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# Policy and Institutional Study on the Strategic Role of Water Storage in Bhutan

**Built Water Storage in South Asia Project**

Radheeka Jirasinha, Sanjiv de Silva, Matthew McCartney, and Tenzin Khorlo





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**International Water Management Institute (IWMI)**

## The Authors:

**Radheeka Jirasinha**, Researcher - Freshwater and Wetland Management, International Water Management Institute (IWMI), Colombo, Sri Lanka

**Sanjiv de Silva**, Senior Regional Researcher - Natural Resources Governance, IWMI, Colombo, Sri Lanka

**Matthew McCartney**, Research Group Leader - Sustainable Water Infrastructure and Ecosystems, IWMI, Colombo, Sri Lanka

**Tenzin Khorlo**, Chief Environment Officer, Water Resources Planning and Monitoring Division, Department of Water, Ministry of Energy and Natural Resources, Bhutan

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## Collaborators



International Water Management Institute (IWMI)



Ministry of Energy and Natural Resources, Bhutan



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# Acronyms and Abbreviations

ADB	Asian Development Bank
BhWP	Bhutan Water Partnership
BWSI	Bhutan Water Security Index
BWSSA	Built Water Storage in South Asia
DECC	Department of Environment and Climate Change
DGPC	Druk Green Power Corporation
DITT	Department of IT and Telecommunications
DoA	Department of Agriculture
DoE	Department of Energy
DoF	Department of Forests
DoW	Department of Water
EIA	Environmental impact assessment
EWS	Early warning systems
FEMD	Flood Engineering Management Division
FYP	Five Year Plan
GDP	Gross domestic product
GNH	Gross national happiness
GNHC	Gross National Happiness Commission
GLOF	Glacial lake outburst flood
GWP	Global Water Partnership
IWMI	International Water Management Institute
IWRM	Integrated water resources management
KIIs	Key informant interviews
MoENR	Ministry of Energy and Natural Resources
MoIT	Ministry of Infrastructure and Transport
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NCHM	National Center for Hydrology and Meteorology
NDCs	Nationally Determined Contributions
NEC	National Environment Commission
NIWRMP	National Integrated Water Resources Management Plan
NKRA	National Key Result Area
NLC	National Land Commission
RBM	River basin management
RGoB	Royal Government of Bhutan
RNR	Renewable natural resources
RoR	Run-of-river
RWHTs	Rainwater harvesting technologies
SPCR	Strategic Programme for Climate Resilience
WUAs	Water users' associations

# Key Messages

The Built Water Storage in South Asia (BWSSA) project seeks to address the challenge of water insecurity in Bangladesh, Bhutan, India, Nepal, and Pakistan. This Policy and Institutional Study on water storage in Bhutan was carried out as part of this project. The main findings of the study are summarized as follows:

- Bhutan has the highest per capita availability of water in the South Asian region. Despite this relative abundance and better access to water sources, providing uninterrupted supply of water for irrigation and drinking is still a challenge.
- Given seasonal water variability and the increased frequency and risk of climate change impacts, the need for appropriate water storage systems to meet the demands of different sectors and manage disaster risk has become increasingly evident.
- Domestic sector: Most households in Bhutan have piped water, but supply is often intermittent. To address this challenge, water storage solutions such as rainwater harvesting and management of ponds and check dams for rural water supply have been encouraged. Various government agencies are collaborating to explore options such as construction of multipurpose reservoirs and smaller dams to supply both drinking water and irrigation.
- Agriculture sector: As the largest consumer of water in Bhutan, agriculture has traditionally relied on abstraction from rivers and irrigation channels. Most farmers still depend on seasonal rainfall for cultivation. With a view to attaining water security, government policies promote water storage through protection of water sources, water collection ponds, storage tanks, reservoirs, and other rainwater harvesting technologies.
- Energy sector: The energy sector is the largest contributor to Bhutan's gross domestic product (GDP). Hydropower generation happens mainly through run-of-river (RoR) schemes. Ensuring energy security during the winter months and promoting economic growth through export of energy are the main aims of Bhutan's plans to develop large-scale hydropower reservoirs.
- Environment: Protection and sustainable management of watersheds and wetlands as natural forms of water storage is a central principle in Bhutan's policies, in which natural resources are accorded a crucial role in maintaining water supply, promoting ecosystem health, and supporting resilience to climate impacts.
- Since 2008-09, decentralized planning has in theory empowered local government to formulate strategies and identify priority programs for efficient management of water and other natural resources. However, in practice, the planning function continues to reside with central government agencies with 15 entities (ministries, departments, and others) directly or indirectly involved in water storage planning and development.
- A positive outcome of the government reorganization carried out in 2022 was the consolidation of different departments—energy, water, environment, and geology—into a single ministry and the creation of a Department of Water (DoW) to plan and coordinate water resource management across sectors.
- Local communities participate in the management of water storage systems through water users' associations (WUAs) and informal groups. However, the role of informal groups remains under-recognized in policy and literature. In areas where there is high reliance on government agencies for water provision, there is a need to raise awareness and build capacity for greater community participation in water management.
- Cross-border considerations: Bhutan has bilateral agreements with India on hydropower under which it receives technical support for flood warning systems. However, with China, there are no agreements or data sharing arrangements despite three of the main rivers of Bhutan originating in the Tibet region of China. The absence of cross-border cooperation arrangements poses a challenge in effectively managing the water resources of Bhutan.

# 1. Overview

## 1.1 Built Water Storage in South Asia Project

The BWSSA project seeks to address the challenge of water insecurity in the South Asian region. Funded by the US Department of State and implemented by the International Water Management Institute (IWMI) and the Global Water Partnership (GWP), it is a three-year project (2023-2026) that aims to contribute to a transformation in the way water storage is perceived, planned, and managed in Bangladesh, Bhutan, India, Nepal, and Pakistan. Water storage here refers to all built (gray) infrastructure and natural (green) infrastructure across scales, be it a small pond or spring, or a large reservoir or wetland. The overall objectives of the project are to:

- Strengthen national capacities for integrated water storage planning and management;
- Enable relevant ministries and line agencies to make better use of data to understand gaps in water storage and the options available to fill them;
- Facilitate cross-border and regional dialogues to address water storage gaps; and
- Address historical inequalities, especially in terms of who benefits from water storage, and the technical and management aspects of planning and implementing water storage.

Working in close collaboration with relevant government ministries and other stakeholders, the BWSSA project operates along three interlinked work streams. The first, **understanding water storage gaps and the options available to fill them**, relates to development of tools and approaches to map and investigate the seasonal dynamics of and prevalent trends in different types of water storage. It will identify the critical water services provided by different water storage options and determine future water demand across sectors.

The second work stream, **capacity development for sustainable and integrated water storage**, works with a cohort of 30 technical staff (43% women) drawn from different government ministries on raising awareness and building technical skills. Regular workshops are co-designed with this cohort to share knowledge and experience on issues that the cohort prioritizes, including topics such as data collection, storage mapping, and modeling, the implications of climate change for water resources, and optimizing water use and infrastructure management.

The third work stream, **transboundary water storage cooperation**, promotes international cooperation in water storage planning and management. Working with relevant national stakeholders, it identifies opportunities as well as constraints to international cooperation and convenes technical dialogues on specific topics to build trust and cooperation.

In this workstream, the BWSSA project conducted inception workshops in each member country in January 2023, identified cohort groups of six members from each country, and organized six workshops for the cohort in 2023 and 2024.

## 1.2 Policy and Institutional Study on the Strategic Role of Water Storage

To identify water storage solutions for current water-related challenges and to prepare for future scenarios in the target countries, the BWSSA project is studying how more effective water storage, in all its forms, can best support the development needs of the project's focal countries. This Policy and Institutional Study addresses the following questions:

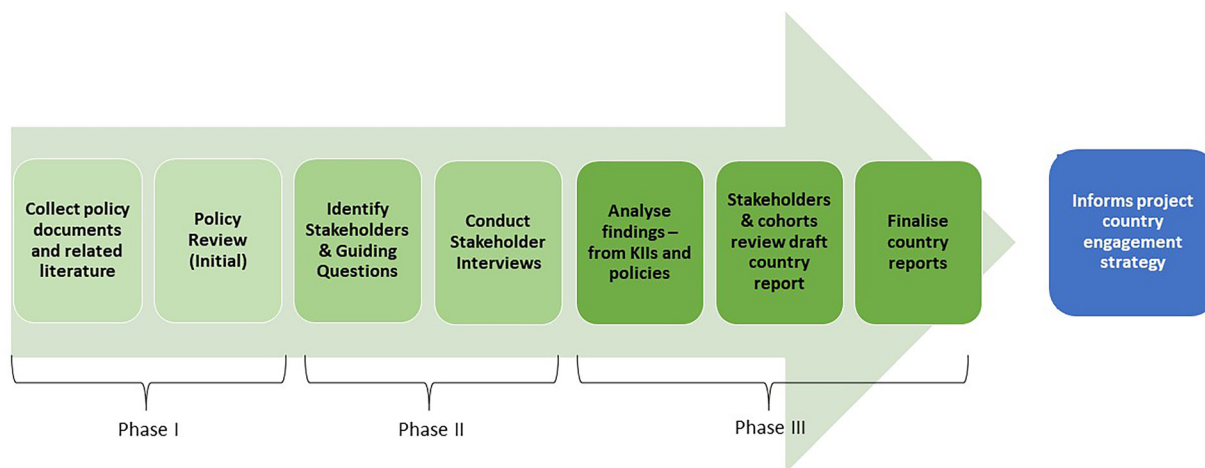
1. What types of water storage are possible within the various topographic contexts, and what are the current storage types and their uses?
2. What strategic roles do different water storage types play across sectors, and how do they contribute to achieving sector goals, including climate and other risk mitigation? What current and future investments are planned?
3. What is the institutional and decision-making landscape specifically in relation to water management and storage, including the roles of decentralized administrative levels?

4. How coherent are sectoral storage plans with broader integrated water resources management (IWRM) and river basin management (RBM) planning processes? How are potential trade-offs between different water storage types (current and planned) addressed?
5. What knowledge gaps hinder informed and integrated planning?
6. What opportunities exist for community involvement in planning, implementing, and managing different storage types, and how can women’s roles be strengthened?

