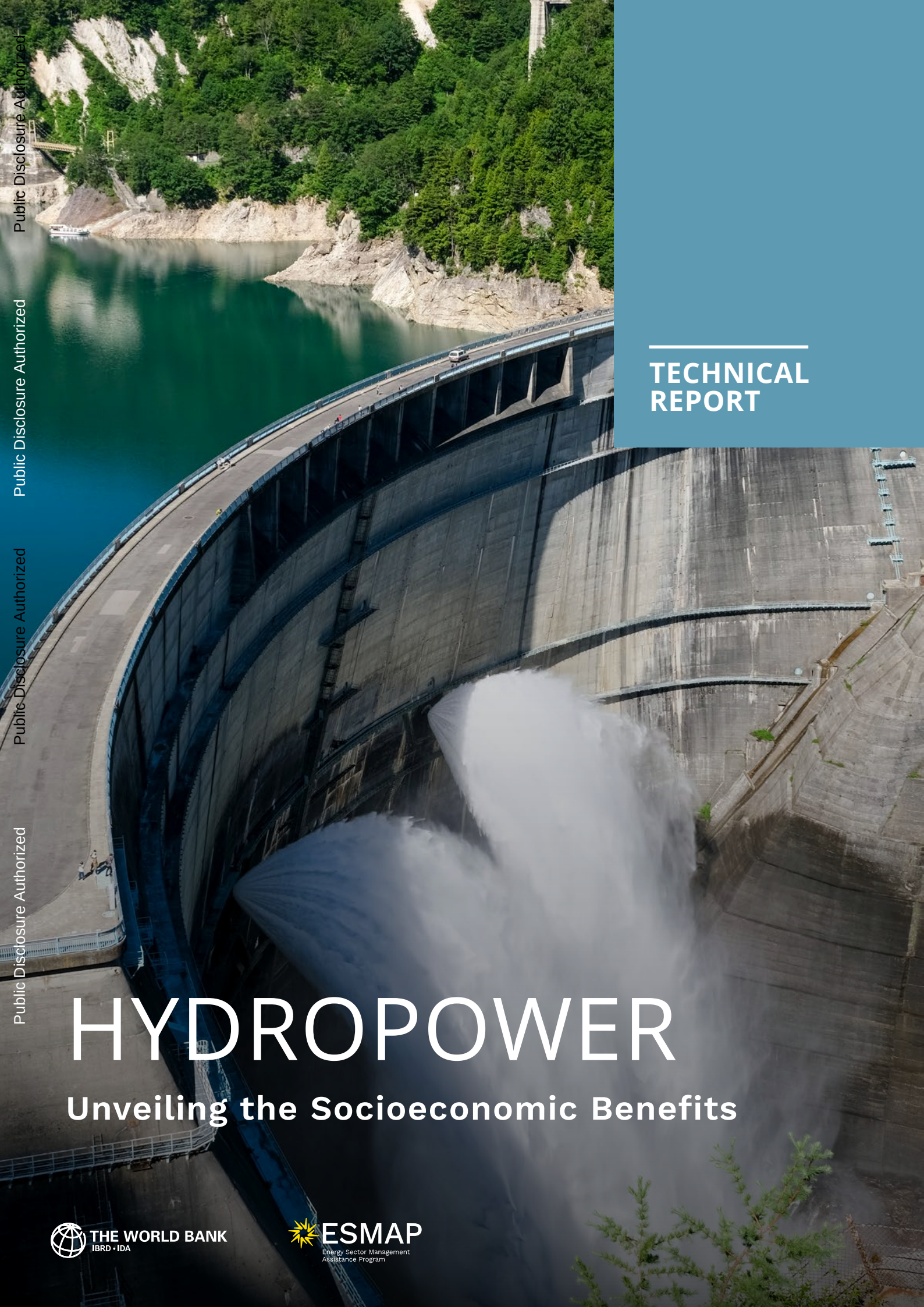

TECHNICAL REPORT

HYDROPOWER

Unveiling the Socioeconomic Benefits

THE WORLD BANK
IBRD • IDA

ESMAP
Energy Sector Management Assistance Program

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Table of Contents

LIST OF BOXES

LIST OF TABLES

LIST OF FIGURES

Abbreviations

BHSL	Bhutan Hydropower Service Limited
CAPEX	capital expenditure
CSR	corporate social responsibility
DFI	development finance institution
E&M	electromechanical
EDF	Électricité de France
ESMAP	Energy Sector Management Assistance Program
FTE	full-time equivalent
GDP	gross domestic product
ha	hectare
ICE	Instituto Costarricense de Electricidad (Costa Rica)
ICH	International Centre for Hydropower
IHA	International Hydropower Association
KGRTC	Kafue Gorge Regional Training Centre (Zambia)
MW	megawatt
NGO	nongovernmental organization
NTPC	Nam Theun 2 Power Company (Lao PDR)
O&M	operation and maintenance
PPP	public-private partnership
REDP	Renewable Energy Development Project
SHP	small hydropower plant
SMEs	small and medium-sized enterprises
STEM	science, technology, engineering, and mathematics
TVET	technical and vocational education and training

All currency is in United States dollars (US$, USD), unless otherwise indicated.

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The Energy Sector Management Assistance Program (ESMAP) is a partnership between the World Bank and 24 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector. ESMAP works through the World Bank to accelerate the energy transition required to achieve Sustainable Development Goal 7 to ensure access to affordable, reliable, sustainable, and modern energy for all. It helps to shape World Bank strategies and programs to achieve the World Bank Climate Change Action Plan targets.

Learn more at: https://esmap.org

Key Findings

Hydropower, which represents nearly half of the world's renewable energy generation, plays a pivotal role in reducing global emissions and combating climate change. Beyond their remarkable capacity to generate clean electricity, hydropower dams and reservoirs provide water storage and energy services crucial for enhancing power system balance so as to enable greater shares of solar and wind energy (Brunes, Harby, and Hallgrimsdottir 2024).

Dams and reservoirs have been used for centuries to serve important societal needs. Today, approximately 40 percent of all hydropower dams serve multiple purposes—meaning they generate electricity while also supporting other societal needs, such as irrigation, fishing, navigation, recreation, flood control, or fresh water supply.

Hydropower projects are significant contributors to government revenue, through electricity sales, taxes, and royalties. The resulting funds can be strategically directed toward achieving socioeconomic development priorities. Besides government revenue, hydropower brings other economic benefits. Given its capacity to deliver clean, reliable, and low-cost electricity, it can attract industries to set up domestic operations, stimulate the creation of new small and medium enterprises through improved energy access, and generate many new jobs.

Meanwhile, one must acknowledge that developing hydropower infrastructure can have social and environmental implications, as most major infrastructure projects do. Over the years, the hydropower sector has responded to criticism effectively and strived to improve regulations and practices so as to mitigate and compensate for impacts and ensure sustainable development.

Careful government planning and project implementation can help realize a number of benefits. Key among these are:

- **Participation of domestic companies in the hydropower value chain.** Developing and operating hydropower projects creates opportunities for domestic companies to offer goods and services. This positively affects economies. Contracts, varying in size, contribute to fiscal revenues, gross domestic product, and job growth.
- **Hydropower employment and skill development**. Projects generate direct, indirect, and induced jobs and foster on-the-job learning and formal education opportunities. This results in new skills and greater diversity in the national workforce, in turn improving employment outcomes.
- **Local development/benefit sharing.** Developers collaborate with local communities to ensure lasting benefits and community acceptance. Approaches range from

infrastructure enhancements and skill development programs to revenue-sharing mechanisms, which allow communities to reap the direct financial rewards of a project. Moreover, projects can be designed to maximize water service benefits to the local region, including the provision of water for domestic, industrial, and agricultural uses; navigation; and fishing, recreation, and tourism, besides other co-benefits of hydropower infrastructure development.

- **Gender equality and social inclusion**. Hydropower projects, when carefully designed, can be a catalyst for social change. They can advance gender equality and social inclusion, in turn addressing disparities based on social identity factors, and generate far-reaching benefits, which encompass access to job opportunities, education and training, business opportunities, and local development initiatives.

Much can be done along the hydropower value chain, from project planning through to operations and maintenance, to maximize the socioeconomic benefits of hydropower development. This report highlights the aspects that can be controlled and maximized at the project level, and what governments can orchestrate in the lead-up to project development to foster socioeconomic benefits. Countries worldwide have leveraged project development as a tool to achieve more comprehensive local, regional, and national socioeconomic development, and this report aims to highlight these successes as best practices that can be replicated and implemented elsewhere. Additionally, this report is designed to be used in conjunction with the Sustainable Renewables Risk Mitigation Initiative (SRMI) handbook "A Sure Path to Sustainable Renewable Energy: Maximizing the Socioeconomic Benefits Triggered by Renewables" (World Bank 2022a), which is a technology-agnostic, step-by-step framework for how governments can approach this topic. The theory of change for this handbook is provided in annex 2.

Executive Summary

Among hydropower's myriad benefits (e.g., greater energy security, reduced greenhouse gas emissions), this report focuses specifically on its *socioeconomic benefits*—and how governments can maximize them through policy and planning. The report also considers outcomes that can be controlled and maximized at the project level, beyond the risk mitigation requirements of environmental and social safeguard frameworks. Notably, benefits can be felt at both national and local levels throughout a hydropower project's planning, development, and operation.

While hydropower projects carry undeniable overall benefits, they also bring challenges. Construction and operation alter the natural environment and change the ways people interact with and utilize natural resources. The journey to operational status can disrupt local communities, generating noise, waste, and an influx of workers that may change the social fabric. Such disruptions may impact livelihoods and challenge cultural traditions.

In the face of change, maximizing the socioeconomic benefits of hydropower projects—new business opportunities, new jobs, and new skill development—is critical. Every opportunity must be nurtured to bring the greatest benefit to the project country and its people, particularly local communities.

This report's preparation included an extensive literature review. This was combined with a market sounding that engaged 50 stakeholders in the hydropower sector, including governments, industry associations, academia, public and private sector developers, and technical experts. In addition, nine hydropower developers were asked about the quantitative data and figures developed from the literature review. Key lessons and best practices gathered from these important contributors are outlined in the text and showcased across 30 case studies.

This report complements the 2022 World Bank handbook "A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables," which offers guidance to governments on designing renewable energy programs that have extensive benefits, for communities and the broader society (World Bank 2022a). Although the handbook does not specifically focus on hydropower, it provides an underpinning framework and step-by-step process that governments can follow. The theory of change for the handbook, designed from the government perspective, is provided in annex 2. The present report is intended for governments, developers, and operators to learn from the examples and case studies featured, take inspiration from the successes, and replicate the best practices to generate positive socioeconomic outcomes.

The report examines benefits across the following four categories, derived from the World Bank's Sustainable Renewables Risk Mitigation Initiative (SRMI):

1. Participation of domestic companies in the hydropower value chain
2. Hydropower employment and skill development
3. Local development and benefit sharing
4. Gender equality and social inclusion

The following subsections outline key findings across these four categories. Gender equality and social inclusion are addressed through an intersectional lens. When considering the recommendations offered in this report, policy makers and practitioners should remember that each country has its own unique circumstances that call for customized approaches.

Participation of Domestic Companies in the Hydropower Value Chain

Mapping the hydropower value chain is a crucial first step toward maximizing the potential socioeconomic benefits of hydropower projects. Localization opportunities can be created by identifying where goods, services, and labor can be sourced domestically; this in turn adds value and bolsters a country's gross domestic product. Recognizing the gaps in domestically available goods, services, and labor presents an opportunity to develop support programs to enhance the domestic industry's capabilities over the medium to long term. This proactive approach enables greater added value to be captured within the industry.

Specific value chain segments—for example, the manufacturing of electromechanical equipment, including turbines, generators, and control systems—require highly specialized expertise and are less likely to be localized. However, depending on each country's industrial capacity, components like smaller valves, steelworks, and piping may feasibly be manufactured domestically.

Many countries present significant potential to localize activities of the value chain's construction and operation and maintenance (O&M) segments. Even when international companies are engaged, it is feasible and advantageous to employ local labor or subcontract portions of the work to domestic firms.

Governments can leverage project procurement to promote localization within the hydropower value chain. They can help domestic companies grow and develop by incentivizing domestic procurement of certain components and services by developers. However, such procurement practices should be carefully balanced to ensure they do not adversely affect project viability and tariffs.

Clusters and industry associations play a pivotal role in enhancing the capacities of the domestic industry. These entities contribute significantly to industry growth through activities such as training domestic workers, facilitating stakeholder collaboration, and fostering an environment conducive to technology transfer and research and development.

Crafting specialized financial products can help domestic companies access the capital they need to participate in the hydropower value chain and achieve scale. For example, they may require financing to adapt their business operations or hire and train new staff. Such tailored financial solutions help to overcome financing barriers and facilitate greater participation in the industry.

Hydropower Employment and Skill Development

In 2021, the hydropower sector provided direct employment to approximately 2.36 million individuals (IRENA 2022).

As of 2022, women held only 25 percent of the jobs in the hydropower sector. Also, the distribution of roles showed significant gender gaps: only 21 percent held technical positions, compared with 79 percent in nontechnical roles (ESMAP 2023b). Governments and companies are helping to address these disparities by successfully implementing progressive policies, support programs, and initiatives to boost women's employment.

Construction along with O&M generate the most direct employment across a project's life cycle. While construction roles are more abundant, they tend to be short term. Conversely, O&M positions, although fewer, offer employment over the entire lifespan of a hydropower plant (more than 100 years). The creation of induced jobs, although challenging to quantify, can be substantial for hydropower projects. These jobs may stem from greater energy access, increased growth of domestic industries due to greater energy reliability, or local opportunities arising from the multipurpose functions of hydropower infrastructure, for example, tourism-related roles linked to the presence of a reservoir.

Skill shortages are greater among high-skilled than medium-skilled roles in the hydropower sector. Domestic recruitment for low-skilled roles poses minimal challenges for developers. Governments and developers are addressing skill shortages by introducing new hydropower curricula and sending individuals abroad for training in established hydropower markets. Additionally, developers often hire individuals lacking hydropower-specific experience and provide on-the-job training.

To expand the hydropower workforce, it is important to disseminate information about job opportunities. Initiatives such as student competitions, mentorship programs, internships, and apprenticeships are instrumental in introducing individuals to career paths in the sector.

Some governments integrate incentives into the project procurement process to encourage developers and subcontractors to train and hire domestic or local labor. Similarly, several governments have instituted targets for increasing women's participation in the hydropower workforce.

Local Development and Benefit Sharing

Nurturing a positive and enduring relationship with local communities is important for developers to gain trust and secure a social license to operate. Establishing such a relationship typically involves contributing to lasting benefits within these communities and going beyond what is required through legal social and environmental frameworks to compensate for losses incurred during project development. Developers have many other motivations to share benefits, beyond gaining acceptance for project development. At times, benefit sharing is driven by a need to attain favorable environmental, social, and governance ratings or to secure financing, whereas in other cases, it is driven by the desire to create a positive company image.

To effectively share benefits with local communities, developers must prioritize timely and transparent communication, conduct detailed consultations, and implement collaborative programmatic interventions. For developers, it is imperative to strike the right balance between their realistic capabilities and communities' aspirations.

Three primary categories for benefit sharing can be explored:

1. Improvements or additions to local infrastructure and services—for example, building or improving health, education, and sanitation infrastructure, or assessing how water resources and reservoirs can be shared for general community purposes, such as navigation or irrigation.
2. Enhancing skills and capability at the community level, including training in hydropower-specific skills or other subjects, for example, empowering trainees to launch enterprises in different industries.
3. Revenue-/ownership-sharing arrangements, for example, offering equity stakes in projects, establishing a taxation system that benefits both national and local government, or directing a portion of revenue to a community-controlled entity like a trust.

Including benefit-sharing elements in procurement documents ensures developers fulfill their commitments to communities; it also allows governments to align project objectives with their local development plans. In some countries, constitutional or macrolevel legal frameworks already facilitate benefit distribution at the regional and/or local level, such as through royalty and licensing frameworks. Similarly, government-implemented policies promoting gender equality and social inclusion have bolstered the participation of women and vulnerable groups in benefit sharing activities.

Above all, cultivating an enduring trust with local communities is paramount. Sustained engagement and transparent information mitigate the risk of costly delays or litigation. A dedicated team with equal gender representation is indispensable for maintaining trust and fostering lasting relationships with communities over time.

1. Leveraging Hydropower for Sustainable Development

As nations strive to tackle the dual challenge of mitigating climate change and ensuring universal energy access, the multifaceted advantages of hydropower are crucial. Hydropower is the cornerstone of low-carbon electricity generation and represents almost half of the world's renewable generation (IEA 2021). Its contribution surpasses those of all other renewables combined, including wind, solar photovoltaic, bioenergy, and geothermal sources. In 2021, hydropower generated 26 percent of the world's electricity, with an installed global capacity of 1,360 gigawatts (GW), and total generation of 4,250 terawatt-hours (TWh) (IHA 2022).

Besides their impressive capacity for electricity generation, hydropower plants play other vital roles in energy systems. They provide flexible energy services like energy control and energy storage, which are critical in balancing power systems and maintaining power quality in the short and long terms. The ability to respond to demand shifts, compensate for fluctuations in supply from other electricity sources, and contribute toward long-term energy balance are key capabilities that enable the integration of greater shares of variable renewable energy sources, such as solar and wind (Brunes, Harby, and Hallgrimsdottir 2024).

But the advantages of hydropower extend even further. Hydropower supports the provision of water services and brings diverse socioeconomic benefits that can be realized through government planning, project development, and operation. This report examines these socioeconomic dimensions, investigating the contributions of hydropower projects to domestic market development, job creation, skill development, and community well-being, as well as their pivotal role in water resource management.

The International Hydropower Association (IHA 2022) forecasts that a minimum additional capacity of 1,200 GW will be necessary to keep global temperature rise below 1.5°C and achieve net-zero emissions by 2050. On a global scale, almost half of hydropower's economically viable potential remains untapped, much of it in emerging and developing economies (IEA 2021). New projects could open avenues for clean energy generation and catalyze positive socioeconomic outcomes for the countries involved.

Forecasts indicate that by 2030, over 75 percent of new hydropower capacity worldwide will be in large-scale projects in Asia and Africa, primarily commissioned by state-owned enterprises (IEA 2021). In vertically integrated and single-buyer markets like China, the public sector continues to play a predominant role. Conversely, some Latin American and European countries have adopted supportive policies like auctions and feed-in tariffs, fostering greater private sector investment in hydropower plants.

When planned effectively, all hydropower projects, regardless of size, can be designed to maximize positive socioeconomic outcomes. These outcomes are critical to all stakeholders, including governments, developers (public and private), operators, and the citizens of the project country (at large and at the project site level). Often these benefits extend beyond borders to have positive regional impacts.

Governments can strategically harness hydropower projects as powerful instruments for economic growth, development, poverty reduction, and social justice.

- Government fiscal gains extend beyond income taxes levied on those directly or indirectly engaged in the hydropower sector, which include taxes on businesses and goods and services, royalties for utilizing resources, and land leasing agreements.
- Developing new hydropower projects presents a valuable opportunity to cultivate local industry. There is potential to nurture the growth of domestic companies capable of providing essential goods and services for project development, and operation and maintenance, depending on market readiness. Such companies can often grow to cater to multiple industries.
- The availability of reliable and affordable energy has extensive economic implications. It can act as a catalyst for industrial players to establish local operations and further nurture the growth of small and medium enterprises.
- Projects can effectively align with local, regional, and national priorities for socioeconomic development. The infrastructure developed for a project, for example, to improve road access, can benefit communities. Developers also often pledge to bring additional benefits to communities through other infrastructure projects (e.g., schools, health centers, and drinking water) and socioeconomic development programs (e.g., literacy training and agriculture development programs). In doing so, they can contribute to government plans for local development, when efforts are coordinated effectively.
- With proactive policies in place, governments can ensure the equitable distribution of benefits among their populations, fostering inclusive prosperity for all, irrespective of social identity.
- Hydropower projects offer a wide range of benefits besides energy production. Multipurpose dams are often crucial sources of water for domestic, industrial, and agricultural use. They can also play a critical role in flood control and climate change adaptation. In their initial planning stages, projects can be conceptualized to meet multiple government priorities besides clean energy generation.

- Hydropower projects can bring about substantial cost savings through lower-cost electricity generation, improved grid flexibility, reduced reliance on imported fuel, and water service benefits such as irrigation and flood control.

Optimizing socioeconomic benefits within the project country is a pivotal strategy for developers and operators to achieve desired project outcomes.

- Delivering tangible advantages to the project country, especially in local communities, is a potent risk mitigation tool. It reduces the likelihood of opposition, minimizes conflict management costs, and mitigates the risk of valuable investment opportunities being overlooked. Benefits can include a share of the project's profit, agreements for the shared use of the hydropower reservoir (such as for fishing, recreation, water supply, and irrigation), and local initiatives to improve the livelihoods of the people adjacent to a project.
- Developing local supply chains can reduce project costs and lead to improved operation and maintenance for hydropower plants over the long term.
- Publicly listed companies, which are constantly striving to increase their environmental, social, and governance ratings, acknowledge the strategic significance of a robust corporate social responsibility strategy, which enhances their appeal to retail and institutional investors and contributes significantly to their public image.
- Collaborating with appropriately consulted local communities offers an opportunity to tap into their knowledge and foster trust and partnerships. This collaborative approach increases projects' feasibility and helps them to remain sustainable in the long term.

PHOTO 1.1
Community Consultation in Lao PDR

BOX 1.1

GENERATING GOVERNMENT REVENUE FOR POVERTY REDUCTION IN LAO PDR: NAM THEUN II

The Nam Theun II Hydropower Project was initiated to export electricity to Thailand, supporting economic growth and poverty reduction in the Lao People's Democratic Republic (Lao PDR). It is a model for leveraging hydropower resources and aims to generate revenue for priority poverty reduction and environmental programs.

The 1,070 megawatt hydropower facility exports 5,354 gigawatt-hours (GWh) annually to Thailand and supplies 200 GWh domestically. The project has exceeded the expected electricity generation and contributes US$25 million annually to the government budget. An economic analysis estimates a net benefit of US$550 million for Lao PDR, primarily from electricity exports, by the end of the concession period.

In Lao PDR, the poverty rate declined significantly, from 33.5 percent in 2002–03 to 23.2 percent in 2012–13; it has continued to decline. It is to be noted that this decline in poverty cannot be attributed solely or directly to Nam Theun II. However, as of 2017, approximately US$180 million in government revenues from Nam Theun II likely contributed to the government's successful poverty reduction efforts. This example highlights the fiscal impact of large-scale hydropower development and the possibility to direct funds to development initiatives.

Estimated Allocated Revenues at the End of 2017

Area of Allocation	Revenue	
	($, millions)*	(percent)
Education	65.81	35.3
Health	62.14	33.3
Public works and transport	15.67	8.4
Energy, mining, and agriculture	24.32	13.1
Natural resources environment	1.31	0.7
Poverty-reduction fund	9.91	5.3
Projects implemented by provinces	7.05	3.9
Total	**186.22**	**100**

Source: World Bank 2021. Table: State Audit Organization. Audit Reports 2009/10-2015/16, MInistry of Finance data FY15/16 and FY17.

** Nominal*

Hydropower projects hold the potential to empower citizens.

- Research estimates underscore the employment impact of hydropower projects; they indicate that each installed megawatt (MW) of hydropower capacity results in approximately six full-time equivalent (FTE) jobs[1] (NHA 2010; Paidipadi et al. 2017).
- Beyond direct employment, hydropower projects generate indirect jobs in upstream industries and create additional induced jobs through the spending habits of those directly and indirectly involved in the industry. For instance, workers contribute to the local economy during construction by spending a portion of their income within the project community. Additional jobs in the restaurant, retail, transportation, and hospitality industries are in turn stimulated. The emergence of new employment prospects, particularly in rural and low-income communities, holds the potential for substantial social transformations.
- While economic benefits are often more easily quantified, equally significant social benefits encompass new educational opportunities and achievements, skill development, and diversification. Through ongoing community consultations, local communities are given the voice and agency to direct local development and benefit-sharing activities that they feel are needed and most beneficial to their way of life.
- At the project site and community levels, infrastructure improvements introduced by developers and/or operators, and development programs wield far-reaching socioeconomic impacts, including enhanced mobility, improved health care and education, and increased income generation prospects.
- Hydropower's unique potential to improve water management in local communities distinguishes it from other renewable energy technologies. Many reservoirs and dams are multipurpose, generating electricity while also supporting other valuable uses. Water services such as domestic and industrial water supply, irrigation, flood control, recreation, fishing, and navigation bring immense socioeconomic benefits. These positive impacts can favorably influence community health and well-being, foster economic growth, with new business and job opportunities, and add substantial cost savings due to flood mitigation. Early planning and foresight are required to maximize these "co-benefits."

Annex 3 illustrates the framework for how each stakeholder group stands to benefit.

1 Direct employment for established inland hydropower technologies ranged from five to six FTEs (each "full-time equivalent" unit represents one job for a full year) per megawatt (MW). Less mature technologies and smaller system sizes generally resulted in more FTEs per MW (up to 14 FTEs per MW). Additionally, it must be highlighted that the referenced studies accounted for manufacturing roles within direct employment, whereas this report categorizes manufacturing jobs as indirect, as detailed in chapter 2.

Definition and Scope of Socioeconomic Benefits within This Report

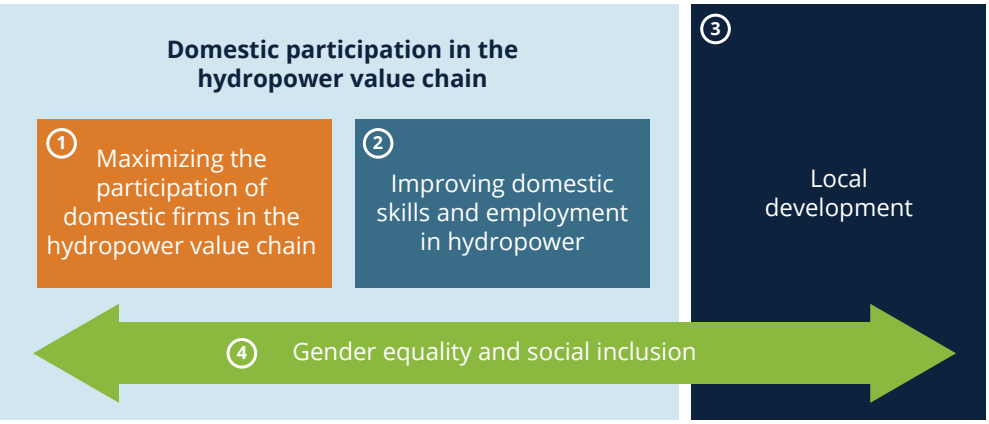
This report delves into the socioeconomic benefits beyond the mandatory risk mitigation outlined in environmental and social safeguard frameworks. These benefits can be actively shaped and significantly enhanced during project development and operation. However, the report does not explore the broader sectoral advantages, for example, the societal and economic benefits attributed to improved energy security, low-cost supply, and reduced greenhouse gas emissions. It also does not deeply examine the social and environmental challenges of hydropower development.

