also received an influx of about 1.2 million displaced Venezuelans, approximately 80 percent of whom have

Figure 4.1 Percentage of Decline in Total Renewable Water Resources Per Capita, 1992–2017



Source: FAO 2019.

Box 4.2 Considering Peru's Climate-Migration Nexus

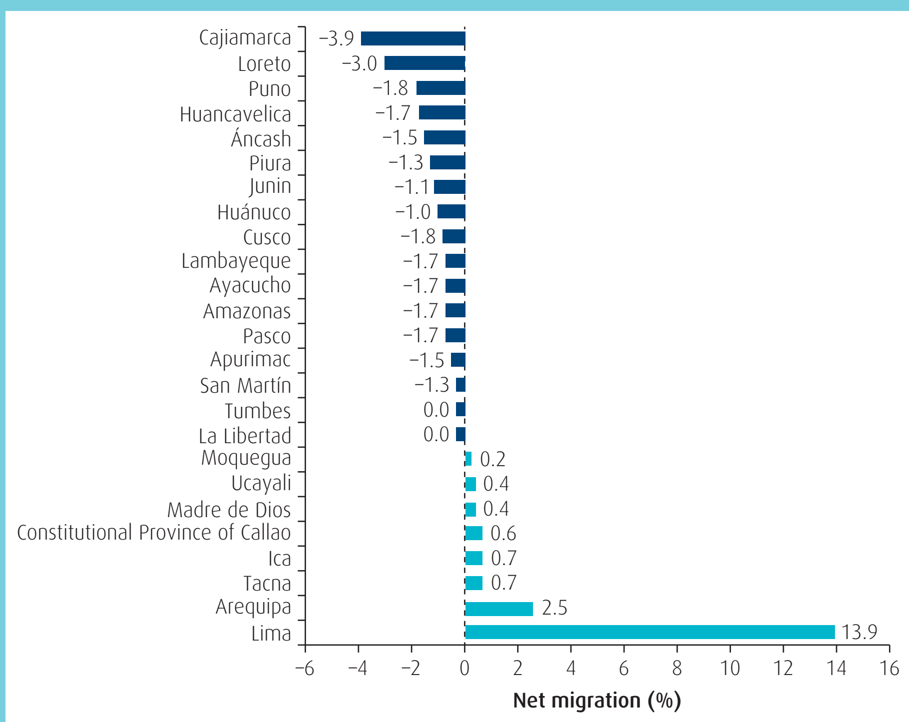
Even though the exact nature of the climate-migration nexus in Peru is not completely understood, there is broad agreement that climate impacts on ecosystem-based rural livelihoods are likely to increase internal migration from rural to urban areas, from the Sierra (highlands) toward the Costa (coast) and, to some extent, toward the Selva (rainforest) (figure B4.2.1).

When and where people move will depend partly on governance efforts and the severity of climate impacts (IDMC 2018; Juřicová and Fratianni 2018). **Water quality is an important consideration in migration patterns.** Industrial, agricultural, and mining activities often result in wastewater spills and polluted runoff that make water bodies unreliable for thriving livelihoods, particularly in rural areas.

Farmers employ various strategies to cope with the negative effects of climate change and water pollution. When they experience extremely high temperatures or prolonged heat waves, they tend to adjust their inputs (Aragón, Oteiza, and Rud 2021), sell livestock, and increase the number of hours they work on off-farm activities. Rainfall shocks also change the water conservation behaviors of small farmers: a year of high rainfall results in farmers reducing fertilizer use and water-conservation practices the following year (Tambet 2018; Tambet and Stopnitzky 2021). By contrast, droughts prompt farmers to use between 7 and 9 percent more fertilizer.

Coping strategies vary depending on what is available to the farmer. Factors such as access to credit and extension services help make water-conservation practices more effective. **Policies that help farmers and vulnerable households adopt better adaptation strategies can lower the tendency to migrate and reduce economic and social disruption.**

Figure B4.2.1 Migration Patterns in Peru Due to Climate Change, 2002–17



Sources: Bergmann et al. 2021; INEI 2020b.
Note: Dark blue indicates negative net migration (more people moving out of the region to another); turquoise blue indicates positive net migration (more people moving into the region).

settled in Lima's urban and peri-urban areas. In addition to further stressing Lima's limited water resource endowment, the expansion of peri-urban areas has created delivery challenges as many peri-urban residents live beyond water supply networks.

Groundwater is Poorly Understood and Unsustainably Used

The sustainable use of Peru's groundwater reserves requires a deep understanding of current data relating to aquifer volume, water quality, recharge rates, and withdrawals. To date ANA monitors only 47 out of 95 potentially important aquifers, representing less than 1 percent of renewable groundwater. Forty-three of these aquifers are in the relatively small Pacific hydrographic region. The aquifers that exist below the rest of Peru's substantial surface have either not been identified or are not being monitored. This lack of data hinders technical decision-making and paves the way for unsustainable water withdrawals, as was the case with the Ica aquifer, where 335 MCM of water is extracted but water use rights are only granted for 134 MCM (ANA 2019).

Those aquifers for which information exists show risks of being overexploited and several are already facing depletion. The Ica, Villacurí, and Lanchas aquifers along the Pacific coast are being overexploited due to limited enforcement of water use rights, poorly monitored use, and illegal extractions (table 4.2). A ban has now been placed on drilling new wells into the Ica aquifer, and there is a limit on the volume of water that existing wells may withdraw. However, these restrictions have not been effective to control overexploitation. In Villaruri, the water use granted exceeds the exploitable reserves, indicating limitations in applying water allocations.

In a step toward ensuring the sustainable use of groundwater reserves, Peru enacted a tariff for groundwater management and monitoring services in 2017. This is one of the world's first groundwater use fees, which help to guarantee that groundwater will remain as a buffer resource that enhances the country's resilience to seasonal water scarcity and drought (WRG2030 2019). The groundwater use fee has to date collected US$20 million, but more needs to be done for service providers to implement groundwater management activities.

Climate Change and Increasing Climate Variability Threaten Economic Growth, Development, and Stability

Between 2003 and 2019, Peru experienced 61,708 emergencies due to intense rains, floods, droughts, earthquakes, and landslides. By the end of the century, the northwest region of South America, where Peru is located, is expected to experience an increase in the number of days per year of extreme heat and cold, with additional loss of glacier volume and permafrost in the Andean mountains causing reductions in river flows and, potentially, high-magnitude glacial lake outburst floods (IPCC 2021).

Climate change is expected to drive up temperatures, accelerate glacial melt, exacerbate rainfall variability, and increase the risk of water-borne diseases across the country in decades to come, intensifying the pressure that water resources already experience due to pollution, poor management of water resources, and inefficient irrigation. The resulting water stress and scarcity will have knock-on effects across all sectors and in all parts of the country.

In rural areas, water scarcity will negatively affect the productivity of rainfed agricultural areas. This, in turn, will increase competition for water and drive internal migration to urban areas as small-scale farmers seek improved food security and alternative incomes. The number of farmers migrating is already on the rise (Bergmann et al. 2021). High-lying areas will additionally face an increase in unwanted insects as climbing temperatures in higher-altitude landscapes expand their habitable area.

Table 4.2 Available Reserves and Exploitation Levels of Ica, Villacurí, and Lanchas Aquifers *(million cubic meters)*

Aquifer	Exploitable groundwater reserves	Exploitation (actual water abstraction)	Overexploitation	Water use rights granted	Assignable volume (exploitable reserves—water use rights)
Ica	189	335	146	134.14	54.86
Villacurí	63	228	165	87.8	−24.8
Lanchas	17	34	17	3.5	13.5

Source: Autoridad Nacional del Agua.

In the cities, utilities will struggle to bring water and sanitation services to underserviced urban and peri-urban areas—a situation that will be exacerbated by rapid population growth in these nodes due to internal migration. Already, a million people lack access to adequate water and sanitation services in the capital city, Lima. Lack of adequate sanitation will aggravate health-related issues, especially when coupled with heavy rainfall events that cause sewage to overflow and enter drinking water sources.

All sectors that depend on water will likely be negatively affected by climate change. The energy sector is especially vulnerable to changes in discharge patterns and soil erosion due to rainfall variability, which may affect the availability of water for hydroelectricity generation (Climate Change Action Plan). These changes may encourage Peru to replace hydropower with natural gas. Indeed, the share of natural gas in the electricity mix increased from 17 percent in 2000 to 34 percent in 2020. In parallel, hydropower generation decreased from 80 percent in 2000 to 57 percent in 2021.

Floods and drought have a greater impact on the poor than on the wealthy

In global terms, wealthier people are 10 times more resilient to climate-related shocks than poor people because their assets, savings, and income allow them to better confront economic damages (Hallegatte et al. 2017). They have greater financial capacity to mitigate losses. In contrast, poor people are largely unable to cover these damages, in part because of the low value of their assets, their high dependence on welfare income, and the poor targeting of recovery programs. In Peru, the population that suffers the most from floods and droughts is concentrated in remote areas of the country, particularly in the northern highlands (in the department of Cajamarca) and in the Selva (in the departments of Loreto, Ucayali, and San Martin), where the incidence of poverty is high (World Bank 2021a) and surface flooding and mass movements are common.

The greater the resilience, the quicker people in the country can bounce back from a disaster shock, and the lower the resilience, the more likely it is for a disaster to create long-term poverty traps. **Slow implementation of disaster risk mitigation policies, coupled with limited safety regulations, protocols and early warning systems, are limiting Peru's resilience to climate change.** This is a particular concern for hydraulic infrastructure.

Climate change and climate variability make it very difficult to plan the sustainable use of water resources. Historical trends are becoming unreliable and the uncertainty of climate change models complicates service providers' and water-related agencies' decision-making regarding costly infrastructure development. Decision-making under deep uncertainty is one way to make long-term investment plans in an uncertain context, through analyzing multiple scenarios and selecting adaptative strategies (box 4.3). However, the adoption of this and other alternate methods is slow since they depart from traditional planning and capacity-building measures.

Pollution is Imposing Economic Costs by Further Limiting the Water Endowment Available to People, the Environment, and the Economy

Only 25 percent of Peru's monitored water bodies have "good" ambient water quality, that is, they are not harmful to people or ecosystems. This is lower than the average of 59 percent for water bodies in LAC. The main cause of water pollution in urban areas is the discharge of point source domestic wastewater into surface water bodies, which reduces the availability of freshwater to people, ecosystems, and the economy.

Only about 60 percent of wastewater generated by urban households is treated at wastewater facilities before being released into the environment.[5] This is influencing ambient water quality, that is, the quality of naturally occurring water in lakes, rivers, and aquifers, taking into consideration both natural influences and human activities.

Further, the performance at wastewater plants varies greatly. A third of Peru's monitored wastewater treatment facilities fail to meet the country's maximum effluent requirements (the maximum amount of contaminants allowed in the treated wastewater that is released into water bodies) (SUNASS 2020). An analysis of pollution hotspots shows that high levels of domestic wastewater pollution are concentrated around cities along the Pacific coast (figure B4.5.1), jeopardizing biodiversity and placing human health at unacceptably high risk (see box 4.5).