The findings of this Policy and Institutional Study support Outcome 1 of the BWSSA project by identifying the factors that shape decisions on storage (type, scale, location, purpose), and by highlighting how water storage decisions impact different stakeholders and the broader national development goals. The study contributes to Outcome 2 by expanding the framework within which storage needs to be assessed, specifically as a sociotechnical intervention with multisector and multistakeholder implications, including the possible synergies and trade-offs between development goals. It also touches upon upstream-downstream issues and hence transboundary cooperation (Outcome 3), though this was emphasized more in some member countries than in others. This report also highlights how a diversity of storage types can improve the response to needs and risks in specific biogeographic contexts and sectors, reinforcing the importance of targeting investments beyond large-scale schemes.

The study was implemented over several phases (Figure 1) in each project country. The first phase analyzed the content of the country’s policies and strategies to understand the status of water storage in various sectors and the contribution water storage makes to overall national development goals, the cross-sector synergies and trade-offs present, and the space available for socially inclusive and stakeholder-responsive planning, design, and management of storage. Key findings from Phase 1 were further explored in Phase 2 through face-to-face interviews with key stakeholders from various agencies and sectors including government officials, NGOs, academia, and the private sector to ascertain diversity in information and perspectives. The interviews explored themes in greater detail, including any key gaps between stated policy and actual practice and the subtexts underlying such gaps. These key informant interviews (KIIs) also helped us map the existing institutional mechanisms for water resources management and assess how sector storage needs are integrated into water sector/basin-scale plans and the extent to which storage investments respond to the needs of diverse water users.

Although most of the river systems in South Asia are transboundary, this aspect was not explicitly covered in the KIIs due to country sensitivities—except when information and perspectives on transboundary issues were volunteered by the respondents. A draft country report was generated after an analysis of data from Phases 1 and 2 and a review of published literature. In Phase 3, the draft country report was shared with the key informants with a request to verify details and narratives and fill in any gaps. The results of this consultative process were used to finalize the report, and they are key to building stakeholder consensus and credibility.



**Figure 1.** Approach for the Policy and Institutional Study conducted in Bangladesh, Bhutan, India, Nepal, and Pakistan.

This report presents the study methodology (Section 2), a brief overview of water resources in Bhutan (Section 3), water storage in policy and practice (Section 4), the institutional structures and governance of water storage (Section 5), cross-border considerations (Section 6), and potential areas for intervention (Section 7).

## 2. Methodology

### 2.1 Phase 1: Policy Review

The Policy and Institutional Study methodology was piloted in Nepal and thereafter implemented in the other project countries. The policies and strategies reviewed for the study included those adopted at the national development level and those at the sectoral level as well, including agriculture, domestic water supply, energy, fisheries, environment, and climate change sectors (Annex 1). The necessary documents and the existing literature on these policies were sourced from databases such as FAOLEX, Google, Google Scholar, IWMI library database, Scopus, and ProQuest. The list of policies was then shared with the Bhutan Water Partnership (BhWP), a consortium of water professionals accredited to coordinate the action of GWP in Bhutan, and the Department of Water (DoW) to review and add other applicable policies.

The information extracted from these documents included: development priorities; types of water storage, plans, targets, challenges, and risks; links to IWRM and RBM and other governance aspects; and the opportunities available for local stakeholder participation. This information was entered into an Excel database categorized according to sectors and thematic areas (Annex 1) that were pre-identified by the project team based on previous approaches to policy and institutional studies but tailored to the overall aim and focus of the BWSSA project. However, information extraction was not limited to these thematic areas; any information that contributed to a deeper understanding of the status of water storage in Bhutan was included.

For the Bhutan review, 21 of the most relevant policy and strategy documents were selected (Table 1). The relevant text extracts from them were added to the Excel database, which enabled an analysis of targets and thematic aspects across two or more documents. This was useful for identifying synergies and gaps across sectors and framing the key focal topics and questions for the KIIs conducted in Phase 2 of the review.

**Table 1.** Policies<sup>a</sup>, plans, and strategies reviewed in Bhutan.

Year of publication timeframe	Policy document	Citation
2024-2029	13 <sup>th</sup> Five Year Plan	RGoB 2024
2023	National Adaptation Plan	DECC 2023
2021	Second Nationally Determined Contribution 2021	RGoB 2021
2021	Sustainable Hydropower Development Policy	MoEA 2021
2021-2040	Renewable Natural Resources Strategy	MoAF 2021
2020-2030	National Environment Strategy	NEC 2019
2020	Economic Contingency Plan	RGoB 2020
2020	Climate Change Policy	NEC 2020
2018-2023	12th Five Year Plan (Volume 1: Main document)	GNHC 2019
2018-2023	12th Five Year Plan (Volume 2: Central plans)	GNHC 2018
2017	Strategic Programme for Climate Resilience	GNHC 2017
2016	National Integrated Water Resources Management Plan	NEC 2016
2016	National Irrigation Master Plan	NEC and DoA 2016
2016	Economic Development Policy	RGoB 2016
2016	E-RNR Masterplan for Bhutan	MoAF and DITT 2016
2015	Intended Nationally Determined Contributions (NDCs)	NEC 2015
2014-2025	Bhutan Water Vision and Water Policy	NEC 2014

continued

Year of publication timeframe	Policy document	Citation
2014	Food and Nutrition Security Policy	RGoB 2014
2013	Alternative Renewable Energy Policy	RGoB 2013
2006	National Adaptation Programme of Action 2006	NEC 2006
2006	National Framework for Organic Farming in Bhutan 2006	DoA 2006

<sup>a</sup> Note: Only policies published prior to 2024 and were available in English were reviewed.

## 2.2 Phase 2: Key Informant Interviews

The KIIs conducted in Phase 2, featuring in-person and in-depth discussions, were designed to build on the analysis done in Phase 1. Interviewees for the KIIs were selected to provide diverse and reliable insights drawing on their experience in government, or perspectives from outside the public sector. This allowed a degree of triangulation on what the priorities were, how policies and plans addressed them, and the strengths and weaknesses of institutional structures. Based on insights gained from the policy review and guidance provided by the BhWP, a list of key stakeholders was compiled across various sectors and areas of expertise in consultation with the DoW, the host government agency. Semi-structured interview questionnaires were developed, covering both common themes and sector-specific topics (Annex 2). The discussions were kept flexible to allow for exploration of emerging topics as the interview progressed.

The aim and approach of the Policy and Institutional Study were presented to cohorts from Bangladesh, Bhutan, Nepal, and Pakistan at a stakeholder workshop in Nepal on June 23, 2023. This proved useful in planning for and coordination of the study in the respective countries. In Bhutan, a total of 15 interviews of approximately one hour each were conducted from the September 11-15, 2023 (Annex 3) and the resulting qualitative data were sorted in Excel. Due to time constraints, the KIIs were limited to central government and private sector representatives, donors, and independent experts and did not involve representatives from local communities, farmer organizations, and local and provincial government. As per government procedure, a briefing and de-briefing was held for representatives from the DoW to discuss the context and logistical arrangements and to share the initial key findings emerging from the KIIs.

## 2.3 Phase 3: Country Report

The analysis and report writing process for this study included a verification step. The draft report was shared with the country focal points (DoW and BhWP) for their feedback and then circulated to the key informants to verify its accuracy and add any further insights. The findings, presented below, are organized around Bhutan's national development goals and priorities on water storage, sectoral plans, institutional structures, cross-border aspects, and areas for further development of water storage planning and implementation.

# 3. Water Storage in Bhutan

## 3.1 Country Overview

The Kingdom of Bhutan is a landlocked country situated between China (north) and India (south, east, and west) with a land area of 38,394 km<sup>2</sup> (Dorji 2016) and a population of approximately 786,000 as of 2023 (WHO 2024). Bhutan is one of the 10 global biodiversity hotspots; over 72% of the country is natural forest; and the constitution of the country mandates maintenance of 60% of the land under forest cover (Dorji 2016). The kingdom is also the world's first carbon-negative country, meaning that it absorbs more carbon dioxide than it emits (Tzung 2022). This is primarily because its forests are carbon sinks. In addition, Bhutan exports low-carbon hydroelectricity to India, thereby contributing to reduction of regional emissions as well (Vives et al. 2023). The country's commitment to maintaining carbon neutrality expresses itself in renewable energy initiatives, particularly hydropower, and sustainable development policies.

Bhutan has six agroecological zones: alpine, cool temperate, warm temperate, dry subtropical, humid subtropical, and wet subtropical (Dorji 2016), which can be broadly categorized into three areas (Tariq et al. 2021) (Figure 2):

*The southern foothills* have a subtropical climate with an average annual rainfall of 2,500-5,500 mm, temperature varying between 15°C and 30°C, and an elevation range of 100-1,500 m a.s.l. (meters above sea level).

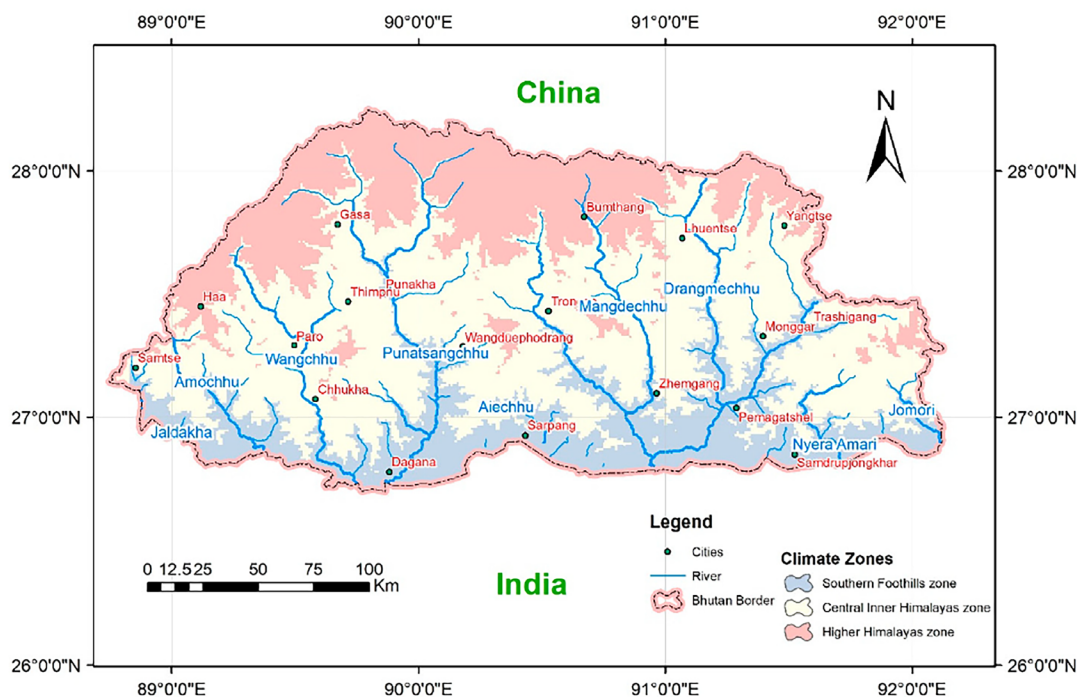
*The central inner Himalayas* have cold and dry winters (4-15°C) and humid summers (5-24°C), with average annual rainfall of 1,000-2,500 mm and elevation of 1,500-3,000 m a.s.l.