In the context of this report, the explored socioeconomic benefits are grouped into the following four categories, which are derived from the World Bank's Sustainable Renewables Risk Mitigation Guidelines:

1. **Participation of domestic companies in the hydropower value chain**. Developing and operating hydropower projects creates opportunities for domestic companies to offer goods and services. This positively impacts economies. Contracts, varying in size, contribute to fiscal revenues, gross domestic product, and job growth. This topic is covered in chapter 2.
2. **Hydropower employment and skill development.** Projects generate direct, indirect, and induced jobs and promote on-the-job learning and formal education opportunities. This results in new skills and greater diversity in the national workforce, promoting domestic employment. This topic is covered in chapter 3.
3. **Local development/benefit sharing.** Developers collaborate with local communities to ensure lasting benefits and gain community acceptance. Approaches range from infrastructure improvements and skill development programs to revenue-sharing mechanisms. This category also includes how projects can be designed to maximize water service benefits to the local region, including the provision of water from the reservoir for domestic, industrial, and agricultural uses; recreation; and tourism, besides other co-benefits of hydropower infrastructure development. These topics are discussed in chapter 4.
4. **Gender equality and social inclusion.** Carefully designed hydropower projects can advance gender equality and social inclusion, addressing disparities based on social identity factors. The benefits include access to job opportunities, education and training, business opportunities, and local development initiatives. The research and results presented in the Energy Sector Management Assistance Program hydropower gender study (ESMAP 2023c) are drawn on throughout this report.

This report covers the first three categories in the sequence shown in figure 1.1. The fourth category—gender equality and social inclusion—is addressed throughout the report through an intersectional lens, which recognizes the interconnectedness of social identities and how

FIGURE 1.1
Socioeconomic Categories



Source: Adapted from World Bank (2022a).

they can either reinforce inequalities or be leveraged for equity. The information for the four socioeconomic categories was derived from extensive literature reviews, consultations, and data received from stakeholders (see annex 1 for methodology).

Evolution of Sustainable Development in the Hydropower Sector

Despite hydropower projects' myriad advantages, it is essential to recognize that they also have significant environmental and social impacts, such as alterations to river ecosystems, effects on aquatic habitats, and displacement of local communities. Consequently, embracing sustainable development practices is imperative to maximize hydropower's positive aspects.

The sector has a rich development history compared with other renewable energy technologies. Since the first hydropower plant generated electricity in 1878 in Northumberland, United Kingdom, hydropower has significantly contributed to developing and advancing society, communities, and countries. However, hydropower faced substantial resistance and negative publicity during the 1990s due to insufficient consideration of adverse environmental and social impacts in several projects (Braeckman, Markkanen, and Souvannaseng 2020). As a result, the rate of implementing new projects has reduced. Hydropower continues to face opposition and garner unfavorable attention. However, there has been an increase in the global recognition of these challenges and the industry has sought to address these concerns and seek solutions for the sustainable development of hydropower that avoid, minimize, mitigate, and offset potential impacts.

A significant milestone was the establishment of the World Commission on Dams (WCD) in 1998, which engaged stakeholders globally. In 2000, the WCD set comprehensive guidelines for future decision-making on hydropower dam projects, aiming to protect the environment and affected communities, and maximize socioeconomic benefits to project countries, with a specific lens on equity considerations.

The IHA then played a crucial role by publishing the Sustainability Guidelines in 2004, which covered six aspects, including policy, government roles, decision-making processes, and sustainability in environmental, social, and economic aspects, and a Sustainability Assessment Protocol in 2006. These guidelines, which have gone through multiple stages over the years, also provided a framework for new projects and the management of existing projects.

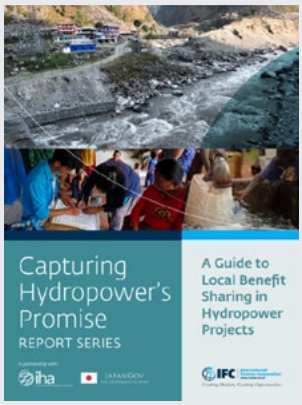
Then in 2021, the IHA launched the Hydropower Sustainability Standard, which serves as a worldwide certification framework, establishing sustainability benchmarks for hydropower initiatives across the globe. Project certification signifies adherence to minimum sustainability standards across 12 key environmental, social, and governance areas, including biodiversity and invasive species, indigenous peoples, and cultural heritage. In November 2023, an independent entity, the Hydropower Sustainability Alliance, was launched to manage the standard, track compliance, and build capacity for project assessment.

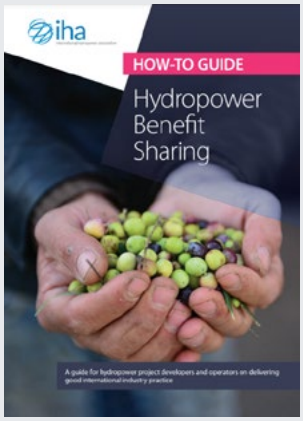
In addition to third-party sustainability bodies and certifiers, development finance institutions, such as the World Bank, have made significant commitments to enhance and enforce their environmental and social frameworks, aiming to minimize negative impacts and maximize positive outcomes. These frameworks vary in nature, and lending for hydropower projects is contingent upon adherence to the specified procedures and standards.

As a wealth of resources already exist on how to pursue sustainable development (see box 1.2), this report does not aim to outline the step-by-step processes of doing so—such as effectively engaging community stakeholders—but instead, seeks to highlight best practices, replicable examples, and critical considerations to be incorporated in decision-making.

BOX 1.2

RESOURCES ON SHARING THE BENEFITS OF HYDROPOWER PROJECTS





Given the long history of the hydropower sector and its encounters with resistance and opposition to projects, considerable resources have been dedicated to exploring the concept of benefit sharing. One of these resources is "A Guide for Local Benefit Sharing in Hydropower Projects," published by the World Bank (Wang 2012).

Another resource is the International Finance Corporation's report series "Capturing Hydropower's Promise." The series presents the recommended process for developing and implementing local benefit-sharing measures in hydropower projects and is supplemented with best practice case studies (IFC 2020b). The report draws from extensive research and the experiences of both public and private developers to underscore how hydropower projects can bolster local communities and address their development needs, surpassing mere mitigation and compensation efforts.

Another valuable resource, "A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables," is produced by the Sustainable Renewables Risk Mitigation Initiative and underscores the significant potential of renewable energy to generate socioeconomic benefits. It also addresses the barriers to countries' ability to fully harness the benefits of renewable energy deployment. The report outlines the step-by-step process necessary to develop a program that maximizes the socioeconomic benefits of renewable energy deployment, emphasizing the interconnectedness of these steps and advocating for an integrated approach. It includes a diagnostic tool to guide national progress toward successful renewable energy programs that optimize socioeconomic benefits.

The Hydropower Sustainability Alliance also offers an array of "how-to" guides to enhance knowledge of the processes and substance required to meet good international industry practice, as defined in the Hydropower Sustainability Standard and Tools. These guides describe practical measures practitioners and stakeholders can take to enhance sustainability performance in hydropower development and operation.

2. The Hydropower Value Chain

The hydropower value chain illustrates the series of interconnected business activities essential for harnessing the power of water to generate electricity. Figure 2.1 presents a high-level depiction of the hydropower value chain, from the early planning phase to electricity generation.

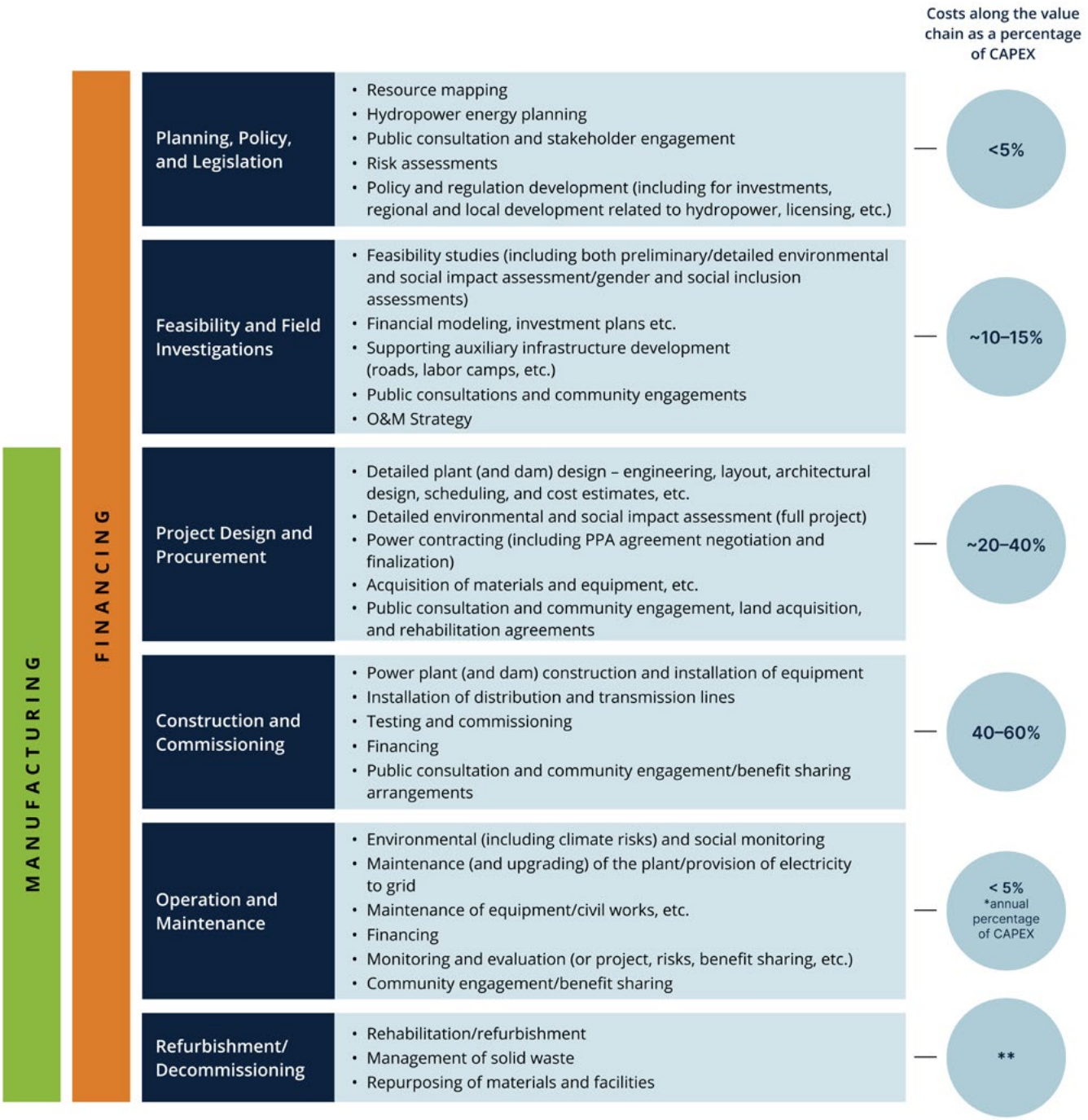
For governments looking to develop hydropower projects, analysis of the value chain is critical to understanding whether the domestic market will be able to benefit from their development. Governments will benefit from a more profound analysis that maps all inputs, such as raw materials, equipment, services, and labor required at each stage. Mapping out the value chain supports the identification of opportunities to procure goods and services locally within the project country, in turn contributing to the national gross domestic product (GDP). It also makes possible the identification of gaps; the need for imports in the short, medium, and long terms; and the possibility to begin planning to address these gaps.

Relevant ministries, utilities, and government agencies can play a pivotal role in the "localization" of goods and services (i.e., the procurement of goods and services from domestic companies) through supportive programs and enabling policies.

Domestic Participation in the Hydropower Value Chain

Certain segments of the value chain are characterized by greater competition, with multiple entities offering similar goods and services. These segments tend to be more amenable to localization due to their less specialized nature. Conversely, activities such as the manufacture of vital electromechanical (E&M) equipment (turbine, generator, operation, and control systems; hydraulic steelworks; substations; transmission lines; and auxiliary systems) are highly specialized, requiring specific expertise and substantial investments, and are not likely to be localized. Depending on the level of industrial development in each country, components such as smaller valves, steelworks, and piping may be manufactured domestically.

FIGURE 2.1
The Hydropower Value Chain



Source: Original figure developed by authors for this report based on findings from World Bank Market Sounding (2023).

Note: CAPEX = capital expenditure; O&M = operation and maintenance; PPA = power purchase agreement.

**O&M costs are part of a separate operating expenses (OPEX) budget, although they can be estimated as a percentage of CAPEX. See further information in annex 4.*

***Refurbishment and decommissioning typically have separate CAPEX budgets and are therefore not included in the cost breakdown. See further information in annex 4.*

Complete E&M equipment packages have just a handful of suppliers, which are more diverse for smaller than larger units. Three major global E&M manufacturers—Andritz, GE Renewable Energy, and Voith—collectively represent nearly 50 percent of the global installed unit capacity in megawatts (US DOE 2022). The top manufacturers are companies from Austria, China, Germany, India, the Russian Federation, Brazil, and the United States. Manufacturing has hence been visualized as an input to the hydropower value chain in figure 2.1, since it is unlikely that equipment manufacturing will be localized beyond this handful of countries, which have highly developed hydropower manufacturing capabilities. E&M contractors, however, do seek to utilize local employees during installation and commissioning, and this is explored in greater detail in chapter 3. The costs of E&M equipment are still captured in capital expenditure (CAPEX) in the value chain under the *Project Design & Procurement* segment.

For micro- and mini-hydro projects (typically up to 100 kilowatts and 1 MW, respectively), it is feasible to manufacture E&M equipment domestically. Box 2.1 illustrates a collaboration between entities in Indonesia and the Philippines that led to the establishment of mini hydro turbine manufacturing in the Philippines.

The construction of a hydropower plant entails not only installation and testing for the E&M systems, but also extensive civil works and auxiliary infrastructures, including:

- Excavation, groundworks, and fundaments
- Intake, dams, and spillways
- Waterways, including tunnels and penstocks tunneling/excavation
- Powerhouse structures.

The main material inputs for these civil works elements are cement, sand, gravel, and steel. In conjunction, a diverse array of mechanical, electrical, and electronic components is integrated so that water flow and power generation can be controlled. Many of these materials and the services essential for the construction of civil works and the related structures can be sourced from domestic companies. In most countries, it is possible to localize, at minimum, a portion of construction, depending on local capacity, such as:

- Access roads and the related infrastructure
- Workers' accommodation and facilities
- Infrastructure developed as part of the development plan/benefit sharing for the local area (e.g., schools and clinics).

BOX 2.1

PHILIPPINES: NURTURING SOUTH-SOUTH TECHNOLOGY TRANSFER

Yamog is a Philippines-based nonprofit organization, which has, for the past 29 years, collaborated with remote communities to develop micro-hydro systems.

One significant challenge in developing such projects is the cost associated with importing the required electromechanical equipment, such as turbines, generators, and electronic control equipment. Historically, Yamog had imported turbines from Indonesia at a cost of approximately ₱1 million. Import taxes and duties added 30 percent to this cost, approximately ₱1.3 million.

In 2022, with funding from the European Union, Yamog formed a partnership with an Indonesia-based entity to develop the capacity to manufacture turbines domestically—the technology transfer involved training in Indonesia and the establishment of a workshop in Davao City, Philippines. Yamog describes the workshop as simplistic—containing solely manual metalworking machines without computer numerical control equipment—something that is readily available in the rural countryside. A certain degree of skill and know-how must be developed to maintain established quality and performance standards. Still, manufacturing will not be overly complex once those elements are in place. The workshop now employs three technicians.

The ability to produce the turbines domestically has significantly reduced the total project costs. The domestically manufactured turbines cost less than half of those imported, at approximately ₱500,000–₱600,000. Also, they are now better equipped to maintain the equipment locally. PT Entec Indonesia, the counterpart in technology transfer and capacity building, has received many similar requests from other countries, especially in Africa. While there is a strong desire to develop micro-scale hydro in countries such as Cameroon, Rwanda, and Ghana, localization of manufacturing has not occurred to date, and equipment imports still pose an enormous challenge in terms of cost and ongoing operation and maintenance once the equipment is installed.

Source: World Bank Market Sounding 2023.

The construction of hydropower infrastructure, and especially the dam, requires oversight from experienced contractors. An international contractor may thus be required, especially for projects in countries and markets where projects of a similar scale have never been developed. Dam design and construction must follow strict standards and guidelines, to ensure the safety of the environment downstream. However, dam construction requires significant manpower, and the contractor will seek to hire local personnel for labor-intensive tasks and often train people to, for example, drive dump trucks and operate excavators.

One aspect of the value chain that deserves special attention is operation and maintenance (O&M). While there is potential to localize this aspect of the value chain, it is an opportunity often underutilized in developing countries, primarily due to insufficient capacity-building initiatives. These tasks are thus either frequently handled by foreign companies and workers, or often executed inadequately when localization is attempted (World Bank 2020b). This shortcoming impedes the realization of the full benefits of hydropower. In stark contrast to most power generation technologies, which typically have a lifespan of 20–30 years, well-maintained hydropower facilities can endure for more than a century. The pivotal factor for ensuring such longevity lies in adopting robust O&M practices (World Bank 2020b).

PHOTO 2.1
Construction of the 140 MW Tanahu Hydropower Project in Nepal, employing 900 workers, 50 percent local hires

On the other hand, neglecting O&M in hydropower facilities can lead to costly and more frequent refurbishments. This is a concern that industry experts are increasingly acknowledging, and they are advocating for action. The urgent need to upskill the hydropower O&M-specific workforce in developing countries is not just about creating jobs but also about improving projects' longevity and avoiding unnecessary financial burdens (World Bank 2020b). Chapter 3 outlines several strategies to fulfill this need.

The data presented in figure 2.2 offer a glimpse into the insights gathered from interviews and a survey conducted during this report's preparation. The figure illustrate which areas of the value chain are typically most amenable to localization, and, conversely, areas that typically present challenges in terms of procuring the needed goods and services from domestic companies; it provides examples from Canada, the Philippines, and Uganda. It must be acknowledged that each country's capacity to engage in the hydropower value chain will be distinctly shaped by factors such as its market maturity, the presence of a skilled workforce, and the workforce's experience in the related industries. Additional activities may become viable as a market matures or as expertise is cultivated over time.

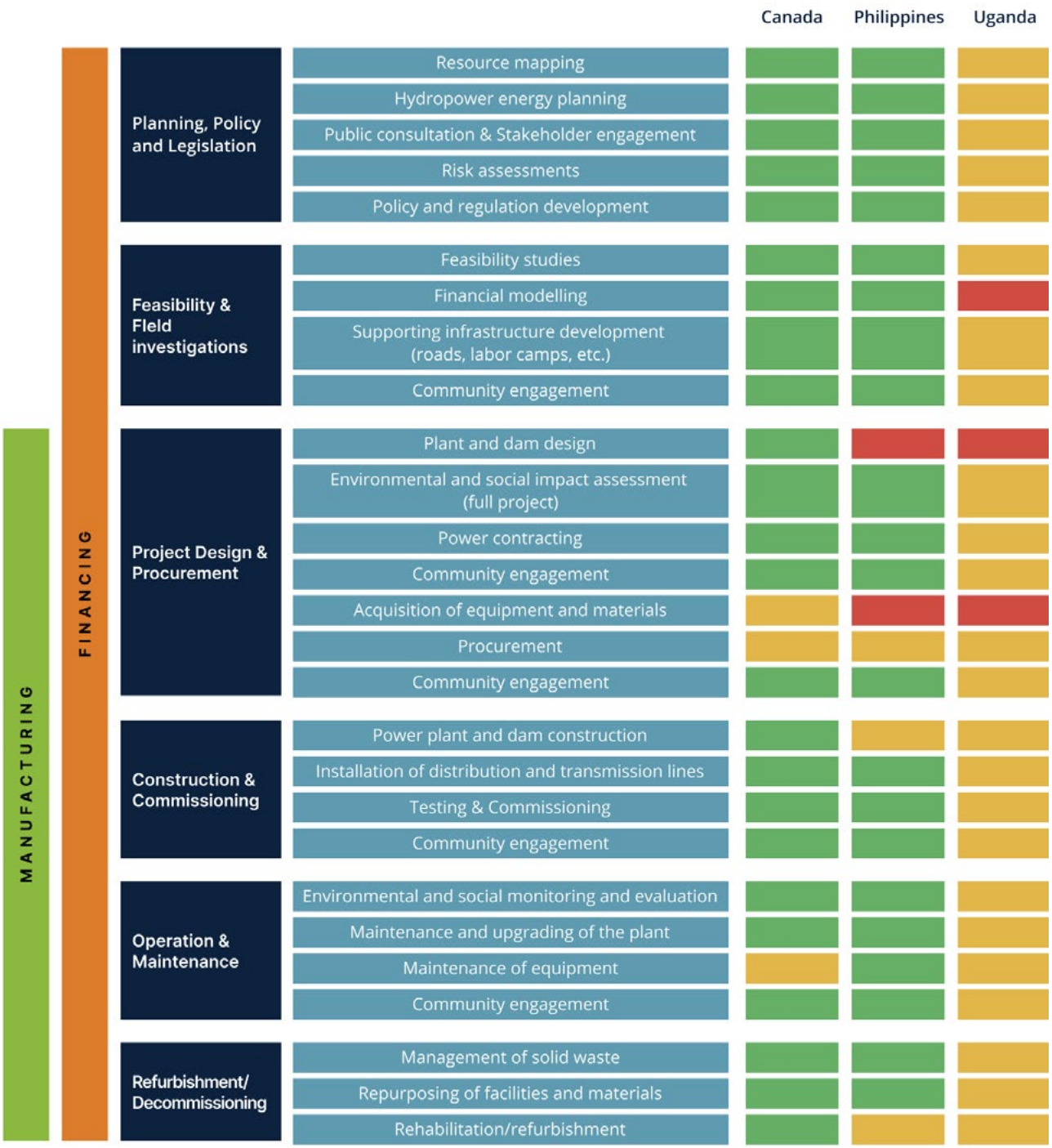
All countries should undertake a customized value chain analysis, encompassing comprehensive documentation of available raw materials, equipment, companies, and labor that can contribute to the hydropower value chain. Such an analysis can unveil distinctive comparative advantages within specific segments of the value chain. In essence, it may reveal that certain countries are better positioned to localize hydropower value chain activities in a manner that meets high quality standards while ensuring cost competitiveness with the global market. For example, Bhutan developed competencies in equipment maintenance and has since been able to leverage this expertise to enter the manufacturing market (see box 2.2).

In the context of regional cross-border hydropower projects, there is significant potential to capitalize on each country's unique competitive advantage. By prioritizing activities where excellence is assured, countries can optimize their own benefits while fostering mutually advantageous outcomes for all parties involved.

Governments also often base their support for developing the hydropower industry on critical factors such as investment breakdown. Figure 2.1 provides a detailed breakdown of the CAPEX associated with hydropower project development. It offers valuable insights for decision-making. Construction requires the most significant investment along the value chain, followed by O&M (where the annual cost has been benchmarked as a percentage of CAPEX). These two phases, therefore, offer the most significant opportunities to contribute to GDP growth if localized within the project country. Additional information on the value chain cost breakdown can be found in annex 4.

FIGURE 2.2

Localization Potential along the Hydropower Value Chain—in Canada, the Philippines, and Uganda



Source: Original figures developed by authors for this report based on finding from World Bank Market Sounding (2023).

Note: green = high, yellow = medium, and red = low.

BOX 2.2

UNLOCKING LOCAL MANUFACTURING POTENTIAL IN BHUTAN'S HYDROPOWER SECTOR

Bhutan Hydropower Service Limited (BHSL) was established in 2012 through a collaborative effort between the Bhutanese government and ALSTOM, a French corporation. The core operations of BHSL, which initially focused on maintenance services, comprised the reclamation of turbines and underwater components; advanced computer numerical control machine tools, metal inert gas/tungsten inert gas welding, and a high-velocity oxygen fuel hard-coating facility were utilized. BHSL's service portfolio expanded to include machining, mechanical material testing, microstructural examination, and repairing and rewinding electric motors.

A pivotal move for BHSL was the exploration of local turbine manufacturing. This strategic move resulted in substantial cost savings for local projects through elimination of the need for transportation and reduction of import taxation.

BHSL's manufacturing journey commenced with the production of a Francis Turbine for the Bajoli Holi Hydroelectric Project in Himachal Pradesh, India, and another for the Alpaslan Hydroelectric Project in Turkey. These initial triumphs paved the way for BHSL to diversify its manufacturing portfolio, culminating in completing a Pelton Turbine for the Basochhu Hydropower Plant in Bhutan. The company is in the advanced stages of manufacturing two fully forged Pelton Turbines for the Tala Hydropower Plant, solidifying its pivotal role in shaping Bhutan's hydropower landscape.

Beyond its manufacturing endeavors, BHSL's success story is intricately linked with developing a skilled and dedicated workforce. BHSL initially sought expertise from GE, one of its shareholders, for turbine manufacturing, but has evolved to have a proficient team managing the plant. Today, BHSL operates with 70 Bhutanese employees, underscoring its commitment to local empowerment and expertise.

Sources: BHSL 2021; DrukGreen 2021; BHSL n.d.
Photo: Alpaslan Hydroelectric Project in Turkey. Photographer: Ian Chris Graham

Enabling Environment for Domestic Companies to Participate in the Hydropower Value Chain

Effective collaboration between governments, developers, and suppliers, coupled with well-crafted incentivizing policies, can create opportunities for localizing various segments within the hydropower value chain. A thoughtfully designed policy should consider the perspectives of both suppliers and developers to strengthen domestic participation.