Other sources of pollution include mining effluents, use of agrochemicals in intensive agriculture, and oil production. Agricultural disperse pollution has the most substantial impact on water quality in inland areas as the nitrogen, sediments, and pesticides present in the runoff are captured over a large area upstream (map 4.4). Meanwhile, the impact of mining is pronounced both inland and along the coast (map 4.4), with mining concessions often overlapping with areas

Box 4.3 Robust Decision-Making in the Water Sector: A Strategy for Implementing Lima's Long-Term Water Resources Master Plan

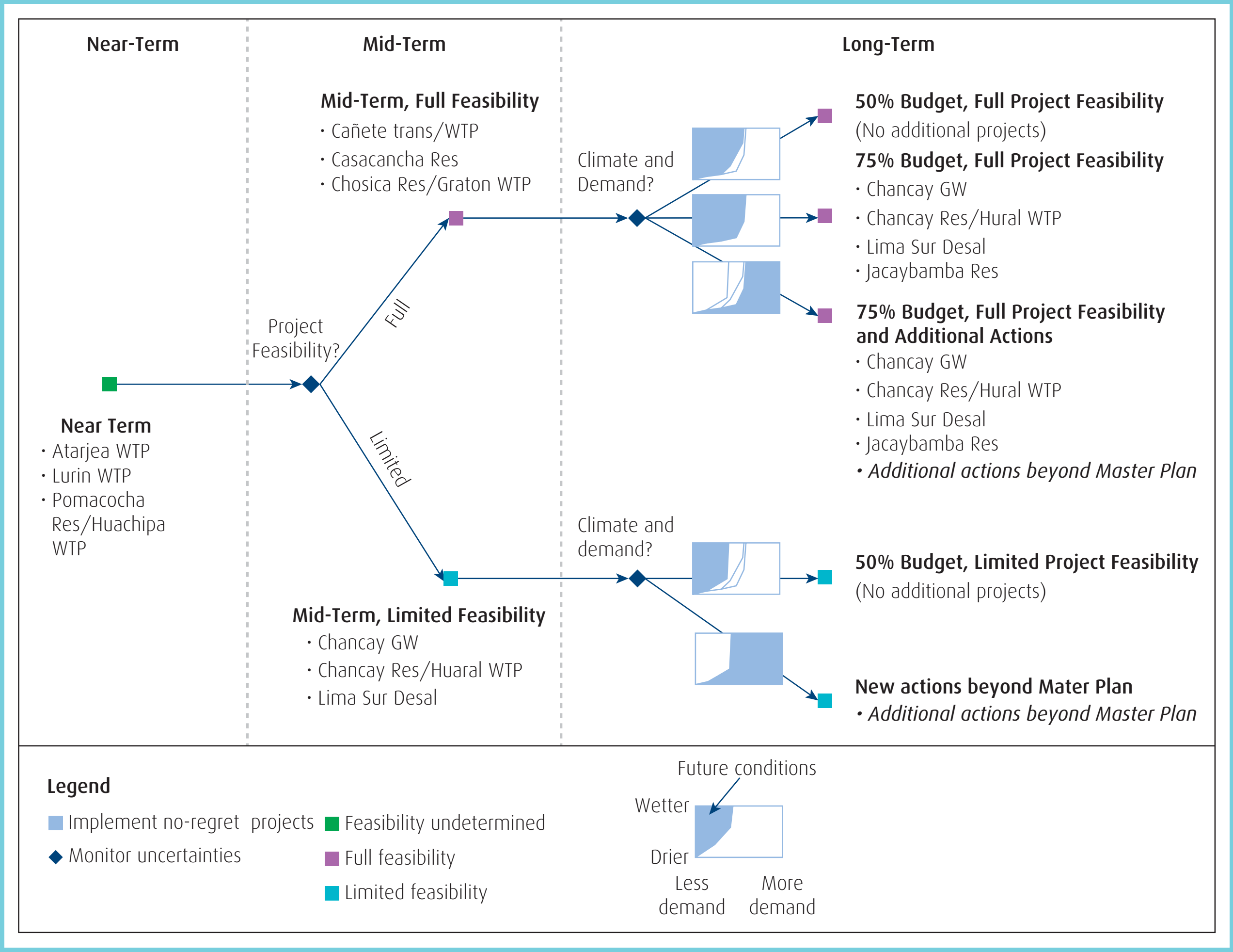
The strategy helped to assess and prioritize investments in the water and sanitation utility's (SEDAPAL's) master plan and to define an investment strategy that is robust, ensuring water reliability across a wide range of future conditions while also being economically efficient. This strategy has two key characteristics of a robust plan:

- *It is no-regret.* It identifies investments and projects that are useful no matter what the future brings.
- *It is adaptive.* It guides decision-makers on how to implement future investments and projects as climate, demand, and other conditions evolve.

The strategy is defined in a decision tree in figure B4.3.1. It consists of a set of near-term, no-regret investments that SEDAPAL can embark upon now; signposts of specific project feasibility, streamflow, and demand conditions SEDAPAL should monitor in the medium and long term; and sets of deferred projects that SEDAPAL should implement if the signposts are triggered.

On completion, the study helped SEDAPAL (i) perceive that not all projects included in the master plan were needed to achieve water reliability, and the utility could save 25 percent (more than US$600 million) in investment costs; (ii) focus future efforts on demand-side management, pricing, and soft infrastructure—a refocusing that is difficult to achieve in traditional utility companies; (iii) gain the support of regulatory and budget agencies through careful analysis of the alternatives; and (iv) postpone lower-priority investments, and analyze future options based on climate and demand information that simply is not available now.

Figure B4.3.1 Strategy for Implementing Lima's Water Resources Master Plan



Source: Kalra et al. 2015.

Box 4.4 Applying the Decision Tree Framework (DTF) to the Chancay-Lambayeque River Basin Plan in Peru

The water resources system of the Chancay-Lambayeque Basin is a complex system experiencing challenges due to rapid population growth, economic development in the context of water scarcity, and increased risk of flooding and environmental degradation. While there has been progress toward integrated water resource management in the region, there is an ever-growing need for a basinwide assessment of water resources, focusing on the medium- to long-term risks associated with population growth, water and land use changes, and climate change.

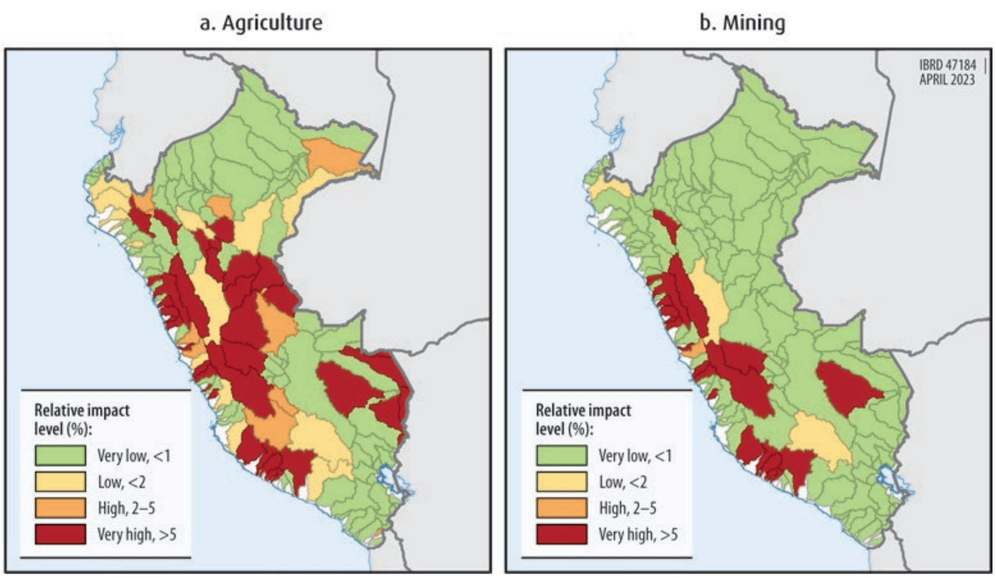
To address these needs, the World Bank developed the DTF to assess the robustness and resilience of the Chancay-Lambayeque system to an uncertain future and guide/prioritize the most cost-effective intervention options. The DTF consists of a four-phase cascade process whereby after the first phase each can be activated only if applicable.

- Phase I aims at defining and describing the context of the analysis, including potential climatic and nonclimatic uncertainties for the study region, the performance indicators to be considered, critical performance thresholds for the system, and adaptation options.
- Phase II (initial analysis) utilizes simple sensitivity analysis techniques to identify uncertainty factors for the system of interest based on the performance indicators and thresholds. If the system is determined to be sensitive, then Phase III will commence.
- Phase III (climate stress analysis): The water resource system is stress tested for a wide range of possible future scenarios (performance indicators are calculated for each scenario). If sensitivity of the system to the different scenarios and uncertainty factors is confirmed, Phase IV will be conducted.
- Phase IV (climate risk management analysis) assesses how different intervention options improve the system's performance in terms of robustness and resilience.

The DTF is a pragmatic decision-making process for risk assessment in the field of water resources, and its usefulness has been demonstrated, among other cases, in Upper Arun (Nepal), Mwache (Kenya), and Cutzamala (Mexico).

Source: Taner et al. 2019.

Map 4.4 Water Pollution Hotspots for Agriculture and Mining



Source: Deltares 2021.
Note: Map panels show the share of river length in each basin where the relative Impact from agriculture and mining exceeds 0.5, half of the nationwide 99th percentile of impact.

Box 4.5 Domestic Wastewater Pollution Hotspots Pose a Danger to Public and Ecosystem Health

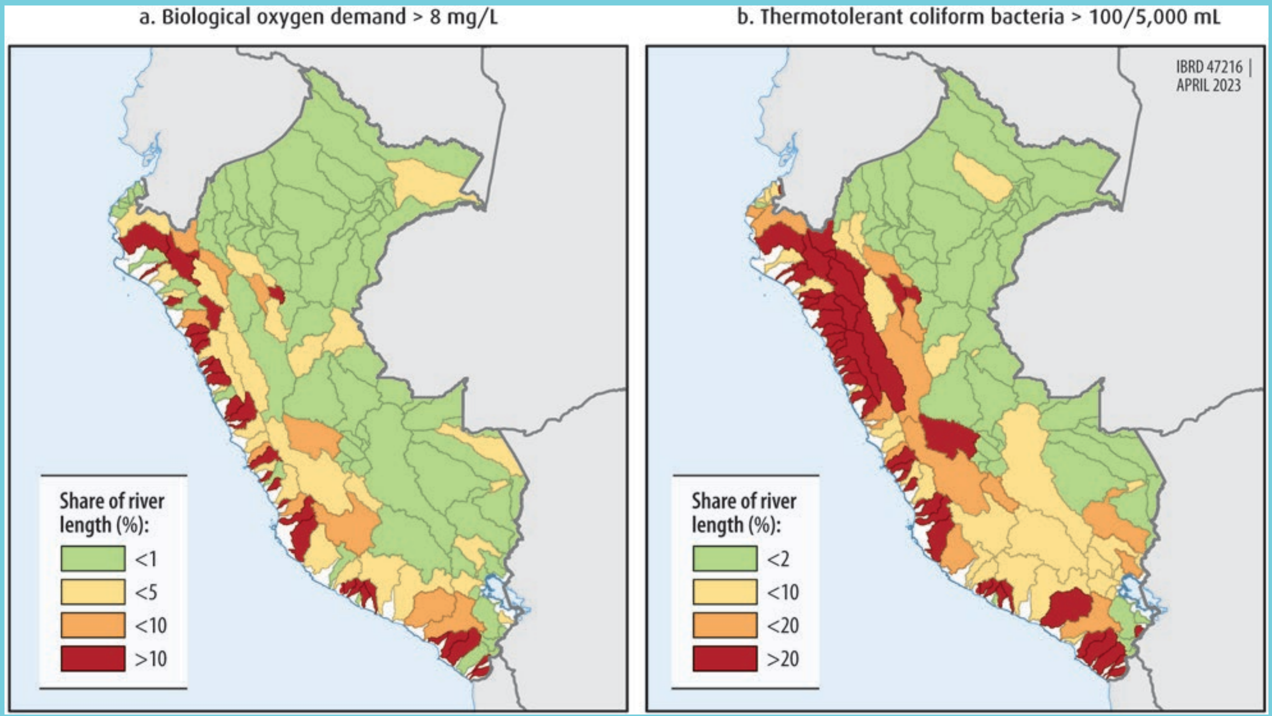
Insufficiently treated domestic wastewater has contaminated several basins along the Pacific coast, endangering the health of residents in this highly populated region.