*The higher Himalayas* have heavy snowfall characteristic of an alpine climate with temperature varying between minus (-)22°C to 11°C and frequently dropping below 0°C, average annual rainfall of 400 mm, and elevation of 3,000-7,550 m.a.s.l.

Given this topography, the majority of the population lives in the southern and central parts of the country. In the 1970s, Bhutan developed, and continues to use, gross national happiness (GNH) as a development indicator. This includes four main pillars: 1) sustainable and equitable socioeconomic development; 2) preservation and promotion of cultural values; 3) conservation, sustainable utilization, and management of the natural environment; and 4) promotion of good governance (Dorji 2016). All policies adopted by the country undergo a GNH screening process prior to approval. Bhutan was able to eliminate extreme poverty (below USD 2.15 per day) by 2022; the population living on less than USD 6.85 per day fell from approximately 39% in 2017 to 8.5% in 2022 (World Bank 2024a).

In terms of GDP, per capita income was USD 3,181 in 2020, which grew to USD 3,704 in 2022 (World Bank 2024b). The main economic drivers are hydropower, tourism, and agriculture, the latter being the primary occupation for over 60% of the population (Dorji 2016). Despite increasing economic prosperity and a strong cultural identity, migration has increased in recent years, especially to countries like Australia, the United States, and neighboring India. Limited job opportunities, high cost of living, and lack of access to advanced education are driving this trend (Shivamurthy 2023).

### 3.2 Bhutan's Water Resources



**Figure 2.** The broad climatic zones and main river basins of Bhutan.

(Source: Tariq et al. 2021)

The agriculture sector's contribution to Bhutan's GDP has increased from approximately 15% in 2010 to 19% in 2020 (IFAD 2024). It is the biggest water user in the country (NEC 2016) (Table 2). Hydropower in contrast contributes to 25% of GDP, making it a key driver of economic growth, far surpassing the contributions of agriculture and tourism, which account for less than 5% (Tariq et al. 2021; Gupta 2024). There are no large reservoirs in Bhutan. Although the country has the potential to generate over 36,900 MW, installed hydropower capacity has reached only 2,334 MW (6.3%) (MoEA 2021). Since most of the existing hydropower plants are run-of-river (RoR), Bhutan is susceptible to seasonal fluctuations in flows and therefore imports electricity from India during the winter (Dorji 2016). To prevent flood damage to hydropower infrastructure, some barrage-type reservoirs have been constructed on the main rivers or their tributaries (NEC 2016).

Water sources in Bhutan include glaciers, high-altitude wetlands, rivers, reservoirs, and groundwater. The country has the highest per capita water availability (100,970 m<sup>3</sup> per year) in the South Asian region (Table 2) (Dorji 2016). Glaciers cover 10% of the total surface area of the country. There are 2,674 glacial lakes, which are an important source of freshwater for Bhutan as well as lower riparian countries India and Bangladesh (Dorji 2016; Tariq et al. 2021). There are five major rivers (Figure 2): the Amochhu (originates in Tibet and flows into India), the Wangchhu (flows into India and then joins the Brahmaputra in Bangladesh; its basin occupies 11% of Bhutan's total land area); the Punatsangchhu (originates in Bhutan and flows into India; it is one of the largest river systems in the country, occupying 25% of the total land area); the Mangdechhu (originates in Bhutan and flows into India; its basin covers 19% of the total land area); and the Drangmechhu (originates in Tibet and India, and flows to India; its basin covers 22% of the total land area)) (Dorji 2016).

Groundwater is used for agriculture and domestic use in the southern part of the country. No systematic assessments of groundwater availability and use have been conducted but its use is limited and there are no reports of depletion. However, the Department of Geology does conduct studies on groundwater levels in Thimphu and Gelephu as and when requested by government agencies. According to some of the key informants interviewed for this study, the government's focus is on improving spring and watershed management rather than extraction of groundwater through wells/boreholes. The topography of Bhutan is such that groundwater is most easily accessible at lower elevations in the south and east of the country close to the border with India (e.g. Gelephu), where it is an essential resource for drinking water and small-scale irrigation. There is no information on groundwater extraction from shared aquifers across the border.

**Table 2.** Water resources availability and use in five South Asian countries in 2020.

	Unit	Bhutan	Bangladesh	India	Nepal	Pakistan
Long-term average annual precipitation	mm/year	2,200	2,666			
	1,083	1,500	494			
Interannual variability <sup>ab)</sup>		0.6	0.7	1.7	1.00	2.40
Dam capacity per capita	m <sup>3</sup> per inhabitant	-	39.33	179.32	2.93	125.89
Total dam capacity	km <sup>3</sup>	-	6.48	247.46	0.09	27.81
Environmental flow requirement	10 <sup>9</sup> m <sup>3</sup> /year	54.10	600.3	937.10	95.94	83.79
Total internal renewable water resources	10 <sup>9</sup> m <sup>3</sup> /year	78.0	105.0	1,446.0	198.20	55.0
Total renewable groundwater	10 <sup>9</sup> m <sup>3</sup> /year	8.10	21.12	432.0	20.0	55.0
Groundwater produced internally	10 <sup>9</sup> m <sup>3</sup> /year	8.10	21.09	432.0	20.0	55.0
Total renewable surface water	10 <sup>9</sup> m <sup>3</sup> /year	78.0	1,205.9	1,868.9	210.2	239.2
Surface water produced internally	10 <sup>9</sup> m <sup>3</sup> /year	78.0	83.91	1,404.0	198.20	47.4
Surface water entering the country (total)	10 <sup>9</sup> m <sup>3</sup> /year	-	1,122.0	635.2	12.00	265.1
Surface water leaving the country to other countries (total)	10 <sup>9</sup> m <sup>3</sup> /year	78.0	0.06	1,385.0	210.20	10.72
Total renewable water resources per capita	m <sup>3</sup> /inhab/year	100,970	7,329	1,368	7,162	1,086
SDG <sup>c</sup> 6.4.2 (water stress)	%	1.41	5.72	66.49	8.31	116.3
Total water withdrawal	10 <sup>9</sup> m <sup>3</sup> /year	0.34	35.87	761.0	9.50	183.4
Agricultural water withdrawal	10 <sup>9</sup> m <sup>3</sup> /year	0.32	31.50	688.0	9.32	172.4
Irrigation water requirement	10 <sup>9</sup> m <sup>3</sup> /year	0.10	24.56	370.8	5.43	126.9
Industrial water withdrawal	10 <sup>9</sup> m <sup>3</sup> /year	0.00	0.77	17.00	0.03	1.4
Municipal water withdrawal	10 <sup>9</sup> m <sup>3</sup> /year	0.02	3.60	56.0	0.15	9.65

Source: FAO AQUAStat.

Notes: <sup>a</sup> Interannual variability measures the average between year variability of available water supply, including both renewable surface water and groundwater supplies. Higher values indicate wider variations in available supply from year to year.

<sup>b</sup> WRI = World Resources Institute.

<sup>c</sup> SDG = Sustainable development goal.

Despite the relative abundance of water in Bhutan and 99.9% access to improved water sources (NSB 2022), there are some challenges in providing uninterrupted supply of irrigation and drinking water. These challenges arise largely due to topography or the location of households (Dorji 2016; NEC 2014). The eastern part of Bhutan is more water-scarce than the western and southern parts which are flatter and have larger irrigation systems (NEC 2016). Households in this region and in the hilly areas mainly rely on springs. However, spring flows have decreased or dried up in some places, leading to fields being abandoned. The causes of this are not fully understood but there is an assumption that this is due to the impacts of climate change (i.e., altered precipitation patterns affecting recharge; higher temperatures increasing evaporation). In some places, land degradation has reduced infiltration, and over-abstraction of groundwater may be impacting springs. However, more research and data are required to fully understand this phenomenon.

In the southern part of Bhutan, climate change impacts and increasingly irregular rainfall patterns are leading to flooding and sedimentation, indicating the need for stormwater drainage and flood control measures. In addition, changes in seasonal water availability can potentially affect hydropower generation. The disappearance of glaciers will have a significant impact on stream flows, reduce dry-season runoff, and affect RoR hydropower production (NEC 2016). Further, glacial lake outburst flooding (GLOF) can exacerbate the risk to downstream communities, which are already experiencing flooding due to poor drainage and rapid urban expansion (Dorji 2016). The 1994 Lugge Tsho (lake) and the 2015 Lemthang Tsho GLOFs resulted in significant infrastructure damage (Wangdi 2016).

Therefore, as climate change impacts intensify, water retention structures become necessary. To cope with the fluctuations in water availability, competing uses, and impacts of climate change, different types of water storage systems must be adopted by various water-use sectors according to the needs and terrain of a location (Table 3). Mountainous areas do have natural water storage systems like glacial ice and snow, ponds and aquifers, but they are vulnerable to human activities such as mining, grazing, and extraction of forest resources (NEC 2019).

In rural areas, households traditionally have only small-scale storage. Even where households receive piped water, it is imperative to encourage rainwater harvesting technologies because piped water supply tends to be intermittent with service durations ranging from 4 to 12 hours a day (ADB 2019). However, this entails a cost. One key informant in our study stated that rainwater harvesting as a water storage option could be a challenge because most of the rainfall occurs during just three months of the year, and storing rainwater for long periods can affect water quality. However, different solutions to maintain water quality through the lean season are being considered. For irrigation purposes, historically, the focus has not been on water storage but rather on water diversion from rivers and conveyance through irrigation channels. However, rainwater harvesting systems for irrigation are now being promoted, comprising four components: catchment, conveyance, storage facility, and target area (NEC and DoA 2016). In these systems, rainwater is collected from micro and macro catchments including roofs, roads, paved areas, natural hill slopes, and farmland, and channelled to storage facilities for irrigation use. Further details of water storage systems implemented in each sector are provided in Section 4.2.

