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

Built Water Storage in South Asia Project

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Contents

Acronyms and Abbreviations

BADC	Bangladesh Agricultural Development Corporation
BDP	Bangladesh Delta Plan 2100
BMDA	Barind Multipurpose Development Authority
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
BWSSA	Built Water Storage in South Asia Project
BWP	Bangladesh Water Partnership
DBHWD	Department of Bangladesh Haor and Wetlands Development
DTW	Deep tube well
EIA	Environmental impact assessment
GWP	Global Water Partnership
Ha	Hectare
IWMI	International Water Management Institute
IWRM	Integrated water resources management
IWT	Inland water transport
JRC	Joint Rivers Commission
KII	Key informant interview
LGED	Local Government Engineering Department
LLP	Low-lift pump
MAR	Managed aquifer recharge
MoWR	Ministry of Water Resources
MLD	Million Liters per Day
MW	Megawatt
NWMP	National Water Management Plan
NWRC	National Water Resources Council
RBM	River basin management
RBO	River basin organization
SAARC	South Asian Association for Regional Cooperation
STW	Shallow tube well
WARPO	Water Resources Planning Organization
WHO	World Health Organization
WUA	Water users' association
SSP585	Shared Socioeconomic Pathway 5, Scenario 8.5
SSPs	Shared Socioeconomic Pathways
VSC	Vector Similarity Coefficient
WMO	World Meteorological Organization

Key Messages

- Bangladesh is among the five fastest growing economies in the world. Agriculture is a major driver of economic development and poverty reduction in the country.

- The agriculture sector, primarily irrigation, is responsible for nearly 90% of the total freshwater withdrawal from surface and underground sources.

- Bangladesh's heavy dependence on irrigation contributes to the severe freshwater deficit experienced during the dry season. This situation arises from a combination of geographical and geopolitical factors. They include a highly dynamic, low-lying, and flood- and salinity-prone deltaic landscape; high vulnerability to climate change, which amplifies hydrological risks; and Bangladesh being the lowest riparian country for 57 transboundary rivers flowing into the country.

- Therefore, the degree of control Bangladesh has over freshwater resources is low. This brings into sharp focus water storage capacity enhancement and management as a vital response to meet dry-season irrigation, domestic, industrial, and urban demands—all of which are forecast to grow.

- Currently, surface water storage in Bangladesh varies widely in terms of scale, form, and actors, reflecting the country's diverse biophysical conditions. Large-scale reservoirs are notably absent due to the relatively flat terrain and a political aversion to the negative social impacts of large infrastructure. As a result, despite the diversity of surface storage strategies, they fall significantly short of meeting the water demand.

- The sizeable gap between surface water storage and dry-season water demand has been bridged by heavy exploitation of groundwater to buttress growth in agriculture, industry, and urban expansion.

- The strain on groundwater resources is emerging due to continuous extraction and increasing water demand across all sectors. This will only intensify in the future. The ability of aquifers to sustain water supply is further compromised by the presence of arsenic and increasing saline intrusion (which is linked to low dry-season river flows and climate change).

- The primary opportunity for increasing water storage may lie in managed aquifer recharge (MAR), which can theoretically lead to the capture of a greater portion of wet-season flood waters. However, the risks of polluted surface water entering aquifers and the challenge of low levels of technical expertise in implementing MAR need to be addressed before existing pilot projects can be scaled up. Effective scaling will require clear rules and technical guidelines to ensure safe and sustainable MAR.

- For the above reasons, water storage is currently considered only a secondary solution in Bangladesh, contingent upon achieving no substantial change in the primary strategy of increasing dry-season river flows from upstream neighbors.

- With 54 of Bangladesh's 57 transboundary rivers flowing in from India (including the Ganges, Brahmaputra, and Meghna), Indo-Bangladesh negotiations over water sharing hold the key to unlocking what the country views as its fair share of water. Currently, the status quo heavily favors India due to its greater political and economic influence and its bilateral approach to negotiation. Given the historical stability of these dynamics, it is a challenge for Bangladesh to effect changes on its own.

- The renegotiation of the Ganges Water Treaty, which will be due in 2026, presents an opportunity to address these issues. However, stakeholders in Bangladesh believe that any meaningful change in the status quo requires the intervention of a neutral external actor. Some of the key informants interviewed for this study expressed concern that Bangladesh and its neighbors are not signatories to the United Nations Law on Non-navigational Uses of Water Courses, which might otherwise have facilitated engagement with UN Water as a mediator. Additionally, it was noted that the South Asian Association for Regional Cooperation (SAARC) lacks a dedicated agenda for water management despite it being a primary forum for regional cooperation.

- In the near-to-medium term, therefore, Bangladesh may need to rely more on water storage to meet its future water demands. In-country stakeholder consultations identified three areas of focus:
    - establishing a coherent and delegated governance framework for more holistic water management;
    - improving data availability for more informed decision-making on storage (and broader water management) options; and
    - building capacity among state and non-state actors as developers and managers of water storage infrastructure to improve effectiveness and sustainability.

- The imperatives identified to manage groundwater align with these three focus areas. Currently, there is no single groundwater authority and there are no comprehensive rules for specific aquifers. Knowledge of aquifers is geographically limited, which inhibits formulation of rules and guidelines and design of capacities to sustainably manage this vital source of water.

1. Overview

1.1 Built Water Storage in South Asia Project

The Built Water Storage in South Asia (BWSSA) project, funded by the US Department of State and implemented by the International Water Management Institute (IWMI) and the Global Water Partnership (GWP), seeks to address water insecurity in the region. The three-year project (2022-2025) will contribute to a transformation in the way water storage is perceived, planned, and managed in Bangladesh, Bhutan, India, Nepal, and Pakistan. 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 in understanding water storage gaps and the options available to fill them;
- Facilitate cross-border and regional dialogue to address these water storage gaps;
- Address historical inequalities, especially in terms of who benefits from water storage and in the technical and management personnel planning and implementing water storage.

In close collaboration with relevant government ministries and other stakeholders, the BWSSA project has been built around three interlinked work streams. The first, ***understanding water storage gaps and the options to fill them***, develops tools and approaches to map and investigate the seasonal dynamics and trends in different types of water storage. This aspect of the project 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 storag***e, involves working with a cohort of 30 technical staff (at least 40% of them women) drawn from different government ministries to raise awareness and build technical skills. Regular workshops are co-designed with the cohort to share knowledge and experiences on issues that they prioritize, including topics such as data collection, storage mapping and modeling, water resource implications of climate change, and optimizing water use and infrastructure management.

The third work stream, ***transboundary water storage cooperation***, promotes the benefits of international cooperation in water storage planning and management. Working with relevant national stakeholders, this work stream identifies opportunities as well as constraints to international cooperation and convenes technical dialogues on specific topics to build trust and enhance cooperation. A high-level political roundtable will be convened to discuss water storage options in the context of transboundary water management.

The BWSSA project conducted inception workshops in each member country in January 2023, identified cohort groups (six members from each country), and conducted cohort workshops in June, September/October, November 2023, and March/August 2024.

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

While seeking to find water storage solutions to current water-related challenges and to prepare for future scenarios in each of the target countries, the BWSSA project is identifying how more effective water storage in all its forms can best support the development needs of the focal countries. Toward this end, 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 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 possible synergies and trade-offs between development goals. The study also touches upon upstream-downstream issues and hence transboundary cooperation (Outcome 3), though this is highlighted more in some countries than in others. Particular attention was given to highlighting how the diversity of storage types can improve the response to needs and risks in specific biogeographic contexts and sectors, to reinforce the importance of targeting investments beyond large-scale schemes.

In each project country, the Policy and Institutional Study was implemented in phases (Figure 1). The first phase analyzed the content of national policies and strategies to understand the positioning of water storage in various sectors and its contribution to overall national development goals, the cross-sector synergies and trade-offs, and the space available for socially inclusive and stakeholder-responsive planning, design, and management of storage. Significant 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, NGOs, academia, and the private sector, to capture diversity in information and perspectives. These interviews explored themes in greater detail, including important gaps between stated policy and actual practice and the subtexts underlying such gaps. The key informant interviews (KIIs) also helped identify the existing institutional mechanisms for water resources management, the status quo on how sector storage needs are aggregated into water-sector/basin-scale plans, and the extent to which storage investments respond to the needs of diverse water users. While river systems in South Asia are distinctly transboundary, this aspect was not explicitly covered during the KIIs due to country sensitivities. However, information and perspectives on transboundary issues volunteered by respondents were recorded and they do inform this report. A draft country report was generated after an analysis of data from Phases 1 and 2 and a review of published literature. The draft report was shared with all key informants with a request to verify the details and narratives, filling in any gaps (Phase 3). The results of this consultative process were used to finalize the report and contributed to building stakeholder consensus and credibility.

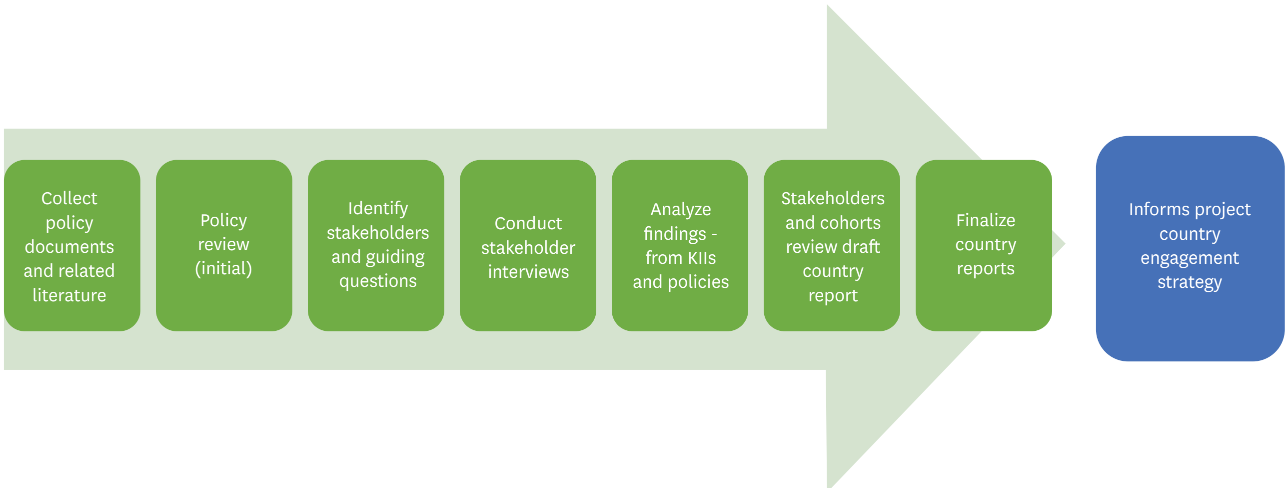

Figure 1. Approach for the Policy and Institutional Study conducted in Bangladesh, Bhutan, India, Nepal, and Pakistan.

This country report on Bangladesh presents the approach undertaken for the Policy and Institutional Study (Section 2), a brief overview of water resources development and the role of water resources in the country (Section 3), the current status of water storage, policy direction, and the governance architecture shaping water resources management (Section 4), and conclusions and recommendations from the study (Section 5).

2. Methodology

2.1 Phase 1: Policy Review

The policies and strategies reviewed in this study were related to national development as well as various sectors such as water resources, agriculture and irrigation, environment/forestry, domestic water supply, energy, and climate change (Annex 1). Documents and literature for the review were sourced from databases such as FAOLEX, Google, Google Scholar, the IWMI library database, Scopus, and ProQuest. The list of policies was shared with the GWP country office in Bangladesh to review and add other applicable policies.