Biological oxygen demand (BOD) and coliform bacteria are proxy measures of water quality, used for testing pollutants linked to domestic wastewater contamination. Coliform bacteria are linked to pathogens, while BOD measures the amount of oxygen required by the bacteria that break down organic material. BOD is a good indicator of the volume of organic pollution in freshwater bodies.

Several watersheds in the Pacific basin have registered high levels of BOD and coliform bacteria (map B4.5.1), creating health risks for residents of this populous region. These risks are intensified in rural areas, where only 4 percent of drinking water is chlorinated. Low rainfall in the Pacific basin also limits the potential of rainwater diluting or washing away the pollutants.

Coastal streams lack the assimilative capacity to cope with the high level of wastewater discharge. They are at a high risk for loss of species due to their low water quality.

Map B4.5.1 River Basins where Biological Oxygen Demand and Coliform Bacteria Exceed Threshold Concentrations



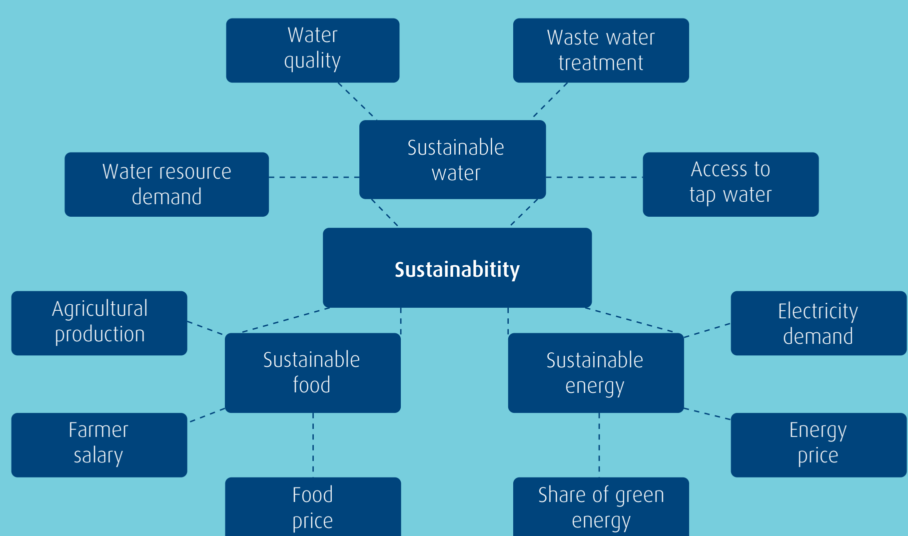
Source: Deltares 2021.
Note: Areas where BOD and coliform are highly concentrated present a public health risk.

Box 4.6 Water Pollution and Its Consequences for Sustainable Livelihoods and Food Security in Peru

Using a novel approach to estimate the contribution of water to sustainable food production in developing countries (Fan, Lin, and Hu 2019), Wang et al. (2021) estimated the impact of water pollution on food security and sustainability in Peru. The approach consisted of merging data from Peru's National Household Panel Survey (ENAHO 2004–19) with water quality data (2000–17) and data from the national environmental information system (SINIA). These sources contain the indicators needed to estimate the longitudinal effect of water on sustainability of food systems based on Fan, Lin, and Hu's (2019) conceptual model (figure B4.6.1). The methodology is based on a three simultaneous equation system, where the explanatory variables are: the service ratio of tap water (the total number of residences with tap water service divided by the total number of residences); the water quality index; the ratio of wastewater being treated (the amount of wastewater being treated before discharge divided by the amount of wastewater generated); the share of renewable energy in total power supply; the price of energy; the average farmer's salary; and the agricultural food prices index. The estimates solved the main outcome of sustainable food, with multiple specifications and local area (basin) and time fixed effects. By solving the water equation, the model helps estimate how important factors like water quality affect the sustainable consumption of water, and how that effect in turn explains changes in overall food consumption.

The results of the analysis showed that a 10 percent increase in water pollution reduces water consumption of all sectors in urban areas by 34.5 percent, resulting in an overall decline in food consumption of 9.9 percent in a 15-year period. The impacts are similar in magnitude for rural areas: a 10 percent higher water pollution rate (lower water quality index) results in a decline of 33.7 percent in water consumption, and of 8.2 percent in food consumption over the same period. These estimates suggest that providing safe, nutritious, sufficient, and affordable food is important for sustainable livelihoods and food systems. Because farming is affected by the degree of soil, groundwater, and environmental pollution, increasing investments in agriculture technology and irrigation could maintain the proper functionality of the ecosystem and, hence, food systems.

Figure B4.6.1 The Web of Sustainability



Source: Fan, Lin, and Hu 2019.

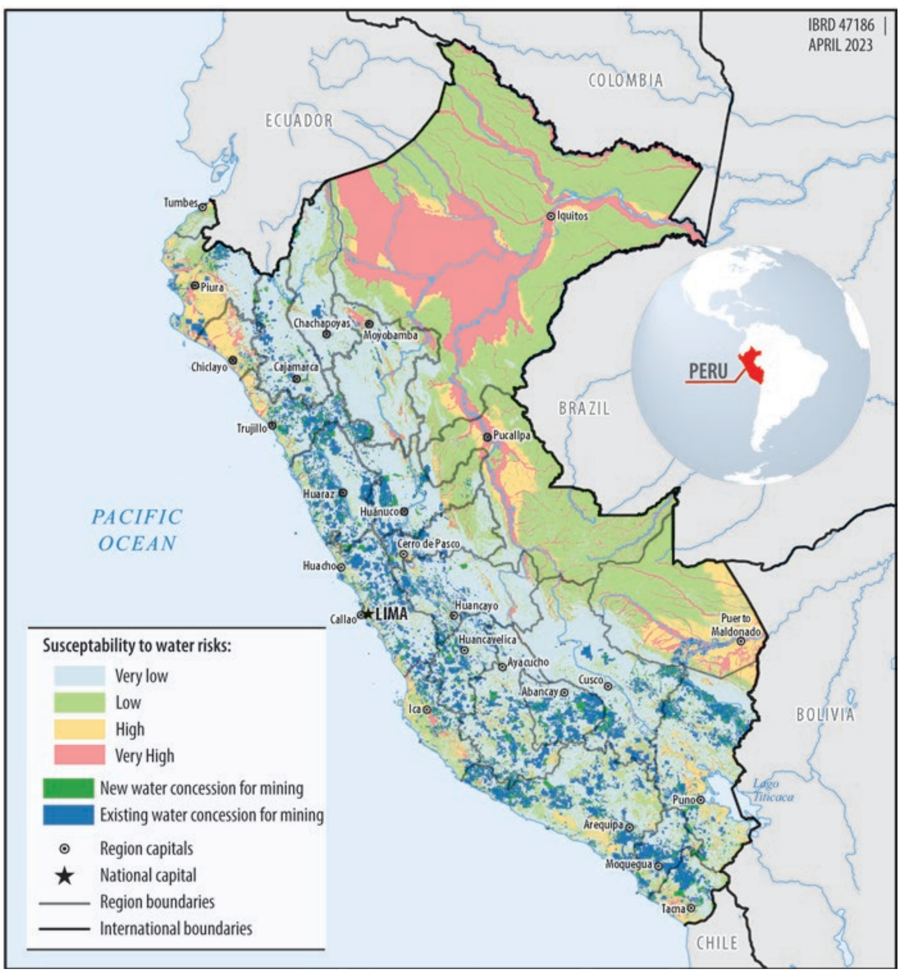
of water scarcity, exacerbating water insecurity and giving rise to social conflicts. Gold mining and oil production contribute significantly to declining water quality in the Atlantic basin, while a high level of noncompliance has been reported in the Titicaca hydrographic region. Natural contamination caused by the continuous weathering of the highland mineralized region pollutes the water with metallic deposits of arsenic, antimony, copper, lead, and zinc.

Pollution from mining is triggering social conflict

Mining concessions, which use significant amounts of water, often overlap with areas of water scarcity, especially along the coast (map 4.5). Local communities are concerned about the impact of mines on the availability of water for other uses and on levels of water pollution, which endangers the environment and people's health. **To date, the mining sector's approach to managing such concerns has resulted in high levels of social conflict**, exacerbated by the fact that mining revenues are typically not used to reduce poverty in mining regions (ITA 2021; Mulé 2018). This has placed water—especially water resources management and efficiency—on the policy agenda.

At the time of writing, an estimated US$30 billion worth of new mining projects were in limbo due to water-related social conflicts (Schneider, Walton, and Kozacek 2016). Sixty-six percent of the 132 socioenvironmental conflicts reported by the Ombudsman's Office in January 2022 were related to mining, of which about 25 percent were related to access and contamination of water sources (Defensoría del Pueblo 2022). Attempts made to resolve these conflicts, only resulted in piecemeal and short-term solutions.

Map 4.5 Mining Concessions and Areas Susceptible to Water Risks



Sources: Estimates based on mining inventory, 2018; INGEMMET data, 2019; IPE 2019.

Even though most water-related conflicts are concentrated around mining, activities by other sectors also give rise to competition and controversy. Disputes include complaints from farmers about cities discharging untreated wastewater in rivers, and conflicts between farmers and hydropower water users on the management of dam discharges.

The following challenges relate to Peru's water governance and infrastructure: Limited Storage Capacity and Insufficient Attention toward Securing the Safety of Existing Large Hydraulic Infrastructure Are Compromising Efforts to boost Water Security

Storage helps manage hydrological risks and variable water supplies over time. Despite efforts during the 1980s and 1990s to address seasonal and interannual variability in river runoffs, Peru's surface water storage capacity is insufficient, ranking well below global benchmarks (figure 4.2). The country's total artificial dam capacity is only about 184 m^3/person, well below the average of 2,500 m^3/person for Latin America. Portugal and Peru have similar degrees of climate variability, but whereas Portugal's water storage capacity is 1,134 m^3/person, Peru's is 184 m^3. Worsening climate change is driving up demand and reducing the volume of available freshwater.

Given the water stress already experienced in the Pacific region, and the seasonal and interannual variability of freshwater in other parts of the country, **this storage capacity will not ensure water security in the face of extreme droughts and floods that occur increasingly due to climate change.** Investments in integrated water storage measures are therefore needed to address seasonal and interannual variability.

The low productivity of existing hydraulic infrastructure, particularly dams, also needs to be addressed. Existing dams are affected by soil erosion from uncontrolled activities in the upper watersheds, causing a higher rate of sediment accumulation in dead storage than the rate for which the infrastructure was designed, reducing the dams' storage capacity and productivity. For example, the Poechos Dam (Peru's largest dam) and the Gallito Ciego Dam, both considered hugely important for storage and regulation of flows, have lost more than 50 percent of their total capacity in less than 50 years and 34 years of operations, respectively (Brissete and Chen 2019). The decline in dam capacity has made agriculture and hydropower production vulnerable, compromising future food and energy security.

Box 4.7 Cerro Verde Public-Private Partnership Success Story: Collaborative Approach Reduces River Pollution and Stress on Water Sources through Circular Economy Principles

Cerro Verde, one of the world's largest copper mines, is located in an arid region near Arequipa, Peru's second-largest city. In 2015, after years of operation, the mine's operator, Freeport-McMoRan, implemented a large-scale project to increase water supply to nearby communities.