**Table 3.** A sector-wise summary of the types of water storage implemented in Bhutan.

Sector	Storage types and roles
Domestic	Management of ponds - primary rural source Rainwater harvesting Check dams for rural water supply
Agriculture	Rainwater harvesting Bentonite-lined water harvesting ponds
Energy	Reservoirs (barrage-type) for flood control and prevention of infrastructure damage
Environment	Watershed protection for surface water and groundwater; Trenches and bunds to prevent erosion
Disaster risk management	Retention ponds to store water from heavy rainfall

The expansion of urban areas coupled with declining water quality in these areas presents another significant challenge to water resource management (Chathuranika et al. 2023). This study focused on highlighting the role of water storage within the context of Bhutan, which is at a crucial juncture where effective planning and implementation of water storage systems are essential to mitigate the impacts of climate change and declining water availability. The study evaluated current policies and practices related to water storage, identified areas of further development and underlined the need for sustainable water management.

## 4. Policies and Realities of Water Storage in Bhutan

This section provides an overview of Bhutan's national-level and sector-specific policies that include water storage planning within their remit. Written policies are then analyzed in relation to insights provided by key informants on the practicalities of implementing water storage initiatives in the country.

### 4.1 National Development Policies and Water Storage

In general, cross-sectoral national policies such as the National Adaptation Plan (NAP) 2023, the National Integrated Water Resources Management Plan (NIWRMP) 2016, the Strategic Programme for Climate Resilience 2017, the Water

Vision and Water Policy 2025, and the 12th Five Year Plan (FYP) all incorporate plans and targets directly and indirectly related to water storage (Table 4). While the main motivation behind water storage is reducing water variability that can affect irrigation and drinking water supplies (GNHC 2019), the emphasis in national policies and practice extends to water storage for climate change and disaster risk reduction as well. For example, the Flood Engineering Management Division (FEMD) incorporated water storage into storm water management plans for Thimphu by including rainwater harvesting and detention ponds in addition to drainage and water diversion.

Consideration also is being given to multiple-use reservoirs to serve hydropower and agriculture purposes. The NIWRMP (NEC 2016) is a national plan for coordinated water management. The Bhutan Water Act of 2011 emphasizes IWRM, and this is captured in the NIWRMP which has the primary aim of developing efficient, equitable, and environmentally sustainable management of water resources in Bhutan (Dorji 2016).

Although the 12th FYP allocated funding to increase water security for irrigation and drinking supply (GNHC 2019), the Economic Development Policy (2016) is focused on achieving economic self-reliance and so prioritizes the hydropower sector in addition to mining, tourism, small industries, and, finally, agriculture. However, the Water Vision and Water Policy (NEC 2014) states that “when water resources are not sufficient either in quantity or quality to meet every legitimate demand, water for drinking and sanitation for human survival shall be the primary priority.”

Almost all the cross-sectoral national policies of Bhutan recognize the importance of sustainable and effective management of watersheds as a natural form of water storage (Table 4).

**Table 4.** A review<sup>a</sup> of the role of water storage in Bhutan’s national policies and plans on water resources management, land use, and related sectors.

Policy/strategy/plan	Overall goals and objectives	Role of water storage
1 National Adaptation Programme of Action (NAPA) 2006	Poverty eradication and food security, especially of rural farmers; hydropower generation; gender equality; environmental sustainability; minimizing natural and climate disaster risk.	Out of the nine prioritized projects of NAPA, six are related to water storage systems: artificial lowering of the Thortomi glacier lake; landslide management & flood prevention; flood protection of downstream industrial and agricultural area; rainwater harvesting; GLOF hazard zoning; promotion of community-based forest fire management and prevention. Projects for promotion of simple, affordable rainwater harvesting systems with an integrated approach: micro and macro catchment runoff farming water harvesting systems; floodwater harvesting or spate irrigation; identifying areas suitable for water harvesting (aerial survey/GIS); emerging technologies like supplemental water system, dual-purpose system, combined system; training farmers in effective utilization of harvested rainwater.

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Policy/strategy/plan	Overall goals and objectives	Role of water storage
2 Water Vision and Water Policy 2014-2025	The overall vision is that water must be used and managed sustainably, efficiently, and equitably. Sustainable agriculture development, harnessing hydropower potential, and industrial development are the main pathways to this vision, in which water plays a key role.	<ul style="list-style-type: none"> <li>• Protect and conserve streams and springs as sources of drinking water.</li> <li>• Explore groundwater and promote rainwater harvesting in areas with water shortage for drinking water and agriculture purposes.</li> <li>• Hydropower development as a nonconsumptive use of water.</li> <li>• Anticipating, preventing, and managing conflicts between competing uses and users of water resources.</li> </ul>
3 Intended NDCs 2015	<p>Main mitigation objective is to remain carbon neutral, and maintain a minimum of 60% forest cover at all times in accordance with the constitution.</p> <p>Adaptation objectives are to prepare for climate change impacts such as flash floods, GLOF, windstorms, landslides, and forest fires.</p>	<p>Bhutan currently offsets 4.4 million tons of carbon dioxide equivalent (CO<sub>2</sub>e) and can offset up to 22.4 million tons of CO<sub>2</sub>e per year by 2025 through export of hydroelectricity. Under adaptation, the goal is to increase resilience to the impacts of climate change on water security through IWRM approaches, including:</p> <ul style="list-style-type: none"> <li>• Water resources monitoring, assessment, and mapping</li> <li>• Adoption and diffusion of appropriate technologies for water harvesting and efficient use</li> <li>• Integrated watershed and wetland management.</li> </ul>
4 National Integrated Water Resources Management Plan 2016	Establishes the foundations and framework for coordinated planning, implementation, and monitoring of the status of water security in the country. Improving food self-sufficiency through agricultural development and irrigation is a key water-related objective of the Royal Government of Bhutan.	<p>Contains the Bhutan Water Security Index (BWSI), which provides the framework for planning, monitoring, and interagency coordination through the 5 key dimensions of water resources in Bhutan:</p> <ul style="list-style-type: none"> <li>• Rural drinking water supply, sanitation, and hygiene</li> <li>• Economic water supply for agriculture, industries, and hydropower</li> <li>• Urban water supply, sanitation, and drainage</li> <li>• Environmental water security</li> <li>• Disaster and climate change.</li> </ul> <p>Under BWSI, water storage related programs and activities include improving access to alternative drinking water sources (water harvesting, groundwater development); improving the condition of catchment areas and water sources (reforestation and conservation measures); increased number/volume of water retention structures to enhance resilience of the agriculture sector to the adverse effects of climate change.</p>

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Policy/strategy/plan	Overall goals and objectives	Role of water storage
5 Strategic Programme for Climate Resilience (SPCR) 2017	The adverse impacts of climate change on water and socioeconomic development are highlighted. The SPCR's pillars are: 1) Enhancing the information base for hydro-met services and climate resilience; 2) Preparedness, food, and water security; 3) Sustainable growth and resilient infrastructure; 4) Strengthening governance, institutional coordination, and human resource capacity.	Investment seeks to restore critical watersheds and at-risk wetlands with climate-oriented watershed and wetland management plans; focus on climate-resilient water security (and potable water) to protect the integrity of farmlands and rural enterprises; apply an ecosystem-based approach to river basin integrated flood management to minimize climate-induced hazards; and to make responsible agencies and communities (especially women/youth groups) knowledgeable in climate-resilient practices through adaptive watershed and water conservation policies and practices.
6 Climate Change Policy 2020	Ecologically balanced sustainable development in line with the development philosophy of gross national happiness, commitment to remain carbon neutral in alignment with the NDCs.	Under cross-cutting issues and synergies, water security is identified as an area for action to address adaptation and mitigation.
7 12th Five Year Plan 2018-2023 (Vol. 1: Main Document)	The objective is to create a just, harmonious, and sustainable society through enhanced decentralization. Toward sustainable society, priorities include ensuring water security and renewable energy supply.	Under the national key result area (NKRA <sup>b</sup> ) on sustainable water, a program is designed to undertake effective management of wetlands and watersheds to ensure reliable drinking and irrigation water. Under the NKRA on climate and disaster resilience, a program is designed to strengthen water security and enhance management, which involves monitoring the e-flows of major rivers.
8 12th Five Year Plan 2018-2023 (Vol. 2: Central Plans)	Contains the plan priorities and program profiles of ministries, constitutional bodies, and autonomous agencies. The program matrix illustrates 153 agency key result areas and their corresponding 653 key performance indicators, which contribute to the achievement of 17 NKRAs.	Sustainable natural resources management and utilization activities including effective management of wetlands and watersheds; protection of water sources; reservoir scheme to enhance water security and flood control; assessment of surface water and groundwater availability; and emphasis on strengthening water security.
9 Second Nationally Determined Contributions (NDCs) 2021	Contains mitigation and adaptation NDCs. Under mitigation: forest conservation and management, and sustainable hydropower development measures that include some form of water storage.	<ul style="list-style-type: none"> <li>• Refers to the sustainable hydropower development policy and its focus on reservoir or pumped storage schemes to ensure energy and water security.</li> <li>• Conservation of wetlands.</li> </ul>

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Policy/strategy/plan	Overall goals and objectives	Role of water storage
10 National Adaptation Plan (NAP) 2023	Builds on adaptation projects taken up under NAPA 2006 and consolidates adaptation priorities from Intended NDCs 2015. Aligned with Climate Change Policy 2020. The NAP involves (i) policy and institutional arrangements for adaptation planning and implementation; (ii) priorities to build adaptive capacity and resilience and enhance the enabling environment; (iii) implementation strategy; and (iv) monitoring and evaluation systems.	<ul style="list-style-type: none"> <li>Improved flood risk management and planning by building emergency storage bypasses on river systems.</li> <li>Increase resilience in the water supply sector by generating additional water buffers for drought periods. Short-term actions include rainwater harvesting and additional storage capacity at the community level.</li> <li>Water storage systems for forest fire risk mitigation measures.</li> <li>Increase resilience of hydropower sector by assessing feasibility of pumped storage schemes and developing reservoir-type hydropower projects.</li> <li>Spring-shed conservation, restoration of wetlands and lakes/ponds to ensure water storage and recharge of aquifers.</li> </ul>
11 13 <sup>th</sup> Five Year Plan 2024-2029 <sup>c</sup>	<p>Ensures continuity of interventions to support the country's long-term goals of becoming a high-income GNH economy by 2034: healthy and productive society; strengthened sovereignty, territorial integrity, security, unity, well-being, resilience, and economic prosperity; transformed and trusted governance system.</p> <p>In alignment with public sector transformation in 2022, the plan adopted an approach to enhance coordination and collaboration.</p>	<ul style="list-style-type: none"> <li>Completion of ongoing hydropower projects and initiation of new projects along with development of storage-based hydropower.</li> <li>Development of project reports for the 1,800 MW Gongri-Jericho pumped storage project.</li> <li>Avenues for natural and built water storage explored and developed, and nature-based solutions for watershed conservation and restoration.</li> </ul>

Notes:

<sup>a</sup> Only policies that were available in English and published before 2024 were reviewed for this study.