From the suppliers' standpoint. It is crucial to understand companies' interests in providing goods and services, assess their capacity to do so, and identify any potential obstacles they might encounter.

- Do the companies know what opportunities exist along various segments of the hydro value chain?
- Do they have a proven track record to compete?
- Do they have the necessary technology and equipment to do the job?
- Do they have the required skills and know-how to respond to procurement calls?
- Are there government incentives and schemes in which they could participate? Are there specific incentives for women-led enterprises?

From the developers' perspective. It is essential to understand the challenges and implications associated with sourcing goods and services from within the project country.

- Will the project timeline allow the developer time to investigate and source from domestic companies?
- Can domestic companies fulfill financial and regulatory requirements?
- Do the products/services they offer compare in quality with what is offered on the global market?
- Do domestic companies have adequate standards and procedures for worker health and safety, management, and project coordination?

Increasing the provision of goods and services from domestic firms requires equipping the firms with resources, for example, technology, equipment, and the related skills, to help them become competitive. It also involves the establishment of communication channels and trade groups to disseminate information about opportunities and facilitate business relationship formation. Also critical is to design and implement financial mechanisms to help companies attain operational readiness. Such measures are generally under the purview of the government.

Many countries already have initiatives to support and strengthen domestic companies. Linking with such well-established programs to help the hydropower industry grow can also be an important tactic.

Actions to support the growth of the domestic hydropower industry should also be gender sensitive and acknowledge the unique barriers faced by women-led businesses and entrepreneurs. For more recommendations, see the Energy Sector Management Assistance Program (ESMAP 2023c) report on gender equality in the hydropower sector.

The overall growth of the domestic hydropower industry will undoubtedly rest on the viability of domestic hydropower development, and the pipeline of projects. This success will depend on a supportive regulatory environment for hydropower development. For example, box 2.3 illustrates how implementing results-based financing in conjunction with World Bank financing led to improved outcomes for the Vietnamese small hydropower industry. While this report does not examine such regulatory frameworks, other reports, such as the ESMAP report "How to Unlock Pipelines of Bankable Renewable Energy Projects in Emerging Markets and Developing Countries?" provide detailed recommendations to governments on regulations that can be enacted to create a more enabling environment for investments into renewable energy sectors (Cornieti and Nicolas 2023).

PHOTO 2.2

Construction Workers at the Trung Son Hydropower Project in Vietnam

BOX 2.3

RESULTS-BASED FINANCING STRENGTHENS THE SOCIOECONOMIC OUTCOMES OF THE RENEWABLE ENERGY DEVELOPMENT PROJECT IN VIETNAM

Vietnam's Renewable Energy Development Project (REDP), supported by the World Bank, showcases how World Bank assistance can be blended with results-based climate finance to strengthen program sustainability and encourage private investment.

With a US$202 million budget, the REDP aimed to boost Vietnam's renewables-based electricity supply by improving the regulatory framework, enhancing government capacity, and providing local banks with credit lines for renewable energy investments, which were hindered by market barriers, despite the private sector's interest in small hydropower.

In 2014, the Carbon Partnership Facility committed to purchasing carbon credits from small hydropower projects under the REDP. This introduced a pioneering revenue stream for projects and mitigated investment risks. This innovative financing model, which combines concessional investment financing with results-based climate finance, enabled local banks to align risk management with commercial standards. According to the REDP, as confidence in small hydropower grew, commercial financing increased, with local banks and the private sector contributing 50 percent of project costs, totaling over US$220 million for 19 projects.

The REDP's impact extended to rural communities. Taxes from projects helped fund local development initiatives and improvements to local infrastructure. The projects increased electricity access and created employment opportunities for residents, during construction and ongoing operations. The influx of investment and infrastructure development also opened doors for local enterprises to participate in supply chains and service provision, in turn amplifying the REDP's positive economic impact.

Source: Cheng 2020.

Industry clusters and associations. Renewable energy associations and industry clusters play a critical role in nurturing the hydropower sector's growth. They promote collaboration among industry stakeholders, leverage synergies, and catalyze innovation and knowledge exchange. The International Hydropower Association serves these objectives globally, but associations often exist at the country level. For example, Canada, China, Colombia, Indonesia, the Kyrgyz Republic, Mexico, Mongolia, Norway, Poland, Russia, Uganda, and the United States are some countries that have industry associations explicitly dedicated to the hydropower sector. Box 2.4 outlines the role of Vietnam's Medium and Small Hydro Association, established in 2015, and also the case of Rwanda, where private sector actors in the sector have formed an energy association to make their voices heard.

BOX 2.4

ROLES OF RENEWABLE ENERGY ASSOCIATIONS IN RWANDA AND VIETNAM

Energy Private Developers is a professional association of all private companies operating in Rwanda's energy sector. It plays a critical role in fostering public-private collaboration within the hydropower subsector. It serves an essential platform for hydropower stakeholders to inform government policies and advocate for the sector's growth. Energy Private Developers organizes training sessions, supports resource mobilization, facilitates knowledge exchange among members and stakeholders, promotes networking, and actively champions gender equality in the sector.

The Vietnam-based Medium and Small Hydropower Association–Green Energy focuses specifically on driving local industry development in the hydropower sector through government collaboration. With an emphasis on domestic enterprises, the association strives to shape a conducive environment to attract local and foreign investments. Capacity-building initiatives, in partnership with the Ministry of Industry and Trade, are helping to establish a robust domestic industry.

Both associations demonstrate unique approaches tailored to their respective contexts, and both contribute significantly to the evolution of the hydropower sector in their countries.

Sources: EPD n.d.; VNEEP 2015.

These clusters and industry associations fulfill several essential roles: they raise awareness about the domestic industry and help developers, investors, and policy makers identify domestic companies looking to participate in the hydropower value chain. They also act as vital conduits, facilitating connections between developers and local entities capable of supplying goods and services. For instance, industry associations or clusters sometimes maintain online directories of domestic firms engaged in the hydropower value chain or organize events that enable this business collaboration. They also play a significant part in helping domestic companies become more capable by offering training programs and facilitating peer-to-peer learning experiences.

Institutions bridging academia, research entities, and enterprises can contribute significantly to industrial development by nurturing a conducive environment for technology transfer. This stimulation in technology exchange fosters greater competitiveness among companies, helping them grow and adapt to industry dynamics.

Facilitating funding and support to small and medium enterprises (SMEs). Investment in strengthening SMEs and advancing research and innovation can lead to significant growth and success within the hydropower sector. Such funding mechanisms may be channeled through government initiatives, facilitated via industry associations and clusters, or offered by development finance institutions (DFIs).

The entire hydropower value chain presents opportunities for SMEs. These could range from smaller contracts to provide uniforms and catering services, to larger-scale contracts to carry out portions of civil works. Access to financing is pivotal for enterprises striving to expand their presence in the hydropower sector. It enables them to secure contracts and ensures the delivery of the promised goods and services. To illustrate, companies may need capital to expand their workforce; boost production capacity; or procure essential materials, equipment, or inventory.

Assistance extended to domestic banks, whether initiated by the government or facilitated by DFIs, can play a pivotal role in the creation of tailored financial instruments that empower companies to engage more effectively in the hydropower sector. These financial tools are instrumental in helping businesses within the industry grow and participate.

Procurement from Companies in Project Countries

Some governments have promoted collaboration between hydropower developers and domestic companies (goods suppliers and service providers) by including incentives into project procurement documents. A government may encourage private developers and their subcontractors to source goods and services from domestic firms in a competitive bidding process. Typically, this is communicated to potential bidders early in the process, during the prebidding phase, to solicit their input on the procurement framework and provide ample time for companies to forge partnerships with domestic entities. Subsequently, incentives are incorporated into the procurement documents, including the request for quotations and proposals, potentially providing preferential points to bidding companies that demonstrate a willingness and ability to procure from domestic companies. These aspects can be discussed and determined during project negotiations when a competitive bidding process is not pursued.

Governments should assess the market's preparedness to meet the demand for goods and services. It should be noted that many of the stakeholders interviewed highlighted that when goods and services of sufficient quality can be competitively procured domestically, it will be the preferred option because it is more cost-effective. Localization is often hindered by inadequate awareness of local capabilities and connections within the country. This suggests that in certain circumstances, efforts to build visibility in the domestic industry and establish new connections can be more effective than incentives to procure goods and services domestically.

International DFIs, such as the World Bank, require competitive procurement. Procurement documents can be designed with incentives and weighted assessment criteria, however, local content requirements—which mandate the domestic procurement of a fixed percentage of goods and services—are not permitted. Governments, therefore, must carefully consider how to incentivize local procurement without limiting the funding potential for their projects. Local content requirements can also lead to challenges including:

- Price distortion due to a lack of competition and increasing energy tariffs due to an overall increase in project costs.
- Challenges with the quality of goods, services, and labor being subpar to what the global market can offer.

Given below are more flexible approaches proposed by the stakeholders consulted in this report's production:

- **Encouraging joint ventures with local partners.** This can be effective for engaging a domestic company without the track record or the ability to meet the financial guarantee requirements to compete alone. Not only does this make partial localization possible, it also helps to build domestic capacities for future projects. The smaller, domestic player gains the needed experience and track record to compete in future bids.
- **Encouraging the developer to produce a plan on how it intends to procure goods and services domestically.** This does not place a percentage on what needs to be procured domestically, as a local content requirement would, but ensures that the developer has done their homework on what companies exist domestically and what their capabilities are. If feasible, domestic procurement will usually be prioritized from a cost perspective. The ability to purchase in local currency is often a significant advantage.
- **Developers can be encouraged to establish supplier development programs**, which build the capacities of domestic companies. For example, through a supplier development program, a large multinational engineering, procurement, and construction company may upskill the workforce of a smaller contractor, training its staff on how to use specialized equipment or helping them gain the required certifications. Training may also be provided on how to respond to requests for proposals put out by the company.
- **Before initiating the bidding process, conduct a life cycle analysis to gain insights into materials' sourcing locations** and the production chain's overall environmental impact. This analysis can be integrated into the bid evaluation process and encourage projects committing to minimizing their footprint, potentially leading to increased local procurement.

Box 2.5 highlights how public-private partnerships can be an effective model conducive to the strategies above.

BOX 2.5

ENHANCING SOCIOECONOMIC DEVELOPMENT THROUGH PUBLIC-PRIVATE PARTNERSHIPS

Public-private partnerships (PPPs) play a pivotal role in strengthening government initiatives, especially in countries grappling with financial constraints. While a universally accepted definition of a PPP may be elusive, it fundamentally involves a collaborative contractual arrangement between a public and a private entity. In this setup, the private entity contributes by delivering infrastructure or services in exchange for compensation. This fosters a sense of shared responsibility and mutual benefit.

PPPs can take diverse forms. For example, in a build-own-operate arrangement, the public sector's sole role is to authorize the contracting and procurement of the service for a predetermined duration, whereas in an operate-maintain arrangement, the government finances, designs, and constructs the project, whereas the private entity is solely responsible for operating and maintaining it.

Both governments and private sector entities have various reasons for preferring PPPs to strictly public or private investments:

- Partnering facilitates the diversification of financial and nonfinancial risks.
- PPPs help governments maintain budget discipline and reduce deficits, since private partners typically cover up-front capital investments.
- Project implementation is often more efficient because the PPP enables access to the specialized skills and knowledge of private entities.
- Importantly, in the context of this report, PPPs are often used to encourage broader socioeconomic development.

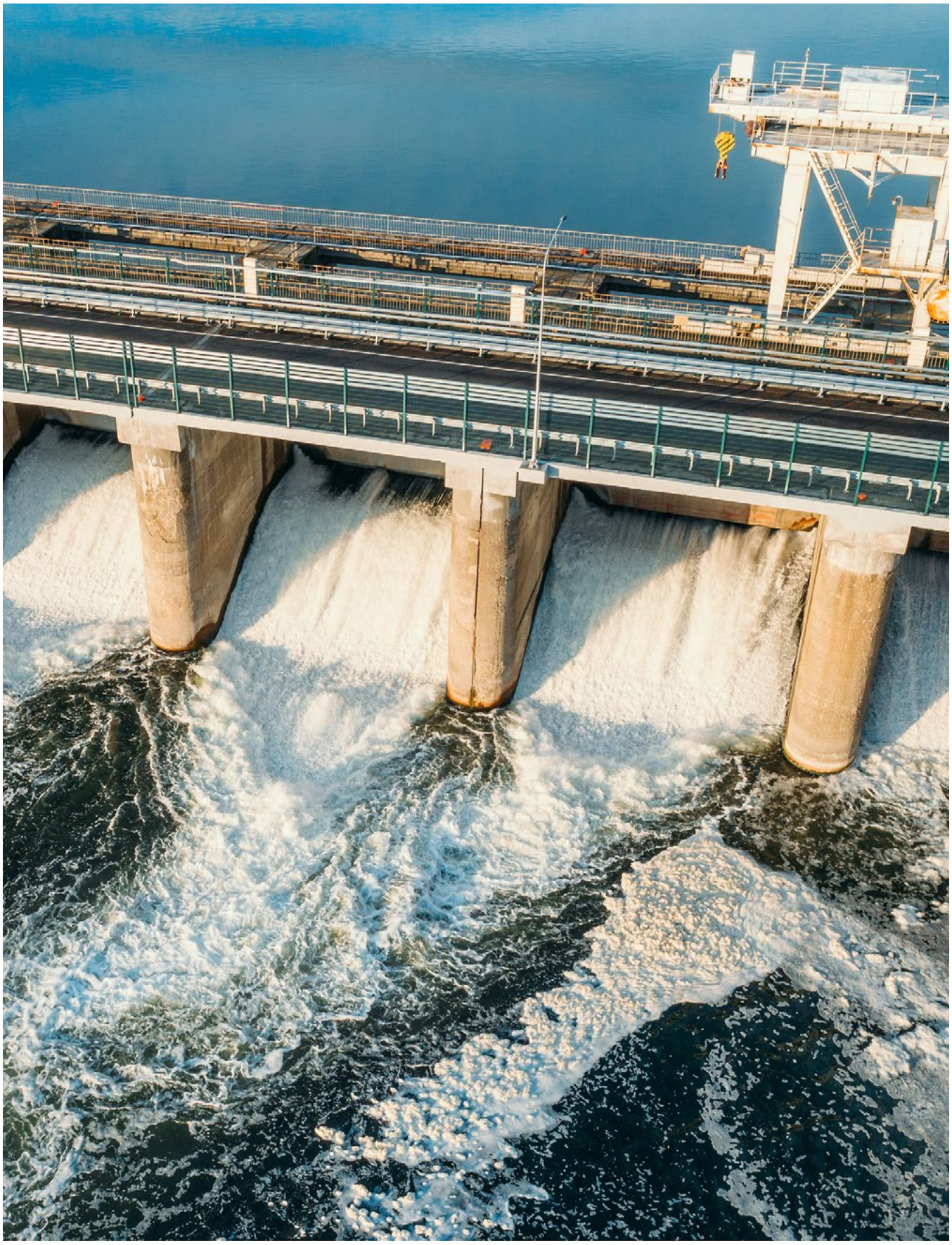
A robust procurement system backed by a competent and strong private consortium is essential in ensuring a PPP project achieves its goals. The procurement process is also critical to outlining and ensuring the delivery of the desired socioeconomic outcomes. Through a transparent procurement process with weighted evaluation criteria, bidders can be incentivized to commit to defined socioeconomic criteria.

In some countries, development objectives are fully integrated into PPP policy frameworks. For example, in South Africa, renewable energy PPPs, including those for small hydro, are evaluated on various socioeconomic targets, including domestic procurement, domestic employment creation, local development programs, and black economic empowerment.

BOX. 2.5 *(CONTINUED)*

In the Solomon Islands, the International Finance Corporation collaborated with the government to establish the country's first PPP for a hydropower facility. The PPP for the Tina River Hydropower Project aimed to align project development with broader socioeconomic goals, including education, employment, and community development. The project is expected to generate 440 jobs during construction, boosting the Solomon Islands' economy and enhancing the local workforce's skills. As part of the PPP, a benefit-sharing mechanism was also devised to distribute project royalties among residents near the Tina River; this promoted inclusivity and community engagement. Accountability mechanisms integrated into the PPP agreement help the stakeholders ensure these objectives will be met as intended.

Sources: Nyirinkindi 2023; Mfunwa, Taylor, and Kreiter 2016.



3.Hydropower Jobs and Skills

Estimates from 2021 indicate that the hydropower sector directly employed approximately 2.36 million individuals (IRENA 2022). Sixty-four percent of these jobs were associated with manufacturing, 30 percent with construction and installation activities, and approximately 6 percent with operation and maintenance (O&M) services. China led the global hydropower job market, contributing 37 percent of the sector's total employment, followed by India at 18 percent.

Regarding workforce composition, women held only 25 percent of the jobs in the hydropower sector in 2022 (ESMAP 2023c). There are also substantial gender disparities in the roles held: only 21 percent of women with jobs in the hydropower sector were in technical positions, compared with 79 percent in nontechnical roles (ESMAP 2023c). Technical careers often lead to senior management roles, possibly explaining women's underrepresentation in midlevel and senior management positions. Another contributing factor could be disparities in promotions between male and female employees.

Figure 3.1 provides insights into key hydropower professions categorized by skill levels, distinguishing high-skilled roles requiring advanced education, medium-skilled roles requiring vocational or on-the-job training, and low-skilled roles with minimal or no education requirements. Figure 3.2 illustrates the distribution of employment opportunities across the hydropower value chain; a 100-year O&M period is assumed, emphasizing the significant job creation potential in construction and O&M.

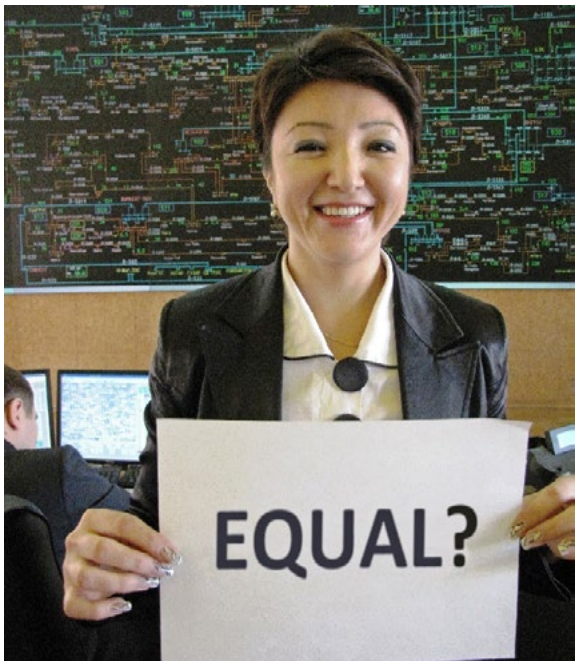


PHOTO 3.1
Dispatcher at the Energy Transmission Control Center in Kazakhstan

FIGURE 3.1

Hydropower Jobs along the Value Chain, by Skill Level

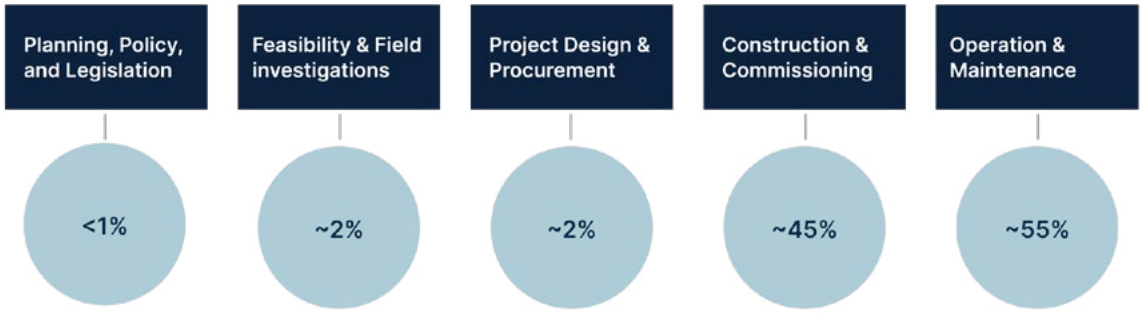
	Planning, Policy, and Legislation	Feasibility and Field investigations	Project Design and Procurement	Construction and Commissioning	Operation and Maintenance	Refurbishment/ Decommissioning
HIGH SKILLED	• Policy makers • Energy sector planner • Energy modelers • Energy regulation experts • Environmental, social and gender experts • Legal experts	• Environmental scientists • Hydrologists/ Engineers (hydraulic, civil, mechanical, electrical, etc.) • Geoscientists; Wildlife biologists, wildlife/fish scientists • Environmental, social and gender experts • Community engagement specialists • Financial advisors • Transaction advisors • Legal experts	• Hydrologists • Engineers (hydraulic, civil, mech, environmental, etc.) • Geoscientists • Environmental, social and gender experts • Logistics experts • Procurement specialists • Community engagement specialists • Finance, accounting, human resources, Legal experts • M&E • Contract Managers • Public Relations Officers	• Project managers • Engineers (hydraulic, civil, mechanical, electrical, environmental, etc.) • Geoscientists • Environmental, social and gender experts • Community engagement specialists • Finance, accounting, human resources, Legal experts • Information system specialists • M&E • Contract managers • Procurement specialists • Public relations officers • Medical professionals	• Project managers • Engineers (hydraulic, civil, mechanical, electrical, environmental, etc.) • Environmental, social and gender experts • Community engagement specialists • Finance, accounting, human resources, Legal experts • Information system specialists • M&E • Energy traders • Contract manager • Procurement specialists • Public relations officers • Medical professionals	• Project managers • Engineers (hydraulic, civil, mechanical, electrical, environmental, etc.) • Environmental, social and gender experts • Community engagement specialists • Finance, accounting, human resources, Legal experts
MEDIUM SKILLED	• Administration staff • Surveyors • Secretarial • Various assistants	• Surveyors • Equipment operators • Translators • Secretarial • Various assistants • Administration and HR staff	• Surveyors, quantity surveyors • Translators • Document control • Various assistants • Administration and HR staff	• Tradesmen • Technicians, welders and carpenters • Managers • Equipment operators • Document control • Quantity surveyors • Various assistants • Translators • Bookkeeping • HSE monitoring • Administration and HR staff	• Plant operators • Tradesmen • Technicians • Electricians • Mechanics • HSE experts • Shift supervisors • Secretarial • Document control, bookkeeping • Construction workers • Administration and HR staff	• Tradesmen • Surveyors • Technicians • Secretarial • Document control • Bookkeeping • Managers • HSE experts • Administration and HR staff
LOW SKILLED	• Survey assistants • Drivers	• Survey assistants • Drivers • Guides	• Survey assistants • Drivers • Guides • Security guards	• Survey assistants • Drivers, Guides, • Laborers • Cleaners, kitchen staff • Security guards	• Drivers • Laborers • Cleaners, kitchen staff • Security guards	• Laborers, • Drivers • Security guards
	5–15 years	5–15 years	7–10 years		+100 years	2–3 years

Source: Original figure developed by authors for this report based on findings from World Bank Market Sounding (2023).

Note: HR = human resource; HSE = health, safety, and environment; M&E = monitoring and evaluation.

FIGURE 3.2

Estimated Share of Full-Time Equivalents along the Hydropower Value Chain Assuming a 100-Year Lifespan of Hydropower Projects



Source: Original figure developed by authors for this report based on findings from World Bank Market Sounding (2023).

Notes: In this report's context, manufacturing is viewed as an input to the value chain, rather than a direct component, because it is very unlikely that manufacturing will take place in the project country. Manufacturing jobs are hence not accounted for in the graphic. The "Project Design and Procurement" component only accounts for the labor required to design a project and acquire the necessary equipment from manufacturers (e.g., procurement and logistics specialists); it does not account for the jobs to produce the equipment.

Also note that this figure considers the distribution of full-time equivalents (FTEs, often referred to as job years). One job for one year is one FTE. If that job continues for another 12 months, then it is two FTEs. This is an important point to distinguish because construction creates the largest number of jobs in terms of the required manpower at a given time, even though the jobs are short term, lasting only for the duration of construction. Conversely, O&M jobs are far fewer in number but are long term, and would continue for as long as the plant is in operation (e.g., 100 years).

Construction undoubtedly creates the largest number of jobs in terms of the required manpower at a given time. However, it must be understood that most of these jobs are largely temporary. This is especially the case for low- or unskilled roles, which constitute about 70–80 percent of the labor force during the construction phase (World Bank Market Sounding 2023). In a well-established market with a robust project pipeline and a flexible workforce, this labor pool may seamlessly transition to upcoming hydropower projects, or these workers may secure employment in other industries, because the skills required for the construction phase are often not technology specific and highly transferable with other industries and infrastructure projects. For roles requiring higher skills, there is a well-established global labor pool, and it is common for these employees to be transferred within countries or internationally for them to provide their expertise on projects.

As an example of the scale of construction-related jobs created, for a 193 MW hydropower project in Cambodia, 5,200 workers were employed in construction between 2006 and 2011 (Urban et al. 2015). Box 3.1 highlights the employment impacts of the Rampur Hydropower Project in India and illustrates the scale and phases of employment in a hydropower project.

BOX 3.1

ESTIMATING THE EMPLOYMENT IMPACT OF THE RAMPUR HYDROPOWER PLANT IN INDIA

The World Bank's publication series "Estimating the Job Creation Potential of the Clean Energy Transition" focuses on quantifying the employment impacts of the clean energy transition. It features a detailed exploration of two hydropower projects, including the Rampur Hydropower Plant (RHP) in India.

The RHP, a 412 MW run-of-river project, created many jobs across various skill levels. Between 2007 and 2014, 18,131 individuals were employed in direct jobs, which spanned design, construction, and operation and maintenance (O&M). An additional 15,084 full-time equivalents will be needed for O&M, in anticipation of a 35-year project lifespan. This would result in about 33,215 direct person-years of employment.

Skilled jobs, requiring certifications or university diplomas, were primarily filled by permanent staff; a few specialized roles were filled by foreign experts. Semiskilled workers, including operators and technicians, were often selected from a database of experienced workers in the region. Training initiatives, averaging 30 individuals annually, facilitated the transition from apprenticeship to employment. Unskilled jobs, comprising construction workers, cleaners, gardeners, and security guards, were successfully prioritized for local recruitment, a testament to the project's commitment to community development. While some of these roles, such as cleaners, were informally reserved for women, cultural barriers hindered women's participation in construction roles.