Information extracted from these documents—on development priorities; types of water storage, plans, targets, challenges, and risks; links to IWRM, RBM, and other governance aspects; and opportunities for local stakeholder roles—was added to an Excel database with pre-identified sectors and thematic areas (Annex 1). These thematic areas were identified by the project team based on previous approaches to policy and institutional studies in keeping with the overall aim and focus of the BWSSA project. However, the information extracted from the documents was not limited to thematic areas; any area that provided further understanding of the water storage situation within a project country was included. For the Bangladesh review, for instance, 14 documents representing the most relevant policies and strategies were reviewed (Table 1). Relevant text from these documents was entered into the Excel database, which enabled analysis of thematic aspects and targets across multiple documents. This helped identify synergies and gaps across sectors as well as key topics and questions for inclusion in the KIIs conducted in Phase 2 of the review.

Table 1. Policies, plans, and strategies reviewed for Bangladesh.

Year of publication/timeframe	Policy document
2022	National Adaptation Plan of Bangladesh 2023-2050
2022	National Plan for Disaster Management 2021-2025
2021	Nationally Determined Contributions (NDCs) 2021
2021	National Food and Nutrition Security Policy 2021-2030
2020	Perspective Plan of Bangladesh 2021-2041
2020	8th Five Year Plan 2020-2025
2018	Bangladesh Delta Plan (BDP) 2100
2018	National Agricultural Policy 2018
2017	Second National Plan of Action for Nutrition (NPAN) 2016-2025
2014	National Strategy for Water Supply and Sanitation 2014
2014	Climate Change and Gender Action Plan 2014
2008	Renewable Energy Policy 2008
2005	National Energy Policy (2005 update)
1999	National Water Policy 1999

2.2 Phase 2: Key Informant Interviews

The KIIs conducted in Phase 2, featuring in-person and in-depth discussions, built on the analysis done in Phase 1. Interviewees for the KIIs were selected to provide diverse and reliable information drawing on their position and experience within the government structure, or to offer perspectives from outside the public sector. This allowed a degree of triangulation with respect to what the priorities were and how policies and plans responded to them, the planning and implementation processes, and the institutional structures and their strengths and weaknesses. Based on the policy review and aided by the guidance provided by the country focal points (IWMI and GWP), a list of key stakeholders across sectors and expertise was created (Annex 2), and semi-structured interview questionnaires were developed encompassing a combination of common and key informant- or sector-specific topics (Annex 3). Selection of the key informants was informed by the need to strike a balance among the government sector, NGOs, and academia. The approach to the discussions was expansive, leaving room for deviations if an important supplemental topic emerged. A total of 15 KIIs, lasting approximately one hour each, were conducted from the 21st to 24th August 2023 in Dhaka. The resulting qualitative data were sorted in Excel.

The overall aim and approach of the Policy and Institutional Study was explained to the cohort in Bangladesh, which assisted in the coordination and planning of the study.

2.3 Phase 3: Country Report on the Strategic Role of Water Storage

The analysis and report writing process included a verification step by which the draft report was initially shared with the country focal points for inputs and thereafter with the key informants for accuracy and any further insights. The findings are presented below according to the national development goals and priorities around water storage, the sectoral plans, the institutional structure, decision-makers on water storage, the cross-border aspects, and areas for further development of water storage planning and implementation.

3. Water and Development in Bangladesh

3.1 Impressive Development Achievements Despite Severe Water Resources Constraints

Bangladesh is a densely populated country of 167.6 million people, 85% of whom live in rural areas (ADB 2023). It is among the five fastest growing economies globally (World Bank 2020) and is expected to move out of the UN's Least Developed Countries (LDC) list in 2026[1]. It achieved a lower middle-income country status in 2014 (ADB 2021), driven by export-oriented manufacturing and construction industries. Poverty decreased to 18.7% in relation to the national poverty line and to 5% relative to the international poverty line in 2022 (World Bank 2023). According to the World Bank (2020), agriculture contributed to almost half of the poverty reduction between 2000 and 2010. Ahmed (2024) estimates agricultural growth elasticity of poverty to have been -2.26 during 2016-2022, meaning that a 10% increase in per capita real agriculture GDP led to a 22.6% reduction in poverty during this period. Agriculture accounts for about 14% of Bangladesh's GDP and employs 42% of its population (World Bank 2020). It is also responsible for nearly 90% of the total freshwater withdrawals (World Bank 2020). This is not surprising given that significant investments in irrigation have underwritten poverty reduction and self-sufficiency in rice production (World Bank 2020). Avoiding flood-induced famines and attaining food security have been the defining motivations of Bangladesh's water management. Bangladesh is in fact the third largest producer of rice in the world (al Mamun et al. 2021), ensuring both self-sufficiency and export revenue.

However, these economic and food security achievements are both significant accomplishments as well as drivers of water resources management challenges. These results have been achieved despite the challenging agroecological

[1] Source: The World Bank website https://www.worldbank.org/en/country/bangladesh/overview

context, given that Bangladesh is the seventh most climate-vulnerable country (Global Climate Risk Index 2021). This is partly because river floodplains and deltaic plains account for most of the country's area. Bangladesh has a unique hydrological regime that lends itself to severe flooding and significant saline intrusion. This landscape, where 10% of the area consists of lakes and rivers, is shaped by the confluence of the Ganges, Brahmaputra, and Meghna rivers inside Bangladesh. They form the largest delta in the world in which around 70% of the total area is less than three meters above sea level (GoPRB 2018a). Furthermore, the country experiences extreme seasonality in surface water availability: 80% of the total annual runoff occurs in just over four months between June and September (World Bank 2020). Although average annual rainfall[2] is about 2,200 mm, geographical variation between 1,250 mm and 5,500 mm is substantial, with the northwestern (Barind) region being drought-prone.

Bangladesh's unique waterscape (Figure 2) and rainfall patterns make large areas of the country prone to annual flooding and more severe intermittent flash floods, especially in the northeastern region. On average, an estimated 20-25% of the country becomes inundated in most years due to river spilling and drainage congestion. Extreme situations arise when the three major rivers reach their flood peak at a similar time, when 55-60% of the country can be inundated. Recent evidence reveals that the magnitude and frequency of mega floods are increasing as a consequence of climate change and possibly other human causes like construction of dams in the upper riparian countries, unplanned urbanization in illegally encroached floodplains, etc. (GoPRB 2018a). This is expected to increase the flood extent for all areas of the country by 2050 (GoPRB 2018a), and the population exposed to floods with a 10-year return-period[3] is projected to rise significantly even under the moderate climate change scenario (World Bank 2020). However, not all floods are considered destructive, given that communities have adapted to predictable patterns of flooding over the course of time. This adaptation involves learning to take advantage of the annual replenishment of soils and wetlands, groundwater recharge, and freshwater fisheries (the primary source of animal protein) supported by floods. Consequently, as explained by Haque et al. (2019), "normal floods" are seen as positive and socially desired events. The issue today is the altering of flood patterns as a consequence of climate change and other human activities.

Large areas of Bangladesh, especially along the western border, are also prone to droughts before and after the monsoon. Due to the combined effect of soils with low moisture-holding capacity (<200 mm available moisture), an increasing number of dry days (precipitation <0.5 potential evapotranspiration for 32-48 days), and extreme summer temperatures of more than 40°C, droughts in the dry areas are extremely severe during April and May (MoEFCC 2022). The World Bank (2020) has observed that these dry periods are expanding, affecting the rainfed cultivation season. Some droughts are induced by the very low dry-season river flows and the ever-increasing water demand, especially for agriculture, during the seven-month-long dry period (GoPRB 2018a). Economic losses from some droughts are greater than that from floods, and the costs of groundwater extraction are estimated to rise more than proportionally as groundwater continues to be depleted in some areas (World Bank 2020).

Thus, achieving a balance between too much water and too little water is the core perennial challenge for the water sector in Bangladesh – a key need given that around 85% of the poor live in rural areas with low agricultural productivity and unreliable water and food supplies (ADB 2023).

3.2 Everything Flows from Above: The Realities of a Lower Riparian Country

The most fundamental driver of Bangladesh's water resources context is its position as the lowest riparian country for 57 transboundary rivers that also flow through India, China, Bhutan, Nepal, and Myanmar; 54 of them flow into Bangladesh from India. Bangladesh's dependence on freshwater flows from India in particular, and from Nepal as well, is clear when one considers that 92-93% of the three main river systems supplying freshwater to Bangladesh (the Ganges, Brahmaputra, and Meghna) lie outside Bangladesh. With climate change affecting hydrological cycles and human populations growing across the Indian subcontinent, Bangladesh's ability to access increasingly contested river waters emerges as an overarching

[2] Source: https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-historical
[3] The average period of time expected to elapse between occurrences of floods of a particular magnitude.

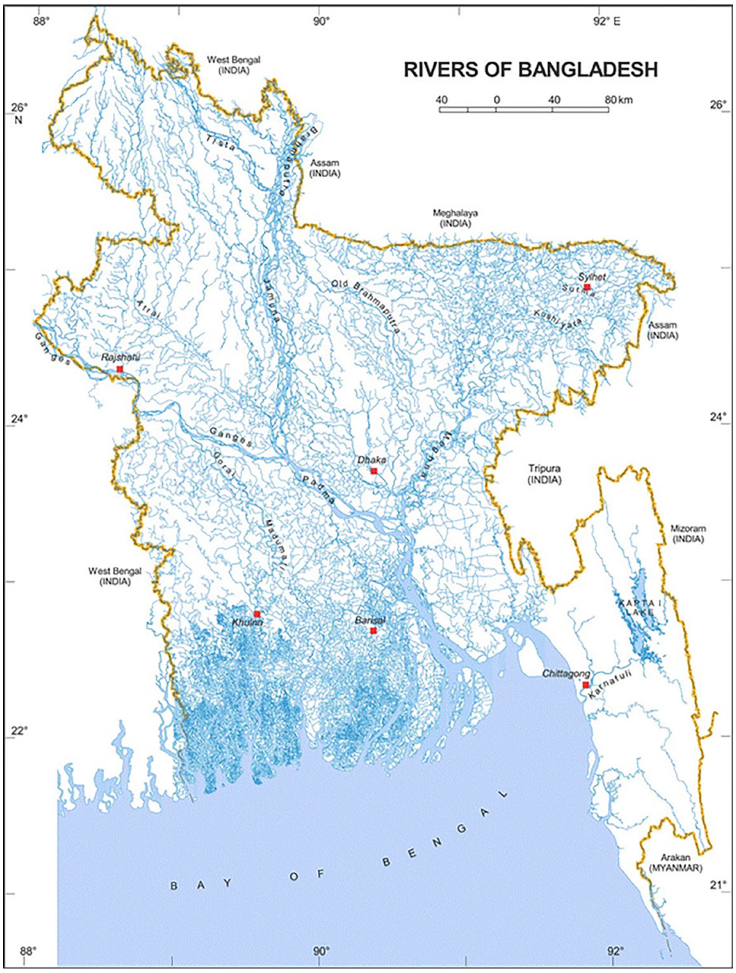

Figure 2. River systems in Bangladesh.
Source: https://qph.cf2.quoracdn.net/main-qimg-3701c7d557958191c30f7e934f73f31d

driver of the country's water insecurities. Currently, while wet-season flows reach 140,000 cubic meters per second (m^3s^{-1}) in August, dry-season flows drop to as low as 7,000 m^3s^{-1} in February (Amin et al. 2018) when water demand is high. In addition to being insufficient for the demands of households, agriculture, industry, and urban stakeholders, this meager dry-season flow is also linked to intensifying salinity levels in coastal areas. This severely affects access to drinking water and curtails crop production. Furthermore, heavy sediment loads increase the river dredging burden on the Bangladesh side.[4] About 53% of Bangladesh's coastal areas have high salinity in soil and groundwater. As a result, about half of the cultivable land in the coastal districts has low or no yields and only one rainfed crop is possible at best (World Bank 2020). This is compounded by approximately a quarter of the structurally improved drinking water sources (mainly shallow tube wells) containing arsenic levels greater than the World Health Organization limit (World Bank 2020). Prevalent gender norms whereby men control household spending decisions imply that expenditure is not always allocated to pay for filtered water. As a result, women and girls walk great distances to source fresh water and consequently there is a high level of school dropout of girls. Overall, coverage of piped water has been largely stagnant in the past 10 years, indicating that utilities have done no more than keep up with population growth (World Bank 2020).