<sup>b</sup> National key result area (NKRA) is a national-level development outcome that contributes to achieving the 12th FYP's objectives. There are 17 NKRAs and each is important in and of itself and is interlinked with the other NKRAs. A lead agency and collaborating agencies have been identified for the delivery of each NKRA. Progress is measured through key performance indicators (Source: GNHC 2019).

<sup>c</sup> The 13th Five-Year Plan was developed and published at the end of 2023 after the initial policy review; therefore, both FYPs were included in the study.

## 4.2 Sectoral Policies and Water Storage

Table 5 presents a review of the status of water storage in Bhutan's sectoral policies on domestic water supply and sanitation, agriculture and irrigation, energy, and environment, and discusses the extent to which provisions for water storage are manifest in practice.

*Water supply and sanitation sector.* Policies in this sector include activities and targets relating to water conservation and harvesting as a contribution to improving water security (Table 5). While there has been some progress on this count in rural and urban water supply, infrastructure needs to be improved if national goals are to be achieved (NEC 2019).

Bhutan's Water Vision and Water Policy (NEC 2014) has a target of 100% safe water supply and sanitation in urban and rural areas by 2025. According to the 2022 Bhutan Living Standard Survey Report, 99.9% of households have access to an improved water source, out of which approximately 57% have piped water within their dwelling and 42% within their compound (NSB 2022). About 83% of households have 24-hour access to drinking water.

According to the 12th FYP, integrated watershed management is necessary to ensure water security. However, implementation has been a challenge across agencies, as we shall discuss in Section 5. To date, efforts to achieve water security have been limited to schools and hospitals (GNHC 2019). Furthermore, despite high investment in water storage and distribution systems for safe drinking water, the National Environment Strategy (2019) highlights what it calls “inefficiencies and wastage” in these systems.

In some hilly areas of the country, water supply remains intermittent with service availability ranging from 4 hours to 12 hours per day (ADB 2019) due to the high costs of pumping. Water users are not willing to pay high rates for intermittent supply. The need for storage systems in these areas is therefore significant. The Water and Sanitation Division in collaboration with the Department of Energy is weighing the option of multipurpose reservoirs to serve this need. While construction of smaller dams is being considered for drinking water and irrigation purposes, nonavailability of land and scattered distribution of communities remain key constraints, both to small as well as large reservoirs.

*Agriculture and irrigation.* There is significant focus on water storage planning in Bhutan's sectoral policies on agriculture and irrigation. These policies emphasize protection of water sources and recommend construction of different types of water chambers in conveyance networks, water collection ponds, storage tanks, reservoirs, and other rainwater harvesting technologies (Table 5). The agriculture sector is the biggest consumer of water in Bhutan, and the need for and significance of water storage systems to increase crop productivity and resilience to climate change is emphasized in policy. However, in practice, the National Irrigation Policy (DoA 2011) has highlighted limited technical capacity and inefficient irrigation schemes as constraints. In addition, since most fields in Bhutan are small and scattered on hill slopes, water supply and storage systems are challenging and costly to construct. Currently, farmers rely on seasonal rainfall. The heavy monsoon season serves them between June and September, but intermittent local water shortages occur throughout the rest of the year. The World Bank Project on Remote Rural Communities Development implemented small and micro irrigation interventions focused on water harvesting (tanks, ponds, small lifts, etc) and calculated the average cost per acre of these systems to be Bhutanese ngultrum (BTN) 70,000 (approximately USD 1,044 at 2016 prices) (NEC and DoA 2016). Nine water storage systems to serve 72 ha were constructed between 2016 and 2017 and installation of pipes to the fields was completed by the end of 2018 (World Bank 2018). However, there has been no information on the impact of this initiative on crop productivity or farmer livelihoods since the project ended.

One key informant stated during a KII that water storage may be more needed and more easily constructed in the southern lowland areas (where the landscape is a combination of slopes and plains). There is a shortage of water for agriculture during the winter months in this part of the country. Bhutan has a goal of rice self-sufficiency, but has experienced a decline in production over the past few years with the self-sufficiency ratio dropping from 40.8% in 2018 to 25.2% in 2022 (from 41,520 metric tonnes to 26,680 metric tonnes). Concurrently, rice imports have increased, amounting to nearly 90,000 metric tonnes in 2022. Several reasons have been identified for this decline including, among others, reduced farmer interest in rice cultivation, low government investment in rice production, and climate change impacts on the monsoons and water availability (BBS 2023; Poudel 2023). According to the Department of Agriculture (DoA), development of new irrigation systems and improvement of existing ones are needed to achieve rice self-sufficiency .

All 20 districts of Bhutan focus on rice production while differing on crop selection. Some key informants were of the view that the drive toward cereal self-sufficiency and the resulting increased water demand due to expanded irrigation may negatively affect the amount of water available for hydropower generation. However, the NIWRMP (2016) states that the impact of irrigation on hydropower production is expected to be minimal, as rice cultivation tends to be concentrated

in flatter areas and hydropower development in steeper areas. In addition, rainfall during July-August meets most of the crop water requirement, leaving more than sufficient water in the rivers for hydropower generation. The NIWRMP also assumes that increased rainfall due to climate change may increase water availability for hydropower generation, and also that increased efficiency of irrigation systems will spare water for hydropower generation.

*Hydropower/energy.* The hydropower sector is the largest contributor to Bhutan's GDP. As the goal of developing hydropower for export to India is thought to be of critical importance, the country is striving to increase the number and volume of hydropower storage schemes. Energy security, especially in the dry (winter) season, is thus a major driver of the water storage development policy (Table 5).

The Royal Government of Bhutan (RGoB) intends to double hydropower production by 2030 from the 2019 level of 2,326 MW. Several projects are in the pipeline to meet this target (Table 5). However, despite the vast potential for hydropower generation, Bhutan has faced several challenges in meeting past hydropower development targets. A previous target of 10,000 MW by 2020 for export to India had to be revised due to geological, administrative, and financial challenges (Dema 2023). Key reasons for these target revisions include: i) project delays due to infrastructure challenges, bureaucratic hurdles, and elaborate permit processes; ii) delays in securing project funding (much of which comes from India); iii) lack of engineering and technical expertise to manage and implement large hydropower projects; iv) concerns over the environmental and social impacts of large-scale infrastructure development; and v) geopolitical challenges. As Bhutan's hydropower sector is heavily reliant on India for technical expertise as well as financial support, negotiations consume significant time.

The Sustainable Hydropower Development Policy (MoEA 2021) aims to optimize the use of water resources for hydropower; promote bilateral or regional energy agreements; and reinvest the income from sale of electricity for the development of further hydropower projects. However, despite the prominence of hydropower in Bhutan's national policies and plans, key informants from the energy sector noted that in practice, prioritization of water for hydropower is secondary to its use for irrigation and drinking water.

Hydropower development in Bhutan has been mainly RoR. However, some reservoirs have been built for flood control and prevention of infrastructure damage as well (NEC 2016). The NIWRMP (NEC 2016) indicates plans to develop larger hydropower reservoirs (e.g. on the Amochhu, Bunakha, and Sunkosh) as a solution to seasonal fluctuations. Storage is necessary to circumvent the need to import energy during winter but for the reasons indicated above there has been little development of large-scale storage. The hydropower development project on the Amochhu seems to have been halted due to environmental concerns (The Bhutanese 2018); the Bunakha project is undergoing the permit process (Power Technology 2024); and plans for the Sunkosh project appear uncertain since the government halted its development in 2022 (Subba 2022) because of financial constraints and the lack of agreement on implementation modalities. However, after the implementation of the Gelephu Mindfulness City Project, the King of Bhutan highlighted the importance of completing the Sunkosh and other hydropower development projects (Tenzing 2024).

The RGoB intends to develop hydropower projects on its own as well as in partnership with other countries in the region. The Sustainable Hydropower Development Policy (MoEA 2021) identifies factors that must be incorporated into agreements with partners (Box 1). According to a few key informants, there may be potential for hydropower development in the southern areas of Bhutan due to the intense rainfall there and the opportunity of building check dams upstream. The Druk Green Power Corporation (DGPC) is in discussion with the Asian Development Bank (ADB) on potential reservoir storage and pump storage projects for which location identification and feasibility assessments are ongoing.

Other key experts were, however, of the view that Bhutan should pursue only small-scale hydropower, and that energy diversification was necessary because high dependency on hydropower was making the country vulnerable to the impacts of climate change.

### Box 1. Hydropower development partnerships

The RGoB has said it will independently undertake development of hydropower projects with 100% equity ownership. Additionally, for projects taken up in collaboration with partner countries, full financing is required to be provided by the partner country in the form of untied equity grants and loans for the remaining balance. In projects where hydroelectricity is sold to the partner country within the region/subregion, RGoB will first seek full financing from the partner country while ownership remains with RGoB. Public-public partnerships will mandate that RGoB maintains a minimum of 51% shareholding; public-private partnerships will allow private partners only minority shareholding of not more than 26%. Projects developed under the build-own-operate-transfer (BOOT) model will be granted to a developer with a concession period of 30 years not including the construction period.

(Source: MoEA 2021).

According to several policies, the existing reliance on RoR hydropower does not adversely affect irrigation and drinking water supply. The environmental impact too was minimal and accounted for in environmental impact assessments (EIAs) prior to construction (NEC 2016). However, one key informant warned that large dams and reservoirs, depending on where they are constructed, could lead to loss of forest land, agricultural land, and settlements.

Regulations governing environmental flows (e-flows) are outlined in the EIA process. A minimum e-flow requirement of 30% was established in 2018. However, the Department of Environment and Climate Change (DECC) can review this and approve a reduced e-flow of 10-20% if evidence is provided that it is sufficient. One KII participant pointed out that these e-flow regulations were developed with RoR systems in mind; the requirement may be different for large hydropower storage reservoirs. DECC has acknowledged the lack of sufficient data and emphasized the need for further research to guide its approach to promoting hydropower development. While most river basins have already been used for hydropower generation, organizations such as Bhutan for Life (BFL) are advocating some rivers to be declared “free flow rivers” for ecological preservation. The newly formed DoW is currently undertaking a study on e-flows and trade-offs and will revise the guidelines in collaboration with DECC.