Despite the impressive job creation, some challenges arose post project completion, particularly for unskilled workers. While beneficial, the state's 70 percent local hiring requirement posed challenges for companies seeking staff relocation for future projects, impacting long-term job sustainability.

BOX. 3.1 *(CONTINUED)*

Beyond direct job estimates, the project significantly contributed to community development, improving infrastructure, health care, and water supply. Resettlement and rehabilitation activities further spurred employment opportunities, with increased income in the project-affected communities.

Indirect jobs resulted from the demand for inputs; 95 percent of components were sourced domestically. Applying a ratio derived from literature yielded an estimated 18,530 indirect domestic person-years of employment. The study also considered induced jobs, associated with worker spending and "productive use of electricity." While not quantified, sectoral shifts in employment were observed, indicating a promising movement from agriculture to the services sector, a sign of the project's potential for long-term economic growth.

The positive findings from the Rampur Hydropower Plant case study echo the significance of clean energy initiatives in fostering job creation and economic growth. By recognizing and leveraging the insights gained from these studies, decision-makers can make informed choices that seek to maximize these positive outcomes.

Source: ESMAP 2023a.

O&M activities provide fewer but enduring employment prospects. These opportunities persist throughout a plant's operational lifespan. In the same 193 MW hydropower project in Cambodia, mentioned above, 60 workers are employed for ongoing O&M for the hydro plant (Urban et al. 2015). If one assumes that the plant's life cycle will extend to 100 years, then the total employment for O&M would be 6,000 full-time equivalents—a considerable economic benefit to the project country. Table 3.1 captures O&M job numbers across six other projects. Bear in mind that occasionally, multiple hydropower plants share O&M resources.

TABLE 3.1

O&M Staffing Requirements for a Selection of Hydropower Plants

NAME	COUNTRY	CAPACITY (MW)	NO. OF PLANTS	NO. OF STAFF
Starkraft Portfolio	Brazil	188	6	45
Mount Coffee	Liberia	88	1	36 (18 national + 18 international)
Kainji and Jebba	Nigeria	922	2	159
New Bong	Pakistan	84	1	69
Nalubaale and Kiira	Uganda	380	2	120
Salto Grande	Uruguay/Argentina	1,890	1	>300

Source: World Bank 2020b.

Note: MW = megawatt.

PHOTO 3.2

Staff Operating the Nam Theun II Powerhouse Facility in Lao PDR

Besides the direct jobs shown in figure 3.1 (related to project design, construction, and O&M), hydropower projects also generate indirect and induced employment opportunities. While induced jobs are more challenging to quantify, they can be highly significant. These jobs transpire from the spending of those directly or indirectly employed because of a hydropower project. For example, as shown in table 3.2, an induced job could be that of a tailor suddenly able to open a shop because of electricity access granted by a hydropower project. This is termed a "productive use job." Other important induced jobs include those created because of other co-benefits and uses of hydropower dams and reservoirs. Many reservoirs are designed to be multipurpose, supporting electricity generation as well as other essential societal needs, such as recreation, irrigation, food supply, and domestic and industrial water supply. The jobs that could be created in this context include jobs in tourism, because of new opportunities to use the reservoir for sightseeing and navigation; jobs in the fisheries industry, because of new opportunities in aquaculture or line fishing; or new jobs in agriculture, because of expanded production due to access to irrigation. Box 3.2, on the other hand, illustrates the employment impacts of micro-hydro installations.

PHOTO 3.3

A Shopkeeper near the Bandipur Municipality Substation in Tanahun District, Nepal

TABLE 3.2

Job Categories Created through Hydropower Project Development and Operation

JOB CATEGORY	DESCRIPTION	EXAMPLE
Direct jobs	Jobs resulting from the design, development, management, construction, and operation and maintenance of a hydropower project.	Hydropower plant operator
Indirect jobs	Jobs resulting from the demand for material inputs in project development and operation, including building material and equipment.	Factory worker in a manufacturing facility producing hydropower turbines
Induced jobs	Jobs resulting from the spending of those directly and indirectly employed in hydropower projects.	A server at a restaurant in a project community
Productive use jobs	Productive use jobs are considered a type of induced job and result from the increased use of energy amid improved quality and quantity of supply.	A tailor who can open a shop because they have access to electricity to power a sewing machine

Source: Original compilation for this report, based on World Bank (2022a).

BOX 3.2

EMPLOYMENT IMPACTS OF MICRO-HYDRO PROJECTS IN RURAL COMMUNITIES

Micro-hydro projects are not just a sustainable energy solution, they can also catalyze economic development and revitalization, especially in rural areas. Insights drawn from projects in the United Kingdom reveal that each 1 MW of community-owned micro-hydro installed generates approximately 10 full-time equivalent jobs annually. Qualitative studies in developing countries, such as the micro-hydro scheme in Bellah, Cameroon, highlight how micro-hydro projects meet energy needs and foster robust local economic growth.

For the Bellah project, engagement of the beneficiary communities was a crucial success factor. In civil works construction, the communities contributed by providing locally sourced materials such as sand, stones, and wood. The communities also contributed to the installation of electromechanical components, involving labor for equipment transportation and assistance to the engineers employed by the implementing nongovernmental organization (NGO). In installing the distribution network, the community members contributed in the provision and erection of poles, while electrical engineers and technicians from the NGO managed the technical aspects. The beneficiary communities were required to make a 10 percent up-front financial contribution to the project to ensure community ownership. While interest-free loans were provided, the community members could also make in-kind contributions through participation in the labor force.

The community formed a seven-member Local Project Management Committee (LPMC) to streamline operations. The democratically elected LPMC members underwent training in daily operations and basic technical maintenance, including turbine control, greasing turbine bearings, intake cleaning, and basic troubleshooting. The implementing NGO conducts regular visits to provide technical assistance and guidance, and the LPMC takes charge of tariff collection, operator payment, and loan repayment. Operators work in alternating shifts, ensuring continuous management.

While not quantified for the Bellah project, the induced employment resulting from micro-hydro systems may be more substantial than direct employment. Electricity access can support the establishment of small businesses, creating new job opportunities and income sources. In Bellah, electrification due to the project not only improved household amenities like entertainment and lighting by electrifying 50 households, it also supported productive uses, including food processing and the electrification of the local school. This multifaceted impact underscores the transformative role of micro-hydro initiatives in driving community development and economic prosperity.

Sources: Bere, Jones, and Jones 2015; Mungwe, Mandelli, and Colombo 2016.
Assessing the Skill Gaps in the Hydropower Sector

Assessing the Skill Gaps in the Hydropower Sector

The literature on hydropower skills indicates lack of skills as a persistent challenge to project planning, development, and operation despite the industry being well developed overall. For example, a study involving interviews with national and local stakeholders in Latin America (Bolivia, Colombia, and Ecuador) and Africa (Cameroon and Uganda) found widespread acute skill shortages (Marence et al. 2020). The case study in box 3.3 examines Uganda's experience in greater detail.

An overview of the existing educational systems in these countries revealed that while skilled workers, such as engineers, are produced, the education system does not facilitate the production of hydropower-specific experts. Highly skilled individuals looking to enter the sector typically do so with an engineering degree and acquire specialized hydropower knowledge on the job. None of the countries analyzed offer a master's program in hydropower development. While this study is specific to five developing countries, interviews with industry stakeholders support this finding across all low- and middle-income countries and many high-income countries.

BOX 3.3

THE COST OF HYDROPOWER SKILL SHORTAGES IN UGANDA

Uganda's hydropower sector faces a significant challenge due to insufficient human and institutional capacity to effectively manage hydropower projects. The country hence relies heavily on international experts to oversee its hydropower facilities. This results in higher life cycle costs and diminished local involvement.

This overreliance on foreign expertise in Uganda's hydropower sector not only has tangible financial repercussions, but also underscores the urgent need for developing local expertise. For instance, the Kiira and Nalubaale hydropower stations outsource their operation and maintenance entirely to foreign entities. This results in relatively higher operating expenses per kilowatt-hour compared with neighboring East African countries. This reliance on foreign expatriates to manage hydropower plants drives up OPEX, highlighting the importance of developing and retaining skilled local personnel.

A World Bank Study on the Democratic Republic of Congo revealed similar human resource–related challenges for operation and maintenance and highlights that physical investments must be accompanied by sufficient training.

BOX. 3.3 *(CONTINUED)*

One way to overcome this challenge is for hydropower development agreements to include a clause to train local talent to assume responsibilities from foreign experts within specified deadlines.

Furthermore, Uganda's universities could collaborate with industry partners to develop specialized curricula focused on hydropower. Investing in local education and training can help Uganda reduce its reliance on costly foreign experts and cultivate a skilled workforce to drive its energy sector forward.

Source: Katutsi et al. 2021; World Bank 2020a.

Companies, particularly those in developing countries, report significant challenges in retaining a skilled workforce. Workers trained during their employment, especially in O&M for power plants, are frequently headhunted by other industries. Moreover, higher salaries and more attractive working opportunities in urban areas lead personnel to seek employment in these areas, which are more convenient than remote hydropower plant locations.

Even high-income countries with established hydropower markets are not immune to workforce challenges. A comprehensive analysis of the United States conducted by the National Renewable Energy Laboratory (NREL) in 2019 projected a potential workforce of 120,000 jobs by 2030, with a further increase to 150,000 jobs by 2050 (NREL 2019). However, a significant concern arises because approximately 26 percent of the current hydropower workforce is 55 years or older. This demographic trend suggests that around 9,000 workers will retire from the industry by 2030, with a projected 13,000 retirements by 2040. The impending shortage of skilled labor requires immediate attention.

Interviews with global stakeholders reveal that this is not an issue unique to the United States. In many developed countries, the peak of hydropower development was between the 1930s and 1970s. Consequently, many who gained extensive experience during this hydro boom are now beyond or reaching retirement. Some roles that were reported to be challenging to hire for across the value chain include senior and principal engineering roles (electromechanical engineers, civil engineers, environmental engineers, etc.); social and gender specialists; project directors; contract managers; construction managers; skilled site supervisors; qualified health, safety, and environment managers; and dam safety experts. In addition, many struggle to recruit for O&M roles in rural locations. Attracting youth into the field is a consistent challenge, as reported by industry stakeholders.

A 2021 survey jointly conducted by NREL and the Hydropower Foundation underscored this challenge to recruiting entry-level workers (NREL 2022). The survey evaluated the readiness of recent graduates entering the hydropower industry. The results unveiled a significant

issue: only 10 percent of students were considered adequately prepared for hydropower jobs upon entering the industry (NREL 2022). Also, 73 percent of the responses to the study's survey indicated difficulty in hiring women, minorities, tribal members, and veterans. This challenge was attributed to limited interest from these groups and a low number of qualified applicants.

To fully realize the employment potentials of hydropower, these challenges point to a need for improved strategies to:

- Attract young graduates to the sector,
- Upskill individuals—in classrooms as well as on the job, and
- Increase the availability of training and education opportunities domestically as well as globally.

Another key factor in ensuring an adequate and skilled workforce will be improving gender equality, which is currently lacking in the hydropower sector (ESMAP 2023c). Box 3.4 shares a successful World Bank initiative striving to improve gender equality in the energy sector.

BOX 3.4

WEPOWER: A WOMEN'S PROFESSIONAL NETWORK

WePOWER, started in 2019, is a dynamic professional network for women in South Asia's energy and power sector. WePOWER supports participation in energy projects and institutions and promotes normative change regarding female participation in science, technology, engineering, and mathematics (STEM) education. WePOWER is led by the World Bank and supported by ESMAP, the Asian Development Bank, and Australian Aid. The program convenes 33 partners, which implement gender activities under five strategic pillars to address gaps in women's employment in the energy sector and enrolment in STEM education.

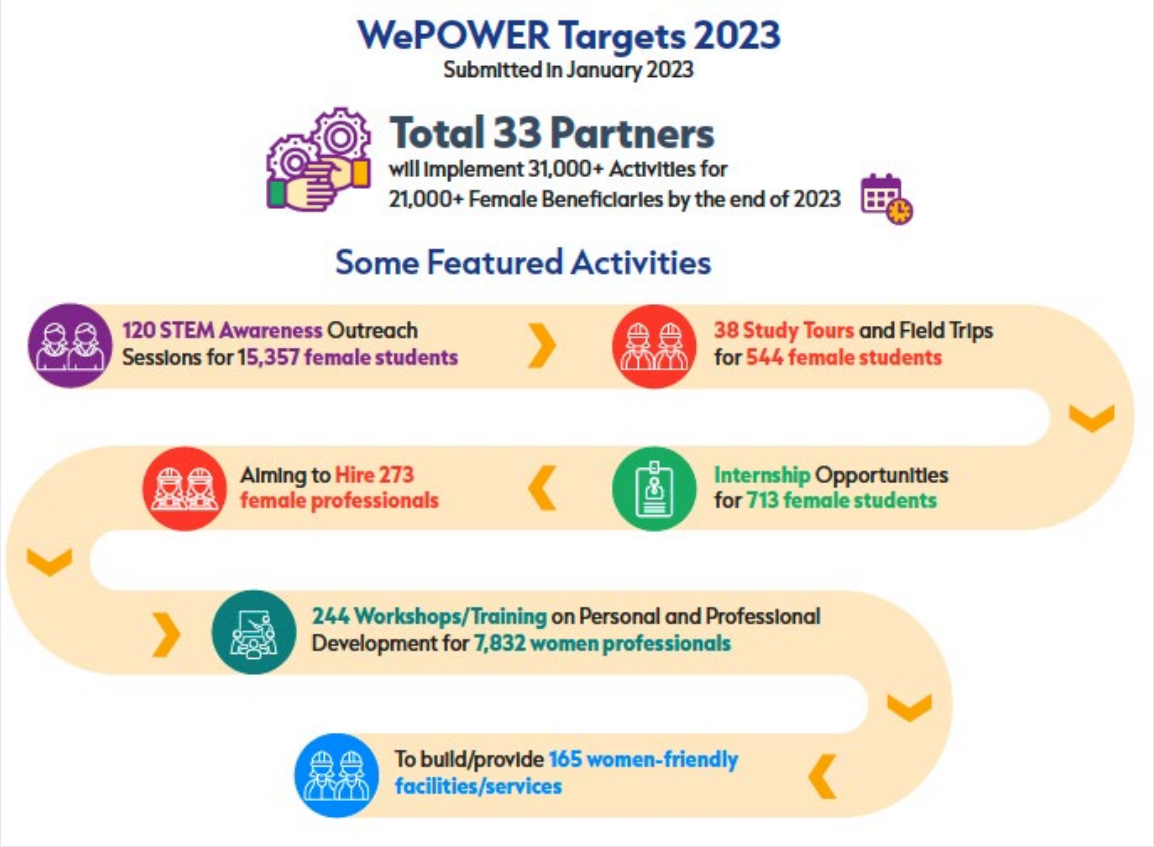
Cumulative results from 2019–22 are transformational:

- Partners in South Asia implemented over 2,700 activities for approximately 68,000 female beneficiaries/participants, including students, interns, young professionals, engineers, and returning mothers.
- More than 500 professional women were hired and 1,325 female interns recruited in technical roles.
- Nearly 900 female mentees were supported by 113 mentors.

BOX. 3.4 *(CONTINUED)*

- Over 140 STEM Outreach workshops were created for approximately 25,000 female students.
- Over 600 personal and professional development workshops were attended by approximately 25,000 female participants.
- Approximately 350 women-friendly facilities or services were built or provided, such as daycare centers and separate prayer rooms.

Key Statistics as of 2023:



Source: Collaboration for Development n.d.

Key Lessons for the Development of Hydropower Education

The skill gap in the global hydropower sector demands increased training and education at all levels to maximize the employment prospects stemming from hydropower project planning, development, and operation and maintenance. This gap is especially acute in engineering, managerial, and medium-skilled positions, such as O&M technicians (World Bank Market Sounding 2023). At the same time, there is a need for greater participation of project-affected communities in employment. Low-medium-skilled roles can often be filled by local hiring if adequate planning and training begin in the early stages of project development. Addressing these challenges requires a comprehensive approach, including higher education, vocational training, professional development, and on-the-job training across various skill levels.

Governments can play a pivotal role in ensuring that countries' skill development systems can meet the needs of the domestic industry. They can promote collaboration among hydropower developers and operators, educational and training institutions, and relevant ministries. Such collaboration ensures that academic programs are designed intentionally, to nurture skills that align with industry requirements (see box 3.5).

BOX 3.5

INDIA'S SKILL RESPONSE SYSTEM FOR THE HYDROPOWER SECTOR

The Indian Skill Council for Green Jobs, spearheaded by the Ministry of New and Renewable Energy, the National Skill Development Corporation, and the Confederation of Indian Industry, is a crucial link between the Government of India, state governments, and industry stakeholders. Its primary focus is formulating strategies and executing programs catering to industry-specific skill requirements, following global best practices. After identifying industry needs, the council harnesses the resources of various ministries to assess skill gaps, design curricula, train educators, conduct evaluations, and equip the workforce with essential skills. The council's efforts foster increased employment opportunities.

As a direct response to the documented skill gap for hydropower operators and technicians, the Ministry of New and Renewable Energy has initiated the Jal-Urjamitra Skill Development Programme, which includes technical and vocational training initiatives designed to upskill 1,780 individuals over five years, addressing the industry's pressing need for skilled professionals.

Sources: Government of India n.d.; Tyagi et al. 2022.

It is important to forecast skills requirements, and also formulate strategies for skills and education development, to ensure that:

- The skills being developed match the sector's needs;
- There is sufficient demand to develop hydro-specific education; and
- The domestic workforce is not overtrained, which could lead to underemployment.

The World Bank handbook "Maximizing Socioeconomic Benefits Triggered by Renewables" offers a step-by-step process for how governments can go about assessing the skill demand and developing a relevant education and training strategy (World Bank 2022a).

Below are the key lessons on education and training strategies. The lessons are grouped by education category: higher education, professional development, technical and vocational training, and on-the-job training.

Higher Education

When demand does not warrant the development of hydropower-specific programs, it is possible to take a regional approach to higher education and leverage nearby existing programs. This typically involves sending employees abroad to receive training. Universities such as Indian Institute of Technology (IIT) Roorkee in India and The Norwegian University of Science and Technology are critical in building both domestic capacities and educating foreign nationals (refer to box 3.6). For example, about 20 percent of the students enrolled in a master's program at India's IIT Roorkee originate from countries such as Bhutan, Cambodia, Ghana, Lao PDR, Liberia, Myanmar, Nepal, Nigeria, and Rwanda.

Another effective approach is to add hydropower specializations to the curricula of existing university degree programs, especially those in the engineering discipline. For example Kathmandu University in Nepal offers a bachelor's degree in civil engineering with an optional specialization in hydropower. Such an approach allows educational institutions to leverage existing teaching staff, attract students from an existing program, and reduce the overhead costs associated with developing a stand-alone program.

A key strategy in expanding the pool of skilled applicants in the hydropower workforce is setting policies to encourage the recruitment of women and socially disadvantaged groups to engineering programs and help address the underrepresentation issue that has long plagued the field. Women have been traditionally underrepresented in science, technology, engineering, and mathematics (STEM) education (ESMAP 2023c). Many higher education institutions have successfully utilized positive discrimination to address this gender imbalance (i.e., when there are two candidates of equal quality, the female candidate will be given preference). In addition, greater diversity can be created through establishing and running programs that engage high school students and opens their eyes to STEM career prospects. Box 3.7 shares an example from Brazil.

BOX 3.6.

REGIONALLY IMPORTANT HIGHER EDUCATION PROGRAMS IN HYDROPOWER

The Norwegian University of Science and Technology in Trondheim has an interdisciplinary program called hydropower development. This two-year course educates future project managers and planners in the hydropower sector. The curriculum covers various aspects of hydropower planning, river system analysis, rock engineering, and more. Students also engage in group projects related to prefeasibility studies and the hydropower development of river basins. The program aims to address international professional needs in the field of hydropower engineering.

Hohai University in Nanjing, China, houses the College of Water Conservancy and Hydropower Engineering, which comprises the Department of Hydropower Engineering, the Department of Irrigation and Drainage Engineering, and the Institute of Water Conservancy and Hydropower Engineering. This university's comprehensive four-semester program covers various aspects of hydropower, irrigation, and drainage, as well as auxiliary areas. Students delve into subjects like hydro structure engineering, hydraulic and river dynamics, hydrology, water resources, fluid machinery, computational fluid mechanics, and more. The program also includes topics related to dam safety, inspection, and monitoring, and design and testing for hydro turbines and pumps.

The Indian Institute of Technology (IIT) Roorkee offers an international, comprehensive four-semester MS in technology, focused on hydropower. This unique course, tailored for national and international engineering professionals, focuses on developing small hydropower plants (SHPs) up to 25 MW. The course covers various topics, including an overview of SHP components , the use of modern technology like global positioning systems and geographic information systems for surveys and planning, technology selection for civil structures, hydraulic turbines, gates, valves, and hydroelectric generators. Participants also explore conventional and digital governors, power evacuation systems, auto and remote SHP operation, and the economic and financial aspects of technology selection. The course also incorporates case studies, site excursions, and tours to provide a holistic learning experience. IIT Roorkee also offers national and international training courses on different aspects of small hydropower development, a real-time digital simulator for small hydropower, and model testing for turbines and pumps. These follow international standards and are conducted under the Department of Hydro and Renewable Energy.

Sources: NTNU n.d.; Hohai University 2013; IIT Roorkee n.d.

BOX 3.7

ADVANCING DIVERSITY, EQUITY, AND INCLUSION IN BRAZIL'S HYDROPOWER SECTOR

ENGIE Brasil has launched a pioneering program for female engineers, which attracted 2,800 applications in its inaugural year. Thirteen engineers were chosen to participate in a comprehensive year-long training program. The culmination of this initiative was marked by a final capstone project, and upon completion, ENGIE Brasil welcomed all 13 engineers into its workforce full time.

Besides the program for female engineers, ENGIE Brasil's technical intern, graduate, and junior apprentice programs are actively contributing to affirmative action by ensuring that 50 percent of vacancies are reserved for women. These collective efforts have resulted in significant improvements in gender equality within the company. In 2022, women's share in ENGIE Brasil's staff was 26.7 percent—a notable increase, of 2.3 percentage points, from 24.4 percent in 2021.

ENGIE Brasil has gone beyond gender diversity, having systematically implemented a series of coordinated actions to boost equity and inclusion. In 2022, the company's headquarters welcomed the first cohort of the "People with Disabilities" training program, which was designed to foster technical development for professionals with disabilities. The group, comprising 15 college students selected from 305 candidates with compatible educational backgrounds, embarked on a 15-month journey focused on career progression.

The group's members were strategically allocated to areas aligning with their existing knowledge and company requirements and did not have to fulfil prior experience requirements. The program introduced additional vacancies with the specific objective of providing this group with their first work opportunity.

Sources: World Bank Market Sounding 2023; ENGIE Brasil 2022.

Building awareness about the broad spectrum of career paths available within the hydropower sector is key (ESMAP 2023c). Forging stronger ties between the hydropower industry and academic institutions can be important in cultivating early interest and awareness of career opportunities. Initiatives like student hydropower competitions, guest speaker programs, and industry tours can provide students with invaluable insights and practical exposure to the workings of the hydropower sector, making the industry more accessible and appealing (see box 3.8).

BOX 3.8

NURTURING TALENT FOR A HYDROPOWER FUTURE IN THE UNITED STATES

The Hydropower Collegiate Competition (HCC), an initiative of the US Department of Energy, is designed to stimulate innovation within the hydropower sector while attracting a new generation of talent. The 2024 challenge focuses on the conversion of nonpowered dams to hydroelectric dams.

The HCC engages multidisciplinary teams of students, encouraging them to craft unique solutions to hydropower challenges. Participating students gain hands-on industry experience and get exposure to diverse career pathways in hydropower. The competition emphasizes the inclusion of a diverse range of academic disciplines and promotes collaboration among students from engineering, business, marketing, communications, environmental and public policy, and social sciences. Emphasis is placed on including individuals from groups historically underrepresented in science, technology, engineering, and mathematics (STEM) fields.

Besides the competition, the US Department of Energy provides tools to accelerate skill development and attract talent to the hydropower sector. The National Renewable Energy Laboratory's dedicated website offers hydropower-related resources with a specific focus on STEM education and workforce development. The goal is to inspire and educate the next generation of hydropower professionals, in turn promoting innovation in the industry.

The website (https://openei.org/wiki/Hydropower/STEM) serves as a comprehensive portal and provides access to workforce data, job-related information, education and training programs, curricula, career-building resources, and networking tools. It also facilitates participation in competitions and offers site tours, both physical and virtual, of hydropower generation and research facilities. The platform is crucial in guiding individuals interested in exploring career paths in hydropower.

BOX. 3.8 *(CONTINUED)*

Hydropower Workforce Development Tools:

Sources: US DOE 2023; OpenEI n.d.

Note: STEM = science, technology, engineering, and mathematics.

Professional Development

As technology and the demands on hydropower systems change, skills have to be refreshed. Continuous professional development is important across high- and medium-skilled roles. Box 3.9 illustrates the importance of professional development in rehabilitation for hydropower plants.

Professional development can be especially critical for underrepresented groups in the hydropower sector. Participation in professional development programs can ensure women have competitive skills to progress to more senior positions. It can also cultivate greater awareness of attractive career opportunities for women. The 2020s present a massive opportunity for the hydropower sector to assert its position as a driver for energy transition; for the dismissal of the perception of hydropower as an old, traditional, male-dominated industry; and for inspiring current and future generations of environmentally conscious individuals.

BOX 3.9

TRAINING TO ACCOMPANY THE REHABILITATION OF AFGHANISTAN'S NAGHLU HYDROPOWER PLANT

In 2018, Afghanistan's largest hydropower plant, the Naghlu Hydropower Plant (NHPP), resumed operations of one of its four turbines, which had been inactive since 2012. This revival marked a significant milestone in Afghanistan's hydropower infrastructure development, bringing electricity to thousands in the Kabul, Kapisa, and Nangarhar provinces. The NHPP's four turbines, which were initially constructed by the Soviet Union in the 1960s, have a collective capacity of 100 MW, which is capable of serving 100,000 households.