Any further upstream developments on these rivers may aggravate the already vulnerable situation of Bangladesh in terms of water availability (GoPRB 2020a). In fact, as observed by the World Bank (2020), interbasin water diversion schemes in India and China threaten to further reduce dry-season water availability in Bangladesh. India's pursuit of diversions from the Brahmaputra to increase dry-season availability in the Ganges basin is likely to be detrimental to

[4] The Brahmaputra-Jamuna system is one of the most heavily sediment-laden large rivers of the world (World Bank 2020).

Bangladesh. These risks are compounded by changing climate and slowly disappearing glaciers higher up in the basin, which poses an additional long-term threat of reduced dry-season flows in Bangladesh. Indeed, Mondal and Wasimi (2007) and Mondal et al. (2010) observed that the need for water storage in Bangladesh will increase in the future with growing water demand and increasing uncertainties due to climate change and upstream withdrawals.

The importance to Bangladesh of regional cooperation on transboundary river management therefore cannot be overemphasized. Several informants pointed out in KIIs that water storage is not an alternative to regional cooperation based on equitable transboundary river governance. This lies at the center of addressing the water insecurity Bangladesh faces in the dry season. Resolving this core constraint is clearly intensely political. Key informants pointed out that Bangladesh's single bilateral agreement with India (the Ganges Water Treaty signed in 1996)[5] on water sharing via the Farakka Barrage is wholly insufficient for several reasons. Firstly, it is claimed that Bangladesh receives significantly less than the agreed 50% share of the dry-season flow. The absence of real-time flow data undermines the possibility of a data-driven dialogue on water sharing, flood management, and augmenting dry-season flows to enable navigation and maintenance of river-dependent ecosystems in Bangladesh. Some key informants pointed out the occurrence of flash floods when it rains in India even if there was no rain in Bangladesh and underlined the need to share upstream dam operating regimes.

A fundamental feature of current transboundary river relations in South Asia is their bilateral nature rather than a multilateral arrangement involving all riparian countries. In the case of the Ganges Treaty with India, in which the Farakka Barrage is the issue, a multilateral approach would involve Nepal. As it currently stands, the Ganges Treaty does not deal with the impacts of the 10 upstream dams; and the absence of Nepal means that how Nepal uses tributaries of the Ganges River is also not addressed. Moreover, the environmental impact assessments (EIAs) conducted for Indian investments on the river do not consider the impacts in Bangladesh. The lack of data and data sharing makes it difficult to make a compelling case on the impacts of upstream dams on Bangladesh. In fact, salinization and siltation in the southwestern part of Bangladesh are principally due to the drastic reduction of the Ganges flow since the commissioning of the Farakka Barrage in 1975 (Mondal et al. 2013).

The current Ganges Treaty thus fragments the Ganges River. There is a need for a basinwide agreement that would also fill the considerable data gaps on flows and river uses. What is desired by the Bangladesh stakeholders, at least, is a shift to joint planning through a river basin organization (RBO) comprising of representatives from the respective riparian countries, and development of the basin as an integrated unit. The Bangladesh Delta Plan (BDP) 2100 (GoPRB 2018a) and the 8th Five Year Plan 2020-2025 (GoPRB 2020a) thus propose RBOs for the Ganges (Bangladesh, India, and Nepal), the Brahmaputra (Bangladesh, India, Bhutan, and China), and the Meghna/Barak River (Bangladesh and India). A consensus amongst the other riparian countries will be needed for such RBOs to be realized. A joint initiative to develop a shared reservoir on the Brahmaputra involving China, India, Nepal, and Bangladesh is ongoing, based on a memorandum of understanding that proposes a basinwide perspective informed by equitable benefit-sharing principles. These benefits are expected to include jointly developed hydropower that Bangladesh can purchase from India and landlocked Nepal.

Overall and from the standpoint of the disadvantaged lowest riparian country, the status quo appears a result of a bilateral as opposed to a multilateral dialogue strategy used by India through whose territory 54 rivers flow. These lower riparian perspectives take cognizance of India's economic dominance in the region and its ability to leverage dependencies on India by smaller neighbors—for example, Nepal in terms of access to trade routes given it is landlocked. The experience-based argument is that bilateral negotiations underlain by economic and other forms of leverage allow India to shape how its neighbors use shared rivers—for example, when it objected to the Ganges Barrage proposed in Bangladesh's National Water Policy to serve the latter country's southwestern region. The influence of India on transboundary river governance is further complicated by jurisdiction over rivers in India being shared between that country's Central Government and State governments where dissonance between these two governance levels can impact transboundary river negotiations. According to the key informants interviewed, this was the case when the government of West Bengal State in India did not agree to the consensus reached between the Prime Ministers of India and Bangladesh on the Teesta Treaty.

[5] An agreement with India on the Teesta River is under negotiation.

These experiences, and the relative ineffectiveness of current dialogue mechanisms including the Joint Rivers Commission (JRC) between Bangladesh and India have led stakeholders in Bangladesh to believe in the need for an external organization or country as a neutral mediator who could help cooperation move beyond both bilateral negotiations and individual rivers. The ability to do this is undermined by Bangladesh and its neighbors not being signatories to the United Nations Law on Non-navigational Uses of Water Courses, which could provide the basis for engaging with UN Water as a mediator. It is noteworthy that the South Asian multilateral forum SAARC does not have an agenda for water management.

According to the KIIs, cooperation with Nepal is ongoing through a joint study using secondary data that identified 30 locations in Nepal for potential dams, although technical, social, and environmental feasibility studies need to be done. However, here too, negotiations with Nepal seem to be influenced by India.

3.3 Groundwater to the Rescue...But for How Long?

In the context of too much monsoon water and too low dry-season flows with limited large-scale water storage, groundwater has met a significant proportion of water demand from the domestic, industrial, and agriculture sectors in Bangladesh. Investments in deep tube wells (DTWs) commenced in the 1960s, first by the Bangladesh Agricultural Development Corporation (BADC) and later also by the Barind Multipurpose Development Authority (BMDA). Shallow tube wells (STWs) were introduced in the 1970s (Rahman and Mondal 2015). Approximately 95% of domestic and industrial water supplies (Amin et al. 2018) and 77% of irrigation supplies (Ahmed et al. 2023) are now drawn from groundwater. Abstractions in urban areas are approaching aquifer limits given atomized pumping by households. Aquifer levels are declining in areas such as the Barind region, where irrigation is high, and in cities like Dhaka and Chattogram, which rely almost exclusively on groundwater (Ahmed et al. 2023; Moshfika et al. 2022). Urbanization and industrialization are converging in areas such as peri-urban Dhaka, which houses a part of Bangladesh's large textile sector. Water demand from the textile sector by 2030 (roughly 6,800 megaliters per day) is projected to be equivalent to almost three times domestic water demand in that year. Similarly, the leather industry is projected to grow significantly by 2030 (World Bank 2020). Thus, as observed by the World Bank (2020), although the National Water Policy (GoPRB 1999) recommends conjunctive use of both surface and groundwater, Bangladesh in fact relies almost entirely on the latter.

Agricultural groundwater withdrawals escalated from the 1980s and continue to date, with an estimated 37,000 DTWs and almost 14,000,000 STWs (Amin et al. 2018) in operation across the country. Groundwater irrigation grew from about 1% of the irrigated arable land in 1965 (World Bank 2020) to approximately 79% in 2020 (Chowdhury 2021). Achieving food (rice) self-sufficiency has been the central narrative, with growth in production fuelled by rice cultivation based on irrigation from individually owned/operated STWs and community-managed diesel and electric DTWs. Questions regarding the sustainability of groundwater-irrigated rice production have arisen, especially in drought-prone areas where 95% of the water demand is met by groundwater (Mojid et al. 2019). Many of the 14 million STWs can no longer access water as aquifers have dropped below their reach (approximately 8.54 m). Moreover, as the World Bank (2020) notes, the structural transformation of Bangladesh's economy has also changed water-use patterns, resulting in several pockets of extreme water stress driven by rising demand. Economic growth projections suggest that this geographic imbalance in demand will persist and worsen by 2030. Consequently, demand for irrigation is expected to increase by 43% by 2030 compared to 2014 (Amin et al. 2018), while industrial water demand is expected to increase by 440% and domestic water demand by 200% by 2050 (World Bank 2020). This will take overall water demand to 52.96 billion cubic meters (BCM), up from 35.87 BCM in 2014 (ADB 2021) as Bangladesh aims to become a high-income country by 2041 (GoPRB 2020a). Meanwhile, the stagnation of surface water irrigation by low-lift pumps (LLPs) in recent years as a result of reduced transboundary flows, loss of wetlands, siltation of rivers, and increased salinity will place further pressure on aquifers (GoPRB 2020b). Areas such as the Barind Tract are already experiencing unsustainable abstraction.

4. Water Storage: Status, Policy Direction, and Governance

4.1 Diversity in Scale, Form, and Actors Suggests Storage is a Vibrant Adaptation Practice

As is clear from Section 3, the need for water storage is acute in Bangladesh due to multiple natural and human-induced drivers. The natural factors include the significant variation in rainfall across space and time; Bangladesh's position as the lowest riparian country in transboundary river systems where 92-93% of freshwater flows originate outside the country; poor soil moisture in some areas; and groundwater salinity and arsenic contamination in large areas in southern Bangladesh. These topographical and agroecological factors are compounded by an inability to obtain sufficient dry-season transboundary flows, especially from India, and intensifying demand for water across the agricultural, industrial, and urban sectors. Climate change is another driver through longer spells without rainfall and higher temperatures during the three-month pre-monsoon season (March-May).

Storage is a logical option to smooth out these temporal extremes in water security. Table 2 makes clear that storage already enjoys a long history of diverse forms that respond to topographical and sectoral needs in different regions of Bangladesh. Viewed from sectoral and geographical standpoints (Tables 2 and 3, respectively), storage diversity responds pragmatically to a sector-biophysical context matrix that drives investments by government and local communities in storage systems of varying scale. These range from household ponds and other small-scale options to ponds, canals, and springs managed by communities or through community-government collaboration, to large-scale river dredging that only government can finance. In other words, this diversity demonstrates a vibrant adaptive culture in government and among communities, exploiting all options for managing the harsh impacts of dry-season water insecurity, coastal salinity, and groundwater arsenic contamination.