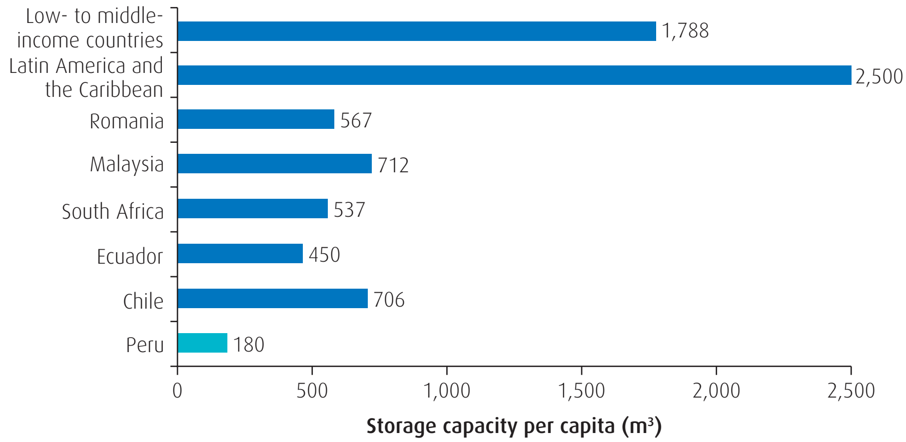
As part of the planning process, Cerro Verde held more than 20 community forums, posted information on social media to ensure transparency, and worked with universities in shaping its environmental impact plan. Extensive engagement between Cerro Verde and Arequipa's public water and sanitation utility (SEDAPAR), civic leaders, municipal and regional leaders, federal officials, and development agencies led to an ambitious, win-win solution for the company and the region's water challenges—a new wastewater treatment plant under a public-private partnership.

Cerro Verde designed, financed, and built the facility and continues to operate it. Under the 29-year contract between Cerro Verde and SEDAPAR, it was agreed that there would be a gradual increase in the facility's capacity, with a final expansion in 2036. In exchange for its US$500 million investment, Cerro Verde received treated wastewater effluent for its mining processes, underpinning the circular economy approach.

The mine expansion was successfully completed on schedule—with no days lost to social protests—and within the planned budget. Thanks to this partnership, 750,000 people now have access to clean water, reducing waterborne diseases. The plant ensures that 99 percent (up from 10 percent in 2013) of Arequipa's wastewater is treated, which has greatly reduced pollution in the nearby Chili River. Due to the proper treatment of sewage, the river's depleted fish stocks recovered in a few years.

Source: Energy Resource Governance Initiative Toolkit, https://ergi.tools/.

Figure 4.2 Peru Dam Storage Capacity versus Other Countries and Regions



Building large, new hydraulic infrastructure that requires interbasin water transfers from relatively water-abundant basins could have unintended consequences and increase conflicts among stakeholders. When exploring this as an option, it is important to engage in genuine public participation in which the potential trade-offs are discussed, and informed by detailed technical, economic, environmental, and social studies. Project proposals should also closely consider climate risks and include mechanisms to ensure the distribution of benefits. Good water governance is essential for such proposals to succeed.

For historic reasons, Peru's dam safety is not optimal—and climate change will likely increase the risk. As in many other Latin American countries, dams in Peru are aging and their safety is at risk. With the passing of the Decentralization Framework Law in 2002, the O&M of major hydraulic infrastructure (including dams) was transferred to regional and local governments and water user boards. This created a legal vacuum regarding who should be responsible for ensuring the safety of the infrastructure. New operators did not have the resources or technical capacity to follow dam safety regulations. The passing of the 2009 Water Resources Law put ANA in charge of coordinating actions to preserve the safety of large public and private dams in partnership with basin councils. As a first step, ANA initiated a national inventory of 730 dams, but to date, complete information is available for only 273 of them. The inventory revealed that only 39 dams had adequate monitoring instrumentation, and plans were underway to modernize the instrumentation of an additional eight dams.

Attention to dam safety has improved in recent years. However, addressing maintenance and safety problems of existing dams requires swift, large-scale action. An important dam safety regulation that targets public dams has been issued since 2019. This needs to be followed up by similar regulations for private dams and legal provisions that ensure adequate implementation and enforcement of safety obligations by dam owners and operators.

Centralized and Inadequately Managed Water Governance is Hindering Policy Rollout and Effectiveness

Over the past two decades, the GoP has demonstrated its commitment to strengthening the water sector by developing policies on water resource management, water and sanitation services delivery, irrigation, and disaster risk mitigation. However, implementation of many of these reforms is lagging due to: (i) limited institutional capacity to enforce, coordinate, and incentivize policies at the local and regional levels; (ii) limited financial and political commitment to consolidate water governance at the basin level; and (iii) frequent political changes (between 2018 and 2021, the Peruvian presidency changed four times). Wider governance challenges are thus undermining the implementation and effectiveness of policies in the water sector (OECD 2021).

ANA, the government entity responsible for overseeing SNGRH, is located under MIDAGRI, limiting its capacity to act independently. Although ANA is tasked with integrated, multisectoral water resources management across all hydrological basins, being structurally located within MIDAGRI hinders its ability to impartially consider broader allocation issues among competing sectors and users and environmental and social consequences. In addition, ANA is burdened with irrigation sector matters that reduce its capacity to carry out its regulatory functions. This is problematic as ANA is responsible for granting, amending, and terminating water usage rights and determining the fees for water usage rights. At present, the agricultural sector uses 89 percent of the country's freshwater resources, yet in many regions, the fee for water use is too low to incentivize efficient water use. Moreover, research indicates that ANA is not performing optimally in issuing technical justifications for granting water use rights. While new water use rights should be issued only when the water balance in the basin or aquifer is positive, ANA has continued to issue provisional water permits while studies on the availability of the resource are being carried out. This practice promotes cropland expansions in areas facing water scarcity and compromises the availability of water for other formal water uses.

Although ANA's 2015 National Water Resources Plan supports decentralization and an integrated approach to water resources management, implementation of the plan's governance model has been slow. The plan places responsibility for local water resources management with river basin councils and tasks ANA's local and regional offices with overseeing the councils. Nevertheless, the establishment of ANA's regional and local offices has been slow, and only 12 of the 29 potential basin councils have been formed. While the plan takes an integrated approach to water resources management that involves a wide range of stakeholders and considers water quantity, quality, continuity, and culture as well as climate change adaptation, agricultural interests predominate. The river basin councils are typically overrepresented by agricultural users, limiting the voice of nonagricultural users with regard to budget allocations and revenue collected from water user fees as well as decisions regarding interbasin transfer projects.

ANA does not have adequate financial resources to operate effectively. While the budget allocation for water resource management increased with the creation of ANA in 2008, it is still insufficient to retain qualified personnel and incentivize improved performance in ANA's decentralized entities. Various ongoing studies (mostly financed by the World Bank and the Inter-American Development Bank) are exploring strategies to ensure sufficient financial resources for participatory, integrated, basin-scale water resources management.

ANA has noted that SNGRH is struggling to achieve its mandate as a multisectoral platform that coordinates water-related policies and efforts between various ministries and community organizations. The SNGRH's intersectoral coordinating mechanism, which is chaired by the minister of the MIDAGRI and includes representatives from national, regional, and local governments, is not functioning satisfactorily. Its members meet only occasionally, and when meetings take place, its decisions are not binding because of the low level of representation. In addition, participants in the system typically fail to include allocations for integrated water resources management in their annual budgets. To be effective, the board needs support from the highest level of government.

Disaster risk management (DRM) policies are not being fully implemented at the local level

Peru has made substantial progress in DRM; however, the implementation and coordination of policies and instruments have been slow and ineffective at the local level. Peru has a DRM regulatory framework that incorporates prevention and mitigation through economic instruments to foster resilience, resilient infrastructure planning, and risk management plans. However, the level of implementation is limited at the local level and with service providers. For example, of the S/. 555 million collected (US$154 million) through water tariffs for the adoption of nature-based solutions and to improve risk management in urban water utilities, only 20 percent has been used (box 4.8). Moreover, only 40 percent of urban water utilities have DRM plans (World Bank 2021a). This situation is problematic given the high vulnerability of these systems to hydrometeorological and seismic events.

A World Bank (2021a) study indicates that the following weaknesses are hindering adoption of risk management plans at the local level:

- The national DRM policy does not fully articulate water-specific policies, causing confusion among municipalities and service providers on how best to develop and implement risk management plans.
- Local governments and service providers have not been able to generate planning instruments to increase the resiliency of water management. For example, only about 11 percent of the municipalities have approved land management plans, which complicates water and sanitation master planning and overall service provision due to increased urban informal settlements in vulnerable areas. In addition, physical inventories of water and sewage networks are low, complicating vulnerability assessments and targeted mitigation measures.

Box 4.8 MERESE—An Innovative Mechanism to Increase Water Supply Resilience through Nature-Based Solutions

Recognizing the need to prevent the environmental deterioration of ecosystems, particularly in the face of water scarcity, desertification, and deforestation, the Peruvian government introduced an innovative legal framework (Law 30215) for payments for environmental services called "Mechanisms of Compensation for Ecosystem Services" (Mecanismos de Retribución por Servicios Ecosistémicos, MERESE) in 2014. Within this legal framework, the National Superintendence of Sanitation Services (Superintendencia Nacional de Servicios de Saneamiento, SUNASS), developed and approved an innovative regulatory structure that allows water utilities to invest in nature-based solutions to protect water sources by improving water quality and availability. To finance MERESE, SUNASS requires water utilities to earmark 1 percent of their revenues from water tariffs toward protection of water sources. MERESE recognizes that upstream communities should be remunerated for the implementation of nature-based solutions, such as reforestation and watershed restoration. It places particular emphasis on promoting the strategic participation of rural communities and women as key actors in the governance and management of water resources.

Today, 40 out of Peru's 50 water utilities have incorporated a MERESE fund in their tariff scheme, and 7 water utilities are executing projects funded through MERESE. The implementation of MERESE is a good step toward fostering greater accountability when it comes to safeguarding water sources. However, execution has been slow and its full potential is yet to be realized. The challenges MERESE faces include the complexity of Peru's public investment system, limited implementation of a monitoring and evaluation system to calculate expected hydrological benefits, limited engagement with local communities, limited local government participation, and difficulties in compensating communities directly.

The role of executing units (*nucleos ejecutores*) in ramping up nature-based solutions

The Government of Peru formed *núcleos ejecutores* in 2020 to facilitate community participation in the execution of the public budget for the rollout of nature-based solutions for irrigation and water management. Nature-based solutions reinforce resilience, food security, and climate change adaptation with consequences for human health and improved social development. Supporting the technical capacities of execution units can be an effective avenue for streamlining nature-based solutions for sustainable irrigation and ecosystem health.

Source: Based on contributions from the SUNASS website and local interviews.

- Vulnerability reduction, prevention measures, and planning are not prioritized by service providers and local governments. Moreover, local entities lack the financial capacity, human resources, and management tools to carry out the actions and investments necessary to significantly reduce the vulnerability of water and sanitation systems.

Women's voices in water governance could be strengthened

Although women play an integral part in water management given their traditional roles in agriculture, households, and the community, institutional arrangements rarely reflect the fact that women are disproportionately impacted by lack of access to water and inadequate water quality. Women are often excluded from water-related decision-making and rarely occupy management positions in water sector entities.

The Peruvian government, through the leadership of the Ministry of Women and Vulnerable Populations (Ministerio de la Mujer y Poblaciones Vulnerables, MIMP), has started working toward enhancing gender equity in both policies and public administration. **Including women in decision-making spaces and in water-related project implementation not only creates more employment opportunities for women, but also improves service outcomes.**

Efforts to Close Water and Sanitation Services Gaps Have Been Slower in Rural and Peri-Urban Areas

The lack of focused planning, the need for innovative and appropriate solutions, and the limited coordination between the different sectors and government levels pose the main challenges to achieving universal access to WSS services in Peru. Over the past 20 years, Peru has made remarkable progress in closing the WSS basic service gap; from 2000 to 2020, access to water services went from 70 to 93 percent and access to sanitation services

Box 4.9 Lack of Women's Voices in Governance (in Numbers)

22 of 78 municipal technical areas for water reported women in leadership roles.