Central to the plant's rejuvenation was the dedication of its employees, who underwent extensive training in English language proficiency to operate the newly implemented computer control systems. The adept use of these improved systems by the workforce not only improves plant functionality but also aids in conserving water, reducing reliance on imported or costly diesel-generated power for meeting Kabul's increasing energy demands. As an added incentive, the top eight engineers, who demonstrated commendable English and computer skills, were sent overseas for specialized hydropower plant training, which significantly improved the local capacities of Da Afghanistan Breshna Sherkat, the national electric company. This impactful program was made possible by funding from the United States Agency for International Development.

Source: USAID n.d.

Hydropower can become a front-runner in gender equality by telling the stories of the women involved in it, thus encouraging them to share their adventures, enthusiasm, and pride as ambassadors of hydropower with the broader world (ESMAP 2023c). The International Centre for Hydropower echoes this sentiment. It has taken proactive measures to ensure more women are participating in its programs and advancing in their careers (see box 3.11).

PHOTO 3.4

Training Program Offered by the Kafue Gorge Regional Training Centre in Zambia

BOX 3.10

PROFESSIONAL DEVELOPMENT IN HYDROPOWER TO ADVANCE WOMEN'S CAREERS

The mission of the International Centre for Hydropower (ICH) mission is to contribute to institution building and improved management by disseminating knowledge on hydropower. In 2022, the ICH offered 25 courses to 486 participants. These courses have a wide coverage and encompass subjects such as reservoir sediment management for sustainable hydropower, financial modeling, PPA structuring and negotiations, environmental and social monitoring, risk management, conflict resolution, and rehabilitation and modernization of hydropower assets.

BOX. 3.10 *(CONTINUED)*

The ICH is dedicated to delivering impactful programs. It conducts in-person sessions globally, focusing explicitly on Africa, Asia, and Latin America. The in-person sessions are complemented by online modules. A remarkable achievement was the significant increase in female participation in its sessions during the COVID-19 pandemic, when all programs were delivered online. Over 2020–23, women's participation increased from 17 percent to 30 percent, underscoring the need to recognize and address the distinct cultural pressures and barriers women may encounter compared with men. This trend also highlights the strategic advantages of offering online training alongside traditional in-person programs.

In its commitment to promoting gender inclusivity, the ICH employs a "positive discrimination" strategy. This is a proactive approach to engaging more women in its programming. The strategy aligns with the ICH's recognition of a substantial need for career advancement initiatives specifically tailored for women in the hydropower sector.

Source: World Bank Market Sounding 2023.

Technical and Vocational Training

New technical and vocational education and training (TVET) programs will have to be created to meet the global demand for skilled tradespeople, technicians, and operators, and existing institutions will require support, which may involve financial backing to hire new teaching staff or upskill current faculty, expand educational facilities, and acquire state-of-the-art equipment. Besides financial aid, technical assistance will be crucial for designing innovative curricula and programs that align with the industry's dynamic demands.

Engaging the private sector, including engineering, procurement, and construction entities and equipment manufacturers, to jointly establish programs with technical and vocational training institutes, can be highly beneficial. This helps ensure that a country's skill delivery system matches the sector's skill needs. Box 3.11 presents an example of a partnership between a university in Türkiye and ANDRITZ, one of the largest electromechanical equipment manufacturers in the hydropower sector.

A regional approach to technical and vocational training can also ensure programs are not created without sufficient demand. This typically involves sending employees abroad to receive training. Several regional hubs, such as the Kafue Gorge Regional Training Centre (detailed in box 3.12), are essential.

BOX 3.11

A PUBLIC-PRIVATE EDUCATION INITIATIVE IN MARDIN, TÜRKIYE

On May 4, 2012, an apprentice training center was officially established in Mardin, South-East Anatolia, following efforts initiated in 2010 by Andritz Hydropower, a subsidiary of the international technology group ANDRITZ. Over three years, the center has trained 100 young individuals from the region as skilled metal workers, electricians, and certified welders. The training programs were entirely financed by ANDRITZ. The trainees received stipends. The initial trainers were from Austria and collaborated with staff at the Technical Institute in Mardin. As the program progressed, local staff took over under ANDRITZ's supervision. In the final year, ANDRITZ played an advisory role, before handing over the center's operations and ownership to the local Technical Institute.

In collaboration with the Technical Institute, the curriculum mirrored Austrian apprenticeship training. A unique combination of theoretical and practical education was offered, including instruction in English. This curriculum, a first in Türkiye, sets an example for other industries and addresses the country's high unemployment rate and the need for a qualified workforce.

Source: Andritz 2012.

BOX 3.12

HYDROPOWER TRAINING IN ZAMBIA AND BEYOND

The Kafue Gorge Regional Training Centre (KGRTC) in Zambia plays a crucial role in helping the country fulfil its hydropower training needs. It contributes by offering training for operation and maintenance personnel at all levels. The center was established as a result of a joint Zambian and Norwegian investigation in 1987, which recommended the rehabilitation and reopening of ZESCO's existing training center at the Kafue Gorge Power Station to serve as a regional training hub.

Funded by ZESCO Limited (the national power utility), the Norwegian Agency for Development Cooperation, and the Swedish International Development Cooperation Agency, the KGRTC project aimed to expand the existing training center and implement various training courses for hydroelectric station personnel in the Southern Africa Development Community countries. A subsequent training needs assessment in 1993–95 highlighted the evolving demands for specialized training within the power sector. Since then, the KGRTC has repeatedly interacted with over 27 countries.

As power utilities undergo changes, including unbundling and streamlining, staff often need to transition to different roles or professions. The KGRTC responds to this by offering courses, like Plant Operations, which equip professionals with the skills required for hydropower operations and maintenance. The KGRTC is also dedicated to empowering women in the sector. It offers a scholarship (provided by the Swedish International Development Cooperation Agency), which results in female participants needing to pay only 50 percent of the course fee. Besides scheduled courses, the center can provide customized courses at its facility or clients' premises.

BOX. 3.12 *(CONTINUED)*

The practical approach at the KGRTC, including simulator training, has been well received by the participants and improves their understanding of operation and maintenance activities. The courses also facilitate study tours to various power stations and control centers. These study tours encourage mutual understanding, knowledge sharing, and close cooperation among participants, thus ensuring training is always relevant and up to date.

The training center continuously evaluates course components. It takes participants' feedback, based on which it improves course content and duration. Deliberate follow-up visits to utilities and needs analysis further identify training gaps in hydropower operations in the region. The KGRTC remains committed to enhancing participants' knowledge, skills, and personal development in the ever-evolving field of hydropower. In the past decade, the KGRTC expanded its portfolio to provide training and consultancy services in all renewable energy technologies.

In a bid to promote the continued development of hydropower, the KGRTC serves as the secretariat of the African Hydro Symposium, which is an annual conference of African hydropower utilities, together with international original equipment manufacturers, consultants, contractors, researchers, and other stakeholders. The conference's objective is to facilitate technical interaction to improve hydro plant performance and spur new project development and innovations for the mutual benefit of the participating utilities, independent power producers, and players in the industry.

Source: World Bank Market Sounding 2023; KGRTC n.d.

For governments designing technical and vocational training strategies, focusing on roles that are highly transferable to other sectors (e.g., roles in the trades, such as welders, electricians, and heavy equipment operators, etc.), can be an effective strategy. This is especially true when a substantial pipeline of projects to offer continuous employment is absent. Building transferable skills can ensure that those trained and employed on hydropower projects can find jobs in other sectors post construction.

Technical and vocational training delivered to communities before projects' construction can help to ensure that local people can reap the benefits of employment on the project. Training needs to start one or two years before construction to maximize local hiring during the construction phase. Training during construction can be extremely challenging due to the large number of people on-site, highly complex project oversight, and pressing deadlines. Delaying training until construction commences will result in training becoming a priority, but it would be too late to upskill local individuals to participate meaningfully.

Early planning for O&M skill development is a cornerstone of successful project development. In the context of launching new hydropower projects, a strategic approach to training is not just beneficial but essential. Planning for O&M training—to be conducted during the O&M phase—should commence before construction (ideally one to two years before commissioning) (World Bank 2020b).

On-The-Job Training

The scarcity of structured educational opportunities (both higher education, and technical and vocational training) results in developers and operators often being responsible for the development of hydro-specific skills. On-the-job learning is a practical solution to bridge this gap. It ensures that the workforce is adequately equipped with the skills they need to deliver with quality.

On-the-job training can be critical to ensuring that local communities surrounding projects can leverage employment opportunities in the projects. Local hiring and then on-the-job workforce upskilling are often possible if more formal technical and vocational training is not provided before construction. This sometimes involves training in soft skills, such as workplace etiquette, and, in other instances, it can be to deliver technical skills, such as health and safety training. For example, community members might receive on-the-job training to be employed as security guards or drivers.

On-the-job training is also vital for higher-skilled roles. Graduates are often recruited directly from university programs but lack specific field knowledge. Many companies offer six-month to one-year on-the-job training to ensure graduates are equipped to perform their roles. This often comprises a combination of classroom learning and on-the-field peer mentorship and oversight.

PHOTO 3.6
Staff Operating the Nam Theun II Facility in Lao PDR

O&M requires a specific focus in terms of education and training. Improper execution can adversely impact projects' longevity. The long-term success of hydropower projects necessitates an ongoing commitment to developing human resources capable of effectively executing O&M tasks throughout the operational lifespan. The World Bank report *Operation & Maintenance Strategies for Hydropower: Handbook for Practitioners and Decision-Makers* (World Bank 2020b) is a valuable resource providing O&M capacity-building strategies, detailed job descriptions, and training requirements for critical roles.

A handover period for O&M is typically negotiated between the equipment manufacturer and the operator. While this period is often a year or two, it is possible to extend it if a need for more in-depth upskilling and on-the-job learning is identified. For example, in the past, Andritz Hydro has coordinated a handover period of up to five years, which was to ensure local employees were positioned to perform day-to-day operations in a manner that maximized plant efficiency. External partners, other than the equipment manufacturer, are at times involved to support this transition and handover. For instance, a comprehensive training program was implemented for the Lesotho-based 76 MW Muela hydropower plant in Lesotho. The program involved year-long hands-on training at an ESBI hydropower plant in Ireland before the Muela hydropower plant was commissioned (World Bank 2020b). Following commissioning and training from the equipment manufacturer, an operations management specialist from Manitoba Hydro provided ongoing support to the staff of the Muela hydropower plant for an additional five years during the operations phase.

Encouraging the Private Sector to Hire Domestically

The construction phase of the value chain creates a significant number of new job opportunities. Approximately 70–80 percent of the new positions created are unskilled (World Bank Market Sounding 2023). Even when foreign companies are awarded major construction contracts, there remains potential to encourage local hiring practices. Governments should assess what roles can be localized and build plans to encourage localization where it is feasible and cost-effective. A case in point is Bhutan, where a substantial run-of-river project exclusively engaged foreign companies and labor, while workers from India, most of whom were farmers with no experience in the construction sector in their home country, predominantly filled low-skilled position. This prompts a fundamental question: why were these jobs not directed toward local individuals? The answer lies in the absence of government direction to do so.

One practical approach involves encouraging engineering, procurement, and construction entities and project operators to compile a list of locally sourced roles. These companies can conduct skill assessments within communities to identify potential matches. Additionally, encouraging the establishment of recruitment centers and preemployment training programs encompassing soft skills and job application techniques can further support local workforce development.

As discussed in chapter 2, the project procurement process can also encourage domestic hiring, training, and workforce upskilling. For example, a request for proposals may award additional points to bids from companies that commit to establishing training programs and upskilling a designated number of individuals. While such programs do not always lead to hiring, in most circumstances, once local individuals are trained, companies prefer to hire locally. Not only are local workers familiar with local conditions, but also they typically ask for lower wages than would foreign labor. Also, local hiring helps secure a social license to operate when communities' livelihoods are linked with project success.

4. Sharing Benefits with Local Communities

Hydropower projects improve communities' livelihoods by bringing to them a range of benefits, from providing improved local infrastructure, to skill development and employment opportunities. Hydropower dams also support valuable services, such as flood control; water storage and supply for industrial, domestic, and agricultural use; navigation; and recreation. Given the scale of hydropower projects, these benefits may be enjoyed by many stakeholders in local communities, or, more broadly, in the region, or the nation at large.

While hydropower projects carry undeniable overall benefits, they impact livelihoods in the surrounding communities. Governments, multilateral development banks, and other key stakeholders therefore rightly expect hydropower development projects to be sustainable by delivering long-term economic, social, and environmental benefits. Projects should also avoid, reduce, or compensate for adverse impacts and ensure that local communities receive a proportional share of the benefits. Many private companies recognize this responsibility and seek to develop and conduct their business in accordance with their own environmental, social, and corporate governance frameworks, which acknowledge and measure the impacts on the local communities surrounding their projects (ILO 2023).

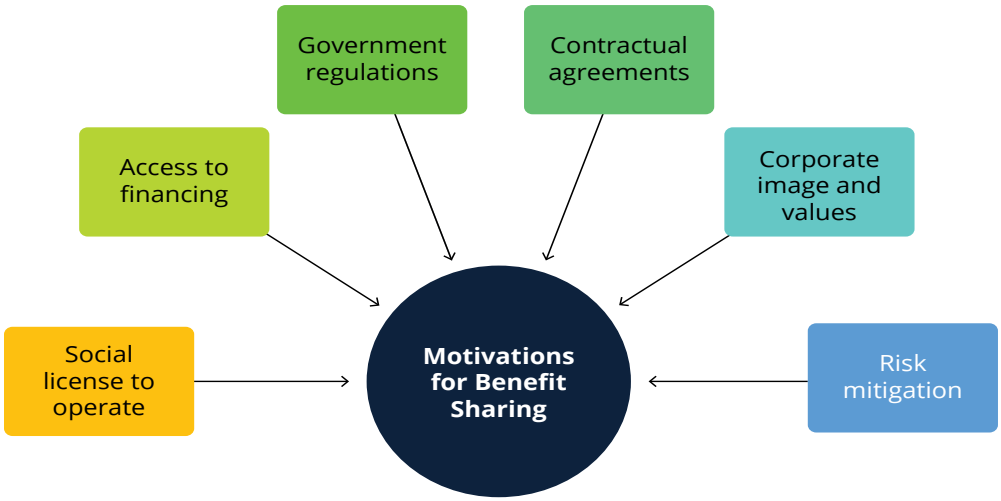
Many countries have also instituted mechanisms to ensure communities are adequately consulted throughout the hydropower value chain, from project design to operation and even closure. Legislation typically mandates adequate compensation for communities directly impacted by the project. However, despite formal policies and mechanisms, some projects do still face resistance from local communities. This is a frequent challenge across all major infrastructure projects given their size and scale could cause disruptions in the daily lives of local communities. The "green light" for a project's advancement—often termed a "social license to operate"—hinges on communities' assessment of the balance between adverse project impacts and potential gains.

However, mitigating adverse impacts and offering compensation may not be enough to secure a social license to operate. Many hydropower projects therefore go above and beyond the mandatory requirements, providing additional benefits to local communities. This is termed "benefit sharing." Project benefit sharing essentially emerges as a strategy to improve the development impacts of hydropower projects, in turn fortifying and sustaining a social license to operate. When community resistance arises, it can often be remedied. For example, in Nepal, the Kaligandaki "A," a 144 MW project, faced community opposition

during construction. The situation was resolved when local requests for water, electrification, irrigation, and health facilities were addressed; project operations were delayed by only 51 days (IFC 2020a).

Besides securing a social license to operate, developers have other motivations to share benefits with communities (figure 4.1).

FIGURE 4.1
Motivations for Benefit Sharing



Source: Adapted from IFC (2020a).

Well-designed benefit-sharing mechanisms may help with timely and effective project completion by enabling local communities to evolve as close partners with project developers. This holds positive implications for technical, economic, financial, and environmental feasibility and fosters a more inclusive and sustainable project development process.

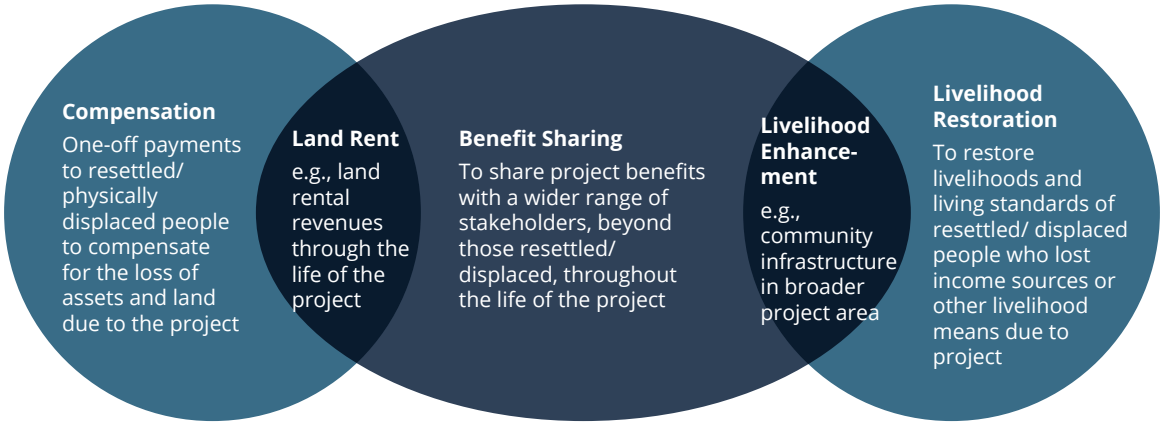
Differentiating between Compensation and Benefit Sharing

Benefit sharing extends beyond the conventional scope of compensation payments or resettlement support associated with environmental and social laws and requirements. Whereas mitigation traditionally addresses adverse impacts through compensation and livelihood restoration, benefit sharing seeks to actively uplift and improve the overall quality of life for those affected beyond the standards that existed before a project (Wang 2012; IHA 2019b; Multiconsult 2019).

Nevertheless, the two concepts often overlap in practice. Benefit-sharing initiatives may function as extensions of compensation measures, incorporating elements like rural infrastructure development that benefits the wider community, not just those directly affected by a project, as depicted in figure 4.2.

FIGURE 4.2

Relationship among Compensation, Livelihood Restoration, and Benefit Sharing



Source: Extracted from World Bank (2022b)

BOX 4.1

BENEFIT SHARING WITHIN THE WORLD BANK'S ENVIRONMENTAL AND SOCIAL FRAMEWORK

The World Bank's Environmental and Social Framework does not explicitly mandate benefit sharing, although the framework's objectives align with the objectives of benefit sharing. World Bank staff are instructed to "do no harm" and maximize development gains, prompting the consideration of benefit-sharing arrangements.

A noteworthy gap deserving further attention is that although all World Bank–financed projects are appraised to evaluate the expected economic costs and benefits, conventional cost-benefit analyses typically do not disaggregate information to determine how different population segments might gain or lose more than others. For example, the assessment does not include how those who only receive power access due to a hydropower project might benefit differently from local communities surrounding a project site.

Source: World Bank 2017, 2022b

A defining feature of benefit sharing is the distribution of benefits across a project's entire value chain (as illustrated in figure 4.3). Compared with compensation measures, which are exclusively funded through a project's investment budget at project start, benefit sharing also has the flexibility to draw funding from the operating income. Before a project's operation phase, funds for benefit-sharing initiatives may originate from the project's capital budget or a dedicated corporate social responsibility budget. Taxes, royalties, and/or project equity participation, such as project shares, may fund benefit sharing during project operation. Special funds, financed through the operating income, may be established to facilitate long-term, community-driven development. For example, a certain percentage of profits may be invested into social responsibility programs and projects. Occasionally, specific funds will be allocated to prepare for an eventual project conclusion, aiming to diversify the local economy in anticipation of the closure of a hydropower plant.

FIGURE 4.3

Benefit-Sharing Process Mapped along the Hydropower Value Chain

<table>
<tr><th></th><th>Planning, Policy, and Legislation</th><th>Feasibility and Field Investigations</th><th>Project Design and Procurement</th><th>Construction and Commissioning</th><th>Operation and Maintenance</th><th>Decommis-sioning and Recycling</th></tr>
<tr><td>Mitigation/ Compensa-tion</td><td rowspan="2">• Design policy/i.e., regulations, and plans
• Plan for potential investment/ funds</td><td>• Identify project affected people/ households, compensatory and mitigation measures</td><td>• Design detailed mitigation measures and compensation plans and procure</td><td colspan="3">• Provide compensation to project affected families (PAPs)
• Implement various mitigation measures especially targeted to PAPs</td></tr>
<tr><td>Benefit sharing</td><td>• Identify benefit sharing mechanisms
• Pilot Identify benefit sharing activities (if funds exist)</td><td>• Design detailed benefit sharing (CSR) strategies/plan
• Procurement</td><td colspan="3">• Implement benefit sharing activities (infrastructure provision, capacity building, revenue sharing, etc.)
• Engage with and provide updated information continuously to all comminities and relevant stakeholders/increase partnerships to enable communities and empower them</td></tr>
<tr><td>Common to both</td><td colspan="3">• Generate data and evidence to plan and design
• Provide appropiate and relevant information
• Engage in dialogue/s with stakeholders including local communities</td><td colspan="3">• Monitor continously and (re)evaluate
• Readjust strategies and plan (and budgets for benefit sharing in particular as it is continuous unlike compensation that is on time).</td></tr>
</table>

Source: Adapted from ESMAP (2023d).

Note: CSR = corporate social responsibility; PAP = project-affected persons.

Types of Benefits That Can Be Shared

Benefit sharing can be through direct monetary or nonmonetary (or in-kind) provisions (World Bank 2022a). Through monetary provisions, funds flow directly to beneficiaries. Conversely, with nonmonetary provisions, beneficiaries do not receive funds directly, but the benefits of fund investments. The use of funds is at times decided by developers or operators, or by beneficiaries or individuals governing on their behalf (i.e., local governments, local nongovernmental organizations, and community cooperatives).

Specifically for hydropower, benefits can be realized through shared access to the water resource and the water services provided by hydropower dams and reservoirs. Enormous benefits are brought through the provision of water for domestic or industrial uses, or for irrigation, for the growth of agriculture, or through sharing the dam for other uses, such as boating and fishing, which may result in new business opportunities. Even dams not designed for multipurpose use would still support intrinsic services like flood control, water storage, and water supply to downstream users. These are essential facets for how hydropower projects can contribute to climate change adaptation—potentially reducing the severity of droughts and flooding, which are likely to become more common and severe as global temperatures increase (Berga 2016). Meanwhile, run-of-river hydropower with intakes in rivers or small intake ponds does not have the same ability as reservoir hydropower to support water services. It can, however, provide water from the intake basin or directly from the waterways.

In the context of this report, benefit sharing is broadly grouped into three categories:

1. Improvements to local services, environment, and infrastructure
2. Community-level skill and capability enhancement and preferential job opportunities
3. Revenue and ownership sharing

PHOTO 4.1
Child Health and Welfare Program Implemented Courtesy of the Nam Theun II Hydropower Project in Lao PDR

Improvements to Services and Local Infrastructure (nonmonetary)

Community infrastructure investments are commonplace in the hydropower sector and are a staple of most benefit-sharing plans. Examples include the construction of local schools; water, sanitation, and irrigation infrastructure; electrification of local communities; clinics; recreational facilities; and watershed protection and enhancement. At times the budgets for infrastructure development are accompanied by funds to ensure that the facilities can continue functioning for a defined period or that infrastructure handover is complete and sustainable. For example, an initiative to construct a clinic might also be associated with a plan to hire and sustain the employment of a local doctor. These funds may at times be combined with local government development funds to maximize positive impacts.

Hydropower reservoirs can also be designed to be multipurpose and deliver myriad additional benefits to local and regional communities. For example, a reservoir may be designated for public use, allowing activities like fishing, boating, and swimming to occur. This may provide a source of recreation for local communities and new business opportunities in tourism. Reservoirs are also commonly a critical source of water supply for domestic and industrial uses. Access to fresh water can have far-reaching health and livelihood benefits for local and regional communities, besides impacts in terms of economic growth. For example, access to irrigation can have a profound impact on regional and national food security issues (see box 4.2). During the early stages of project planning, local governments and community leaders must be consulted on the potential uses of a dam and reservoir so that they can reap the benefits. It is also essential to ensure that the water rights permit these additional uses. In addition, balancing community needs with project requirements can generate revenue. This topic is discussed further in section 4.3.

PHOTO 4.2

School Constructed because of the Rampur Hydropower Project in India

BOX 4.2

THE MULTIPURPOSE NYABARONGO II HYDROPOWER PLANT, RWANDA

The Nyabarongo II Hydropower Plant is being developed by the Rwanda Energy Group, Rwanda's state-owned utility, to fulfil multiple objectives, including water supply, irrigation, and electricity generation.

The hydropower plant, expected to become functional by 2024, marks the initial phase of the Nyabarongo II Multipurpose Development Project, which is structured to achieve the following objectives:

- Generate combined power output of 134 MW, comprising 43.5 MW from the Nyabarongo II Hydropower Plant, 40 MW from the Butamwa Pump Storage Power Plant, 40 MW from the Juru (Bugesera) Pump Storage Power Plant, and 10.5 MW from the Lake Sake Outlet Hydropower Plant.
- Provide municipal water supply to the urban areas of Kigali and Bugesera.
- Manage flooding on marshlands covering 18,080 hectares (ha) along the Nyabarongo and Akagera rivers.

The dam will also help irrigate over 20,000 ha of land, bringing vitality to the valleys of the Nyabarongo, Akagera, and Akanyaru rivers, along with the upstream regions of lakes Cyohoha and Rweru in Bugesera District. The dam will create a reservoir with 803 million cubic meters of storage capacity. It will play a critical role in mitigating flooding risks, which have been disastrous in previous years.

The Nyabarongo multipurpose dam aligns with Rwanda's broader strategy to irrigate 102,284 ha by 2024. With a current cultivation scope of 40,000 ha per season, the dam promises a steady and reliable water supply, ushering in predictability and prosperity. The irrigation program will help to increase the production of rice and sugarcane crops; not only will the local demand be met, but there will be potential to expand to global markets.