*Environment.* Protection, sustainable management, and use of watersheds and wetlands as natural forms of water storage is a principle prominent in Bhutan’s policies. The 12th FYP allocates more funds for management of natural resources than for development of hydropower (GNHC 2019). The plan also includes a specific allocation for strengthening water security and enhancing water management (Table 5), as does the SPCR 2017 (GNHC 2017). These initiatives are focused on enhancing water security for climate resilience by raising awareness and knowledge about water conservation among agencies and communities. The DoW is undertaking an inventory of natural forms of water storage, which includes lakes, wetlands, and marshes. There are now 7,399 geotagged water storage systems. However, the goals of developing a National Wetland Inventory and identifying critical watersheds are yet to be achieved (RGoB 2023).

Bhutan’s policies articulate the need to consider nature as both a water user and an integral element in water allocation decisions (NEC 2014). For example, the National Environment Strategy (NEC 2019), promotes rainwater harvesting and habitat enrichment as solutions to the human-wildlife conflict. This strategy is in alignment with other policies on promoting IWRM, improving access to drinking water, preventing flood damage, and developing hydropower, all of which have a strong environmental focus.

In line with these efforts, the NIWRMP (NEC 2016) has identified potential sites for multipurpose reservoirs (Haa, Burichhu, Yunari, and Nikachhu) and is conducting the initial feasibility assessments for these reservoirs.

**Table 5.** The role of water storage in sectoral policies and implementation of water storage plans/activities.

Sector	Policies and plans reviewed	Water storage types, targets, programs in policy
Drinking water supply and sanitation	<ul style="list-style-type: none"> <li>• National IWRM Plan 2016</li> <li>• Water Vision and Water Policy 2025</li> <li>• National Environment Strategy 2020-2030</li> </ul>	<ul style="list-style-type: none"> <li>• Improving rural and urban water security through reforestation and conservation activities in catchment areas and water sources; water harvesting; groundwater development; water metering and pricing; removing settlements from flood-prone areas; and improving design, maintenance, and management of urban water supply systems.</li> <li>• The Water Vision and Water Policy 2025 includes the goal of 100% coverage of safe water supply and sanitation for rural and urban areas.</li> <li>• Promotion of climate-resilient water harvesting, storage, and distribution systems in several <i>dzongkhags</i> (districts). At the <i>gewog</i> level (local administrative block, see Section 5), water users' associations are taking action to improve water supply by introducing rainwater harvesting, renovating old irrigation channels, and constructing new storage and distribution systems.</li> </ul>
Agriculture and irrigation	<ul style="list-style-type: none"> <li>• National Irrigation Policy 2011</li> <li>• National Irrigation Master Plan 2016</li> <li>• Food and Nutrition Security Policy 2014</li> <li>• National Adaptation Programme of Action 2006</li> <li>• National IWRM Plan 2016</li> <li>• 12th Five Year Plan (Vol. 2: Central Plan)</li> <li>• Water Vision and Water Policy 2025</li> </ul>	<ul style="list-style-type: none"> <li>• Under the National Irrigation Master Plan, a total of 29 irrigation subprojects dedicated to water harvesting (clustered) will be developed, covering a command area of 2,348 acres. Three types of new irrigation systems were proposed (in 2016): New Hill Irrigation Development Project, Dryland Irrigation Development Project, and Wet Subtropical Irrigation Development Project.</li> <li>• Protection of water sources and existing water storage facilities: Protection of catchment areas, treatment of gully erosion, and slope stabilization.</li> <li>• Development of new water storage: Construction of water collection chambers, spring boxes or infiltration galleries; construction of irrigation canals, water conservation ponds and storage tanks; simple and affordable rainwater harvesting technologies (RWHTs); and harvesting systems for micro and macro catchment runoff and floodwater runoff.</li> <li>• Exploration/assessment of potential: Groundwater sources and availability; multipurpose reservoirs; conduct aerial surveys to determine suitable areas for water harvesting; economic analysis of RWHTs.</li> <li>• Demand-side management: Development of irrigation systems like drip, sprinkler, and pipeline irrigation for direct water application in the fields, among other solutions.</li> <li>• Farmer training: Farmers to be trained to maintain their investments in RWHTs and effectively use water storage systems.</li> </ul>

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Sector	Policies and plans reviewed	Water storage types, targets, programs in policy
Energy – hydropower	<ul style="list-style-type: none"> <li>• Sustainable Hydropower Development Policy 2020</li> <li>• Water Vision and Water Policy 2025</li> <li>• 12th Five Year Plan (Vol. 2: Central Plan)</li> <li>• Intended NDCs 2015</li> <li>• Economic Development Policy 2016</li> <li>• National IWRM Plan 2016</li> <li>• National Adaptation Programme of Action 2006</li> </ul>	<ul style="list-style-type: none"> <li>• Target of 5,000 MW of hydropower by 2030 (installed capacity in 2019 was 2,326 MW).</li> <li>• Construction of hydroelectric projects: 1,200 MW Punatsangchhu Phase 1 (RoR hydroelectric project, 88% completed<sup>a</sup>); 1,020 MW Punatsangchhu Phase 2 (reservoir with hydroelectric project, 88% completed); 1,020 MW Punatsangchhu Phase 2 (reservoir with hydroelectric project, 88% completed<sup>b</sup>); 720 MW Mangdechhu Hydroelectric Project (RoR, completed in 2019<sup>c</sup>).</li> <li>• Pipeline projects: Sunkosh, Kuri-Gongri, Chamkharchhu, Bunakha, Wangchhu, Kolangchhu.</li> <li>• A bilateral agreement between RGoB and India signed in 2009, whereby India would buy 10,000 MW by the year 2020.</li> <li>• Efforts to be made to build capacity toward becoming a knowledge center for hydropower development and related services both in the South Asian region and globally.</li> <li>• The 12<sup>th</sup> FYP has a program on enhancing sustainable hydropower generation and transmission (BTN 177.5 million, approx. USD 2.66 million in 2018).</li> </ul>
Environment and natural resource management	<ul style="list-style-type: none"> <li>• National Environment Strategy 2020-2030</li> <li>• National IWRM Plan 2016</li> <li>• National Adaptation Programme of Action 2006</li> <li>• Strategic Programme for Climate Resilience 2017</li> <li>• Renewable Natural Resources Strategy 2021</li> <li>• 12th Five Year Plan (Vols. 1&amp;2)</li> <li>• Second Nationally Determined Contributions 2021</li> </ul>	<p>These policies focus on protection, conservation, and effective management of watersheds and wetlands through (but not limited to):</p> <ul style="list-style-type: none"> <li>• The 12th FYP program on sustainable natural resources management and utilization (BTN 655.9 million, approx. USD 9.84 million in 2018)</li> <li>• Another program of the 12th FYP under the National Environment Commission involves strengthening water security and enhancing management (BTN 22.41 million, approx. USD 336,150 in 2018).</li> <li>• All 186 watersheds assessed by 2023; ten degraded watersheds improved through interventions by 2023; five wetland management interventions developed by 2023; National Wetland Inventory conducted by 2023.</li> </ul>

Sources:

<sup>a</sup> PHPA (2024).

<sup>b</sup> SASEC (2024).

<sup>c</sup> DGPC (2024).

*Climate change.* To a certain extent, sector-specific policies in Bhutan recognize water storage as a response to climate change as a part of broader targets and activities. Water storage is addressed in the National Climate Change Policy (NEC 2020) and the NIWRMP (NEC 2016). For instance, the NIWRMP highlights the need to address glacial lakes at risk of GLOF, identify areas of groundwater recharge, and track key indicators, including the number and storage capacity of water retention and water harvesting structures (NEC 2016).

It was generally agreed among key informants that Bhutan is vulnerable to the impacts of climate change and that most impacts will concern water. However, the lack of historical data by which to establish a baseline is a major concern. The DECC noted that a minimum of 30 years of data are needed for time series analyses, but most data are only available from 1996. Therefore, while the impacts of climate change are already being felt, there are insufficient data to support planning. More research is required to understand the extent of the direct impacts of climate change on water availability, distinct from land use and other human impacts on water.

To prepare for climate change impacts, various agencies are discussing and planning the expansion of the weather station network to improve early warning systems, glacial melt risk assessments, and to assist with climate financing options, such as carbon offsetting (which will be discussed in Section 7).

## 5. Institutional Landscape for Planning and Management of Water Storage

Bhutan's local government is made up of 20 *dzongkhags* (districts); each of these consists of local administrative blocks called *gewogs* (a total 205); and there are four large municipalities or *thromdes* (Dorji 2016). Decentralized planning was introduced in the 9th FYP, mandating sectors and local government down to the *gewog* level to formulate strategies and identify priority programs (NEC 2016). The importance of decentralization was emphasized by the Planning Commission in the 1990s, recognizing that management of water and other natural resources is better done at the local rather than central and basin levels because of the varying terrain of the country and the fact that the impact of water-related issues was felt most at the community level (NEC 2016). However, as one of the key informants mentioned, in practice much of the planning continues to remain with the central agencies. Central government officers are deputed to *gewogs* and grants are provided to the local government.

In 2022, the RGoB implemented a reorganization process in which the Gross National Happiness Commission (GNHC), the agency previously responsible for overall planning, was removed (RGoB 2022). Historically, the National Environment Commission (NEC) used to coordinate water management planning across the mandates of different agencies. Following the reorganization, the scope of the NEC was reduced; the DECC became a secretariat of the NEC; and the DoW was created. This reorganization placed greater emphasis on the economic value of water and the optimization of water resources, an approach that is now being considered for forests and other natural resources as well.

*“The source of economic advancement lies in the environment. If we do not incorporate this thinking into our pursuit of economic development, we might end up uprooting our economy.” - Key informant*

At the central level, 15 entities—ministries, departments, and others—are directly or indirectly involved in water storage planning and development (Table 6).