Unlike many of its neighbors, large-scale storage does not dominate the adaptation response in Bangladesh given the limited topographical scope (hilly areas comprise only 12% of the country) and as a consequence of the social fallout from the inundation that occurred when constructing the Kaptai dam in Chattogram, the only large-scale hydropower dam in the country. Since it was built in the 1960s, the project's power generation capacity has dropped from 250 MW to 50 MW due to outdated technology, siltation, and seasonal transboundary river flows being at record lows[6]. The energy produced by the project is used mostly as a backup during power failures, with the preferred solution for energy being import of 1,000 MW of electricity from India and tapping Bangladesh's large natural gas supplies, supplemented by coal and oil[7]. Domestic coal reserves are not exploited due to the environmental costs, resulting in significant foreign currency expenditure for importing coal from Indonesia. While future increases in hydropower are likely to come from investing in Nepal and Bhutan through ongoing bilateral dialogues, plans to increase investments in solar power generation from 3% of national energy production to 40% by 2040 indicate a shift in reliance toward renewable energy. However, as noted by some key informants, the electricity grid in Bangladesh is not stable enough to accommodate solar power generation contributing more than 10% of the energy need because there has been very little investment in transmission and distribution technology. Large solar power farms also involve the conversion of large land areas and acquisition of land at high prices, suggesting the need to navigate trade-offs involving potential social and environmental concerns. Furthermore, wind power is complicated and expensive due to the nature of wind in coastal areas, high land prices, cyclones in the Bay of Bengal, and large distances to load centers.

According to some of the key informants, smaller dams such as rubber dams[8] (10-15 m high) and simplified elevated dams introduced by China are more suited to Bangladesh's water supply terrain for a range of uses, although they are yet

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[6] Source: Key informant interview.

[7] Source: Key Informant interview.

[8] A structure composed of a rubber bag, anchorage, a pump house, and foundation used to impound water in the rubber bag. When empty of water, this structure lies flat on the river bottom without obstructing the river flow, thereby avoiding undue impact on downstream river environments.

to be used for electricity generation. The Local Government Engineering Department (LGED) has built 52 rubber dams, mainly in hilly areas, to support domestic and agriculture purposes. The BADC has also constructed a few rubber dams in the country and the BMDA a few more in the Barind area. Developing a cascade of dams has been proposed to re-use the same water for generating power multiple times; a masterplan with such an approach has been developed by the Chittagong Development Authority for the Chittagong area to enable irrigation and domestic supply. Another advantage of these smaller dams is that their location on small streams and relatively steep slopes does not overlap with the main river navigation routes, although some trade-offs will arise where more localized navigation exists.

Table 2. A summary of current storage types serving different water sectors in Bangladesh.

Sector	Storage types
Drinking water and household use	• Springs in the northeast and southeast (hilly areas) • Household, community, government ponds • Storage tanks (especially in the coastal belt) • Storage in canals • Dug wells/tube wells
Agriculture including livestock	• Groundwater via STWs and DTWs in large parts of the country, especially drought-prone areas • Conservation of springs in hilly areas (GoPRB 2018b) that can provide water for small-scale storage • Indigenous adaptation practices for floodwater and rainwater harvesting in the floodplains, coastal areas, and hill tracts such as ponds, storage canals, and small hydraulic dams of 20-40 m for capturing water (hilly areas) • Recharge aquifers by storage of rainwater (GoPRB 2018b; GoPRB 2021a)
Energy	• A single large hydropower facility: on the Karnaphuli River, Chittagong
Environment	• Rehabilitation of ponds and lakes • Wetlands conservation including in urban areas| • Small water storage infrastructure for biodiversity

The use of ponds represents a traditional form of rainwater harvesting, primarily to meet domestic needs including homestead-scale vegetable cultivation, poultry raising, and livestock rearing. Most such ponds provide water for domestic purposes other than drinking for about 4-5 months. Their uses have expanded in recent times to include fish culture, encouraged by high fish prices due to growing demand. This economic incentive has also been found to be necessary to encourage communities to invest in managing community ponds. Ponds are especially valuable in hilly areas that experience high water scarcity because a steep gradient means water flows rapidly out of these areas. It has also been suggested that small-scale storage including ponds could reduce landslide risks, though more studies are needed to verify this. Ponds are a lifeline to coastal communities experiencing acute shortage of drinking water due to saline and arsenic-contaminated groundwater. The intensifying search for usable fresh water has increased reliance on ponds,[9] and over 1.2 million with an average size of 1.44 ha are estimated to exist in the country. Many are increasingly used as local small-scale and multiple-use water storage systems. An estimated 17% of them are open-access while the others are private- or government-owned.[10] However, poor maintenance, especially of filters, undermines the contribution of these ponds to drinking water supply. According to some key informants, in some regions as much as 70-80% of filters do not function.

[9] Source: LGED key informant interview.
10 Source: LGED key informant interview.

Table 3. A summary of current water resource challenges in different regions of Bangladesh.

Region	Characteristics and storage types
Coastal areas (southern)	• Severe scarcity of usable water. • Only Aman rice (monocrop), cultivated under rainfed conditions due to lack of fresh water. • Farmers dig mini ponds to store rainwater for irrigation of dry-season rabi crops. • Farmers depend on rainwater, canals, ponds, and rivers. • Fresh groundwater available, but very limited and location-specific. • Water and soil salinity increase in summer. Canals and rivers become silted. • Some river water is less saline and usable up to February. • Rainwater collected in containers for drinking. • Tidal water is saline throughout the year. • Low-lying areas have some fresh water. • Saline water from the rivers is used for shrimp culture. • Salinity increases due to shrimp farming.
Eastern hills	• Fresh groundwater available but very limited and location-specific. • Water and soil salinity increase in summer. Canals and rivers become silted. • Some river water is less saline and usable up to February. • Rainwater collected in containers for drinking. • Tidal water is saline throughout the year. • Low-lying areas have some fresh water.
Northwestern region	• Drought-prone. • Inadequate rainfall. • Limited surface water availability. • High dependence on groundwater for irrigation. • Significant decline in groundwater level. • Inadequate direct recharge due to thick upper clay layer (15 m or more). • Limited percolation capacity. • Inadequate knowledge for sustainable use of groundwater resources.

The conversion of many private ponds to aquaculture has also undermined domestic water supply by introducing organic matter into the water and has caused the Department of Public Health to rely increasingly on a limited number of government ponds.

Rainwater and monsoon flood water are also stored using canals and rooftop tanks. Local canals linked to control structures are a form of flood water storage currently used, mainly for dry-season domestic use other than drinking. While this is already a common strategy, the estimate of 6,500 abandoned canals totalling 20,000 km suggests significant unrealized storage potential, subject to the availability of funds for their renovation. In the Barind area where aquifers are under severe stress, the idea of expanding surface storage through canals will be explored through a planned feasibility study. The intention is a gravity irrigation project using water from the Ganges River via a canal and pumping system. The canal system would include a main canal and secondary and tertiary canals supporting multiple water uses. This will include groundwater recharge by maintaining some canals without a lining.

As with ponds, canals may also be suitable for limited agriculture and fish culture, along with domestic uses other than drinking. The case for making canals multiple-use lies in the need to generate revenue to finance their maintenance, which is currently poor. In the present situation, beneficiary communities are expected to carry out routine maintenance tasks with respect to storage canals usually built by LGED, while the department will carry out cyclical maintenance. Other forms of rainwater harvesting include constructing a 15 cm high bund around fields capable of conserving 15-20% of rainfall for supplementary irrigation. Overall, however, storage is limited, and rooftop storage can be expensive and hence unaffordable, especially for poorer households.

Natural springs are the main source of domestic water in the hilly areas (northeast and southeast). Here too, cross dams and small reservoirs are considered appropriate to store spring water. However, although springs are numerous, their capacity to supply water is unknown and no holistic plan exists for their management. Some will dry up during extended dry seasons. LGED understands the need for assessment and planning and is considering management options to improve sustainability and social equity. While many springs have been identified, studies are needed to understand their capacity and recharge level, which will inform management strategies. Current management of springs is informal. River dredging is expensive but required to remove the vast amounts of silt brought with the waters from upstream. Dredging mitigates the severity of annual flooding and contributes to storing monsoon water for dry-season use as well as facilitating navigation. Groundwater recharge is also an important benefit. The network of about 700 rivers in Bangladesh (covering 24,000 km) offers significant scope to store water by excavation but that is a costly adaptation. Dredging is a core activity of the Bangladesh Water Development Board (BWDB) while the Ministry of Shipping also dredges, as does the BMDA within the Barind area. Thus far 3,500 km has been dredged out of a five-year target of 10,000 km subject to the availability of funds.

As discussed in Section 3.3, groundwater extraction has been pivotal in overcoming dry-season surface water shortages and achieving considerable developmental progress in terms of poverty reduction and rice food security over the past 30-40 years. However, as noted by several key informants, extraction levels may be reaching their sustainable limits in some areas, and in the Barind area, have exceeded recharge rates. Salinization of aquifers in the southern region and widespread arsenic contamination impacting 61 out of 64 districts, particularly in the Ganges-Brahmaputra-Meghna delta areas (Yunus et al. 2016), further constrain groundwater options. With demand for water set to increase across the agriculture, industry, and domestic sectors, and capacity for surface water storage decreasing due to degradation of lakes, wetlands, watersheds, and sedimentation of rivers[11], managed aquifer recharge (MAR) strategies are a recent and potentially important addition to existing forms of storage. MAR works by diverting excess wet-season surface water flows into aquifers to be used during dry spells and droughts. Given that Bangladesh is both flood-prone and severely water-deficient at different times of the year, this is an attractive option offering a win-win outcome. It is currently an emerging area in Bangladesh and is discussed in more detail in Section 4.2 below.

Following the major floods of 1988, deepening haors (a type of wetland) that is part of Bangladesh's extensive and intricate river systems became a potential strategy to capture monsoon flows for use as irrigation and for fish production. Many wetlands were at that time heavily silted, thereby losing[12] their water retention function (Ahmad et al. 2020).

In addition to the above supply-side strategies, demand-side management through crop diversification/replacement is also being pursued and can complement supply augmentation. Some KIIs conducted for this study, however, suggest that this is a challenging endeavor given the deeply entrenched links between food security and rice production. Other factors such as price stability, soil suitability, and low production risk (even flood risk compared to many other crops) add to the attractiveness of rice for risk-averse farmers. The water security provided by cheap STWs and later DTWs further increases farmers' reluctance to grow less thirsty crops. However, this is changing in some areas, especially in the north where STWs and even some DTWs are failing in the winter season (e.g., in February) and farmers have little choice but to grow crops other than rice. Notable in terms of rice substitution is the shift to maize, given its much lower water

[11] Presentation on Water Storage Practice and Potential in Bangladesh by Dr M A Rashid at the Water Storage Project In-country Workshop, 12 June, 2024, Dhaka, Bangladesh.
[12] *Source*: Key informant interview at GWP.

requirement. Maize also has an established market, as do fish and cattle. Agencies such as the Bangladesh Agricultural Research Council, Bangladesh Rice Research Institute, and Bangladesh Agricultural Research Institute also promote water-saving technologies such as alternate wetting and drying of rice and sprinklers, and along with the BMDA, the adoption of buried pipes to reduce irrigation conveyance losses, which are estimated to be around 30-40% (Islam et al. 2024). Buried pipes are, however, an expensive strategy and difficult to maintain against leaks.