Photo: President Paul Kagame Inspects the Plans for the Nyabarongo Multipurpose Dam in Rwanda
Source: REG 2022, The Farmer's Journal Africa 2023

Hydropower projects' ability to manage and mitigate the impacts of climate change on water resources makes them crucial in adapting to climate change. With climate change causing global temperature increase, sea level rise, and snow cover depletion, the hydrological cycle is expected to undergo significant alterations, including shifts in precipitation patterns, evapotranspiration rates, and soil moisture levels, as well as increased variability in river flows due to glacial and ice cap melting. These changes pose significant challenges for water resource management, exacerbating floods and droughts (IHA 2019a). However, hydropower systems, especially those with regulated basins and large reservoir capacities, offer a solution by providing resilience against water resource fluctuations and acting as storage buffers against the impacts of climate change. Sensitivity analyses indicate that regulated basins with substantial reservoir capacity are less vulnerable to climate-change-induced water resource changes than unregulated basins (Berga 2016). This resilience is essential for ensuring water availability in regions facing water scarcity. Likewise, the storage capacity of reservoirs can play a critical role in preventing and/or mitigating floods.

Numerous case studies offer valuable insights into the effectiveness of reservoirs and dams in reducing flood-related losses. For example, in Myanmar, dams resulted in a 50 percent decrease in flood damage to buildings and assets (IHA 2023). Similarly, the Soyanggang Dam along the Han River in South Korea achieved a 68 percent success rate in mitigating flood losses (IHA 2023). Eight heavily modified river basins in Austria demonstrated substantial flood peak reduction, averaging over 33 percent for extreme events with return periods exceeding 30 years (Stecher and Herrnegger 2022). These findings underscore the significant contribution of reservoirs—even those initially designed solely for hydropower generation—to flood control and mitigation efforts. The economic implications of preventing flood-induced damages and drought are immense and offer enormous benefits to local communities at the national level.

Community-Level Skill and Capability Enhancement and Preferential Job Opportunities (nonmonetary)

It is also commonplace for project developers to invest in building the capacity of the local population. Occasionally, training will be provided specifically to upskill the local workforce so that they may be employed on projects themselves, which may help prioritize local hiring (an example is provided in box 4.3). In other instances, training may focus on building capabilities in different areas to empower people economically. For example, this might include computer and literacy training or improved agricultural practices. Enterprise development training is occasionally pursued to ensure that local people maximize the benefits from an influx of workers that will demand an array of goods and services (e.g., accommodation, food, transport). Enterprise development training can formalize and enhance business and enterprise development activities to increase project-associated (induced) employment.

PHOTO 4.3
Young Women Receive Computer Training in Pakistan

BOX 4.3

PRIORITIZING LOCAL HIRING AND GENDER DIVERSITY IN COSTA RICA'S HYDROPOWER DEVELOPMENT

The Intercontinental Exchange (Instituto Costarricense de Electricidad, ICE)—a state company responsible for providing public electricity and telecommunications services in Costa Rica—has, as part of its good practices for public infrastructure construction, instituted a progressive employment policy that prioritizes hiring individuals from the territories where it operates or develops hydroelectric projects. Although finding personnel for highly skilled positions in these communities can be difficult, the organization has hired individuals with medium and low qualifications especially for construction positions. It has also created alliances with public entities for training and capacity building to close the skill gap and build new local competencies.

For the Reventazón Hydroelectric Project, ICE implemented specialized training programs to help local women become more capable and participate more in technical and coordination roles. This initiative yielded positive results, as women represented 7 percent of staff in technical positions—a notable improvement compared with previous projects, where these roles were generally performed exclusively by men, following social norms. Women actively participated in construction tasks such as placing steel reinforcements, excavation, and pouring concrete, challenging stereotypes surrounding specific gender roles.

Beyond the construction phase, ICE, in coordination with other state organizations linked to education, has implemented mechanisms for the accreditation of trained individuals so that they can quickly enter the labor market or pursue entrepreneurship. This forward-thinking approach underlines ICE's commitment to the success of its projects, the enduring positive impact on local communities, and improving gender inclusion and management within the workforce.

Source: World Bank Market Sounding 2023.

Revenue and Ownership Sharing (monetary)

Financial rewards can be shared in many ways. For example, they can be shared through taxes dispersed at various levels of government, royalties, the establishment of a community development fund, which receives a portion of project revenue, or an equity-sharing arrangement where the community owns a portion of the project. These measures tie project success to the long-term prosperity of communities. Box 4.4 illustrates an example in Brazil and Paraguay.

Whether the sharing of such benefits is obligatory or voluntary, varies according to the situation. Typically, all actions are voluntary, unless mandated by the government, financing institutions, or the operating policies of developers and operators. The entities responsible for implementing benefit-sharing initiatives and the beneficiaries are greatly influenced by the specific circumstances and the benefit-sharing mechanisms put in place. Subsection 4.3 outlines this in greater detail.

BOX 4.4

SOCIOECONOMIC BENEFITS OF THE ITAIPU HYDROELECTRIC DAM

The Itaipu Hydroelectric Dam is located on the Paraná River, on the border between Brazil and Paraguay. During the 1960s, both Brazil and Paraguay realized the river's untapped energy potential, and this led to a conflict over land at the border. In 1966, they signed the Act of Iguaçu, followed by the Treaty of Itaipu in 1973. Argentina was also affected by the dam's development. In 1979, Argentina, Brazil, and Paraguay signed a treaty (the 1979 Tripartite Itaipu-Corpuse Agreement), which set out the requirements on Itaipu Binacional for downstream flows.

Itaipu Binacional is a company jointly owned by Brazil and Paraguay. It was created by the Treaty of Itaipu to operate the Itaipu Hydroelectric Dam. The project caused various environmental and social impacts and was the subject of corruption charges during the construction stage when the politicians in power selected private companies with ties to political figures. However, since then, Itaipu Binacional has prioritized combating corruption and fraud; it established the General Ombudsman's office, Ethics Committee, and Internal Audits and Compliance advisory functions.

The power plant has 14 GW of installed capacity, and each country has equal access to the electricity generated. However, since Paraguay only consumes about 15 percent of its share, it is obliged to sell the remaining electricity to Brazil. Since its completion, the dam has become a project of great significance in the economic and diplomatic history of these two countries.

BOX. 3.10 *(CONTINUED)*

Their joint mission is "to generate quality electricity with social and environmental responsibility, driving economic, touristic, and technological sustainable development in Brazil and Paraguay."

Both Paraguay and Brazil benefit from electrical generation; Paraguay is especially benefited since approximately 10 percent of the public revenue comes from the royalties of two hydropower plants—Itaipu and Yacyretá. Social and economic benefits are seen at many levels, besides electricity generation.

Since 2003, Itaipu Binacional has carried out social and environmental protection activities as mandated by both governments. The activities focus on educating the local population on how to coexist with the dam, including agriculture productivity, fishing protection, water quality control, creation of protected areas for biodiversity around the reservoir, aquaculture development, provision of rehabilitation and development support for indigenous communities, and health services delivery to locals. The power plant is inland and contributes to the development of infrastructure such as bridges and hospitals.

According to the Treaty of Itaipu signed in 1973, all cost and benefits, and the implementation of social and environmental mitigation measures from Itaipu Binacional, are distributed equally between the two countries. This means the debt for the dam's construction and the costs for its maintenance are also distributed evenly. As per the treaty, both governments receive royalties, with Brazil distributing 25 percent to the state, 65 percent to cities, and 10 percent to federal bodies. Paraguay's government, however, has the autonomy to decide how to redistribute the royalties. Since 1987, Brazil has received about U$5.7 billion and Paraguay has received US$5.4 billion in royalties.

Finally, today, Itaipu Binacional offers various tours and attractions around its facilities. The hydropower plant is the primary attraction, supported by an ecomuseum and a biological refuge, and the history of the plant's construction is displayed. The exhibition further highlights the environmental impact of construction in the region and describes the measures adopted by Itaipu to ensure local fauna and flora species were not harmed during construction. Another exhibition, named "Itaipu: A Diplomatic Work," focuses on the diplomatic and political procedures that preceded the construction of the Itaipu Plant located in Foz do Iguaçu. The biological refuge offers a tour, which includes a zoo and also demonstrates how the area is being reforested with indigenous plants and trees.

Source: Global Infrastructure Hub n.d.; Itaipu Binacional n.d.

Mechanisms for Sharing Benefits

There are many mechanisms for financing and implementing the categories of benefit-sharing activities. Table 4.1 introduces these approaches. As discussed in chapters 2 and 3, utilizing the project procurement process can be an important way to implement benefit-sharing mechanisms and ensure that developers and operators deliver on the benefits promised to local communities.

When designing benefit-sharing activities, it is important to assess the local context and the fit of the mechanism of interest. Section 4.4 outlines many crucial considerations in making such a decision.

TABLE 4.1

Mechanisms to Share Benefits due to Hydropower Development and Operation

MECHANISM	DESCRIPTION	EXAMPLE OF MECHANISM IN PRACTICE
Royalties	Royalties compensate for the right to use and obtain some economic benefits from natural resources. Depending on how royalties are structured in a country, they may benefit any or all levels of government.	In **Brazil**, hydropower projects must allocate a 6.75 percent royalty, which is calculated based on the monthly total energy production and multiplied by an energy tariff. Of this royalty, 0.75 percent is directed to the Ministry of the Environment to support the management of the country's water resources. The distribution further designates 6 percent to benefit local municipalities and states impacted by the dams. Each local municipality and state receives 45 percent of the total. The remaining 10 percent is allocated to the federal government.
Licensing	The right to generate hydropower using public bodies of water is often granted in the form of a license. This means license holders are required to pay an annual fee to the license issuer, which can vary from one country to another—in some cases, it may be the ministry of natural resources, while in others, it could be the local municipality.	In **Switzerland**, cantons (municipalities) specify the amount of the annual license fee (levy) within the limits specified in the applicable federal legislation. From 2015 to 2030, the defined limit was Sw F 110 per kilowatt (gross output). Hydropower plants with gross output of up to 1 megawatt (MW) are exempt from the levy.
Taxation	Taxation is a vital mechanism for governments to harness hydropower projects' economic benefits. While in many countries taxes imposed on hydro projects primarily contribute to the national/federal budget, it is possible to devise a taxation system that implements tiered taxation, channeling revenue to local, regional, and national levels of government.	In **Norway**, the taxation framework for hydropower projects is governed by Chapter 18 of the Taxation Act. The framework is specifically structured to address taxation at the local, country, and federal levels, with a primary emphasis on social benefits. The framework delicately balances industry sustainability and community welfare. At the federal level, a 22 percent general income tax contributes to the national fund, while a 45 percent resource rent tax for larger plants effectively redistributes profits to society. At the municipal and county levels, a natural resource tax of NKr 0.013 per kilowatt-hour is imposed, offering additional income to local communities.

MECHANISM	DESCRIPTION	EXAMPLE OF MECHANISM IN PRACTICE
Tax relief	Certain countries encourage benefit sharing by offering corporate tax relief to companies with designated community development initiatives.	In **Brazil**, corporations receive tax relief when they commit to specific corporate social responsibility (CSR) activities. This leads to substantial financial rewards. ENGIE Brasil, for instance, funds over half of its benefit-sharing initiatives through tax relief programs.
Land lease agreements	Land access arrangements can be structured to provide lasting benefits to communities, moving beyond a one-time land purchase model.	In the **Solomon Islands**, the landowners near the Tina River hydropower project received compensation for their land, and ownership was subsequently transferred to the government. The government, in turn, transferred the land to a newly established community-controlled entity specifically structured for community welfare. The government leases the land from this entity to facilitate the 30-year power purchase agreement; this creates a continuous revenue stream, which is directed into a Benefit Sharing Fund. This fund will become a platform for the community to submit proposals for various development initiatives.
Equity sharing	Projects can be structured to allow community ownership. Sometimes a community-controlled entity will be established to hold the equity stake. In other cases, individual shares may be offered to the public, with preference to local communities. Sometimes shares are granted, whereas in other cases, they must be purchased.	In **Canada**, for the 695 MW Keeyask generating station, Manitoba Hydro established a formal equity partnership with the local Indigenous Nations through the Keeyask Hydropower Limited Partnership. The equity partnership was entered into with the Tataskweyak Cree Nation, War Lake First Nation, York Factory First Nation, and Fox Lake Cree Nation. The Keeyask Hydropower Limited Partnership holds a significant 25 percent stake. While Manitoba Hydro managed the construction and continues to be responsible for operation, oversight for the facility is performed by a board with representation from both Manitoba Hydro and Cree. The board meets quarterly to assess and guide the business's trajectory.
		In **Nepal**, hydropower companies can issue local shares directly to individual investors, including community members, to foster local ownership and support. In publicly owned projects, the project-affected communities have a constitutional right to invest up to 10 percent in a hydropower project company; shares are issued at a par value of NPR 100 (approximately US$0.87). Shareholders make capital gains and earn dividends based on their stockholdings, but they are required to retain stock for at least three years before selling.

MECHANISM	DESCRIPTION	EXAMPLE OF MECHANISM IN PRACTICE
Contractual agreements between developers/ operators and the government	When benefit sharing is not mandated in policy, it is often negotiated on a project-by-project basis between the government, developers, and operators. The developers' commitments will likely then become the elements of contractual agreements, with penalties defined for noncompliance.	The Rogun Hydropower Project in **Tajikistan** involved negotiations with local communities on benefit sharing. It was decided that a certain percentage of project revenue would be committed to actions to uplift local communities.
		It is also possible for governments to mandate multiple uses for a hydropower reservoir. For example, they may stipulate that water be made available for domestic, agricultural, or industrial uses, or mandate that the reservoir be accessible to the public for recreational or commercial purposes. The Intercontinental Exchange (ICE), **Costa Rica**, always prioritizes and designs its reservoirs for multiple uses. It also voluntarily provides infrastructure to ease the public use of the reservoir, for example, by providing docks and boat ramps.
Developer/ operator-driven CSR programs	Where governments do not mandate benefit sharing in any form, most developers would still decide to allocate a budget for benefit sharing. In these cases, developers maintain full control over the funds and prioritize the actions to be funded.	In **Lao PDR**, benefit sharing is not mandated in policy. However, when Statkraft has been involved in hydropower development in the country, it has worked with government entities to assess development priorities in the local region. For example, childhood health was a priority action, and Statkraft made concerted efforts to address malnutrition and vaccination rates, with a high level of success. Such CSR programs are commonly found, albeit at varying scales.
Percentage of revenue or capital expenditure	It can go to the local government or to a community-controlled entity.	In **India**, regulations require that 1.5 percent of project revenue be directed toward community development initiatives.

Sources: World Bank Market Sounding 2023; SFOE n.d.; APPrO 2106; World Bank 2021.

For private companies, the degree of ambition in benefit sharing hinges on the interest of their leadership and the anticipated advantages. By contrast, public companies, comprising many large global hydropower entities, are under distinct expectations set by their owners—the governments. Governments may actively leverage projects for development, achieving additional objectives (e.g., infrastructure projects), or they may adopt a more conservative approach, limiting funds to maximize direct government revenue. This cautious stance aims to prevent public sector projects with generous benefit-sharing programs from operating outside budget constraints, ensuring alignment with government priorities.

Ambition levels in benefit sharing are not solely determined by willingness but also by the intricate dynamics of financial capacity. The cash flow dynamics of companies, especially domestic companies, undergoes significant shifts throughout a project's life cycle and is

BOX 4.5

SUSTAINING LONG-TERM IMPACT DUE TO BENEFIT-SHARING INITIATIVES THROUGH EDUCATION—INSIGHTS FROM THE NAM THEUN II PROJECT

In the Nam Theun II Project, the NTPC (Nam Theun II Power Company, in which *Électricité de France* [EDF] is a 40 percent shareholder) introduced a scholarship program for local students. However, the distance from Vientiane, more than 400 kilometers, meant many aspiring students faced financial barriers to pursuing higher education away from home. The NTPC responded by instituting a program that annually sponsored 15–20 students, covering not only their university tuition but also all living expenses. While the NTPC anticipated that these scholars would remain in the urban capital of Vientiane, the majority returned to their villages; a desire to contribute to their local communities' development was thus noted.

The NTPC and EDF underscore the enduring impact of education in benefit-sharing plans, emphasizing the positive effects of education in general. Education, they contend, yields significant returns relative to the investment required.

Source: World Bank Market Sounding 2023.

influenced by factors such as lender restrictions on noncore activities and varying project profitability. Over time, the market position of hydropower projects may fluctuate, affecting their ability to provide benefits. As illustrated in box 4.5, Électricité de France (EDF) and other developers consulted in preparation of this report shared their beliefs that investing in education, for example, yields high impact for comparatively low costs.

Considerations for Selecting and Implementing Benefit-Sharing Mechanisms

The following section outlines a selection of the lessons learned from engaging with stakeholders in the hydropower sector. These lessons may be helpful to governments and project developers as they design and implement community benefit-sharing approaches.

Defining who will benefit is essential to managing expectations and delivering benefits effectively. In many countries, the absence of formal regulations delineating a project's area of influence poses challenges in defining local beneficiary groups for mitigation and benefit-sharing activities. Where there are no formal regulations, it typically falls on the environmental and social impact assessment consultants to define the area of influence around the project area.

Directly affected persons: This classification encompasses those who experience direct asset loss or permanently lose access to resources due to projects. It includes individuals losing land under customary or traditional rights, utilizing common property resources, and losing established access to resources. It also includes individuals with formally recognized property rights, tenants, artisans, and wage earners whose livelihoods or living standards are directly adversely affected by projects. The definition also incorporates infringement and loss of customary and ritual areas; this means that directly impacted communities may include those at a distance who use the project-affected sites for cultural practices. Individuals falling within the category of those directly affected by projects, will be actively included in all mitigation activities, including compensation, and will share in the advantages provided by benefit-sharing programs.

Indirectly affected persons: Individuals falling in the category of those indirectly affected by projects may include householders who do not experience direct loss of personal property but still experience minor economic losses related to their livelihoods. This economic impact is typically measured below a specified threshold, for example, 10 percent of annual income or productive assets. However, these individuals may have alternative resources nearby, which can be utilized without a significant impact. The need for physical relocation may be alleviated, or no substantial economic loss in livelihood may result for them. Additionally, indirectly affected persons may comprise those who temporarily lose access and are exposed to noise or pollution due to project activities. Those categorized as indirectly affected persons typically only access benefits through benefit-sharing programs.

PHOTO 4.4
Community consultation for a micro hydro project in the Philippines

Several developers shared that benefit-sharing activities are critical because it is challenging to accurately define individuals or communities impacted directly and indirectly, and there is often "spillover." Benefit-sharing programs help ensure a wider net is cast, preventing repercussions due to the miscategorization of individuals and communities. They also shared that the definitions of project-affected individuals and a clear categorization of all project-affected persons should be communicated early on to those who are affected, since this shapes how compensation and, eventually, benefit-sharing programs may be defined spatially. Not sharing the categorization of affected and unaffected persons can lead to confusion among stakeholders, create tension, and, ultimately, pose a threat later during project development.

The successful implementation of benefit-sharing programs requires stakeholder engagement throughout the project life cycle. Community consultation and engagement serve as the foundation for the feasibility and design of such programs. They ensure the programs are relevant and effective.

Developers and operators typically have a community relationships office, which works closely with local communities. Leveraging this team's expertise in benefit-sharing discussions can be invaluable as it possesses on-the-ground intelligence about stakeholders, community dynamics, and vulnerable groups. Establishing this community relationships team early in project development is imperative. The team's composition must be diverse, with an equal gender balance. This team will lead the process of designing and implementing a benefit-sharing plan that consists of the following process:

1. Conduct baseline studies:
   - Baseline studies are conducted at the outset of project development to understand the existing socioeconomic and environmental conditions of the project area.
   - These studies aid in tracking the impacts of benefit-sharing mechanisms over time. After implementation, baseline data help focus expenditure on successful activities and amend those that did not go as planned.
2. Identify opportunities for a benefit-sharing plan:
   - A scoping activity is conducted, which includes consultations with a wide range of stakeholders to gather diverse perspectives and insights.
   - Opportunities for benefit sharing are identified with the input of local communities to develop a plan.
3. Implementation—Ensure equitable distribution of benefits:
   - Efforts are made to ensure that benefits are distributed evenly across communities.
   - Projects with the most significant potential to create long-term and sustained benefits are selected.

— Some developers, those aspiring for inclusive and sustainable development outcomes, prioritize activities directly benefiting women and disadvantaged populations.

4. Monitor the performance of benefit-sharing programs:
   — Ongoing consultations are conducted to track the success of benefit-sharing activities and modify them when needed.
   — Who benefits is monitored, and equitable access to new opportunities, services, and infrastructure is ensured.

Ensuring inclusivity in all engagement efforts is crucial for the success and sustainability of benefit-sharing programs in hydropower projects. Engagement with a narrow group of influential stakeholders can lead to a distortion of issues and needs. The circle of engagement must be broadened to address this challenge, even during the early stages, to ensure representation of and participation by local communities from diverse perspectives. Thorough community engagement requires reaching out to the full range of affected individuals, regardless of gender, religion, culture, or social status. Smaller, targeted consultations may be more effective in ensuring meaningful engagement when specific groups may be hesitant to attend or speak out.

Gender-inclusive engagement is particularly critical, yet remains a challenge in the hydropower sector. Studies have shown that community programs designed with women's input tend to positively impact the overall community (IFC 2020a). Women often prioritize

PHOTO 4.5
Women-led micro hydro system in the Philippines

productive income management, health, education, and safety, benefiting their families and the community at large. Developers should prioritize separate consultations with women stakeholders and undertake gender impact assessments to ensure their voices are heard and their needs addressed effectively.

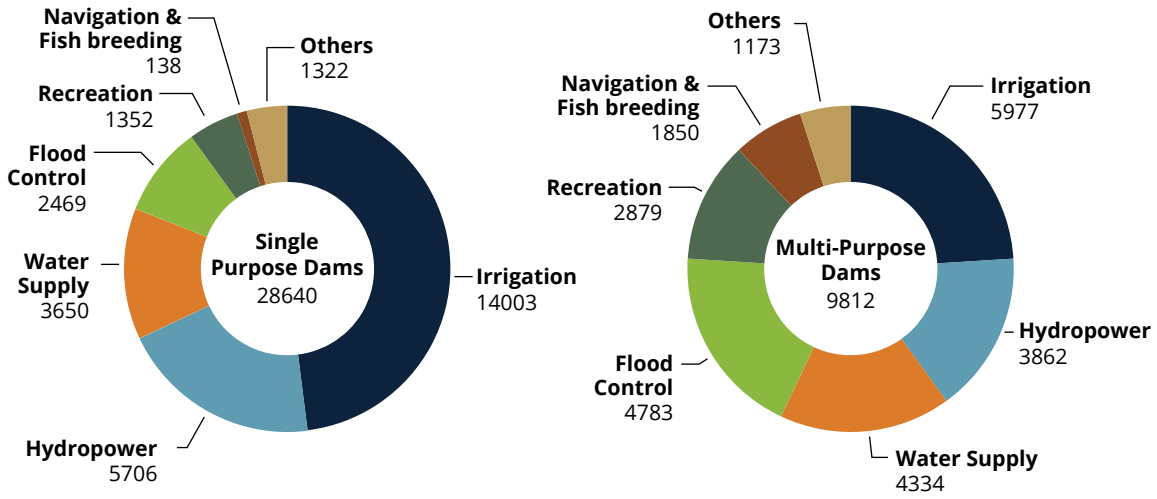
Besides gender inclusivity, other stakeholders play important roles in benefit sharing and should be engaged throughout the project life cycle. These stakeholders include governments at various levels, educational institutions, community development organizations, watershed/basin management entities, nongovernmental organizations, financial institutions, and local/international contractors and suppliers. Engaging with these stakeholders could provide valuable information, build institutional capacities, identify co-funding opportunities, and foster partnerships to advocate for and implement benefit-sharing programs.

Community stakeholders should be involved in decision-making regarding the use of and access to the hydropower reservoir. In 2015, the International Commission on Large Dams recorded 38,452 large dams in its register. Notably, 26 percent of these dams are multipurpose (EDF and WWC 2015). Besides hydroelectricity generation, other critical uses and services are listed below and illustrated in figure 4.4.

- **Irrigation.** Supplying water to farmland aids in cultivating crops and revegetating disturbed soils, particularly in arid regions. Most large dams worldwide have been built for irrigation, either by their design or as a by-product. This function plays a crucial role in the water-energy-food nexus.

FIGURE 4.4

Uses of Dams/Reservoirs by Purpose according to the International Commission on Large Dams Database



Source: EDF and WWC 2015.

- **Drinking water supply.** In the early days of dam development, one motivation was the storage of water for a secure and accessible supply of drinking water. Reservoirs remain critical today for supplying fresh water through pump and pipe systems.
- **Recreation.** Many reservoirs offer opportunities for recreational activities such as fishing, sailing, water skiing, swimming, among others. However, while fishing is usually a recreational activity in developed economies, it is critical to food supply in developing economies. These recreational activities, often incidental, have become a priority for local communities, attracting tourists to the surrounding areas. Box 4.6 illustrates the impact of the Kaligandaki hydroelectric project in Nepal.
- **Navigation**. Dam construction creates reservoirs, which elevate water levels upstream and regulate flow rates, resulting in improved navigational conditions. This involves submerging hazardous areas, such as rocks and sandbanks, and maintaining adequate water depth downstream year-round. While dams pose a navigational barrier, boat passages like locks, lifts, and ramps are implemented to facilitate safe passage. Inland navigation is critical to transportation and trade, and, consequently, economic growth.
- **Flood control**. Dams regulate river flows by storing and controlling floodwater discharge, thereby protecting people and assets and supporting agriculture and industry. Reservoir regulations are established to balance drawdown levels and prevent spills, while maintaining optimal hydraulic heads for hydro generation.
- **Drought mitigation**. Dams and their reservoirs contribute significantly by storing water and enabling its additional supply during droughts, mitigating impacts on ecosystems and agriculture in the affected regions.
- **Commercial fisheries**. Besides recreational fishing, some reservoirs support commercial fisheries through boat fishing, trapping, and artificial stock enhancement. Commercial fish farming has witnessed increased development in various regions.

Box 4.7 highlights an interesting study in the United States on the impact of multipurpose dams and reservoirs on national economic development.

When hydropower infrastructure is designed to have multiple uses (besides electricity generation), it may impact the ability to provide flexibility to the grid. Rapid changes in electricity generation, causing rapid variation in water flow in downstream rivers and/or water level in reservoirs, are not always compatible with many of the services to navigation, recreation, or ecosystems. Therefore, a balance among revenues, grid flexibility needs, and service provision must be carefully considered and agreed upon among the responsible authorities (see box 4.8).