**Table 6.** Key government institutions involved in water storage in Bhutan.

Department/ division	Role in water storage/water management	Ministry/agency
Department of Energy (DoE)	This is the agency for all matters related to energy. It formulates policies, plans, and guidelines; ensures energy security; develops innovative technologies; and assesses power markets and cross-border sales, among other responsibilities. It is a new department created by the reorganization process, amalgamating the departments of hydropower and other renewable energy forms.	Ministry of Energy and Natural Resources (MoENR)
Department of Water (DoW)	This department develops and updates policies, plans, and guidelines to ensure integrated water resources management, including the National IWRM Plan and the Bhutan Water Security Index in line with SDGs and national development goals. DoW ensures compliance on the quality and quantity of water resources, and governs protection, conservation, and management of water. It also assesses and categorizes the condition of watersheds (e.g. if a watershed is critical by function, it is certified as protected; if critical by score, then no intervention or use can take place in the watershed).	MoENR
Department of Environment and Climate Change (DECC)/NEC	DECC acts as the secretariat of the NEC. The climate change division, the environment assessment and compliance division, and the waste management division come under this department. Incorporation of water storage into plans and policies is a part of this department's responsibilities relating to climate change risk assessment and planning and enforcement of environmental rules and regulations, for e.g. through EIA processes.	MoENR
Department of Forests and Park Services (DoF)	This department's mandate is management of forests, biodiversity, and ecosystem services. This involves the protection of natural habitats such as wetlands and watersheds. Prior to reorganization, the watershed management division was part of the DoF. It is now under DoW.	MoENR
Department of Geology and Mines	This agency conducts geological mapping; maintains data and information; formulates policy; controls and regulates mineral resources, mining, and geoscientific activities. It has groundwater expertise and assists DoW in groundwater exploration even though it is not a direct mandate. Its studies involve groundwater levels and saturation, but not groundwater quality. It is the DECC that assesses and monitors water quality. Further studies (e.g. aquifer mapping) can be conducted on request from DoW.	MoENR

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Department/ division	Role in water storage/water management	Ministry/agency
Flood Engineering Management Division (FEMD)	Responsible for reducing the vulnerability of communities to flooding by taking up engineered construction. It specializes in flood adaptation and modeling of rivers, including identifying flood-prone areas and developing hydrological models, developing integrated stormwater management plans, maintaining flood/storm data, and providing technical assistance to local governments.	Ministry of Infrastructure and Transport (MoIT)
Department of Infrastructure Development	The Water Supply and Sanitation Division, which functions under the Department of Infrastructure Development, has recently undergone changes due to reorganization. It works with municipal bodies to ensure access to water and sanitation facilities and also works on capacity and infrastructure development.	MoIT
Department of Agriculture (DoA)	Its engineering division assists the department in promoting agriculture through planning and implementation of irrigation projects.	Ministry of Agriculture and Livestock
National Center for Hydrology and Meteorology (NCHM)	This agency carries out water resource assessments, hydrological forecasting, data management and dissemination, monitoring of early warning systems (EWS), assessment and mapping of GLOF, among other functions. It provides flow, sediment, and rainfall data to other agencies, including hydropower projects, and monitors the main river basins.	Autonomous agency under the Royal Government of Bhutan
Druk Green Power Corporation (DGPC)	Develops and manages Bhutan's hydropower resources and assets in line with the Sustainable Hydropower Development Policy. While DoE identifies suitable locations (based on initial studies) for hydropower projects, DGPC does further in-depth assessment and submits its findings to various agencies for approval. If approved, DGPC implements the project.	Subsidiary of Druk Holding and Investments Ltd.
National Land Commission (NLC)	Includes the Department of Land Administration and Management and the Department of Survey and Mapping. Makes recommendations on declaring areas as municipalities (thromde), industrial, and protected agricultural areas, and to approve the exchange of rural registered land with State Reserved Forest land. Coordinates with agencies to conduct land-use zoning and mapping.	Royal Government of Bhutan

Source: Government websites; KIIs

One positive outcome of the reorganization process, as identified by some key informants, is the amalgamation of different departments—energy, water, environment, and geology—under one ministry, MoENR, which is expected to help with coordination. Prior to the reorganization, the NEC was viewed as the apex body on water resource management as provided in the Water Act of Bhutan (Parliament of Bhutan 2011). With the creation of the DoW, a revision to the Water Act (2011) needs to occur to align institutional changes and policies within the legal framework.

The role of the DoW is still evolving. While it is clear that the department will handle policy and coordination, much of the on-the-ground implementation may still fall to the Department of Forests (DoF) due to its greater capacity (number of technical staff) in offices across the country and its historical role in water-related management. The DoF's expertise in water sources and the NCHM's focus on glaciers make interagency coordination essential for effective water storage planning and implementation.

The National Land Commission (NLC) has observed that coordination among different agencies has improved, especially in land-use planning. However, while the restructuring process is now complete, behavioral change needs to occur. It is envisaged that land-use planning will generate this change. The NLC suggests that water storage could follow a similar process to that followed by the hydropower sector whereby the respective hydropower entity presents the proposed area to the NLC before construction as part of the approval process (see the subsection on hydropower in Section 4.2).

Before the reorganization process, policy documents used to highlight the role of multiple central agencies and levels of local government involved in water management. But there was a lack of clarity on mandates and responsibilities. This led to a lack of coordination and accountability, as well as duplication of some activities (GNHC 2019; NEC 2020). The Water Vision and Water Policy (NEC 2014) notes that subsectors have been working in silos, resulting in fragmented data, poor data sharing, and inefficient resource management. An example provided during a KII was the construction of a school on a water source in East Bhutan which disrupted water availability for downstream villagers, leading to the necessity of a costly piped water solution. Proper land-use planning and coordination would have prevented this issue.

Despite the restructuring, some of the key informants felt that there was still a lack of clarity and a weakening of institutions. For instance, the moving of engineers from the Department of Agriculture to the Ministry of Infrastructure and Transport was seen as weakening the DoA. According to one of the key informants, the links between some agencies such as DoW and FEMD remain weak, resulting in scattered implementation, though planning is recognized to be improving among these agencies (e.g. in the Wangchhu basin). Others suggested that the impact of the reorganization on improved planning and coordination within the water sector is not yet visible, recognizing that time is needed to fully realize the roles and responsibilities of all agencies.

*“What really matters is how we implement.*

*This is why synergy is important, and this will be the focus moving forward.”*

*- Key informant*

*River basin management.* The Bhutan Water Vision and Water Policy (NEC 2014) states that the management of water resources will be based on river basins. Land use will be planned and conflicting uses will be resolved at the river basin level. The NIWRMP (2016) identifies five river basins in the country: (i) Amochhu, (ii) Wangchhu, (iii) Punatsangchhu, (iv) Mangdechhu, and (v) Drangmechhu. It describes the role of the river basin committees in coordinating the management of these basins in alignment with existing institutions and mandates. However, since the formation of the DoW, there has been a lack of clarity about the coordinating role. Some key informants suggested that RBM and IWRM should be overseen by the DoW, with the department serving as the central coordinator for all stakeholders including central agencies, local government, and water users' associations (WUAs).

*Local communities.* The Water Vision and Water Policy (NEC 2014), in line with the Bhutan Water Act (2011) and the decentralization process, stresses the importance of the involvement of central, *dzongkhag*, and *gewog* levels of administration in the planning, allocation, and use of water resources and the implementation, operation, and management of water programs. Indeed, in the development of the Climate Change Policy 2020, including the NDCs and the NAP, a stakeholder consultation process was followed that included local government, communities, civil society groups, and other entities (NEC 2020).

Several policies emphasize gender equity in the planning, development, and management of water resources programs, ensuring that burdens and benefits are shared fairly (e.g. the Water Vision and Water Policy 2014-2025; the Climate Change Policy 2020; NAP 2006). In discussions with key informants, it was mentioned that gender inequality is much lower in Bhutan than in other South Asian countries. One key informant stated that there is mixed participation of women and men in irrigation schemes; and participation is based on time availability. Women are also represented in leadership positions in central government agencies (e.g. director of DoW). However, further research is needed to understand the sharing of burdens and benefits in water use and management at the household and community levels.

The NGOs interviewed for this study indicated that they engage directly with local governments and communities, and therefore understand the needs and challenges faced on the ground. Some NGOs, such as the Royal Society for Protection of Nature, are working with communities to develop rainwater harvesting and springshed management.

Local government works directly with communities and households in various ways, including through watershed management committees or water user groups. Once irrigation schemes and water and sanitation programs are constructed, they are handed over to WUAs to maintain and manage. If any major renovation and technical works are required, they are provided by government agencies.

The WUAs that are registered under the Water Act (2011) exist only in some areas. In most areas there are informal groups that make use of traditional local knowledge in the management and sharing of water resources. There is limited literature on the status and experiences of WUAs (formal and informal) in Bhutan, but it is understood that informal water user groups existed and were successful in water resources management before the formalization of WUAs by donors and various agencies. For example, the *dong-bandh* system practised in Bhutan's Himalayan foothill zone of Assam is a traditional community approach to managing water for irrigation and domestic use (Box 2) (Saha et al. 2020). According to one key informant, the role of informal groups is not captured in policy documents and reports. In addition, establishment of a formal, registered WUA may be a financial burden on communities that are already informally organized. For both formal and informal water user groups, however, the lack of labor and nonavailability of technical capacity due to migration of youth out of rural areas are significant challenges to active community management of water resources.

### **Box 2. Dong-bandh irrigation system**

The communities living in Bhutan's Himalayan foothill zone of Assam have developed a local irrigation system called *dong-bandh* to meet domestic and agricultural water needs, especially during the winter and premonsoon seasons. It consists of a network of canals to divert the flow of stream water from the hills. The canal is called *dong* and the check dam *bandh*. These systems are developed and managed by the local water users' associations called *dong-bandh* committees. All activities such as water distribution, canal repair, labor mobilization, and conflict resolution are carried out by the respective committee of each area. However, due to out-migration and changes in cropping patterns, management of these systems is becoming increasingly challenging.

(Source: Saha et al. 2020.)

Community groups in the western part of Bhutan are actively engaged in watershed management and use small-scale, traditional forms of water storage such as rainwater harvesting and ponds. Watershed management and forestry management are often integrated in the same community group, as used to be the practice under the Department of Forests (DoF) (see Box 3). While water sources and forests are managed together by communities, key informants from central government agencies highlighted the need for capacity-building and ongoing support to strengthen community governance. In certain areas of Bhutan, however, communities remain reliant on government agencies for resources and services. In such areas it is crucial to provide training that highlights the importance of community participation in water and resource management, fostering a sense of ownership and responsibility for sustainable practices.