4.2 Policy Landscape: Diversity, Groundwater Recharge, and Transboundary Flows

The policy landscape in Bangladesh clearly supports an intensification of investments in storage diversity (Table 4; Annex 4). The 8th Five Year Plan 2020-2025 (GoPRB 2020a) emphasizes the importance of long-term investments in water management for dealing with climate change risks and protecting areas of high economic activity from floods. Multiple policy instruments across different sectors highlight similar storage strategies currently in play in Bangladesh. These include overall development policies and plans, and policy instruments in sectors such as water, climate, disaster management, agriculture and nutrition, and domestic water supply. This cross-sectoral dimension suggests the need for storage to be designed and managed as multifunctional systems be it at the household, community, or larger government-managed scales. These systems may represent the sole sources of water, especially for household consumption and food production, in the dry season. Thus, while not made explicit in the policies themselves, this multisector dependence on storage in discrete biophysical contexts suggests that increasing water productivity should be a core goal in the way storage is conceived and managed, although trade-offs (e.g., switching ponds from household to fish culture) will need to be managed.

A notable feature of the policy content on water storage is the limited emphasis on large dams. There is a focus on diverse forms and scales of rainwater harvesting and flood water storage in several of these policies. This is no surprise given the very limited suitable topography and a political preference in Bangladesh (unlike its neighbors) to avoid the high social and environmental costs associated with large dams. This follows the experience of social unrest when large areas of productive land were inundated by building the Kaptai dam in Chittagong, the country's only large hydropower dam. Instead, Bangladesh seeks to expand the purchase of energy from India and other large-scale producers such as Nepal and Bhutan through outright purchases and joint investments in hydropower in their territories (GoPRB 2020a), and by expanding the country's renewable energy portfolio (GoPRB 2021b; GoPRB 2020a). This includes hydropower from smaller dams and cascades of dams, subject to their economic, social, and environmental viability (GoPRB 1999; GoPRB 2008). Since similar small-scale dams (e.g., rubber dams) are proposed for irrigation (GoPRB 2018b), these smaller dams may offer significant scope as multiple-use storage options, especially in hilly areas.

For harvesting rainwater and flood water, a wide menu of approaches is proposed. These include pools/ponds, jars, check/rubber dams, storage canals, pits, and retaining ridges, each catering to specific topographic and agroecological conditions to serve the needs of one or more sectors. Also mentioned in policy documents is the larger-scale and mostly government-driven dredging of all major and medium rivers for simultaneously draining excess monsoon flows to minimize extreme flooding and increasing capacity to store water for dry-season use, given that upstream flows greatly diminish in the post-monsoon months (GoPRB 2020c; GoPRB 2022).

These diverse storage approaches dispersed across the country are seen as a way to alleviate pressure on aquifers by augmenting surface water supply and enhancing groundwater recharge, especially in depleted aquifers such as the Barind area (northwest) and large urban centers such as Dhaka, and to reduce salinity in the south (GoPRB 2014; GoPRB 2021a; GoPRB 1999). MAR also features in several policies such as the National Adaptation Plan of Bangladesh 2023-2050 (GoPRB 2022) and the National Strategy for Water Supply and Sanitation (GoPRB 2014); a draft Managed Aquifer Plan already exists. The National Building Code also requires rainwater harvesting. The primary rationale for MAR is the limited capacity to store the abundant flood water on the surface. So, aquifers are the other option for a potentially win-win result of less flooding and more stored water for dry-season use. The challenge with MAR on a large scale is purifying surface water before it goes into the ground. This is further complicated because much of this water originates from India where pollution levels are unknown to MAR implementers in Bangladesh. Any resulting contamination may take over 20 years or more to rectify. Nevertheless, given the constraints to large-scale surface storage, MAR remains a tempting option, especially in coastal areas where drinking water is a big political issue.

MAR is currently in the pilot stage where these risks and risk management options can be better assessed. The pilots are being implemented by government and other actors, including BMDA, Dhaka University, and Water Aid, while the Asian Development Bank and Dhaka city are preparing plans for underground storage. Another challenge, as with most infrastructure-based solutions, will be maintenance, and the pilots indicate that maintenance is difficult to sustain. The pilots involve pre-treatment of the surface water through a sand filter and need energy to pump the water into the filtration tank. This requires local beneficiaries to pay a small fee, which has been difficult to realize. In some areas, these pilots compete with privately-run small-scale reverse osmosis plants that supply households. Aside from these practical challenges, guidelines for MAR are required for overall system management, especially to avoid contamination. These are expected to be framed by the Managed Aquifer High Level Committee and a Technical Committee established by the Prime Minister's Office. The Managed Aquifer High Level Committee has developed a draft national strategy which the Ministry of Water Resources is expected to review and submit to the Cabinet. Development of guidelines following the policy will need to be informed by technical studies to identify suitable areas. A master plan for MAR for Dhaka has been drafted. Overall, opinions on MAR amongst key informants are somewhat polarized between those who focus on the storage potential and others who feel the risks of pollution and sustainability challenges outweigh the potential benefits. The latter key informants believe that more conventional storage options such as in-stream storage through dredging and hydraulic structures and small-scale surface storage should be prioritized.

Several policies recognize the services provided by natural wetlands in relation to both surface water and groundwater systems. The 8th Five Year Plan 2020-2025 (GoPRB 2020a) and the BDP 2100 (GoPRB 2018a), for example, call for improving connectivity between floodplains, wetlands, and rivers; the National Adaptation Plan of Bangladesh 2023-2050 (GoPRB 2022) requires the conservation of wetlands and the Nationally Determined Contributions (NDCs) 2021 (GoPRB 2021b) advocate wetlands rehabilitation to facilitate fish culture to enhance rural livelihoods. These policy provisions could also provide the basis for exploring more nature-based solutions that combine gray and green approaches to offer solutions that might require fewer trade-offs to water resource challenges.

It is important to also note that increasing soil moisture and water-use efficiency while reducing water demand, especially in the agriculture sector, are complementary strategies in several policies. For example, the Perspective Plan of Bangladesh 2021-2041 (GoPRB 2020b) calls for reduced wastage of irrigation water, which it considers rampant (due to reliance on traditional flood irrigation methods), while the same Plan and the National Food and Nutrition Security Policy 2021-2030 (GoPRB 2021a) both call for increasing soil organic matter, which would increase water storage in the soil.

Despite the promotion of these diverse storage strategies, the ultimate solution to Bangladesh's water resource constraints lies in increased dry-season transboundary flows. Reducing reliance on groundwater (GoPRB 1999) is a complex challenge, considering the uncertainties associated with transboundary surface water flows (World Bank 2020), and the lack of storage facilities. The 8th Five Year Plan (2020-2025) (GoPRB 2020a) and the BDP 2100 (GoPRB 2018a) emphasize the need for basinwide cooperation for the management of transboundary rivers using a demand-based approach and the simultaneous negotiation of multiple treaties, including the revision of the Ganges Water Treaty for increased dry-season flows, a framework of agreement for sharing the Teesta waters, and water-sharing agreements for six other prioritized transboundary rivers: the Dharla, Dudhkumar, Manu, Khowai, Gumti, and Muhuri. The Plan also recognizes the importance of involving a neutral third-party organization or country to break the impasse in negotiations, especially with India, given the power asymmetry India enjoys over Bangladesh (and other riparian countries).

Table 4[a]. Water storage in the policy landscape of Bangladesh.

Storage-related strategy	Policies/strategies/plans
Hydropower development (large)	• Nationally Determined Contributions (NDCs) 2021
Hydropower development (small)	• Nationally Determined Contributions (NDCs) 2021 • National Water Policy 1999 • Renewable Energy Policy 2008
Small-scale water harvesting: Ponds, pools, check/rubber dams, pits, retaining ridges (includes focus on community-managed systems)	• 8th Five Year Plan 2020-2025 • Perspective Plan of Bangladesh 2021-2041 • National Adaptation Plan of Bangladesh 2023-2050 • Nationally Determined Contributions (NDCs) 2021 • National Plan for Disaster Management 2021-2025 • Bangladesh Delta Plan 2100 (2018) • National Agricultural Policy 2018 • National Food and Nutrition Security Policy 2021-2030 • National Water Policy 1999
River dredging for flood protection (improved conveyance) and flood water storage	• National Adaptation Plan of Bangladesh 2023-2050 • Nationally Determined Contributions (NDCs) 2021 • National Plan for Disaster Management 2021-2025
Excavation or re-excavation of khals (polder drainage canals), canals for flood protection (improved conveyance), and flood water storage	• National Adaptation Plan of Bangladesh 2023-2050 • Nationally Determined Contributions (NDCs) 2021 • National Plan for Disaster Management 2021-2025 • Bangladesh Delta Plan 2100 (2018) • National Agricultural Policy 2018
Conservation of natural springs	• National Adaptation Plan of Bangladesh 2023-2050
Reducing dependence on groundwater/artificial aquifer recharge	• National Adaptation Plan of Bangladesh 2023-2050 • Nationally Determined Contributions (NDCs) 2021 • National Agricultural Policy 2018 • National Strategy for Water Supply and Sanitation 2014
Conservation of wetlands	• National Adaptation Plan of Bangladesh 2023-2050 • Nationally Determined Contributions (NDCs) 2021
Irrigation efficiency Demand-side management	• Perspective Plan of Bangladesh 2021-2041 • 8th Five Year Plan 2020-2025 • Bangladesh Delta Plan 2100 (2018)
Increasing soil organic matter	• 8th Five Year Plan 2020-2025 • Perspective Plan of Bangladesh 2021-2041 • Bangladesh Delta Plan 2100 (2018) • National Food and Nutrition Security Policy 2021-2030
Integrated water resources management	• 8th Five Year Plan 2020-2025 • Bangladesh Delta Plan 2100 (2018) • National Strategy for Water Supply and Sanitation 2014
Institutional strengthening for more integrated water resources management	• 8th Five Year Plan 2020-2025 • Bangladesh Delta Plan 2100 (2018) • National Water Policy 1999
Basinwide water management for more holistic and optimal water management	• National Adaptation Plan of Bangladesh 2023-2050
Improved transboundary cooperation	• 8th Five Year Plan 2020-2025 • National Adaptation Plan of Bangladesh 2023-2050 • Bangladesh Delta Plan 2100 (2018) • National Food and Nutrition Security Policy 2021-2030

Notes: [a] See Annex 5 for a more detailed version of this table.

4.3 Institutional Planning of Storage Remains Disjointed, Reflecting a Broader Lack of Cross-sector Institutional Coordination

In Bangladesh, responsibilities for water resources management are dispersed over several agencies, which represents a specialization-driven approach to the water sector's institutional architecture (Table 5). Overall planning occurs through the National Water Resources Council (NWRC), the Ministry of Water Resources (MoWR), and the Water Resources Planning Organization (WARPO). The MoWR and WARPO (situated in the MoWR) lead the formulation of overarching policies and plans while other specialized agencies, mostly under the MoWR, are tasked with policy and plan implementation. These agencies include BWDB and the Department of Bangladesh Haor and Wetlands Development (DBHWD), which have important functions in relation to water storage and access (Table 5). Three key agencies that do not report to the MoWR are the LGED, BMDA, an autonomous umbrella agency to promote integrated development in the Barind region, and the Bangladesh Agricultural Development Corporation (BADC).