Regulatory requirements become significantly more intricate for multipurpose dams than projects dedicated to a single function. Allocating water rights and quotas among users, often with conflicting demands, extends across a substantial section of the river basin.

BOX 4.6

IMPACT OF THE KALIGANDAKI, A HYDROELECTRIC PROJECT ON TOURISM IN MIRMI, NEPAL

A 2022 study surveyed local communities surrounding the Kaligandaki, a hydroelectric project, to understand how the presence of the dam and reservoir has impacted tourism and, consequently, livelihoods in Mirmi, Nepal. A total of 162 community members shared their perceptions. Following are the key findings from the survey:

- Forty percent of the respondents stated that their household income increased after the construction of the hydroelectric project. More than half of the respondents (54.9 percent) stated that their household income remained the same after the project's construction. A very small fraction reported lower income.
- Most respondents (93.2 percent) stated that hydropower had positively affected their local community.
- 64.2 percent said that the location had become more easily accessible.
- 42.6 percent said that tourism in the area had improved significantly, and 40.1 percent said it had improved somewhat.
- Respondents stated that the number of hotels, shops, restaurants, homestays, resorts, and recreational centers had grown significantly.
- 66.7 percent stated that they had either directly or indirectly benefited from growth in the tourism industry, and 60.5 percent said their quality of life had improved because of the increase in tourism.
- 81.5 percent had a positive perception of tourism development in the area.

Photo: Kaligandaki, a Hydroelectric Power Station, Situated near Mirmi, about 300 Kilometers West of Kathmandu

Source: Sunuwar 2022.

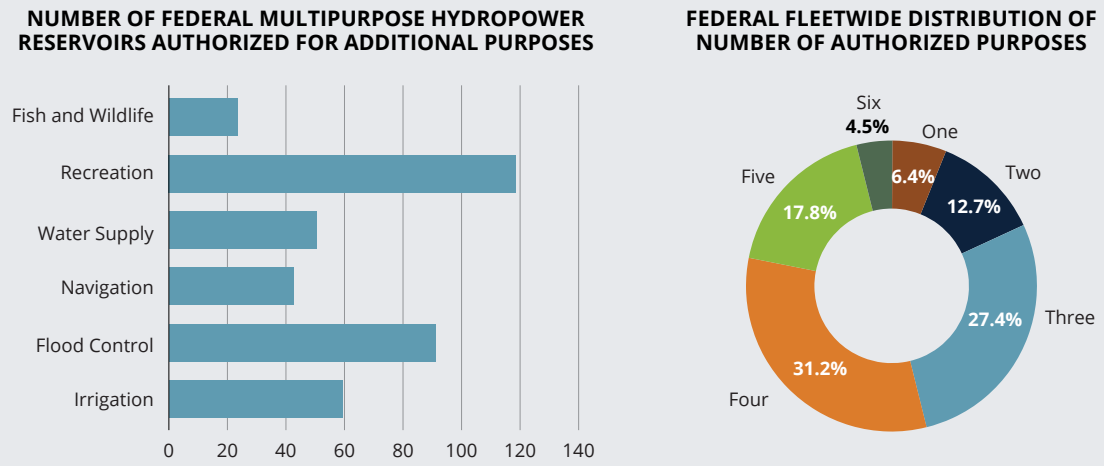
BOX 4.7

CONTRIBUTION OF MULTIPURPOSE DAMS TO NATIONAL ECONOMIC DEVELOPMENT IN THE UNITED STATES

In 2015, the Oak Ridge National Laboratory in the United States embarked on a comprehensive study to assess the annual contribution of multipurpose dams to national economic development. This investigation centered on three key federal hydropower entities: the Tennessee Valley Authority, the US Army Corps of Engineers, and the US Bureau of Reclamation. Collectively, these agencies own and oversee 157 powered dams, constituting nearly half of the total installed hydropower capacity in the United States.

The majority of these hydropower reservoirs were authorized for recreational use, 119 out of 157 dams (76 percent), whereas only 42 were authorized for navigation purposes. Notably, over 58 percent of federal reservoirs play a crucial role in preventing flood damages; two-thirds of these reservoirs were initially designed primarily for flood control. A discernible trend emerges in the distribution of multipurpose reservoirs(refer to the graph on the right in figure B4.7.1): a substantial majority, exceeding 80 percent, serve three or more distinct purposes. It must be highlighted that this study exclusively considers reservoirs with authorized hydroelectric generation; 6.4 percent of the reservoirs authorized for a solitary purpose, are solely designated for hydropower. The remaining segments of the graph represent a combination of hydropower and another purpose, such as flood control or irrigation.

Distribution of Authorized Uses for All Federal Multipurpose Hydropower Reservoirs:



Source: NHAAP 2015.

BOX. 4.7 *(CONTINUED)*

The subsequent benefits analysis uncovered a noteworthy insight—while power generation constitutes a critical aspect of many multipurpose projects, it does not consistently yield the most considerable national economic development benefit. Instead, recreation and irrigation emerged as the primary contributors to the most substantial economic gains for federal multipurpose reservoirs. Key factors influencing these benefit distributions encompassed metrics such as the number of recreation visitors, associated spending, and the economic value derived from irrigated crops.

Source: ORNL 2015.

BOX 4.8

WATER MANAGEMENT: SRIRAM SAGAR IN THE GODAVARI BASIN, INDIA

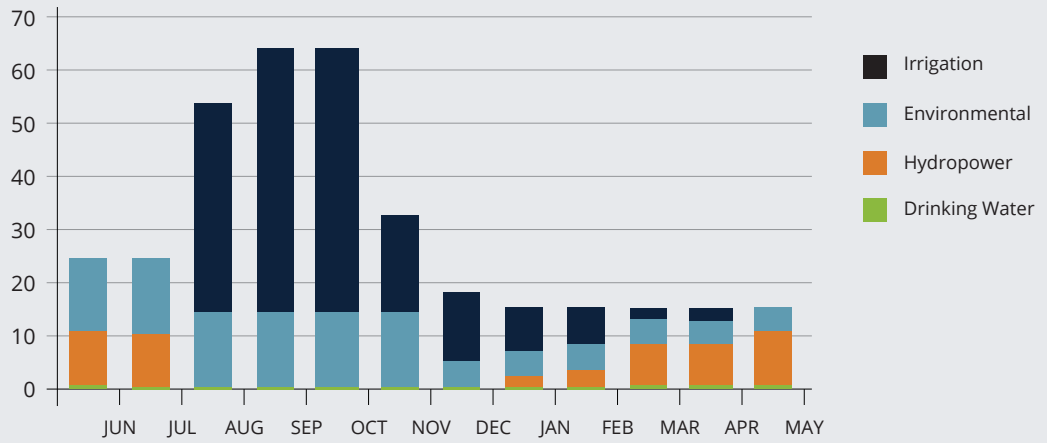
The Sriram Sagar Project is a multipurpose project located across the Godavari River near Pochampad of Nizamabad District in Andhra Pradesh, India. The reservoir water irrigates 390,000 hectares of land through three canals, supplying drinking water to the more than 12 million people residing nearby, while also supplying water for a 36 MW hydropower plant.

During a typical year, the Sriram Sagar Project area may experience water shortages at the beginning of the wet season if inflow has not been sufficient large to fill the reservoir but the optimum quantity of water to meet demand is withdrawn. Then, water shortage is also indicated for the second half of the dry season (March to May). For a dry year, water shortage is evident for both optimum and minimum water demand. The predominant use of water is for irrigation. Allocations of water for drinking and industrial use are minimal. However, during years of scarcity, priority is given to drinking water through the same canal system, which prevents water from being drawn for irrigation.

The Building Block Methodology showed to be a potential educational tool to develop strategies on how hydropower development can be sustained, while addressing the needs of other water uses, especially irrigation, and adverse impacts on environment and society. Each user group was allowed to define their optimum and minimum water demand for each month, presented as a "building block" in a graph over the year. Using such a system enables better planning and makes it possible to meet different demands of water management. For Sriram Sagar, hydropower generation and downstream environmental flows had lower priority than irrigation and water supply. However, in dry years, all services would receive enough water to meet the minimum demands.

BOX. 4.8 *(CONTINUED)*

Optimum water demand as defined by user groups:



Source: Bakken et al. 2013.

Note: TMC = thousand million cubic feet.

Consequently, the need for inter- and cross-sectoral coordination intensifies, requiring strong institutional capabilities.

In multipurpose dam projects, a crucial challenge is to balance a project's financial viability with communities' needs. Potential conflicts between a reservoir's community uses, such as navigation or water supply, and energy generation potential can be significant. It must be noted that in some cases, accommodating additional uses of a reservoir may not be financially feasible or may incur additional costs. For example, the ability to support irrigation is often dictated by the surrounding landscape. These factors must be carefully considered before committing to any decisions that may impact local communities.

Economic analyses for multipurpose hydropower projects can help to empower decision-makers to assess the projects' costs and benefits, in turn aiding the identification of the most economically feasible approach. Such economic analyses would estimate the costs for construction, and operation and maintenance and compare them against the expected benefits, such as revenue from electricity sales and other project-related societal advantages, for example, irrigation and navigation. Moreover, these analyses help identify the most cost-effective project design and management strategies considering variables such as energy demand and water availability. In 2024, the World Bank will release a new guideline on conducting economic analyses for multipurpose hydropower projects (World Bank forthcoming).

BOX4.9

ISSUING LOCAL SHARES IN HYDROPOWER PROJECTS IN NEPAL

In Nepal, a unique approach to equity sharing has emerged. Companies issue local shares directly to individual investors, aspiring to raise capital or grant equity partnerships to local communities. Unlike approaches in other countries, Nepal focuses primarily on individuals rather than entire communities or local governments. The approach originated with the 22.1 MW Chilime hydropower project, in which the local demands for equity shareholding were met seven years into the project's operations. Shareholders were allowed to purchase up to 10 percent of shares at a par value of NPR 100, below the market value. Positive early returns and financial empowerment have been notable benefits. One primary driver in the movement to acquire local shares, has been a lack of trust in the local governments and community entities that are traditionally responsible for handling benefit-sharing funds. This distrust is deeply rooted in a tradition of weak governance and concerns about elite capture and social discrimination. Consequently, people have reported feeling more secure in making their own investment decisions independently.

However, recent downward trends in share prices have raised some concerns about the sustainability and understanding of this relatively new approach. Recommendations to address these challenges include:

- Enhanced community education on financial literacy and hydropower,
- Strengthened disclosure of project information through user-friendly content, and
- The creation of low-risk financing mechanisms for vulnerable households.
- Sustained outreach, communication, and public consultation throughout the project life cycle are also important.

Source: IFC 2018.

Government trust and recognition should be critical factors in deciding which benefit-sharing mechanisms to pursue. Administering benefit sharing through government entities, such as through tax, royalty, and license revenue, can effectively help deliver benefits to local communities, especially if they are designed to ensure direct fund flow to the municipal level. However, if this becomes the primary method for communities to share in the financial rewards of projects, then the government entities overseeing fund allocation need to have the trust of the local population. A case in point is in Norway, where taxation serves as the primary method for distributing benefits to local communities. The success of this approach is significantly connected to the strong trust in Norwegian government institutions, which ensure the just and equitable management and administration of funds.

When corruption is prevalent in local entities or when there is a history of distrust in local governments, then developer- or operator-led programs may be perceived as more effective and garnering more significant support from local populations. Another viable option is to implement mechanisms that place control over benefit-sharing activities in the hands of communities, as shown in box 4.9. This approach empowers communities and fosters a sense of ownership and trust in the equitable distribution of project benefits.

Where the financial rewards of projects are shared directly with community-controlled entities, such as community trusts, measures must be implemented to prevent "elite capture," which involves undue control gained by a select few individuals in influential positions. Governments should contemplate establishing principles for developers and communities to uphold when forming such funds. Additionally, governments must ensure that communities receive adequate training and support to manage these funds transparently and responsibly. Fostering a commitment to integrity and providing the necessary tools for transparent fund management can help governments mitigate the risk of elite capture, in turn making benefit-sharing initiatives more effective overall. Box 4.10 illustrates a successful example from Canada.

BOX 4.10

AVOIDING ELITE CAPTURE IN THE EASTMAIN DEVELOPMENT IN CANADA

Hydro-Québec, a key player in electricity generation, transmission, and distribution in Quebec, collaborates closely with local communities and adheres to three core principles: profitability, environmental responsibility, and positive community reception.

The Eastmain development, where two hydropower generation facilities have a combined capacity of 1,248 MW, involved collaboration with six indigenous communities. The developer prioritized local acceptance by engaging in consultations with stakeholders, including Cree land users with family hunting territories in the project area. In 2002, after a formal vote, the communities consented to the project under specified conditions, leading to the signing of two impact benefit agreements.

BOX. 4.10 *(CONTINUED)*

These agreements encompass a broad spectrum of commitments, which help ensure fair distribution of benefits and meaningful involvement of Cree communities in decision-making processes. To operationalize these agreements, the parties established the Niskamoon Corporation—a joint Cree/Hydro-Québec nonprofit. It is governed by an eight-member board appointed by the Cree Nation Government, and has three additional directors from Hydro-Québec. The corporation is structured to prevent elite capture by ensuring that individuals from the beneficiary communities can attain board positions, whereas elected officials are not eligible.

Niskamoon's primary objective is to help the Cree communities, land users, and entities affected by hydroelectric development gain access to funds and programs. The corporation supports local officers in proposal and report preparation, communication, and project monitoring. Its inclusive approach extends to cultural initiatives, training programs, employment initiatives, and participation in research projects.

Transparency is a cornerstone of Niskamoon's operations, as demonstrated by detailed annual reports distributed to Cree Nation members through their Band Office. These reports include audited financial statements, which ensure accountability and trust. Through Niskamoon, Hydro-Québec and the Cree communities aim to promote coexistence on the land for both the present and future generations.

The Eastmain-1 Development is the first recipient of a gold-level certification under the Hydropower Sustainability Standard. Also, it was the winner of the International Hydropower Association's Blue Planet Prize, with particular merit for the work engaging indigenous groups.

Source: Chisasibi n.d.; World Bank Market Sounding 2023; IFC 2020a.

The design of benefit-sharing initiatives should consider any existing tension within or between communities. While promoting socioeconomic development within the project-affected communities is undoubtedly positive, it could also create unwanted social tensions regionally. The delineation of who will and will not benefit, creates a natural divide between "haves" and "have nots." Addressing this divide can be challenging, and thus underscores the importance of obtaining a comprehensive understanding of the region's social fabric before designing and implementing benefit-sharing initiatives. This approach helps prevent preexisting tensions from compounding and allows for a more informed forecast of how the influx of funding and programming might impact local dynamics. For instance, unequal access to public services can trigger tensions within and between communities, while providing free electricity to nearby communities may lead to undesired migration into the area, contrary to the local community's wishes. Box 4.11 illustrates how benefit sharing was designed to prevent tensions surrounding the Rusumo Falls project.

Monitoring and evaluation of the impacts of benefit sharing should be sustained over the long term. When selecting the mechanism for delivering benefits, consideration must be given to how monitoring and evaluation can be performed and who will be responsible for them. The lessons learned from the monitoring processes can fit into a circular loop of improved benefit-sharing practices and implementation, maximizing positive impacts, as shown in box 4.12.

PHOTO 4.6

Remote community in the Philippines receives electricity for the first time from a community-run micro hydro installation

BOX 4.11

RUSUMO FALLS PROJECT: FOSTERING EQUITABLE COLLABORATION FOR REGIONAL PROSPERITY

Addressing historical tensions in the region was a key consideration in the Rusumo Falls project. This led to a strategic decision to hire 80 percent of construction staff from the three countries involved—Tanzania, Rwanda, and Burundi. A total of 410 individuals were hired, and employment was distributed evenly, with an aim to foster inclusivity and avoid exacerbating existing clashes.

To ensure fairness, each country was allocated an equal benefit-sharing budget, of US$5 million. Although Tanzania initially opposed this allocation—because it wanted a larger portion of the budget, due to greater impacts from construction—it was acknowledged that it also reaped significant benefits in terms of new business opportunities around the project site. The final decision was to divide the funds equally.

The benefit-sharing projects were self-directed, empowering the community to prioritize initiatives. While the Project Implementation Unit supervised the budget, the communities underwent procurement and financial management training, which enhanced their capacity to manage the allocated resources effectively.

For the operation and maintenance phase, the project had three options: complete outsourcing, hiring one of the three state utilities, or establishing a jointly owned company, which would equally employ individuals from all three countries. Choosing the third option, the project enlisted Manitoba Hydro to design the jointly owned company's structure and support recruitment and training. This ensured a collaborative and equitable approach to operations and maintenance.

Again, the strategic decision to equitably divide responsibilities and benefits between the three countries was made to avoid any potential tensions.

Photo: Rusumo Falls Hydropower Project. A Joint Initiative among Tanzania, Rwanda, and Burundi
Source: Interviews with World Bank staff; ESMAP 2023b.

BOX 4.12

LOM PANGAR PROJECT: UNINTENDED CONSEQUENCES AND THE NEED FOR ADAPTIVE MANAGEMENT

The Cameroon-based Lom Pangar project illustrates how unintended impacts can create challenges, underscoring the critical importance of ongoing monitoring and course correction in large-scale development initiatives.

The local community surrounding the Lom Pangar project was assured that the dam's construction would enhance their fishing yields. However, the community, for which river fishing is the traditional livelihood, struggled to adapt to the new conditions in the reservoir.

Remarkably, the reservoir's introduction triggered mass in-migration; thousands of individuals relocated to the area to fish. Among the migrants were experienced fishermen and their families, who had spent their entire lives fishing on lakes. Unlike the local community, they adapted swiftly and thrived in their new environment.

This influx of newcomers can be viewed from both a positive and negative perspective, and is not uncommon with the introduction of major infrastructure projects. While fish yields for local inhabitants declined, the emergence of a new village has undoubtedly created a host of new business activities.

Ongoing monitoring can maximize the positive aspects of such circumstances. For example, for Lom Pangar, corrective action was taken by training the original inhabitants to improve their lake fishing skills and improve fishing yields. They were also provided with new equipment. In other major infrastructure projects that have resulted in population growth, equipping the local people with skills to develop small businesses has proven effective.

Sources: World Bank Market Sounding 2023; Diki 2021.

When designing benefit-sharing measures, developers and operators must balance what they can realistically deliver over the long term and communities' expectations. Often, hydropower projects are located in historically underserved, remote communities without essential infrastructure and educational access. Many of these communities, physically isolated due to inadequate road infrastructure, look to developers to address long-standing issues often stemming from historical neglect by governments. While expecting a single project or company to address these complex issues is unrealistic, it is crucial to recognize legitimate claims for inclusion.

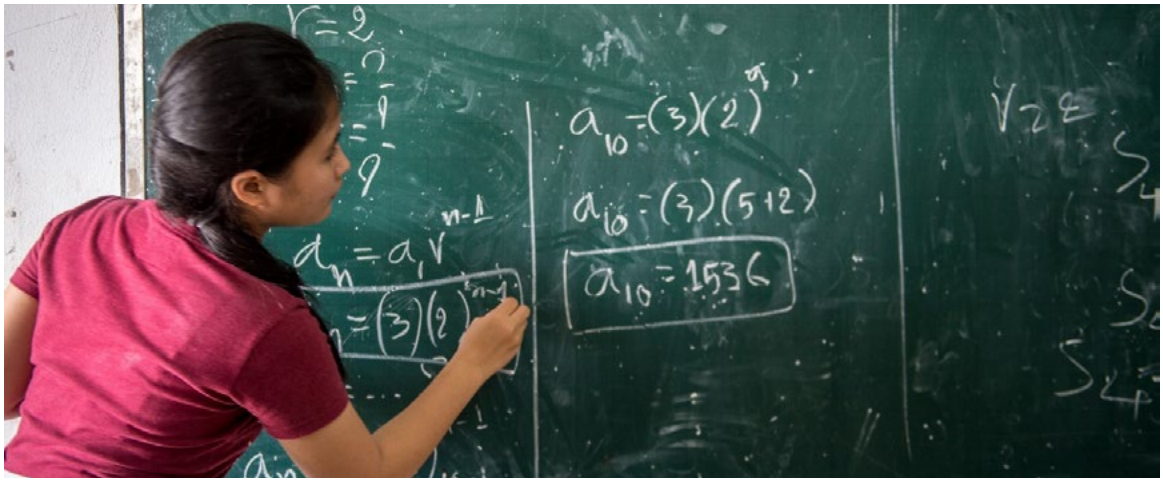
Choosing the most suitable entity to address development issues becomes a pivotal question. Developers or operators can handle smaller projects, but megaprojects with substantial benefit-sharing budgets (e.g., greater than US$5 million per year) require extensive administration and oversight. Identifying the most effective entity is essential for successful outcomes. Often, having a government partner can help ensure the longevity of impacts and alignment with overarching national and regional development goals. It may also ease the administration of funds over the long term.

Effective timing plays a crucial role in managing expectations. Limited funds for benefit sharing may be available during the planning stage, and uncertainties about project progression persist. Early community buy-in is essential, since communities are reluctant to wait until the construction phase for benefits. Funding for benefit sharing becomes more accessible after projects become operational, drawing from project revenue. However, the lead time to operations could extend over 10 years, causing frustration among locals. The expected benefits must be clearly communicated early to prevent disappointment and conflict.

A crucial aspect demanding thoughtful consideration is the duration and consequences of benefit-sharing activities. While well intentioned, models where local communities consistently receive financial compensation could inadvertently foster a sense of dependency, especially when the developer retains control over the benefit-sharing fund and holds the authority to disperse funds over the long term.

To counteract this, benefit-sharing activities should be structured to empower local communities, providing them with the agency to lead their development. An emphasis on education can prove particularly transformative and empowering, equipping community members with skills and knowledge that extend beyond the immediate project timeline.

PHOTO 4.4
School in a Resettlement Village near the Nanai Reservoir



BOX 4.13

PLANNING FOR POST-CONSTRUCTION EMPLOYMENT FOR LOCAL PEOPLE: THE CASE OF THE NACHTIGAL HYDROPOWER PROJECT IN CAMEROON

The Nachtigal hydropower plant, currently under construction, is a 420 MW run-of-river project on the Sanaga River in Nachtigal, Cameroon. The project is spearheaded by the Nachtigal Hydro Power Company, and ownership is shared among Électricité de France (40 percent), the International Finance Corporation (30 percent), and the Republic of Cameroon (30 percent).

Recognizing the significance of sustainability, project developers have prioritized planning for the postconstruction phase with the local community. The project is slated to generate up to 1,500 direct jobs during construction with a substantial 65 percent locally sourced workforce. Project developers acknowledge the need to proactively address the conclusion of these roles and mitigate potential unemployment challenges. The project has forged a close collaboration with Cameroon's agency for unemployment, which conducts training and coaching initiatives to help individuals seamlessly transition into new employment opportunities as the construction phase draws to a close. This comprehensive assistance extends to supporting individuals in preparing their CVs and navigating the job search and application process.

Source: World Bank Market Sounding 2023; NS Energy n.d.

Looking toward the future, it becomes imperative to contemplate the long-term sustainability of benefit-sharing initiatives. Questions arise concerning the fate of these programs when projects eventually reach their conclusion. Sustainability and exit considerations, such as the ones below, must be integrated into the design and management of community development programs:

- Can the program persist independently once the company withdraws its support?
- What are the existing plans for a seamless transition from project sponsorship to community-managed program management?

Postexit scenarios necessitate attention to the proper maintenance and operation of public infrastructure. A lack of resources, from communities and governments, may raise challenges, potentially hindering the upkeep of vital facilities. Addressing these concerns up front ensures that the positive impacts of benefit sharing endure, helping local communities to continue developing and remain self-reliant even after developers exit (see boxes 4.13 and 4.14).

The governance structures of benefit-sharing measures imply varying degrees of beneficiary involvement, partnership, and control. For instance, a community development fund might be overseen by the developer's corporate social responsibility department or the public works department of a district administration, or it may operate independently. Two common pitfalls must be addressed. First, projects may impose their perspective on communities' best interests. This leads to a top-down provision of benefits, which may not align with the communities' needs, or a nontransparent selection process, resulting in continuous requests for handouts. Second, projects may relinquish responsibility by handing over funding to recipients, risking unwise management if communities are not adequately equipped and prepared to administer the benefit-sharing program.

BOX 4.14

EMPOWERING COMMUNITIES THROUGH SUSTAINABLE INFRASTRUCTURE IN BRAZIL

ENGIE Brasil has established a network of cultural centers in the areas where it operates across Brazil. These centers provide a space for community members to meet and interact, offer a range of recreational programs, and also provide training, catering to individuals of all ages. However, the primary emphasis is on engaging young adults, getting them off the streets, and helping them build their skills, in turn reducing crime and drug use.

In the initial years of the centers' operation, ENGIE Brasil will cover all expenses. However, the goal is to ensure they are self-sufficient and sustainable over the long term. To achieve this, ENGIE collaborates with local nongovernmental organizations (NGOs) in each location, facilitating a transfer of operations to the local entity. ENGIE trains these NGOs to build their capacity for securing funding independently.

Source: World Bank Market Sounding 2023; ENGIE Brasil Energia 2022.

Involving different levels of government in implementation arrangements can help avoid these pitfalls. The case study in box 4.15 illustrates how the Intercontinental Exchange (Instituto Costarricense de Electricidad, ICE) in Costa Rica has worked closely with the government entity for ecosystem services to create a new income stream for farmers committed to engaging in ecologically restorative farming techniques.

BOX 4.15

CREATING A NEW SOURCE OF INCOME FOR FARMERS IN COSTA RICA FROM ECOLOGICAL SERVICES

Within the Payment for Environmental Services Program (Pago por Servicios Ambientales, PSA) framework, the Intercontinental Exchange (Instituto Costarricense de Electricidad, ICE), in close coordination with the National Forestry Financing Fund (Fondo Nacional de Financiamiento Forestal, FONAFIFO), has implemented a strategy to share benefits with landowners near its hydroelectric plants. The goal is to compensate these landowners for conserving and protecting forested areas, ecological restoration, and improving the ecological connectivity of protected areas.