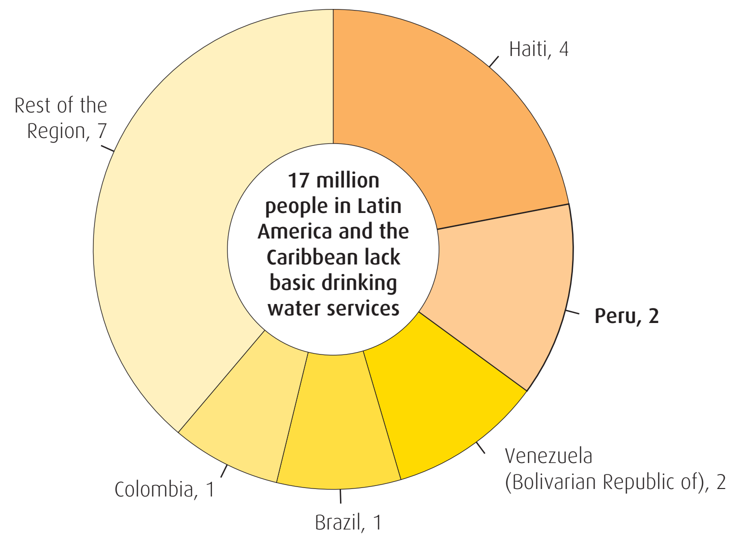
7 out of 93 water-related community organizations have a woman as president.

8 out of 170 registered water user organizations are managed by women.

25 out of 314 general managers of water utilities in the last 10 years were women.

Sources: SUNASS 2018, 2021; UBC 2020.

Figure 4.3 Countries in Latin America and the Caribbean with Least Access to Basic Water Services in 2020, in Millions of People



Source: WHO/UNICEF JMP 2021.

went from 54 to 79 percent. This advance is aligned with a significant increase in government investment in the sector. Progress in closing the gaps, however, has been much slower in rural and peri-urban areas, where technical and management solutions are more complex due to geographic, sociocultural, and political conditions, as well as low population density and logistical difficulties (World Bank 2021b).

Two million Peruvians lacked basic drinking water services in 2020, exacting a toll on human development in the country. Compared with its regional neighbors, only Haiti performs more poorly on this metric (figure 4.3).

Although the coverage and quality of water and sanitation services vary widely between geographic regions, rural areas show concerning characteristics:

i. Sixty percent of those who lack access to water and sanitation services live in rural areas. Almost half of this group—47 percent—are indigenous populations located mostly in the Sierra (Andes) and Selva (Amazon) regions. These regions also registered high levels of poverty with 50 percent of the population in rural Sierra considered poor and 39 percent in the rural Selva.

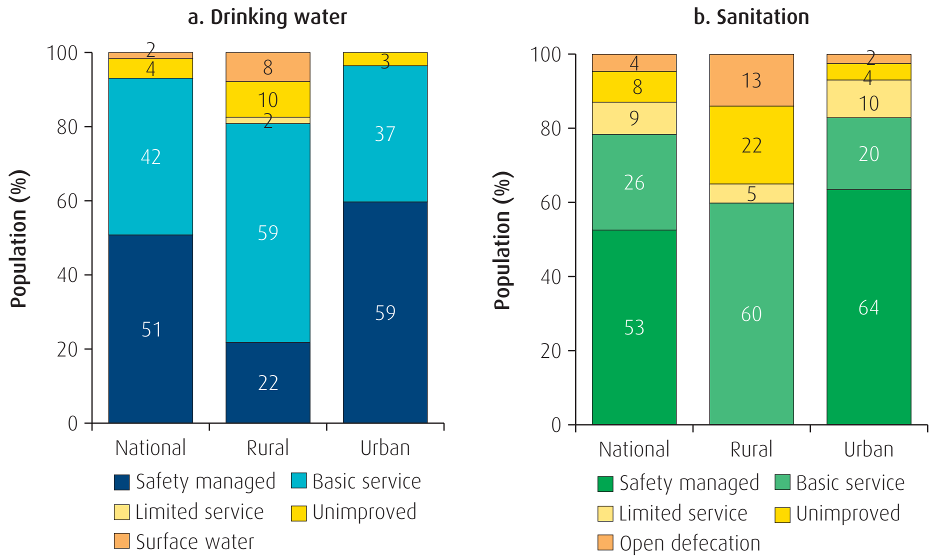
ii. Thirteen percent of the rural population—close to a million people—defecates in the open.

iii. Eight percent of the population relies on untreated surface water, which is often polluted (figure 4.5), and only about 4 percent of the rural population has access to chlorinated water.

When it comes to rural areas, Peru ranks behind most of its regional counterparts in terms of providing safely managed rural water services. Only Honduras lags behind the country in terms of safely managed rural water services; however, because it performs well on basic water services, it outperforms both Peru and Nicaragua in terms of overall rural water access (figure 4.5).

Lack of coverage is also a concern in peri-urban areas of large cities, where high population density, lack of access to safe water, and high

Figure 4.4 Water and Sanitation Ladders in Peru, 2020



Source: WHO/UNICEF JMP 2021.
Note: There is no estimate available for rural access to safely managed sanitation.

Box 4.10 Levels of Safely Managed Water and Sanitation Services

The Joint Monitoring Programme for Water Supply, Sanitation and Hygiene of the World Health Organization and United Nations Children's Fund defines **safely managed drinking water** as coming from an improved source located on premises, available when needed, and free from microbiological and priority chemical contamination. **Basic water access** means there is access to an improved source within 30 minutes (round trip), while **limited drinking water** means there is access to an improved source over 30 minutes away (round trip).

To make an estimate of safely managed services, information on the use of improved drinking water sources is combined with information on the accessibility, availability, and quality of drinking water. Estimates are based on the minimum value of these criteria. As show in figure B4.10.1, the criteria that is limiting the volume of safely managed water in Peru is "free from contamination."

Basic sanitation means having a private, improved facility that separates excreta from human contact. **Limited service** means there is an improved facility shared with other households. An **unimproved facility** is one that does not separate excreta from human contact. **Safely managed sanitation services** are defined as the use of an improved sanitation facility that is not shared with other households and where excreta are disposed in situ or transported and treated offsite. To make an estimate of safely managed services, information on use of different improved sanitation facility types (sewer connections, septic tanks, latrines, and other) is combined with information on containment, emptying, transport, and treatment.

Source: WHO/UNICEF JMP 2021.

Box 4.10 Continued

Figure B4.10.1 Safely Managed Drinking Water, by Area

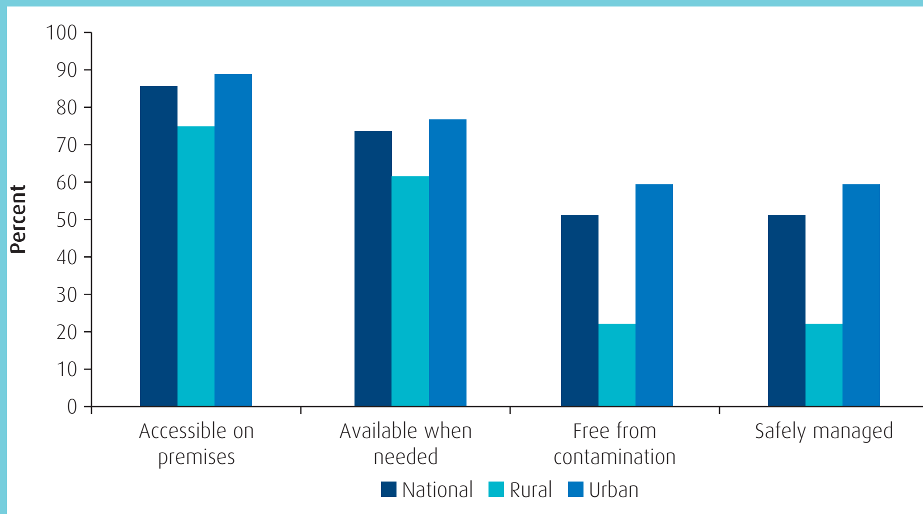
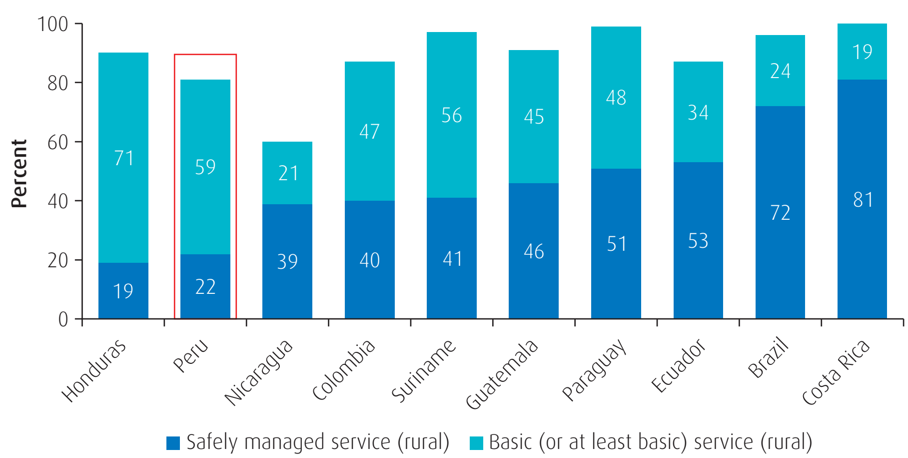


Figure 4.5 Safely Managed and Basic Drinking Water Services in Rural Areas of Latin America, 2020



levels of exposure to sewage create a favorable climate for infection and water-related diseases. About 10.5 million people in urban areas lack access to safely managed drinking water and 9.4 million to safely managed sanitation facilities. Most of the urban underserved population are in the peri-urban areas of large cities characterized as low-income, informal settlements. Reaching this population becomes very expensive and technically difficult, making the incremental cost of service provision between three and six times more expensive.

Schools and health care centers are an overlooked priority

In the quest for universal access, schools and clinics—which deliver crucial developmental services to the public—need to be prioritized

Box 4.11 Sanitary Emergency Program in Lima's Public Schools: A Collaborative Approach to Replicate

As part of the World Bank's COVID-19 emergency response, a Bank team provided support to Peru's Ministry of Education and Lima's water utility (Servicio de Agua Potable y Alcantarillado de Lima, SEDAPAL) in designing a Sanitary Emergency Plan for Water Supply, Sanitation and Hygiene (WASH) in Lima's schools. The plan seeks to extend and improve basic WASH infrastructure and services in schools in Lima's densely populated areas and to offer policy recommendations to promote multilevel and multisectoral coordination toward this goal. It also includes recommendations to improve solid waste management.

The plan proposes four concrete policy actions: (i) the Ministry of Education; Ministry of Housing, Construction, and Sanitation; and Ministry of Economy and Finance would approve resolutions to promote coordination between the Ministry of Education's regional departments and urban water utilities (EPSs); (ii) a policy would support preventive and corrective maintenance and cleaning of sanitary facilities in public schools; (iii) policies would control water demands and promote payments from public schools to EPSs; and (iv) policies would include solid waste management on educational facilities' premises.

This program was part of the overall response to the COVID-19 emergency in Peru, and the Ministry of Education is working on replicating this initiative in other regions with the support of the 2030 Water Resources Group.

in multisectoral water and sanitation services planning. Half of all health care centers do not have access to basic water services and almost none have access to basic sanitation services—which for health care facilities are defined as improved, usable, staff-dedicated, and gender-segregated services that include menstrual hygiene facilities and are adapted for people with limited mobility (WHO/UNICEF JMP 2021). At the same time, one in five public schools nationwide does not have drinking water services, and one in three lacks adequate toilet facilities. This lack of access to adequate sanitary facilities in schools and health care centers disproportionately affects the capacity of women, children, and people with disabilities to access basic health care and educational services, potentially limiting their development and well-being.

Water and Sanitation Service Providers are Vulnerable to Shocks, Given Their Operational and Financial Positions

The operational and financial vulnerability of service providers puts at risk their capacity to provide secure WSS service to Peruvians. WSS providers' performance varies greatly across the country and reflects the highly fragmented nature of service provision. Currently, 50 urban water utilities (EPSs) serve more than 85 percent of the urban population (62 percent of the national population). In addition, there are 500 small municipalities that directly manage services for approximately 14 percent of the population (World Bank 2018). In rural areas, almost 25,000 community organizations provide services and are responsible for 24 percent of the total population (World Bank 2017a). This fragmented landscape limits economies of scale in the sector, reduces the efficiency of service provision, enables greater political interference, hinders effective regulation, and increases costs for the sector. Table 4.3 illustrates the variance in operational performance by company size.