Of the specialist implementing agencies, BWDB and LGED account for a vast array of activities that implement the National Water Policy (GoPRB 1999) and the Bangladesh Water Act 2013. To avoid overlaps, BWDB covers large investments in areas such as climate risk mitigation through flood control, drainage and irrigation development, river erosion control, land reclamation, salinity mitigation, and integrated coastal zone management. LGED, being one of the largest engineering entities in Bangladesh, focuses on rural infrastructure as a key contributor to development, including rural roads and irrigation where the command area is less than 1,000 ha. The two organizations have distinct approaches to working: BWDB primarily does biophysical and engineering work while LGED is explicitly oriented to working with local communities and local government layers such as the upazilas (subdistricts). LGED's participatory development approach is rooted in the need to ensure investments are responsive to local needs; therefore, many of its investments are identified at the local level with technical support from LGED staff. Management of these investments is often done by the beneficiary communities through the formation of cooperative societies, with oversight by LGED. The cooperatives are an important LGED modality to link communities to services provided by other sectors (e.g., training by the Department of Agriculture), to promote capacity building for more holistic and sustainable local development.

Despite the existence of agencies responsible for policy development and planning and those for their implementation, coordination is considered to be weak. The World Bank (2020) argues that addressing institutional constraints in the water sector is the highest-priority intervention for the Government. The problem appears to be rooted in the dispersal of water resources management functions beyond the MoWR, which amplifies the coordination burden. This applies not only to the BMDA and LGED which lie outside the MoWR's purview, but also to other water-consuming-sector agencies such as the BADC which operates LLPs and DTWs; harnesses hill streams and re-excavates canals for irrigation, often unconnected with the plans and activities within MoWR.

From a river basin or IWRM perspective, coordinating the use of the same river, aquifer, or other water sources across dispersed agencies is challenging and perhaps not feasible. This is compounded by an underperforming planning and coordination structure, where, for example, the Executive Committee of NWRC is meant to bring all water stakeholders together to address critical water-sector issues through six-monthly meetings but has met only ten times in the past 20 years (Ahmed et al. 2023). Similar sentiments were expressed by Amin et al. (2018) and some key informants who note that WARPO is heavily understaffed considering its central coordinating role. Consequently, the holistic planning needed to use the limited water resources effectively does not materialize. This is seen in the lack of coordination of wetlands management among the land, fisheries, water, and environment sectors, leading to the continued loss of wetlands that are natural storage.

Table 5. Key government institutions involved in water storage.

Institution	Overall mandate	Role in water storage/water management
National Water Resources Council (NWRC)	The 34-member apex body provides policy guidance to the implementation of water resources initiatives, the National Water Policy, the National Water Management Plan, and the Bangladesh Water Act.	Responsible for coordinating all aspects of water management including policy and rules.
Ministry of Water Resources (MoWR)	Leads policy formulation, monitoring, and implementation of plans and policies relevant to water. Hands over implementation to BWDB, WARPO, DBHWD, and JRC. Liaises with international organizations and matters relating to treaties and agreements.	Responsible for the overall development and management of the country's water resources through the formulation of policies, plans, strategies, laws, etc. It prepares and implements projects on flood control, irrigation and drainage, prevention of riverbank erosion, delta development, land reclamation, etc.
Water Resources Planning Organization (WARPO)	Planning and policy-making institution. Develops and coordinates implementation of the National Water Policy, the Bangladesh Water Act 2013, the National Water Management Plan (NWMP), and Bangladesh Water Rules 2018 that support the Water Act's implementation. Adopts IWRM as a core planning principle and has developed IWRM guidelines at the district, upazila, and union levels. Acts as the secretariat to the Executive Committee of the NWRC headed by the Prime Minister. Reviews large projects before they are sent to the Planning Commission. This includes determining whether an EIA is needed. Coordination at the macro level through its Board of Directors where Secretaries of other water agencies are members. Houses the National and Regional Water Resources Databases and Information system. Represented through district, upazila, and union level committees.	Influences overarching policy, plans, laws, and rules to promote appropriate storage options.
Bangladesh Water Development Board (BWDB)	A key implementing agency under MoWR. Contributes to implementing the NWMP by working on climate risk mitigation through flood control, drainage and irrigation development, river erosion control, land reclamation, salinity mitigation, and integrated coastal zone management, for food security and poverty alleviation. Generally, implements large-scale projects including irrigation investments over 1,000 ha. Also conducts flood forecast and warning, and hydrology studies.	River excavation, large ponds (coastal), large canals, managed aquifers, small dams for storage, e.g., feasibility study in Chattogram area for building a cascade of 10-15 m dams across several creeks for domestic and irrigation use.

Continued

Table 5. Key government institutions involved in water storage.(continued)

Institution	Overall mandate	Role in water storage/water management
Local Government Engineering Department (LGED)	Established in 1982 and thus young relative to other organizations in the sector. Focus on rural infrastructure as key condition for development: rural roads and irrigation. Works with communities to identify needs and co-design appropriate solutions that are often managed by the community solely or in conjunction with LGED. Works closely with upazilas. Undertakes irrigation projects with a command area of less than 1,000 ha, which avoids overlaps with BWDB.	Maintenance of multiple-use government ponds, smaller canals, springs, and rubber dams for irrigation, drinking water, and drainage. Developing a management regime to maintain springs and ensure equitable access. Deepens local canals and manages control structures for storage and distribution. especially in the dry season. Does not work directly on groundwater.
Bangladesh Agricultural Research Council (BARC)	The apex body under the Ministry of Agriculture managing the national agricultural research system. Entrusted with preparing the vision document and the national agricultural research plan.	Coordinating agricultural research across organizations such as BRRI, BARI and BINA. Also allocates research funding among these organizations.
Barind Multipurpose Development Authority (BMDA)	Autonomous organization independent of WARPO. The closest structure to a river basin organization. Empowered to coordinate all sectors and line agencies working in the Barind region toward multidimensional solutions. Deep tube wells are maintained by BMDA in the Barind area.	Small-scale dams (e.g. check, rubber) and significant reliance on groundwater, especially through development of electric DTWs.
Bangladesh Agricultural Development Corporation (BADC)	Tasked with ensuring essential agricultural inputs such as seeds, fertilizers, and irrigation through utilization of surface and underground water.	Operates low-lift pumps and deep tube wells; harnesses hill streams and re-excavates canals for irrigation, controlling salinity; and groundwater recharge.
Power Division	Planning arm of the Ministry of Power, Energy, and Mineral Resources. Developed the draft Integrated Energy and Power Master Plan.	Large and small dams for hydroelectricity, though this role remains limited given the policy not to invest in large dams.
Joint Rivers Commission (JRC)	Promotes equitable sharing and joint management of transboundary water resources for sustainable water security. Leads dialogue with India on sharing of waters, joint management, transmission of flood-related data, etc. Dialogue with Nepal for jointly harnessing water resources, mitigating floods, and flood damage. Monitoring and sharing of the Ganges River waters at Farakka.	A crucial role in negotiating increased dry-season river flows, which remain the fundamental driver of dry-season water insecurity. The re-negotiation of the Ganges Treaty in 2026 presents an opportunity to win increased water release.
Department of Bangladesh Haor and Wetlands Development (DBHWD)	Mandated to coordinate the holistic development of the haor and wetlands of the country. Leads the development of a master plan to be implemented in coordination with multiple agencies. Key development areas covered in the master plan include flood management and drainage Improvement, environmental sustainability, production of crops, fisheries and livestock, and water supply and sanitation.	River dredging, expansion of irrigation using surface water by double lifting, and supporting minor irrigation with low-lift pumps.

The lack of data emerged as another factor undermining IWRM. There is no clear understanding of how much water is available and how to prioritize water investments beyond the sector hierarchy in the Water Act, given the demands on water made across multiple sector policies and plans. There is also no information system to monitor how much each sector is withdrawing, which makes any form of water accounting impossible. Investments to establish baseline information and a monitoring system using digital platforms are thus a priority given that planning and coordination must be scientifically informed, especially where trade-offs must be considered and choices made. One of the main gaps, according to some key informants, is in the poor understanding of river morphology. This means that no one truly understands the impacts of human actions on the rivers, be it the construction of small dams or diversions. This suggests not only a lack of data on key technical topics that can inform planning, but also the need for more multidisciplinary modes of working to understand water systems and design appropriate water investments. In terms of storage, the risk of the cumulative impacts on water resources of multiple storage investments in the same area is unknown. Consequently, institutions need considerable strengthening in new technologies, innovation, research, and integrated planning.

Planning as well as the sustainability of investments are also affected by an under-resourced local governance system, including upazilas and Union Parishads (lowest local government system in Bangladesh). As a result, planning, budgeting, and implementation responsibilities are left to the line ministries and agencies at the local level, with limited input from these local government institutions that are constitutionally mandated to ensure service delivery. With limited or no control over local-level staffing, and limited fiscal autonomy and revenue discretion, these institutions' ability to engage as active development partners is severely constrained (World Bank 2020). This also places a greater burden on organizations such as BWDB and especially LGED which has officers in the Upazila Parishads and relies on the support of local government in building effective and sustainable community-managed water solutions.

The positioning of groundwater within the current institutional architecture is particularly concerning, given the heavy burden placed on aquifers in recent years. Although the policy landscape appreciates the need to reduce this burden, especially where recharge is falling behind extraction, the absence of a single agency responsible for studying and managing groundwater remains a fundamental institutional gap. Currently, the topic of groundwater is distributed between the MoWR and the Ministry of Agriculture. For example, although WARPO is meant to provide abstraction licenses, it has no basis for doing so without technical studies that enable informed abstraction limits to guide licensing decisions. Thus, a specific agency with the specialist technical capability and sufficient legal authority is needed to standardize the approach to governing groundwater exploitation. Several key informants proposed an institution like India's Central Ground Water Board nested under the MoWR that would work with BMDA, LGED, BADC, and other agencies to ensure all abstractions collectively align with set limits for different regions. The present situation is far from what is needed; there is an absence of geographically comprehensive studies to enable groundwater rules to be established for different regions. Current studies are spatially scattered, and thus some key informants suggest this be coordinated by the Ministries of Water Resources and Agriculture working together until a dedicated agency or department is established. Their task would be to assess aquifer capacity, monsoon-season recharge rates, and how much cultivation these can support.

Rules on groundwater would also need to regulate discharge of wastewater because, according to some key informants, industries are now discharging effluents underground. This tendency for on-ground contexts to outpace policy evolution strengthens the case for a dedicated groundwater agency that can track and respond to new risks. Revision of the Ground Water Management Act appears to also be necessary, again to catch up with on-the-ground developments. Aspects to be covered include setting abstraction limits including for industrial use, groundwater recharge, conjunctive use of surface and groundwater, and long-term planning (World Bank 2020).

5. Conclusions and Recommendations

Storage in Bangladesh remains central to compensating for the insufficient dry-season transboundary river flows that result from a convergence of geographical positioning, topography, multiple agroecological constraints (extreme rainfall patterns, salinity, high vulnerability to climate change), and regional geopolitics. These factors leave Bangladesh to deal with either floods (especially severe floods) or long months of surface-water insecurity. As such, one could argue that in the absence of more favorable arrangements with upper riparian neighbors for dry-season flows, storage represents Bangladesh's Plan B as a coping mechanism. Yet the country has thrived despite this challenging context to become one of South Asia's best performing economies, achieving significant reduction in poverty and meeting its goal of food security, at least in terms of rice production. Water has been at the center of these developments, with groundwater in particular irrigating vast tracts of rice, while diverse permutations of storage strategies have exploited large and niche opportunities to store and supply water to the domestic, agriculture, urban, and industrial sectors.