### **Box 3. Community forests**

Community forests are forest areas entrusted to local communities to manage. When communities recognize that a particular hill/forest area is the source of their water supply, they take proactive steps to protect and maintain it. Some communities have initiated water harvesting and re-planting of areas, whilst others have imposed restrictions on tree harvesting, understanding the crucial role trees play in the maintenance of water resources. For harvesting of trees, communities must obtain clearance from the DoF in addition to community clearance. This process exemplifies a collaborative model of natural resource governance, where communities work alongside the government to ensure sustainable management of vital resources.

## **6. Cross-border Considerations for Water Storage in Bhutan**

Given the geographic location of Bhutan, there are significant interdependencies with neighboring countries concerning trade, transport of goods, and water resources management (among other geopolitical aspects). Due to the sensitivities around cross-border water management, detailed discussions with key informants on this topic were limited. However, India is considered a close and strategic partner, and Bhutan has maintained bilateral agreements with India on hydropower for 50 years (Dorji 2016; NEC 2016). Surplus energy generated during the summer monsoon months is exported; in the dry winter months, though, energy is imported due to low water flow. In addition, the Government of India provides technical support including approximately 200 weather stations for flood warning, which benefits both countries.

Two of the main river basins in Bhutan originate in the Tibet region of China. Despite increased development activity in China, there are currently no formal agreements on data sharing in place regarding water management or water-related risks.

## 7. Conclusion and Potential Areas for Intervention

Water storage planning and development are crucial in Bhutan to address water supply variability across sectors and to prepare for flood, GLOF, drought, and disaster risk management. Policies and discussions acknowledge the importance of storing excess water during the monsoon season to provide multiple benefits including enhancing hydropower generation and agricultural production and guaranteeing a steady drinking water supply (Dorji 2016). One of the key recommendations arising from this study is revision of the Water Act of 2011 to incorporate the newly formed Department of Water. Water-related policies such as the National Irrigation Policy (2011) need to be updated and aligned with the revised Water Act and with the National Water Policy which is due an update after 2025. While this study provides an overview and introduction to aspects of water storage in Bhutan, further research is required to better understand the actual realization of water storage plans and targets on the ground.

Though they remain somewhat fragmented, several programs focus on water storage and its implementation, including:

- The Water Flagship Program, initially funded by the Royal Government of Bhutan and subsequently supported by ADB (USD 22 million) and the Global Environment Facility/United Nations Development Programme (USD 8.9 million), is implemented by the Water and Sanitation Division of the Department of Infrastructure Development. It focuses on the development of schemes for provision of drinking water and irrigation, and addresses water governance issues, watershed management, and climate resilience aspects, among others.
- The Water Stress Project (2023), funded by the Bhutan Trust Fund (USD 10 million), implemented by the DoW, Ministry of Infrastructure and Transport, and the local government in three districts (Paro, Tsirang, and Dagana) involves the development of water storage systems for drinking water and irrigation.
- Donor agencies such as the Green Climate Fund are financing capacity-building programs on a small scale, focusing on the livelihood resilience of communities. ADB is supporting the development of river-based management plans including the Wangchhu Basin management plan.
- Agencies like the Japan International Cooperation Agency (JICA) and the World Bank are funding programs on disaster risk preparedness, GLOF hazard mapping, and early warning systems.

KIIs conducted for this study identified some water storage types as having significant potential for development in Bhutan:

- Reservoirs and water storage areas for forest fire control, proposed by the Department of Forests.
- Spring management and groundwater recharge trenches in water-scarce areas, though this requires further technical capacity on groundwater management.

Some KIIs also identified key needs and areas of support for the planning and development of water storage in Bhutan:

### Human capacity

- Some key informants identified insufficient trained personnel at the local government levels (*dzongkhag* and *gewog*) (NEC 2006), in the National Center for Hydrology and Meteorology (NCHM), and in the DGPC. Migration between government agencies across different sectors, and out of the country, was highlighted as a particular concern. For example, at DGPC, the agency trains staff in specialized skills (e.g. hydrology) but migration results in a loss of skills. There are several factors influencing migration (See Section 3).
- Strengthening NCHM's technical capacity is necessary to move from just flood detection to providing localized warnings. This involves improving the dissemination of forecasting and early warning systems (EWS) information to other agencies (NEC 2006, 2016).

### Technical information and support

- More weather, river flow, and groundwater monitoring stations are needed throughout the country for localized forecasting (NEC 2016).
- Support is needed from technical agencies on methods of rainfall interpolation and data analysis for use in climate modeling and management of water resources.
- Support is needed to enhance the Agromet decision support system implemented by DoA and to provide EWS to farmers.
- Mapping critical watersheds and wetlands is essential for land-use zoning and planning. The potential recharge areas, payments for ecosystem services, and water point sources have been mapped in the recent national land-use zoning report (RGoB 2023).
- Hydrological assessments at the catchment and subcatchment levels are needed for planned investment. There have been instances of investments in areas where water sources have subsequently dried up.
- Groundwater assessments and inventory, including information on aquifers, are essential.
- Assessments of droughts and related impacts, and the development of a drought response plan have been flagged as key areas for development.

Bhutan is ahead of some of its neighboring countries in incorporating water storage systems into planning and development. The country's policies clearly outline the significance of different types of water storage in different sectors with areas identified for further growth and intervention. By addressing the technical and capacity gaps highlighted above, Bhutan can improve planning and arrive at more effective water storage solutions. While water storage systems in other countries in the South Asian region may often be more reactive, Bhutan's more proactive approach to disaster risk management and climate change preparedness position it well to address future water resource management challenges.

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# Annexes

## Annex A. Thematic Areas for Policy Review of Water Storage.

Sectors and themes included in the review of water storage policies and strategies for this Policy and Institutional Study. Broader topics are in bold with subtopics/areas listed under them.

<b>List of sectors and themes</b>	
<b>Key goals/outcomes</b>	<b>Fisheries</b>
Country context	Contribution to development
Water sources	Water security
Scarcity/abundance	Storage as new opportunity; storage as risk
Patterns shaping temporal and spatial water availability	<b>Climate resilience/adaptation</b>
Explicit reference to storage	Water security
<b>Agriculture</b>	Storage for resilience
Contribution to development	<b>Governance</b>
Supply-side requirements	Integrated water resources management
Demand-side management	Transboundary water management
Water storage/harvesting	Cross-sector planning
Soil moisture	Participatory solution identification, design and implementation
Flood management	Focus on vulnerable groups including women
Desalination	Local knowledge in resource management and adaptation
<b>Energy Environment</b>	<b>Other</b>

## Annex B. Questions for Key Informant Interviews.

### DRAFT QUESTIONS Key Stakeholder Interviews – Bhutan

Please note: Not all questions will be asked of every individual respondent. A different combination of the following questions will be asked based on the sector/expertise of the individual. For example, agriculture-related questions are meant for the respondent from the Department of Agriculture. There will be approximately 8 questions and 45 minutes per interview. This is a semi-structured interview, and the questions are to guide the discussion. Further follow-up questions may arise during the discussion.

1. Different sectors may need different types of water storage at different spatial scales, each with its own management regime given the diverse water-related risks (GLOF, floods, landslides, drought) and needs (energy, irrigation, etc.). At what scales and in what types of water storage is Bhutan investing? What development goals drive these investments?
2. Climate change risks include GLOF and other forms of flooding, rainfall and river flow variation, and drying up of water sources like springs and drought. What role does water storage have, if any, in managing these risks?
3. The Bhutan Water Vision and Policy notes the importance of springs and other subsurface water sources for domestic and irrigation purposes. But these sources are drying up. What measures are being taken/planned to protect and secure these sources?
4. Under the NAP 2006, the priority investment on flood protection of downstream communities and activities does not mention storage. Under SPCR 2017, one of the investments seeks to adopt an ecosystems-based approach to river basin integrated flood management. Have storage options been considered in river basin management for flood risk?
5. A key challenge for Bhutan is how it can maintain a balance between rapid growth and environmental sustainability. In the water sector, how is the government thinking about large storage infrastructure and downstream impacts?
6. Bhutan's policies highlight commitment to IWRM in river basin management. How will the implications of different storage investments be factored into these planning and management processes?
7. One of the investments (investment #2) outlined in the SPCR concerns water resource management. To what extent has the management of watersheds and wetlands for climate resilience been achieved? Has this affected other development goals (e.g. hydropower/irrigation)?
8. The NDCs and the hydropower policy of 2021 mention reservoirs and pumped storage for energy security. Are these storage systems planned as multiple-use systems? What is the decision-making process behind them?
9. Is the Renewable Natural Resources (RNR) Strategy 2021 the main policy document for agriculture and does it supersede the organic farming policy document of 2006? The only mention of water storage or water resources management in the RNR relates to watershed and wetland management under the strategic objective of sustainable resource management. Can dry-season agricultural needs/demands for water resources be met without other forms of storage?
10. Which government agencies plan/regulate/implement water storage? Given that different sectors may focus on different storage types, is there a mechanism to coordinate these investments across sectors and river basins?
11. Development goals include the active participation of diverse groups of people and the adoption of local knowledge. How are local knowledge, diversity of stakeholders, and the principles of accountability and inclusion incorporated into water storage planning and implementation?

## Annex C. List of Agencies Interviewed.

Agency/department	Ministry	Type of stakeholder
Department of Water	Ministry of Energy and Natural Resources	Government
Department of Environment and Climate Change	Ministry of Energy and Natural Resources	Government
Department of Geology and Mines	Ministry of Energy and Natural Resources	Government
Department of Forests and Park Services	Ministry of Energy and Natural Resources	Government
National Center for Hydrology and Meteorology		Government
Department of Energy	Ministry of Energy and Natural Resources	Government
Department of Agriculture	Ministry of Agriculture and Livestock	Government
Water and Sanitation Division, Department of Infrastructure Development	Ministry of Infrastructure and Transport	Government
Flood Engineering and Management Division	Ministry of Infrastructure and Transport	Government
National Land Commission		Government
Druk Green Power Corporation		Corporation
Bhutan for Life		NGO
Royal Society for Protection of Nature		Civil Society Organization
Bhutan Trust Fund for Environmental Conservation		Autonomous agency
Bhutan Water Partnership		NGO





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**International Water Management Institute (IWMI)**

**Headquarters**  
127 Sunil Mawatha, Pelawatta  
Battaramulla, Sri Lanka

Mailing address:  
P. O. Box 2075  
Colombo, Sri Lanka  
Tel: +94 11 2880000  
Fax: +94 11 2786854  
Email: [iwmi@cgiar.org](mailto:iwmi@cgiar.org)  
[www.iwmi.org](http://www.iwmi.org)