The EPS management indicators reveal that there are still great opportunities for optimization. Except for SEDAPAL, which provides services to Metropolitan Lima, most EPSs show poor performance, particularly the small ones. Given the coverage and service levels in rural areas, small municipalities and community organizations' performance is expected to be even more fragile.

The COVID-19 pandemic imposed an additional financial strain on EPSs. Government response measures to help citizens deal with the emergency (payment deferrals, suspension of connection cutoffs, and distribution of free water to households without access) led to a decline in revenues. To meet their short-term financial needs, utilities started postponing routine maintenance and planned capital expenditures while drawing on reserves and investment funds earmarked for special projects. Because this could compromise the utilities' longer-term financial sustainability, the government set up a liquidity facility specifically for water and sanitation utilities during this time. However, recent data indicate that the utilities are not back to their pre–COVID-19 financial situation.

Table 4.3 Performance Indicators by Water Supply and Sanitation Provider Size, 2019

Indicator	SEDAPAL	Large companies	Midsize companies	Small companies	Benchmark
Continuity (hours/day)	21	16	19	14	24
Micro-metering (%)	88	61	63	38	100
Nonrevenue water (%)	28	41	46	42	20
Operating margin[a] (%)	33	2	−7	−3	18–30
Pipe rupture (No./km)	0.2	0.6	0.8	0.8	0.2
Wastewater treatment coverage (%)	91	66	32	6	100

Source: SUNASS Benchmarking regulatorio, 2019 data from EPS (complete data from rural and small municipalities were not available for this study).
[a]Operating margin was calculated with 2018 data.

Table 4.4 Direct and Indirect Losses Due to Water Shortages and Intermittent Water and Sanitation Services

Type of loss	Economic cost US$ (US$1 = S/. 3.6)	Percent distribution to total cost
System loss due to water scarcity	284,782,566	56.8
System loss due to intermittency	107,983,741	21.5
Loss due to unbilled water	94,116,509	18.8
Loss due to overpumping	14,513,421	2.9
Total	**501,396,237**	100.0

Source: Based on data from INEI (2020a).

The majority of providers are unable to cover O&M costs or invest in improving their systems. Many municipal utilities can be considered bankrupt because their long-term debts exceed their equity. In addition to operational inefficiencies, another key factor is low tariffs: on average, utilities apply an average tariff of US$0.62/m^3. This is well below the regional average of US$1.44/m^3 (GWI 2020). This financial situation limits providers' ability to engage in proactive maintenance, hire qualified staff, and invest in system improvements, impacting service quality and decreasing the providers' operational and financial sustainability. As a result, consumers experience water shortages and intermittent services, and low-income, underserved populations usually pay significantly more than the average tariff. For example, in Lima, peri-urban dwellers can pay water tankers up to 20 times more than those receiving piped service from SEDAPAL in network-served neighborhoods.

Water shortages and intermittent water services cost utilities more than US$500 million each year—equivalent to about 10 percent of the total health budget for 2020 (table 4.4). This includes the opportunity cost of not being able to supply more than 56/m^3/year per connection, potentially incentivizing illegal connections and increasing the incidence of household connection failures. It also includes the energy cost of pumping additional water to ensure that the sanitation system remains functional.

Service providers' precarious situations are aggravated by a lack of territorial/situational planning and innovative approaches. For instance, service providers oftentimes utilize unsuitable technologies for rural settings, creating technical and operational problems down the line. In addition, service providers often select traditional solutions to extend service to people living in difficult-to-access, peri-urban areas, leading to expensive and hard-to-maintain solutions. However, innovative approaches that could improve the financial and operational performance of utilities are not utilized widely, given a lack of technical guidelines, incentives, and know-how, among other obstacles. For instance, implementing circular water economy approaches would enable utilities to reduce their environmental and health impacts while improving revenue.

To achieve wastewater treatment goals, Peru needs to employ a financing strategy that will cover the significant up-front costs and to ensure

tariffs are adequate for utilities to cover O&M costs. Wastewater management is a core function of water utilities and ensures public health and healthy ecosystems. However, poor wastewater management in Peru requires significant capital investment and an O&M budget. According to the 2022–26 National Sanitation Plan, the government's objective is to reach 100 percent of wastewater collection and treatment of urban areas by 2030, requiring capital investments of S/. 6,372 million (US$1.7 billion) (MVCS 2021). While the government embarks on wastewater collection and treatment programs, it is essential to consider several interrelated challenges to ensure that investments are made most sustainably and efficiently. These include:

i. A lack of effective project planning and execution, which creates technical and operational problems down the line.

ii. The application of uniform or arbitrary water pollution control standards, which may result in unnecessarily strict wastewater effluent criteria that require costly wastewater treatment technology that is challenging to maintain and operate.

iii. Utilities cannot recover sufficient revenues to fund proper O&M of their wastewater facilities.

iv. Utilities currently have a limited focus on resource recovery. Wastewater is and should be considered a valuable resource from which energy and nutrients can be extracted and an additional source of water. Some recent regulations are providing the framework for water reuse in agriculture and biosolids for soil amendment. Still, only about 20 percent of treated wastewater is reused, and biosolids are seldom utilized. Studies from existing wastewater treatment plants indicate that circular economy approaches can significantly reduce O&M costs.

Inefficient Irrigation and Drainage Systems and Low Irrigation Coverage Are Contributing to Low Agricultural and Water Productivity

Irrigation currently accounts for almost 89 percent of water withdrawals in the country, yet between 30 to 45 percent of the water is used for the intended agriculture purpose. Nationally, irrigation water use exceeds 20,000 m^3/hectare/year, which is significantly higher than in other countries such as Chile, which uses less than half that amount. Only 70 percent of existing irrigation infrastructure is used to produce crops, and 57 percent is in poor condition (Agricultural Census 2012). Various interrelated factors contribute to this low rate of use: the growing scarcity of water; seasonal and interannual variability of water resources; lack of technical capacity to conduct maintenance; salinization and swamping of arable land, particularly in the Costa strip; and economic reasons such as lack of profitability and difficulty in accessing credit.

Much of the existing irrigation relies heavily on gravity-fed furrow and flood systems, which are characterized by their low efficiency. Sustainable irrigation techniques that minimize water loss and are able to apply water only where it is needed and in precise volumes would improve irrigation performance, boost agricultural productivity, reduce soil erosion and pollution, and increase agricultural water efficiencies between 10 and 15 percent. However, in 2018 only 12.8 percent of the area under irrigation (335,482 hectares) used efficient irrigation systems (MIDAGRI 2021a). Only 0.9 percent (S/. 21 million, or about US$5.7 million) of irrigation investment is focused on modernization (efficient irrigation). Nevertheless, efficient irrigation systems increased by close to 60 percent from 2012 to 2018, mainly due to investments from local governments. There is great potential for the public and private sectors to collaborate on modernizing irrigation systems. In 2016, the National Agrarian Policy was implemented to make agriculture more competitive and sustainable by, among other interventions, prioritizing the modernization of water resource infrastructure.

Low irrigation efficiency leads to soil salinity of otherwise productive coastal soils. Soils become saline when excess soluble salts accumulate in the topsoil layer, either due to naturally occurring conditions such as parent rock weathering or due to human activities such as poor drainage, resulting in salts not being washed away and increasing in concentration over time. Low irrigation efficiency on the Costa, coupled with the deterioration of drainage infrastructure, has resulted in the salinization of about 25 percent of the coastal irrigated area's soils (300,000 hectares), increasing evapotranspiration losses and preventing crops from adequately absorbing water, with negative consequences for yields and the development of certain types of crops.

Low irrigation coverage is preventing Peru from reaching its production potential

Agriculture would not be possible on the Costa (coast) without irrigation. However, irrigation is also needed in the Sierra (Andes) and Selva (Amazon), where 75 percent of agriculture is subsistence farming but only 41 percent of farmers have access to irrigation. Being able to complement rainfall with irrigation during the dry months is an important factor for improving productivity and encouraging higher-value crops, which are generally more sensitive to water stress. Together, productivity and higher-value crops contribute to development by reducing poverty in the populations that need it most.

The land that is under irrigation (22 percent) produces about two-thirds of the country's agricultural outputs, demonstrating the effect irrigation has on productivity. Indeed, the irrigated regions of Arequipa and Ica yield on average 33.5 and 32.2 tons per hectare, respectively, while the rainfed regions of Piura and Lambayeque barely produce 9.5 and 6.6 tons per hectare (MIDAGRI 2017). Crop management, local climate, and market access also contribute to these differences.

Irrigation coverage is not expanding at the same pace as agricultural land. Between 2012 and 2018, Peru's agricultural land grew by 4.6 million hectares (MIDAGRI 2021b). By contrast, the area under irrigation expanded fractionally, from 2.599 million hectares in 2012 to 2.62 million hectares in 2018. This is less than half of the potential irrigation area of about 6.4 million hectares (FAO 2022). Several challenges are slowing the expansion of irrigation, including the variability of local conditions; insufficient coordination between various government levels; and limited public investment execution, with only 60 percent of the planned budget being executed, on average, in the past decade.

Expanding irrigation and drainage coverage and increasing irrigation efficiency can increase water productivity (economic efficiency). Water productivity (US$/$m^3$) improved from US$0.44/m^3 in 2012 to US$0.60/$m^3$ in 2018, mainly due to the expansion of more profitable and higher-value crops for the international market, particularly along the Costa. Crops with the highest production value are grown in areas with the best irrigation security and other favorable factors, such as a conducive climate and access to roads and markets. Although Peru's productivity value is similar to the LAC average (0.62), Peru should aspire to having each value close to the average of upper-middle-income countries (US$1.53/$m^3$) (FAO 2022).

Water user associations struggle with a lack of adequate institutional support

WUAs are responsible for distributing water and the operational management of irrigation systems. These associations are groups of private water users, including irrigators, who pool their financial, technical, material, and human resources for the O&M of a water system. These organizations coexist with other farming and other water user organizations, sometimes creating confusion regarding their roles and responsibilities.

Despite covering more than 1.4 million hectares and serving almost 750,000 users, WUAs lack technical capacity and specialized equipment to carry out O&M functions, as well as get reliable information about the availability and use of water resources. The limitations and deficiencies in their capacity adversely affect the quality and sustainability of the services they provide to farmers, mainly in terms of flexibility, continuity, efficiency, and uniformity of the irrigation service.

WUAs struggle to achieve financial and technical autonomy. The associations are generally financially weak due to low water tariffs and collection rates. In the highlands, WUAs have either not established a water tariff or the tariff is too low to meet O&M needs, even when combined with significant in-kind contributions from users. Along the coast, efforts to build capacity have resulted in certain improvements. However, the sustainability of these organizations remains threatened by a lack of adequate institutional support. There is currently no entity responsible for providing technical assistance or training to the WUAs.

Women's contributions are not adequately recognized, and women are disadvantaged in access, training, and technical assistance services. It is estimated that 60–80 percent of the world's food is produced by women, who make up 20 percent of the labor force in Latin America. Women are in charge of agricultural activities when

Table 4.5 Types of Water User Organizations and Hectares Covered by Irrigation in Peru, 2019

Geographic area	Water user's associations registered	Water user's commissions registered	Water user's committees registered	Number of registered farmers registered in committees	Hectares under registered users
Coast	66	743	1,259	305,273	898,713
Highlands	51	836	6,811	382,661	415,987
Amazon	11	113	521	36,109	103,988
All Peru	**128**	**1,692**	**8,591**	**724,043**	**1,418,688**

men migrate to seek other income. Despite this, in all 128 WUAs that exist in Peru (where women constitute 31.6 percent of the overall population), women hold only 10.1 percent of positions on boards of directors, and 0.79 percent of president or vice-president positions (Carrillo 2019).