The storage landscape in Bangladesh is characterized by traditional and modern strategies, responding to diverse contexts and consisting of a combination of government and household or community efforts. This is a testament to its people's resilience and imagination in adapting to so many impediments to their development. A comparison between existing storage strategies and those proposed in the current policy landscape demonstrates a close overlap but for MAR, which represents more recent thinking and technology. Considering the very limited potential for large-scale hydropower and the already diverse types of storage in operation, the opportunities for new forms of storage appear to be limited (Annex 6), with the important exception of MAR if the considerable concerns over pollution risks can be resolved, the technical knowledge needed for the safe operation of MAR can be built, and regulations to balance risk management and utility of MAR are put in place. In fact, the water storage 'gap' (the difference between need and availability) is widening, given the expanding demands on water resources. The most feasible options to bridge this gap are investing in expanding existing storage infrastructure, scaling out MAR based on the experience of ongoing pilots and subject to the factors highlighted above, and initiating the technical studies needed for a comprehensive investment in MAR.

With respect to Plan A – more transboundary flows — the year 2026 will be a critical opportunity to renegotiate the Ganges Water Treaty with India, but with demands for water intensifying across the subcontinent, a strong case will need to be built for more dry-season flows for Bangladesh. Therefore, for the time being, consolidating existing storage opportunities combined with significant investments in data and more coherent planning may be the most feasible strategy.

In terms of consolidating existing storage opportunities, we recommend that the priorities include investing in institutional structures and capacities for more coordinated and data-driven water management decisions and actions. This will provide a more robust management framework to meet future demands on Bangladesh's water resources. One important dimension is the need for data to better understand water systems as a basis for more quantitative regulatory mechanisms. This would, however, only work if institutional coordination includes other sector water users. Perhaps the most representative of these needs are the aquifers where abstraction is unchecked, and no scientific basis exists for setting limits and rules. As such, and with demands on groundwater set to grow across the domestic, agriculture, industry, and urban sectors, groundwater is the resource most in need of serious attention in terms of an appropriately capacitated and empowered focal agency, understanding of the resource and implications for sustainable use, a regulatory regime reflective of a deeper understanding of the resource, and an institutional arrangement capable of meaningful rule enforcement. The future sustainability of Bangladesh's groundwater should represent a priority national agenda that brings together all sectors that rely on water.

At the local level, key informants and national expert participants in the Water Storage Project In-country Workshop held in Dhaka on 12 June, 2024 (Annex 7) emphasized the need to further decentralize authority and empower local government institutions such as the Union and Upazila Parishads. This is crucial for continued local innovations and investments in and maintenance of various types and scales of surface water storage. Actions recommended toward this end include:

- **Delegate the authority of the Deputy Commissioner.** Currently, the Deputy Commissioner makes land interventions and water management decisions at the district level. To improve efficiency and responsiveness, these powers should be extended to the Union Parishad, closer to the local communities.
- **Strengthen micro-level management.** Effective water storage solutions require management at the micro watershed level. Union Parishads should be empowered to oversee these areas under the guidance of higher authorities. This localized approach can ensure that interventions are more relevant and tailored to specific community needs.
- **Capacity building.** Local government institutions still need training to discharge their responsibilities effectively. Training should include technical training, resource management, and community engagement strategies.
- **Resource mobilization.** The lack of financial and logistical resources is a notable barrier for local governments to overcome. This should be addressed not just through increased allocations but an assessment of all available sources of funding and revenue for local governments to propose more effective use of funding.
- **Strengthen community engagement.** Engaging local communities in project activities is essential. This not only ensures that projects are more sustainable but also helps in mobilizing local resources and gaining community support.

Information and knowledge are key enablers of policies, plans, and actions in the storage and broader water management space. Recommended actions to plug the key gaps include:

- Harmonize plans and programs to ensure they are complementary and not overlapping or even contradictory. Bangladesh has several comprehensive water management plans, such as the Bangladesh Delta Plan, National Water Management Plan, Integrated Coastal Zone Management Plan, and Haor Master Plan. An audit along with feasibility studies on how they complement, overlap, or contradict each other would enable proposed interventions to be practical, cost-effective, and sustainable, and also ensure the potential for storage to contribute to multiple plans.
- Comprehensive identification of existing floodplains that are critical landscapes for natural water storage and flood management would be a basis for developing and applying restoration strategies. This need also applies to wetlands more broadly in terms of the need for a detailed mapping and assessment of their ecological condition, given their vital importance for biodiversity, water purification, flood mitigation, and as stores of water resources.
- Insights from the performance of water users' associations (WUAs) can help improve their contribution to sustaining water storage (and broader management) infrastructure. Identifying reasons behind the success of well-performing WUAs and barriers faced by underperforming WUAs is needed to determine best-practice guidance for effective community engagement in water management.
- A holistic evaluation is needed of different water storage methods suitable for local conditions including how rainwater, surface water, and groundwater storage can be integrated. Developing integrated water storage plans that combine various types of storage can improve the efficiency of funding and contribute to ensuring that storage solutions are sustainable and resilient to climate change.
- The identification of effective maintenance strategies for different types of storage facilities to prevent them from becoming ineffective over time is also required. A particular challenge is how to involve local communities in the maintenance process that links with, but could be broader than, the study of WUA performance mentioned above.

In conclusion, therefore, although the real solution to the constraints Bangladesh experiences in the water sector lies in the complex and unequal geopolitics of the Indian subcontinent, there are several investments across the physical, institutional, and information domains related to water resources management that current policies and in-country stakeholders consulted for this report believe can help exploit storage options even more efficiently, not forgetting the potential benefits this could generate in terms of service, especially for marginal water stakeholders.

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Annex 1. Thematic Areas for Water Storage Policy Review

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.

List of sectors and themes	
Key goals/outcomes	**Fisheries**
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	**Climate resilience/adaptation**
Explicit reference to storage	Water security
Agriculture	Storage for resilience
Contribution to development	**Governance**
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
Energy Environment	**Other**

Annex 2. List of Key Informants Interviewed

No.	Name	Gender	Position	Organization
1	H.S. Mozaddad Faruque	M	Former Director-General	WARPO, MoWR
2	Mohammad Alamgir	M	Principal Scientific Officer	WARPO, MoWR
3	Shamal Chandra Das	M	Additional Chief Engineer (Civil) - Planning	BWDB, MoWR
4	Rokeya Khatun	F	Gender expert	Freelance
5	Shibendra Narayan Gope	M	Chief Engineer (Minor Irrigation)	BADC
6	Malik Fida A. Khan	M	Executive Director	Center for Environmental and Geographic Information Services
7	Mohammed Abdur Rashid	M	Former Head	Irrigation Water Management Division, Bangladesh Rice Research Institute
8	Farseem Mannan Mohammedy	M	Professor	Center for Energy Studies, BUET
9	M. Anwar Hossen	M	Professor	Department of Sociology, University of Dhaka
10	Shamsher Ali	M	Member Secretary	Nadi Adhikar Mancha
11	Md. Rafiqul Islam Khan	M	Joint Secretary (Development and PPP)	Ministry of Shipping
12	Kazi Matin Uddin Ahmed	M	Professor	Department of Geology, University of Dhaka
13	Mohammed Nurul Huda	M	Additional Chief Engineer	Water Resources Unit, LGED, Ministry of Local Government, Rural Development, and Cooperatives
14	Mohammed Siddiqur Rahman	M	Secretary-General	Bangladesh Water Partnership
15	Uthpal Kumar	M	Manager - IWRM for Climate SMART Agriculture	Solidaridad Network Asia

Annex 3. Questions for Key Informant Interviews

Political economy of built water storage – Bangladesh
Key stakeholder interviews – Guiding questions

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 with their own management regimes. At what scales and in what types of water storage is Bangladesh investing? What development goals drive these investments?
2. The MoWR is the primary water management institution supported by BWDB and WARPO (according to the 8th Five Year Plan and other policies). Given that different sectors may focus on different storage types, is there a mechanism to coordinate these investments across sectors?
3. Are local water storage systems or water harvesting promoted? Who will finance them, and will they form part of larger irrigation investment plans and models?
4. Rainwater harvesting is encouraged for irrigation and drinking water, among other uses (and across different policies). At what scale is this practiced? If at the community level, is rainwater harvesting sufficient for all uses in the community/household? Who finances it?
5. How do hydropower planning mechanisms account for externalities such as loss of e-flows and downstream ecosystem services important for food and livelihood security? Is there an EIA process and is it applied to all water storage related projects?
6. In the promotion/expansion of irrigation, what kinds of storage are needed given the topography and the needs of different food producers? Do these match with the current storage types being invested in?
7. Development goals include the active participation of diverse groups of people and the adoption of local knowledge. How are local knowledge, diverse stakeholders, accountability, and inclusion principles (such as gender equality and social inclusion) incorporated in water storage plans?
8. Who makes the decisions on water storage? Would it help to increase the range of stakeholders in these decisions? How will the shift toward decentralized water management affect decision-making processes?
9. The national disaster management plan and other policies include dredging/re-excavation of water channels, repairing and maintaining the existing flood embankments, dams and reservoirs, retaining ponds, flood channels, and flood walls, building erosion prevention structures, and storage facilities for preserving rainwater. To what extent has this been achieved, and what are some of the associated challenges?
10. Most policies that include water storage stress on rehabilitating/restoring the existing water bodies/storage options. Is there a need for creating new storage options? At what scale?
11. The 8th Five Year Plan outlines the role and importance of RBOs in implementing IWRM and contributing to regional cooperation. To what extent has this been achieved/planned/discussed?

Annex 4. Water Use and Needs of Major Economic Sectors in Bangladesh

Sector	Economic importance	Water use/needs/characteristics
Agriculture	FY18 sectoral share of GPD:14.2% FY18 growth rate: 4.2% Employment share in 2016: 42% Employment growth 2010-2016: -9%	• Share of total water use: 92.8% • Estimated growth in water demand by 2030: 43% • Over 80% of water use from groundwater sources • 95% of the total irrigation water demand is for the dry season Boro rice crop.
Manufacturing	FY18 sectoral share of GDP: 22.9% FY 18 growth rate: 12.1% Employment share: 14.4% Employment growth RMG 2010-2016: 0.8% Employment growth non-RMG 2010-2016: 0.8%	• Share of industrial water use: 0.3% • Estimated growth in industry demand by 2030: 109% • 98% comes from groundwater and 2% from water supply. • Water-intensive textiles and leather industries dominate manufacturing. Their water demand, concentrated in urban areas – 70% textile factories and 95% leather tanneries located in Dhaka – is estimated to increase from 4027 MLD to 10,891 MLD by 2030, a 170% rise in demand, estimated to be 3 times the domestic demand in Dhaka by 2030 (domestic demand to grow by 75%) • They are the two largest polluters.
Mining	FY18 sectoral share of GDP: 1.8% FY18 growth rate: 7% Employment share: 0.2% Employment growth 2010-2016: (not reported)	• Mining is a small but growing water-intensive sector. It is also highly polluting (included in industry water demand). • Need for more wastewater processing, regulation.
Trade services	FY18 sectoral share of GDP: 14% FY18 growth rate: 7.5% Employment share:14.2% Employment growth 2010-2016: - 1.2%	• Wholesale and retail trade and commercial activities rely on adequate transport. • Share of IWT of total cargo market demand fell from 37% in 1996 to 16% in 2005 and is likely smaller today.
Transport, storage, and communication services	FY18 sectoral share of GDP: 11.1% FY18 growth rate: 6.6% Employment share:8.6% Employment growth 2010-2016: 6.6%	• Inland water transport is the second major transport mode and employs over 4.6 million people. • IWT captures 25% of the passenger market and 16% of the cargo market. • IWT is available for 25% of the rural population and the sole mode for about 12%