Through this initiative, the ICE actively interacts with farmers, offering them training and support to develop new capabilities and achieve compliance with the technical and administrative criteria necessary to access benefits. This includes actions to recover degraded farmland, adapt to climate change, and transition to more sustainable farming techniques.

The program has produced multiple benefits. On the one hand, it allows farmers to diversify their sources of income, and on the other, it has improved the positioning of the ICE and the country in terms of implementing good environmental and social practices. Also, it has increased the forest cover and connectivity for protected areas, improving the ecosystem services that these areas provide.

Currently, the ICE Sustainable Farms Program supports 187 farms (850 hectares) by providing advice and technical assistance in the farm transition processes. In 2022, the ICE invested US$25,459 to incorporate 26 new farms into the program, making a tangible difference in local livelihoods and environmental management.

Source: ICE 2022; World Bank Market Sounding 2023.

5. Conclusions and Key Recommendations

The key lessons and best practices from analyzing the socioeconomic categories outlined in this report are summarized below. As in the report, gender and social inclusion are considered through an intersectional lens.

Leveraging the Hydropower Value Chain to Generate Socioeconomic Benefits

Actions to create an enabling environment (taken before project implementation and primarily government led):

1. **Conduct a thorough value chain analysis to capitalize on domestic resources.**
   - Comprehensively analyze the hydropower value chain to identify areas where domestic companies can competitively provide goods, services, and labor.
   - Assess gaps in domestically available resources that could be addressed in the short, medium, and long terms through support programs.
2. **Design programs to strengthen the capabilities of domestic businesses.**
   - Link to other national and regional initiatives that are already actively supporting the creation and growth of domestic companies.
   - Promote the establishment of industry clusters and associations to strengthen the capacities of domestic companies. Facilitate training, networking opportunities, technology transfer, and collaborative research and development through these organizations.
   - Create financial products tailored to the unique needs of the domestic companies participating in the hydropower value chain. Consider specialized programs for women and marginalized groups facing more significant barriers to business creation and growth.
   - Regularly monitor the effectiveness of localization efforts and support programs. Be prepared to adjust strategies based on evolving industry dynamics and economic conditions.

Actions to commence at the outset of project planning (government, developer, and operator led):

3. **Establish connections between developers/operators and domestic companies.**
   - — Share findings from value chain analysis with developers/operators to build awareness of domestic capabilities and facilitate competitive domestic procurement (government led).
   - — Research the capabilities of domestic companies to provide goods and services along the value chain. Explore opportunities for joint ventures with local partners (developer and operator led).
   - — Consider supplier development programs to strengthen the capacities of domestic companies (developer and operator led).
4. **Implement strategic procurement strategies to incentivize competitive domestic procurement.**
   - — Implement project procurement strategies that incentivize the involvement of domestic companies without compromising project viability or increasing tariffs. For example, in a competitive bidding process, preferential points can be given to bidding companies that demonstrate a willingness and ability to procure domestically (government led).

Expanding the Workforce with Jobs and Skills in Hydropower

Actions to create an enabling environment (taken before project implementation and primarily government led):

1. **Foster collaboration for industry-aligned education.**
   - — Facilitate collaboration among hydropower developers, educational institutions, and relevant ministries to ensure educational programs align with the industry's needs.
   - — Purposefully design educational programs (higher education, technical and vocational education and training, and professional development) to nurture the skills required at all levels of the hydropower sector, including engineering, management, and technical positions. Labor requirement assessments should be undertaken to avoid overtraining, given the size and potential of the domestic hydropower sector.
   - — Develop data collection and monitoring systems to track progress in job creation, gender and social diversity, and skill development.

Actions to commence at the outset of project planning (government, developer, and operator led):

1. **Enhance domestic hydropower skills and the domestic labor pool.**
   - Develop structured professional development programs to equip young graduates with hydropower-specific skills through classroom and field learning and ensure that existing employees are reskilled with the latest techniques and approaches (government, developer, and operator led).
   - Leverage public-private partnerships to increase technical and vocational education and training (government, developer, and operator led).
   - Provide on-the-job training opportunities (especially in construction and operation and maintenance) to fill skill gaps and ensure the local/community-level workforce is adequately equipped for employment opportunities (developer and operator led).
2. **Promote gender diversity and social inclusion.**
   - Enact inclusive policies at the government and corporate levels to foster diversity. Establish clear targets for boosting female representation, especially in technical roles (government, developer, and operator led).
   - Implement mentorship, leadership, and professional development programs to empower women and marginalized groups in the hydropower sector (government, developer, and operator led).
3. **Incentivize domestic and local labor through strategic procurement practices.**
   - Implement project procurement procedures that incentivize the recruitment of domestic or local labor. Ensure measures are implemented alongside capacity-building initiatives (government led).

Advancing Local Development and Benefit Sharing

Actions to create an enabling environment (taken before project implementation and primarily government led):

1. **Consider multiple uses of dams and reservoirs as a pathway to share benefits with local communities.**
   - Explore how projects can be designed to support essential societal needs, for example, navigation, recreation, and irrigation, alongside electricity generation. These "co-benefits" can enable significant socioeconomic development within communities, especially through job creation in tourism, recreation, fisheries, and agriculture.

— Involve local communities in decisions regarding the use of and access to hydropower reservoirs; consider their needs and preferences. Provide capacity building where needed to maximize the benefits they can draw from their water services.

2. **Enhance regulatory frameworks for benefit sharing.**

— Evaluate legal frameworks to incorporate comprehensive benefit-sharing strategies, for example, through taxes and royalties.

— Explore how project-specific benefit-sharing programs can contribute to a country's regional socioeconomic development plans. Share local development plans where they exist so that developers can build upon established goals.

— Integrate monitoring and evaluation into the regulatory framework to ensure that the desired impacts are achieved over time.

Actions to commence at the outset of project planning (government, developer, and operator led):

1. **Understand community needs and design tailored benefit-sharing programs to respond.**

— Invest in community engagement to understand communities' wishes and design benefit-sharing programs that balance communities' needs and financial viability. Maintain an open line of communication to prevent project delays and legal issues. Ensure inclusivity in benefit-sharing programs by considering the needs of marginalized groups and promoting the equitable distribution of benefits (developer and operator led).

— Align local communities' needs with government priorities to create benefit-sharing programs that contribute to broader community and development goals (government, developer, and operator led).

— Collect baseline data to monitor and track the success of benefit-sharing programs. Continuously assess and adjust programs based on findings to remain effective (government, developer, and operator led).

2. **Explore pathways for sharing benefits with local communities.**

— Explore opportunities to improve local infrastructure and essential services, develop local skills to empower community members (in hydropower and more broadly), and explore ways to share the financial rewards of projects through revenue sharing and ownership-sharing arrangements (developer and operator led).

— Understand existing social conditions within and between communities before designing benefit-sharing initiatives; this is to prevent exacerbating existing issues or divisions (government, developer, and operator led).

— Plan for the long-term sustainability of benefit-sharing initiatives; while planning initiatives, consider post-project scenarios and the transition to community-managed programs (government, developer, and operator led).

3. **Collaborate with local government entities for oversight.**

   — Collaborate with government entities at different levels to ensure adequate oversight and administration of benefit-sharing programs, leveraging existing infrastructure and expertise (government, developer, and operator led).

   — Avoid pitfalls such as imposing perspectives on communities or relinquishing responsibility without adequate preparation; avoid pitfalls by involving government agencies in implementation arrangements (government, developer, and operator led).

   — Implement a robust monitoring and evaluation system to ensure that the desired impacts transpire.

4. **Leverage the project procurement process to ensure that communities benefit equitably from project development and operation.**

   — Include provisions in procurement documents that incentivize benefit sharing so that project actions are aligned with community expectations and government objectives (government led).

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Annex 1. Methodology

Overall Approach

This report follows the approach outlined in the World Bank's Sustainable Risk Mitigation Initiative report "A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables" (World Bank 2022a). The following four socioeconomic categories are detailed in this report, in section 1.2 and figure 1.2, respectively:

1. Participation of domestic companies in the hydropower value chain
2. Hydropower employment and skill development
3. Local development/benefit sharing, including water-related services
4. Gender equality and social inclusion (a cross-cutting category)

Methods

The information for the socioeconomic categories in this report was derived from an extensive literature review and interviews with stakeholders from the hydropower sector. A thorough literature desk review was initially conducted, which included gathering information and data on each category. Initial interviews were conducted with various technical and social development experts from the World Bank–related hydropower projects. The experts also provided literature and case studies on projects. These, along with the literature review, were consolidated into a draft note, through which gaps in information were drawn up to be filled through additional interviews.

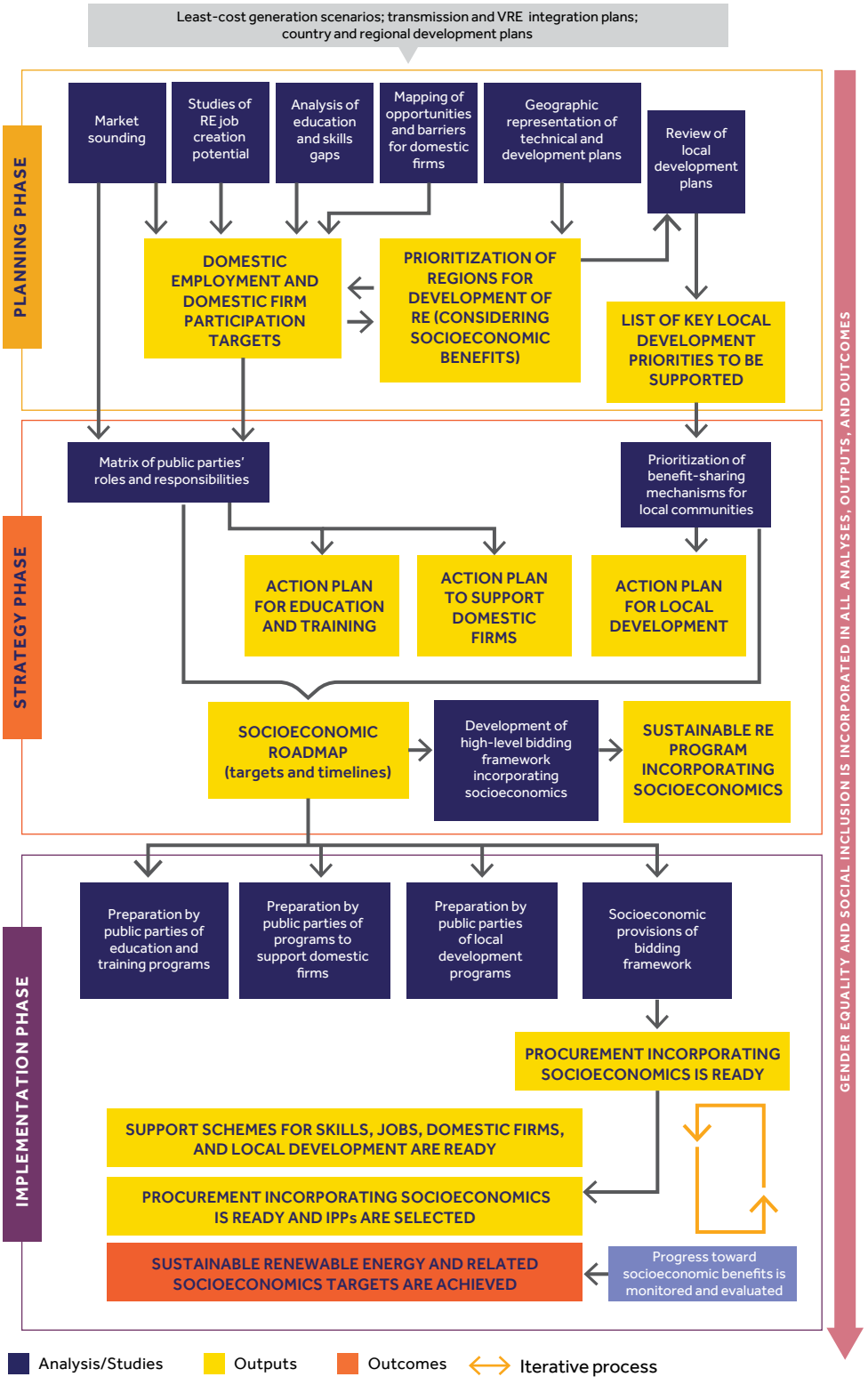
Online interviews were held in October and November 2023. Besides 13 World Bank experts, 37 stakeholder experts from the hydropower industry participated in these interviews; these included experts from governments, industry associations, international organizations, academia, and public and private sector developers. Each interview took about 90 minutes, and some stakeholders provided additional written information and reports after interview. These consultations provided insights and an understanding of ongoing initiatives, projects, and research around socioeconomic benefits in the hydropower sector. While the four socioeconomic categories provided the overall frame, consultations were tailored depending on the type of institutions and experts interviewed. For example, more detailed discussions were held with private sector players—on the participation of domestic companies in the hydropower value chain, and their ongoing efforts on benefit sharing—or for specific inputs, for example, with manufacturing companies.

Following the online consultations, hydropower developers were provided a survey questionnaire, which was designed specifically for them and for collecting quantitative data. Nine developers provided detailed inputs on focused queries around the socioeconomic categories. Queries were both quantitative and qualitative. The survey was put together mainly for companies to review the information of the various figures produced on different aspects of the value chain, for example, the participation of domestic companies, total capital expenditure for each segment, jobs, and whether any roles needed to be added or had been miscategorized. In addition, several queries were also added on the other categories of skill development, gender, and local development.

Annex 2. Underpinning Theory of Change

FIGURE A2.1

Three-Phased Approach to Maximizing the Socioeconomic Benefits of Renewable Energy



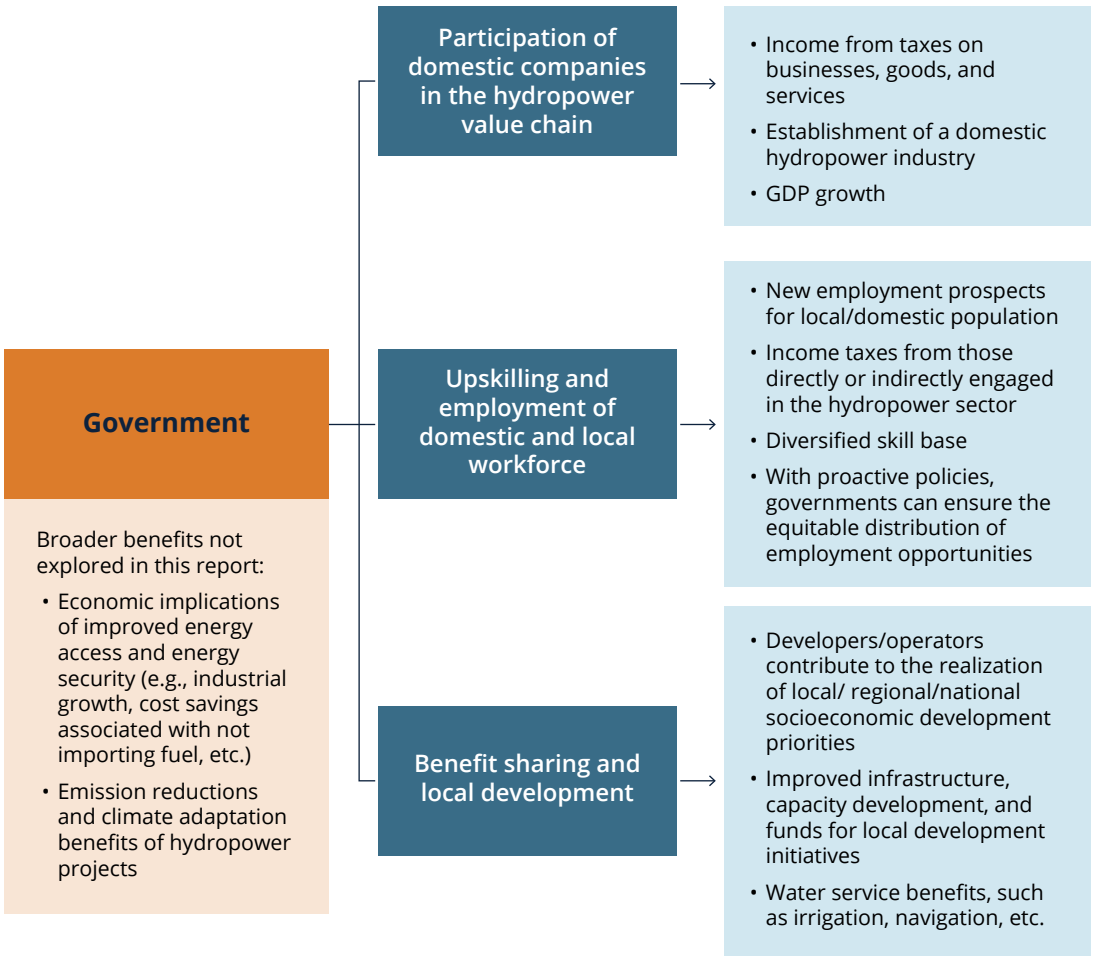
Source: Extracted from World Bank (2022a).

Note: IPP = independent power producer; RE = renewable energy; VRE = variable renewable energy.

Annex 3. Framework for How Stakeholder Groups Benefit

FIGURE A3.1

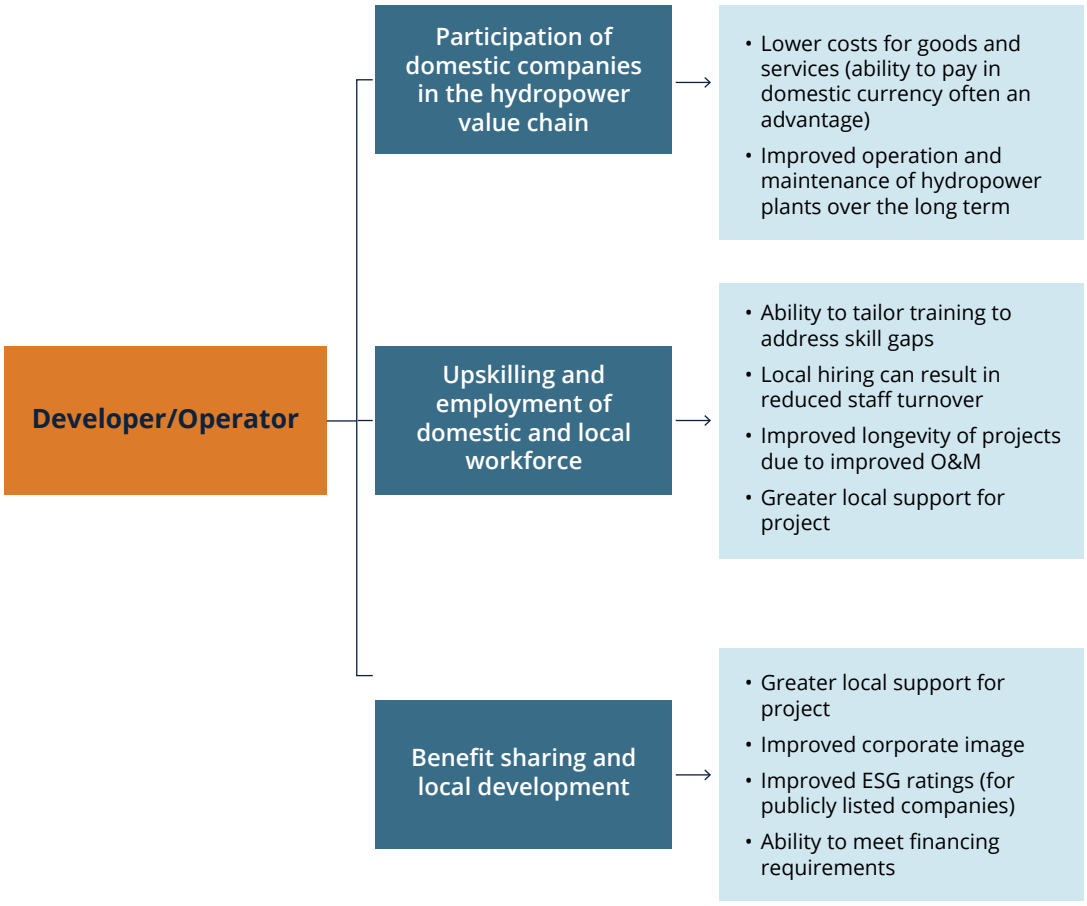
Framework for How the Government Realizes Benefits



Source: Original figure developed by authors for this report.

Note: GDP = gross domestic product.

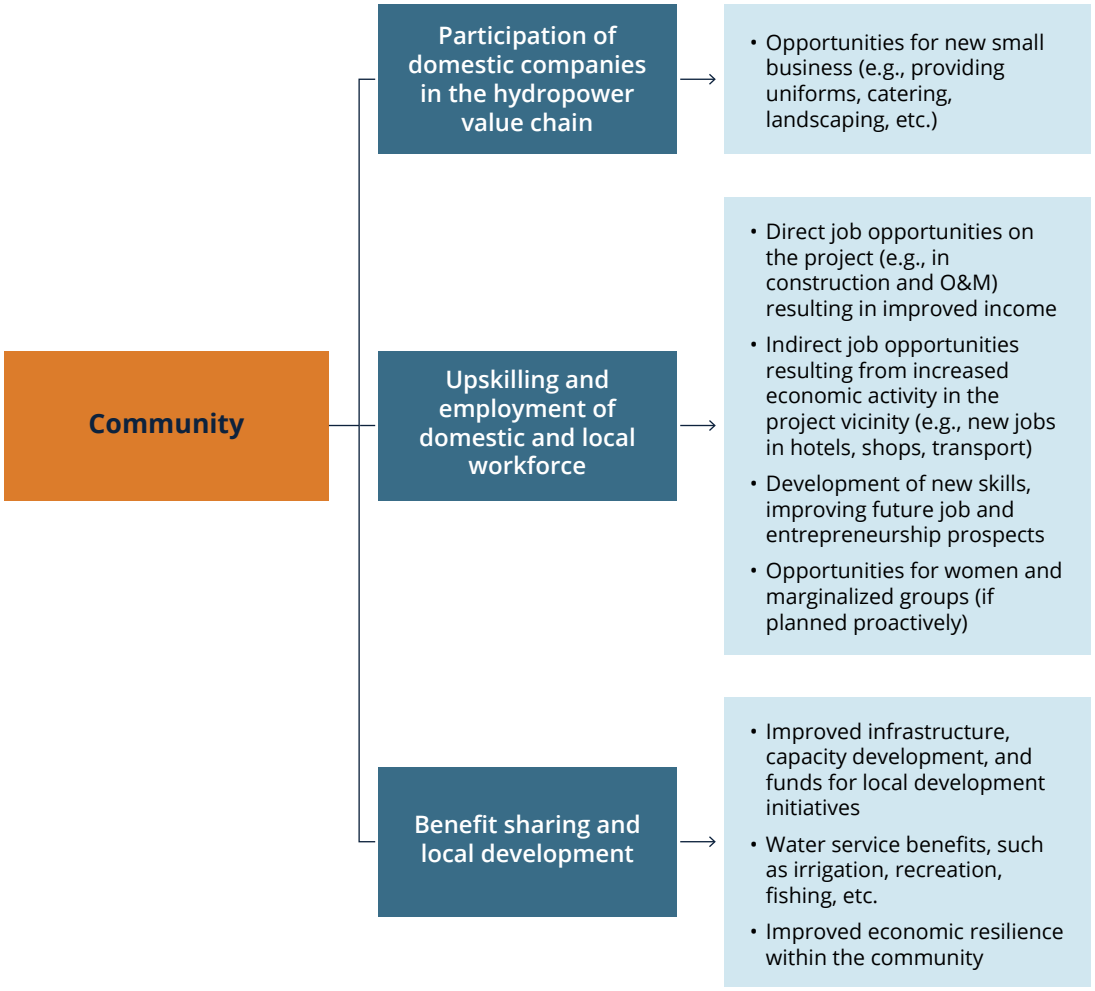
FIGURE A3.2
Framework for How Developers/Operators Realize Benefits



Source: Original figure developed by authors for this report.
Note: ESG = environmental, social, and governance; O&M = operation and maintenance.

FIGURE A3.3

Framework for How Communities Realize Benefits



Source: Original figure developed by authors for this report.

Note: O&M = operation and maintenance.

Annex 4. Notes on the Cost Breakdown for the Value Chain

Various factors influence the costs associated with the construction and operation and maintenance (O&M) of hydropower facilities. These factors include the complexity of the facility and the required civil works, and the project's location. Projects in remote areas, where provisions for staff accommodations, utilities, and other facilities are necessary, generally incur higher costs compared with projects that are nearer to urban centers. Moreover, the cost landscape is heavily influenced by labor costs and skill availability within a country. Costs may escalate if specialized skills are scarce, necessitating the employment of expatriates. Additionally, the regulatory framework governing permits, licenses, and administrative expenses varies by facility and country. Traditional public utilities often maintain more considerable staff resources, contrasting with leaner operations favored by commercial organizations.

Benchmarking offers insights into O&M costs. The International Renewable Energy Agency provides benchmarks ranging from 1 to 4 percent of construction costs, depending on a facility's size. Consultants commonly utilize an average of 1.5–2 percent for medium-sized facilities (World Bank 2020b). Another benchmarking approach considers costs per megawatt per year. The World Bank's "Operations & Maintenance Strategies for Hydropower: Handbook for Practitioners and Decision Makers" (World Bank 2020b) provides more detailed information on these costs. One global hydropower developer consulted in the preparation of this publication reported estimated annual costs of US$5–10/megawatt-hour for medium-sized projects—slightly higher than the 2020 benchmarks, possibly due to price escalations.

O&M costs include:

- Costs for the head office, administration, and engineering;
- Expenses due to power station and control room staff;
- Costs for planned maintenance and inspection;
- Equipment and vehicle costs;
- Insurance, utilities, environmental, and social costs; and
- O&M camp expenditures and contingencies.

Notably, costs due to O&M staff constitute a significant portion of the operating expenditure budget—at times up to 50 percent.

Refurbishment and decommissioning typically entail separate capital expenditure (CAPEX) plans. Major refurbishment programs are estimated to cost approximately 25 percent of the original construction cost, adjusted for inflation, and they are typically initiated 25–30 years after a facility commences. The World Bank's O&M handbook (World Bank 2020b) provides a detailed example of a 100-year O&M + refurbishment CAPEX program, offering valuable insights for practitioners and decision makers in the hydropower sector.

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