Public investment in irrigation is characterized by its low budget execution and limited attention to quality

Public investment in irrigation is characterized by its low-budget execution. Nearly half of the national public budget for agriculture was allocated to irrigation between 2010 and 2020. **However, this investment has not translated to significant improvements in irrigation coverage or efficiencies.** This is in part because only 59.7 percent of irrigation investments were executed, representing a small fraction of potentially viable irrigation projects.

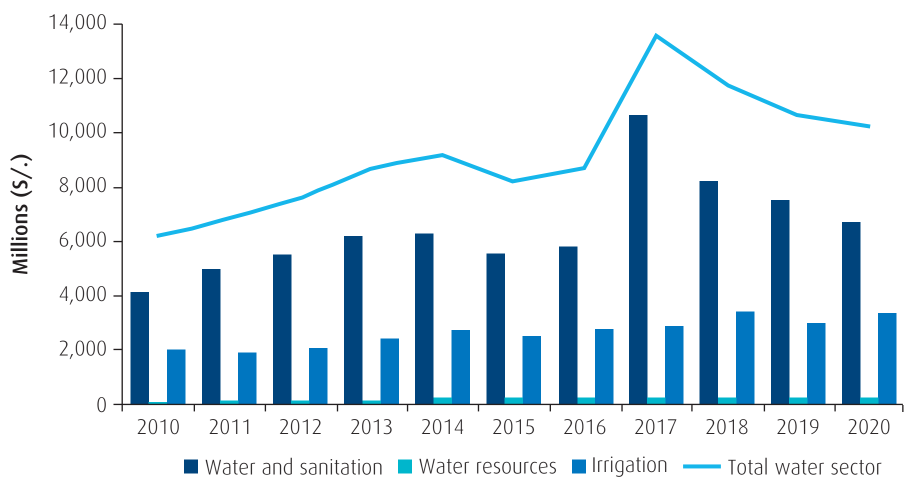
Regarding the quality of public investment, there is little information on the performance of many small-scale projects that are operating. No monitoring and evaluation system is available to help determine the impact of irrigation investment. Many of the projects implemented at the local level lack technical readiness, relevance, and sustainability, which can be explained by several factors: limited capacity and technical assistance during the design process, lack of financial and operational arrangements, and limited involvement and mandatory contribution by project beneficiaries.

Budget Execution and Funding Gaps of Water Services are Hindering the Achievement of National and Sustainable Development Goals

Peru has significantly increased its budgeted public expenditure for the entire water sector since 2010, making it one of the countries that invests the most in the LAC region, especially in the water and sanitation subsector. Since 2010, water-related budgeted expenditures increased from about S/. 6.1 billion (US$2 billion) to S/. 10.2 billion in 2020 (US$2.8 billion) (figure 4.6). This represents an annual water expenditure of 1.2 percent of GDP, above the LAC region average of 0.83 percent. A large portion of the budget goes to water and sanitation at 57 percent, followed by irrigation with 32 percent. Water resources receive only 1 percent of the total budget.

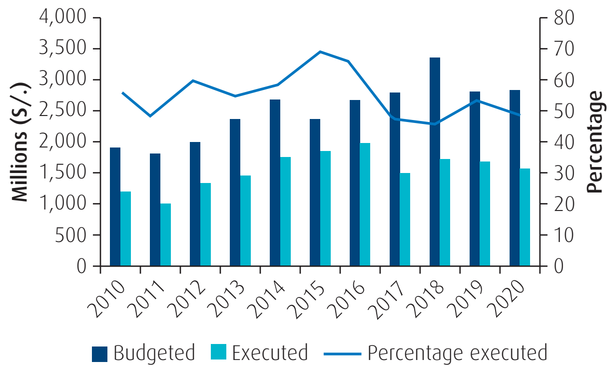
Despite significant budget allocation, challenges persist in Peru's public investment system, hindering capacity to achieve significant progress toward water security. Low execution of the allocated budget in irrigation (figure 4.7) and water supply and sanitation (figure 4.8), spending priorities not fully aligned with national sectoral policies, limited monitoring and evaluation of projects focused on results, and application of solutions that are not context specific are some of the challenges found by the Water Security Diagnostic (box 4.12). As an example of limited alignment with sectoral policies, water resources budget allocation is very low, and about half of what is allocated to water resources goes

Figure 4.6 Water Sector Budgeted Expenditures, 2010–20



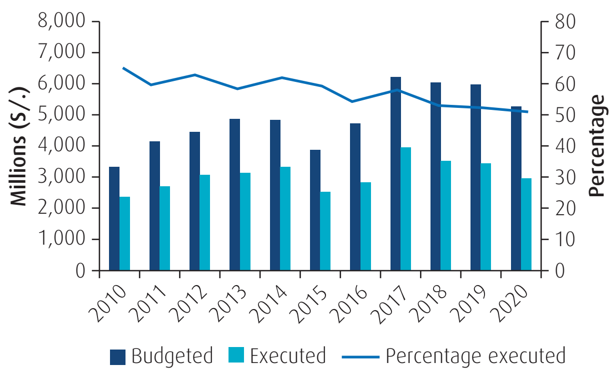
Source: MEF/SIAF 2020.

Figure 4.7 Budget Execution of Irrigation Investments, 2010–20



Note: This shows an abrupt decline between 2016 and 2020. On average, only 65 percent of the irrigation budget was executed over the six-year period.

Figure 4.8 Budget Execution of Water and Sanitation Investments, 2010–20



Note: This shows a steady decline between 2014 and 2020. On average, only 61 percent of the WSS budget was executed over the six-year period.

Box 4.12 Inappropriate Solutions Cause Projects to Stall and Contribute to Low Budget Execution

Too often, inappropriate solutions that are unable to meet the technical, management, and logistical solutions required by geographic, sociocultural, and political conditions in rural and peri-urban areas doom projects to failure from the outset. Unfinished water and sanitation infrastructure projects are a common sight in Peru. Between 2005 and 2015, the Government of Peru invested US$3 billion in 6,000 sewerage projects, 65 percent of which were abandoned at some point. This is not just a service delivery concern but also a public health matter. An analysis of the effect of unfinished sewerage projects on the mortality of children under the age of five found that unfinished water and sanitation works resulted in open ditches of unfinished sewerage systems becoming filled with stagnant water, to the point that every additional unfinished sewerage project increased under-five mortality due to waterborne diseases and accidents by 10 percent over baseline levels. Water cuts required during the installation of sewerage systems also forced the population to rely on unsafe sources of water and led to a decline in hygiene and sanitation practices.

Source: Bancalari 2020.

to additional irrigation projects. In addition, mining districts received higher allocations independent of their water-related gaps and needs. And, as indicated in the section before, efficient irrigation is not prioritized despite its importance for the sector.

Subnational governments represent the main driving force behind larger sector spending in irrigation and WSS (see figure 4.9). The water sector spending is decentralized in nature with local and regional governments undertaking most of the budgetary water sector spending. Since 2018, budgetary local and regional resources (mostly funded through ordinary budget resources [*recursos ordinaries*] and mining canons) have accounted for more than 80 percent of irrigation investment (47 percent regional and 33 percent local). In the case of water and sanitation, local governments accounted for 89 percent of the WSS investment. Strong coordination and collaboration between national and subnational stakeholders are needed to ensure sector and development policies are implemented.

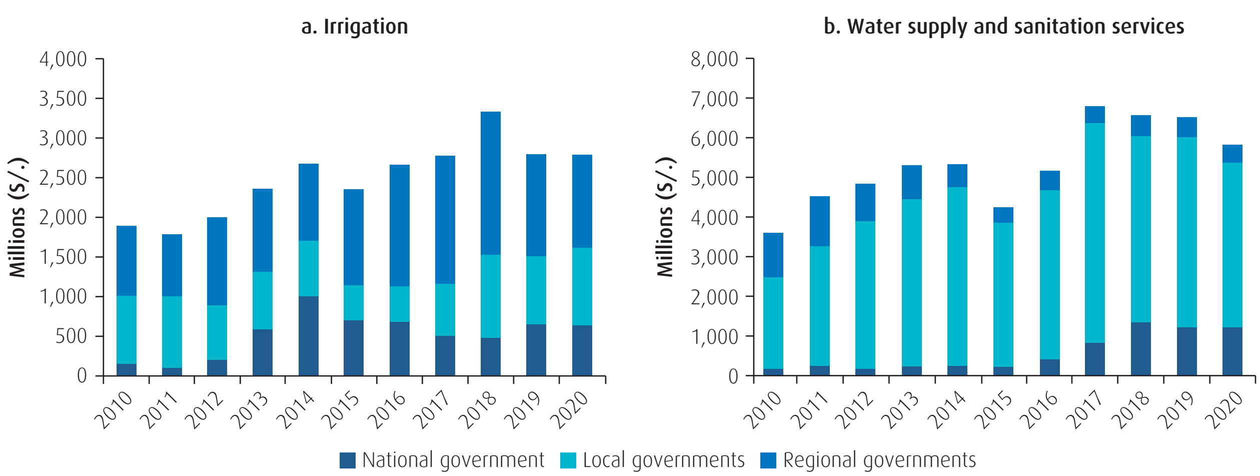
Reaching basic water and sanitation services and closing the financing gap for meeting SDG targets 6.1 and 6.2 will require improving budget execution and accessing other sources of financing

Investment needs and targets vary significantly across the water subsectors, and only the water and sanitation subsector provided information on required investment needs to close the gap. The 2022–26 National Sanitation Plan estimates annual funding needs of S/. 10 billion (US$2.6 billion) per year to reach universal WSS services by 2030. To finance these investment needs, the plan is assuming that public investment levels will continue, that budget execution will significantly improve, and that several public-private partnerships will come to fruition.

In addition, other sources suggest different levels of funding gaps. The United Nations Children's Fund and Sanitation and Water for All with the Joint Monitoring Programme (JMP) data estimate[6] that additional investments needed in Peru are in the order of US$1.3 billion on average per year from 2021 to 2030 for delivering universal safely managed water and sanitation services. A recent study of the Inter-American Development Bank (IDB 2021) estimates that Peru needs an additional US$2.2 billion investments per year on average from 2021 to 2030 to reach safely managed water and sanitation for all.[7] Therefore, when compared with the current budget execution, the funding gap to reach universal access to safely managed WSS services by 2030 is between US$1.9 billion and US$3.2 billion per year. According to the national infrastructure plan approved in July 2019, water and sanitation is the second sector with the largest financial deficit gap to meet the SDGs, after transport (MEF 2019).

To reach these levels of financing, Peru will need to accelerate various financing mechanisms; implement cost-effective, innovative solutions; and improve public budget execution, which is currently at 54 percent for water supply and sanitation. Public funds could be complemented with loans from international donor agencies and through government guarantees for mobilizing private investments. Public-private partnership approaches could be explored to incentivize

Figure 4.9 Capital Investments, by Government Level, 2010–20



Source: Public Expenditure Review Study (World Bank 2021c).

Box 4.13 Government's Private Sector Participation Approaches to Improve Peru's Water Security

Public-private partnership arrangements. Peru has a well-developed regulatory and institutional sector for private sector participation. Pro-Inversion promotes private sector involvement in public infrastructure through build, operate, and transfer (BOT) schemes, and since 2005, promotes an enhanced BOT concession structure (*concesión co-financiada*) whereby the Government of Peru provides financial support to mitigate the construction and performance risks associated with large infrastructure projects, providing the concessionaire with a guaranteed stream of payments to cover construction costs. Both the Huascacocha Bulk Water Supply Project and the constructed Taboada and La Chira wastewater treatment plants in Lima follow this BOT structure.

Mobilize finance for development in local and international currencies. The Peruvian financial sector has the basic conditions to support the financing of water and sanitation projects through local banking, institutional investors, investment funds, and sovereign debt markets. To mobilize this group of financiers and investors, it is important to continue incorporating available payment models, developing new structures to add flexibility to investors' risk profiles. The water sector has several matured projects that can be used to explore this model.