Annex 5. Water Storage in Bangladesh National Policies, Strategies, and Plans

Policy/strategy/plan	Overall goals and objectives of policy	Role of water storage
8th Five Year Plan 2020-2025	Economic development Promotes implementation of BDP 2100 to reduce climate-related vulnerabilities and improve the prospects for sustained development and poverty reduction.	• Emphasizes the importance of long-term investments in water management to deal with climate change risks. • Protection of areas of high economic activity from floods. • Energy sector development, mainly through renewable energy investments. • Scaling up existing good water conservation and management practices within an IWRM approach, including flood control and prevention schemes, irrigation improvement, and demand-side management. • Restoring water bodies to improve connectivity between floodplains, wetlands, and rivers. • Rainwater harvesting. • Strengthening regional and international cooperation for basinwide water resources development and management of transboundary rivers. This includes negotiations with riparian countries for demand-based common river basin management by linking water-related negotiations with other river interests and regional cooperation issues, and simultaneous negotiation of multiple treaties, e.g., revision of the Ganges Treaty for increased dry-season flows, and framework of agreement for sharing of the Teesta water. Recognizes the importance of involving a neutral third-party organization/country. • Implementing water sharing policy for six other prioritized transboundary rivers (Dharla, Dudhkumar, Manu, Khowai, Gumti, and Muhuri) at the technical level. • Strengthening capacities of institutions in water resource management. • Increased use of hydro- and solar power from India, Nepal, and Bhutan given the role imports from India have played in expanding electricity supply at a competitive price. • Implementation of the Delta Plan 2100.
Perspective Plan of Bangladesh 2021-2041		• Sound water management systems that not only help preserve surface water through rainwater harvesting and building reservoirs to hold such water, and also reducing the wastage of irrigation water. • Reservoirs/rainwater harvesting in rainfed/coastal/hilly areas (particularly through LGED/BWDB/BADC/BMDA) maintained by local water management groups/cooperative associations. • Agriculture: Pools, dams, pits, retaining ridges, increasing soil organic matter.
National Adaptation Plan of Bangladesh 2023-2050	To enhance Bangladesh's resilience to climate change through strategies to address adaptation needs for short- (2030s), medium- (2041), and long-term (2050s) planning horizons.	• Community-based rainwater harvesting (e.g., ponds). • Conservation of natural springs for drinking water (hilly areas). • Dredging of all major and medium rivers to minimize extreme flooding. • Excavation or re-excavation of khals or canals for increasing conveyance capacity. • Reservoirs or pond digging to harvest and segment surface water flow in drought-prone and coastal areas. • Increasing freshwater availability in coastal rivers. • Groundwater management through artificial recharge. • Conservation of wetlands. • Basinwide participatory watershed management frameworks to restore, harvest, and optimize the use of water resources.

		Highlights rainwater harvesting and mini ponds for supplementary irrigation during drought spells as preferred indigenous adaptation practices in the floodplains, coastal areas, and hill tracts. Highlights the importance of transboundary river basin management and basin-level cooperation.
Nationally Determined Contributions (NDCs) 2021	Sets out Bangladesh's commitments on action to combat climate change.	• Rainwater harvesting. • Reduce urban groundwater use by increasing surface water use. • Re-excavation of small rivers, canals, and water bodies. • River excavation and dredging. • Rehabilitation of wetlands for fish culture to enhance livelihood activities. • New Hydro-100 MW, New Hydro-1000 MW.
National Plan for Disaster Management 2021-2025	Guide implementation of the Disaster Management Act 2012 and Standing Orders on Disaster 2019 for proactive disaster risk reduction.	• Dredging/re-excavation of water channels, repairing and maintaining existing flood embankments and sluice gates, dams, and reservoirs, dikes and levees, retaining ponds, flood channels, and flood walls, building erosion prevention structures and storage facilities for preserving rainwater. • Ensure incorporation of gender issues in decision-making and ensure participation of women and men, girls and boys in all priority actions.
BDP 2100 (2018)	An adaptive techno-economic plan involving the interaction of water, land use, ecosystem, and climate change with development outcomes.	• Specific goals related to water security: Goal 4 is conservation of wetlands; Goal 5 is transboundary water management. • Excavation of local water reservoirs (canals, ponds, and baors) for restoration of water and rainwater harvesting. • Restoration of natural reservoirs and water bodies along with their biodiversity. • These and other contents are similar to the 8th Five Year Plan.
National Agricultural Policy 2018	Ensure food security and improve socioeconomic conditions.	• Recharge aquifers by building rubber dams in canals and small and medium rivers, and by storage of rainwater. • Excavation of canals, beels, and ponds and reclamation of water bodies for water conservation, drainage, and proper use of surface water. • Harvest rainwater and provide supplementary irrigation by digging ponds, streams, and canals.
National Food and Nutrition Security Policy 2021-2030	Increasing the availability, accessibility, and consumption of safe and nutritious food.	• Recognizes limited investments in infrastructure development related to water treatment, water storage, and transmission and distribution network. • Highlights the point that large infrastructure projects taking place in India, dams in particular, are set to worsen the problem of water availability in Bangladesh by decreasing river volumes. • Promoting more storage facilities and rainwater collection jars/containers to increase the quantity of water delivered, frequency of water availability, and the amount of water used at the household level—all factors that influence health.
	Focus on vulnerable groups and strengthening cross-sectoral food and nutrition security governance.	• Emphasizes rainwater harvesting and promotes storage tanks to reduce groundwater depletion. • Great scope to improve water harvesting through use of pools, dams, pits, retaining ridges, and increasing soil organic matter. • Combine floating vegetable beds with surface water storage and increase productivity of storage through aquaponics.

Second National Plan of Action for Nutrition (NPAN) 2016-2025	Improving the nutritional status of citizens, emphasizing multisectoral programs.	• Cultivation of small fish in homestead water bodies to meet the nutritional needs of rural families.
National Water Policy 1999	Provide direction to all agencies working with the water sector and institutions that relate to the water sector.	• Harnessing and development of all forms of surface water and groundwater. • Rainwater harvesting, especially for safe and affordable drinking water supply. • Preserve natural depressions and water bodies in major urban areas for recharge of underground aquifers and rainwater management. • Cascades of small (rubber) dams for mini-hydropower development—provided they are economically viable and environmentally safe. • Resuscitate natural water bodies such as lakes, ponds, beels, khals, tanks, etc. • Stop the filling of publicly owned water bodies and depressions in urban areas for preservation of natural aquifers and environment. • Institutional changes that will help decentralize management of water resources and enhance the role of women in water management.
National Strategy for Water Supply and Sanitation 2014	Provide a strategic guideline for the goal of safe and sustainable water supply, sanitation, and hygiene services.	• Emphasizes the need for IWRM to ensure this sector is not overshadowed by production sectors. • Notes that groundwater has been a reliable and economic source of domestic water supply. However, its use is being pushed to its limits in water-stressed areas such as large cities due to excessive abstraction for water supply and other industrial uses, and in Barind areas due to high abstraction for irrigation. • Calls for a shift away from reliance on groundwater toward surface water for irrigation in groundwater-stressed areas through more IWRM. • Consider artificial recharge of groundwater and other technical measures in the water-stressed areas.
National Energy Policy (2005 update)	Ensure environmentally sound sustainable energy development programs, with due importance to renewable energy, causing minimum damage to environment.	No specific mention of hydropower.
Renewable Energy Policy 2008	Harness, enable, develop, scale up, promote renewable energy.	• Micro-hydro and mini-hydro power have limited potential in Bangladesh with the exception of Chittagong and the Chittagong Hill Tracts.

Annex 6. Potential for Water Storage

Region	Potential for storage
Coastal region (southern)	• Salinity of some river water remains within the permissible limit up to mid February and so can be used. • Some aquifers are fresh water-bearing but very limited and location-specific. They can be used for domestic purposes only with detailed investigations. Availability of fresh water is limited by salinity and arsenic contamination. • Shrimp culture using fresh water may be a good practice to reduce salinity. • Rainwater harvesting. • Less saline river water can be stored in natural canals before February.
Eastern hills	• Rainwater harvesting for irrigation is possible due to high rainfall; construction of small water reservoirs • Hill-top and hill-slope areas can be irrigated by pumping and valley areas by gravity flow. • Water can be conserved in canals by constructing cross-dams or rubber dams and applied to crops through gravity channels. • Fruit gardens can be established on hill slopes. • Prospects of fruit gardening are very bright if pressurized irrigation distribution systems can be installed. • Possible other options are constructing rubber dams, installation of solar pumps, and modern irrigation distribution systems.
Northwestern region and	• MAR offers a potential solution to restore the groundwater level. • Major opportunities: Re-excavation of natural canals, ponds, beels (a type of wetland), other water bodies which may be used to conserve storm run-off for supplemental irrigation. • Construction of cross-dams and rubber dams on natural canals to conserve water during the rainy season. • The conserved water will be helpful for groundwater recharge and subsequent abstraction for irrigation. • Rooftop rainwater from buildings can be used for groundwater recharge.

Source: Presentation on Water Storage Practice and Potential in Bangladesh by Dr M A Rashid at the Water Storage Project In-country Workshop, 12 June, 2024, Dhaka, Bangladesh.

Annex 7. Workshop Participants

List of participants in the Water Storage Project In-country Workshop held on 12 June, 2024 in Dhaka, Bangladesh

No.	Name	Position	Organization
1	Malik Fida A Khan	Executive Director	Center for Environmental and Geographic Information Services (CEGIS)
2	Mohammed Rezaul Maksud Jahedi	Director-General	WARPO
3	Mohammed Shahidul Hasan	Executive Committee (EC) Member	Bangladesh Water Partnership (BWP) and former Chief Engineer, LGED
4	Monowar Hossain	Regional Council Member	GWP SAS and former Executive Director, International Water Management Institute
5	Nilufa Islam	EC Member, BWP and former Director-General	WARPO
6	Mohammad Alamgir	Principal Scientific Officer	WARPO and EC Member, BWP
7	Shamal Chandra Das	Additional Chief Engineer (Civil)	BWDB
8	Mohammed Abdur Rashid	EC Member	Bangladesh Water Partnership
9	Mohammad Shahjahan Mondal	Professor	IWFM, BUET
10	Afroza Sharmin	Executive Engineer	BADC
11	H.S. Mozaddad Faruque	Former Director-General	BWDB
12	Uthpal Kumar	Water Management Specialist	IFDC
13	Shamsher Ali	Member Secretary	Nadi Adhikar Mancha
14	Farseem Mannan Mohammedy	Professor	BUET
15	Kazi Matin Uddin Ahmed	Professor	University of Dhaka
16	Mohammed Masud Ahmed	Independent Consultant (former Director-General, BWDB)	Independent consultant
17	Ratna Barman	Operation Coordinator	Rupantar
18	S.M. Tanvir Hassan	Water Resource Specialist	International Water Management Institute
19	Moshiur Rahman Peng	President	Bangladesh Water Partnership
20	Mohammed Siddiqur Rahman	General Secretary	Bangladesh Water Partnership
21	Nazmun Naher	Country Coordinator	Bangladesh Water Partnership
22	Lamiya Sharmeen Jaren	Program Officer	Bangladesh Water Partnership
23	Matthew McCartney	Research Group Leader	IWMI
24	Karthikeyan Matheswaran	Researcher	IWMI
25	Sanjiv de Silva	Senior Regional Researcher – Natural Resources Governance	IWMI
26	Diluka PIyasena	Communications Coordinator, Interim Regional Coordinator	Global Water Partnership – South Asia

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Management Institute

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The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 15 countries and a global network of scientists operating in more than 55 countries.

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