Works for taxes. This is an innovative private sector partnership mechanism created in 2009 by the Government of Peru to promote private company investments in public infrastructure. To date, 16 million Peruvians have benefitted from the construction of 398 infrastructure works for a value of S/. 4,900 million (US$1.4 billion) (MVCS 2020), 15 percent of which went to water supply and sanitation investments.

Other innovative approaches. Sale of bulk water in the coastal areas consists of selling bulk water from desalination/mining companies to water utilities to provide water to areas with less access to freshwater. Other initiatives include performance-based contracts to improve operational performance, policies to promote water reuse and biosolids markets, and corporate stewardship through financing of natured-based solutions.

private participation. Public policies designed to improve quality and efficiency of public spending, as well as targeted interventions to reduce coverage gaps and efficiency of water operators, will also be essential. Box 4.13 outlines several models for private participation in the water sector.

Notes

1 This refers to the variation of available renewable water resources within the year.

2 This refers to the variation of available renewable water resources between years.

3 The Falkenmark indicator links freshwater resources with the number of people in a given region to indicate the population's pressure on water resources. A country is said to be experiencing water stress if renewable freshwater is below 1,700 m^3/person/year; water scarcity if it is below 1,000 m^3/person/year; and absolute water scarcity if it is below 500 m^3/person/year.

4 The city of Lima relies on its own natural resources, that is, the Rimac, Chillon, and Lurin river basins (without considering water transfers). The combined contribution of these three rivers is slightly more than 900 MCM per year, which for a population of about 10 million is 90–100 m^3/person/year.

5 Data from (WHO/UNICEF JMP 2021).

6 The WASH costing tool uses data from the JMP and is a joint publication of UNICEF and SWA. The data can be accessed by country at: https://www.sanitationandwaterforall.org/tools-portal/tool/sdg-costing-tool.

7 The data on the additional investments required are from different sources. The JMP estimates it to be US$1.3 billion based on a narrow set of least-cost sanitation technologies. The highest estimate of US$2.6 billion comes from the National Sanitation Plan (2022–26), which incorporates all sanitation projects with a larger set of technologies and options. The UNICEF-SWA-JMP estimates (US$1.3 billion) represent 16 percent of the trade balance of the country in 2020; the IDB estimates (US$2.2 billion) represent one-quarter of all 2020 imports of consumer goods in the country. Calculated based on data from: https://www.bcrp.gob.pe/eng-docs/Statistics/quarterly-indicators.pdf.

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CHAPTER 5

A Way Forward: Nine Recommendations to Improve Water Security in Peru

Peru has taken many important steps to stabilize its water resources, and economy, in a shifting world. Increasing the efficiency of its water infrastructure and institutions promises tremendous future benefits, in terms of poverty reduction, sustainable development, and human capital accumulation.

While the present work leaves many threads untied, it offers nine concrete recommendations to accelerate Peru's path to water security:

i. **Consolidate and implement integrated water resources governance at the national and basin levels.** To overcome its many water endowment challenges (high climate variability, water pollution, and a mismatch between levels of demand and water availability, among others), Peru will need to employ strong water governance and conduct reforms that utilize integrated water resources management strategies at the local and basin levels and ensure that there is coordination and harmonization across water-related agencies.

   First step: Reinstate the interagency water commission to complete the water governance implementation plan based on the findings from the OECD Water Governance report and this WSD. Once complete, the interagency commission may submit the implementation plan to the Presidency of the Council of Ministers (Presidencia del Consejo de Ministros, PCM) and the National Water Resources Management System (Sistema Nacional de Gestión de Recursos Hídricos, SNGRH) for high-level approval. After approval, the PCM might want to establish a monitoring system to track progress.

ii. **Improve the National Water Authority's technical and planning capacity to integrate risk management, improved information systems and efforts to address climate change into water resource management.** Although ANA has made progress with the establishment of the national water resources information management system, the development of six river basin management plans, and the creation of a technical dam safety unit, it needs to scale up these efforts to sustain water resources for current and future generations.

   First step: Finalize and approve updates to the 2015 Water Resources Policy and begin updating the 2015 Water Resources National Plan to integrate water security and climate change elements.

iii. **Improve and expand wastewater management to address water quality and quantity in critical basins.** Pollution due to economic growth and rapid urbanization has decreased the quality and availability of water resources, affected public health, and is posing serious threats to the environment. Given that the main cause of water pollution is the discharge of domestic wastewater into surface water bodies, this diagnostic proposes the development of a wastewater management strategy led by the MVCS as a first step to overcome this challenge.

First step: Develop a wastewater management strategy and pilot, at the basin level, sustainable programs for wastewater treatment that utilize circular economy approaches.

iv. **Utilize differentiated, territorial approaches to increase access to safely managed water and sanitation services for Peru's most vulnerable**. Peru still has significant work to do to improve water and sanitation services in rural and peri-urban areas; reaching these areas, however, requires a differentiated, territorial approach that considers geographic, sociocultural, and political conditions and considers population density and logistical difficulties.

First step: Prepare and begin implementation of a comprehensive water and sanitation policy and strategy for vulnerable populations in rural and peri-urban areas that includes strong community participation in the selection of technical and management solutions, promotes handwashing and hygiene, and utilizes innovative financial strategies.

v. **Establish financial incentives to improve the efficiency, service quality, and sustainability of water and sanitation service providers.** Despite several water and sanitation policies directed at improving performance of water service providers, overall performance has not improved given low adoption and implementation of the policies at the local level. To ensure more sustainable WSS service delivery, the WSD recommends aligning existing policies with financing incentives.

First step: Prepare, adopt, and begin implementation of a performance-based financing policy for water-related capital investments.

vi. **Implement a comprehensive approach to deliver sustainable, efficient, and equitable irrigation and drainage services.** Although irrigated agriculture is critical to achieving better food security, producing higher-value crops, and bolstering the resilience of agriculture to climate change, irrigation-related investments have not kept pace with the expansion of agricultural land in Peru.

First step: Develop a detailed national irrigation strategy and plan that considers water storage, equitable water allocation, modernization of irrigation systems, and differentiated irrigation approaches to allow for the expansion of irrigation systems in undeveloped areas with irrigation potential.

vii. **Strengthen capacity to effectively utilize budget allocation for water, sanitation, and irrigation services.** Strengthening the technical and project management capacity of national, local, and regional agencies to implement public investments in the water, sanitation, and irrigation sectors is key to accelerating efforts to close service gaps and expand access to irrigated agriculture.

First step: Provide capacity building and technical assistance to strengthen project implementation units to support the design and implementation of water and sanitation and irrigation projects and to enhance the capacity of government staff.

viii. **Invest in integrated water storage solutions and improve resilience of existing hydraulic systems.** Peru faces water stress in the Costa region and significant interannual and seasonal variability of surface runoff in the Selva and Sierra regions. To build resilience to extreme droughts and floods, Peru must invest in integrated water storage measures and improve management of existing hydraulic infrastructure.

First step: Develop an integrated water storage strategy focused on ensuring risk-based management of existing hydraulic infrastructure, increasing water storage capacity, and facilitating multipurpose arrangements.[1]

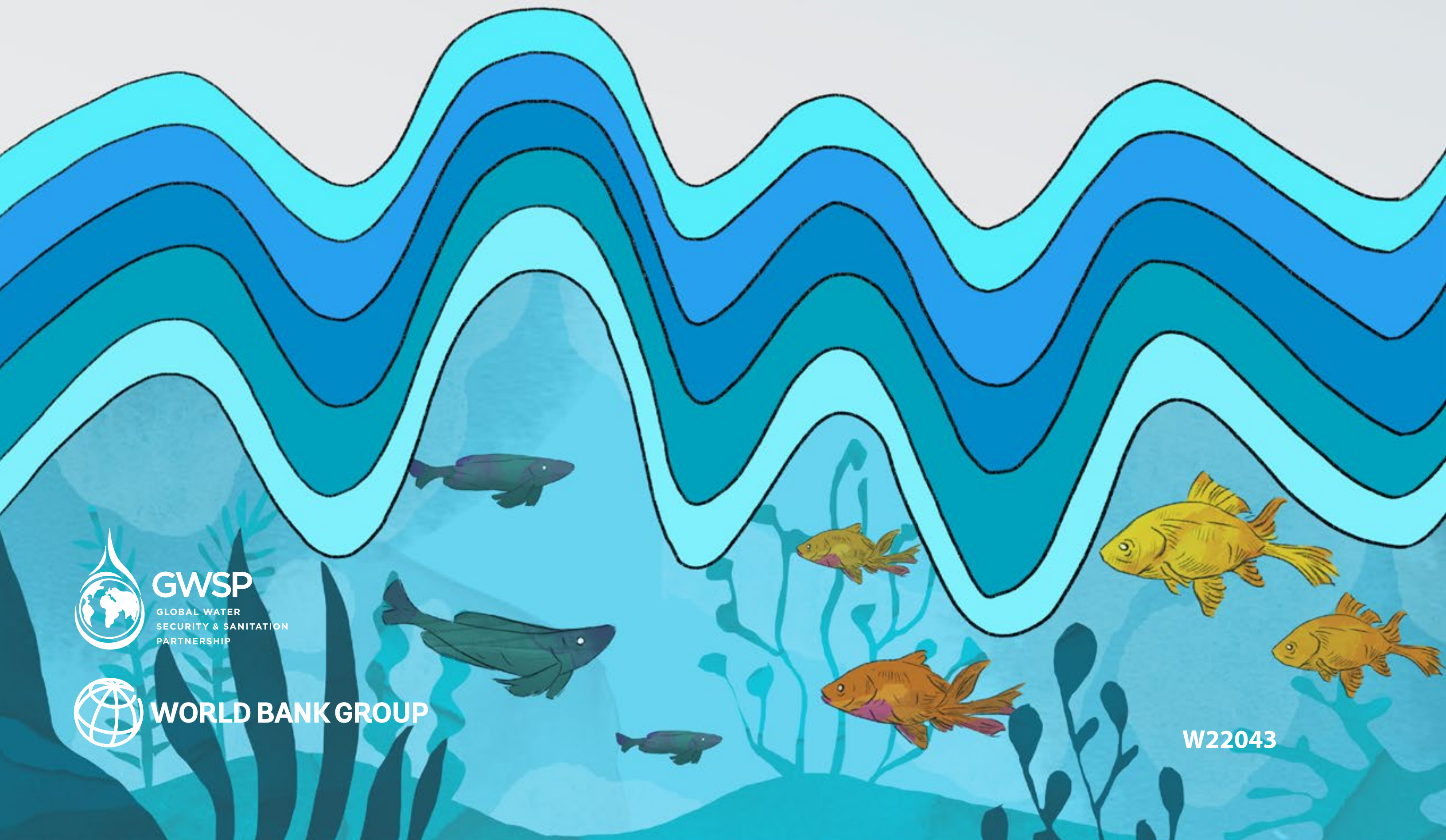
ix. **Build resilience, in the face of an uncertain future, into existing sector planning instruments.** Peru has a national DRM legal framework that focuses on improving prevention of and building resilience to disasters, but adoption by water-related agencies at the local level has been slow.

First step: Develop a pilot program for local water organizations, including river basin councils, water and sanitation service providers, and water user organizations (irrigation) to incorporate DRM measures into existing sectoral planning instruments and operational procedures.

These recommendations lay the necessary groundwork for efficient, effective, and sustainable infrastructure investments. Key infrastructure improvements center on reaching universal access to safely managed WSS services, expanding wastewater treatment to improve water quality, expanding access to efficient irrigation solutions, and increasing integrated water storage solutions to build resilience to water security challenges. It is important to not only tap new sources of funding, but to carefully plan their use in order to spend smarter. Future generations will benefit from every carefully planned step toward sustainable development taken today.

Note

1 Operational and legal arrangements so that storage can serve multiple functions and provide multiple services and uses.



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