GUIDING TOOL FOR DEVELOPMENT OF NATIONAL INTEGRATED WATER MASTER PLAN (NIWMP)

Department of Water
Ministry of Energy and Natural Resources
ROYAL GOVERNMENT OF BHUTAN

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GREEN CLIMATE FUND

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Acknowledgement

The Department of Water (DoW) under the Ministry of Energy and Natural Resources (MoENR), Royal Government of Bhutan (RGoB), is pleased to present the Guiding Tool for the Development of National Integrated Water Master Plan (NIWMP), developed through the Advancing Climate Resilience of Water Sector in Bhutan (ACREWAS) Project. It is the result of concerted efforts by different national and international agencies.

The DoW would like to thank particularly the United Nations Development Programme (UNDP)-Bhutan, National Adaptation Plan (NAP) Project, Global Environment Facility (GEF), and Green Climate Fund for financial support to develop the guiding tool for the development of NIWMP. The DoW is greatly indebted to the Taskforce Members for their valuable inputs and guidance. The Taskforce Members consisted of representatives from the following agencies: Department of Agriculture; Department of Environment and Climate Change; Department of Energy; Department of Forest and Park Services; Department of Human Settlement; Department of Industry; Department of Infrastructure Development; Department of Local Government and Disaster Management; Department of Tourism; Thimphu Thromde, Policy and Planning Division, MoENR; Bhutan Trust Fund for Environment Conservation; Druk Green Power Corporation; SNV-Bhutan; Tarayana Foundation; and UNDP.

The DoW also thanks the other agencies and stakeholders for providing their insights, feedback, and suggestions during the development of this document. Finally, the DoW extends gratitude to the TARU Leading Edge Pvt. Ltd. and their partner for their technical inputs in preparing the guiding tool document.

Foreword

Water is a vital national resource that underpins Bhutan's social well-being, economic development, and environmental sustainability. Blessed with abundant rivers, glaciers, and rainfall, the country's water resources support key sectors such as agriculture, hydropower, industry, tourism, and cultural and ecological systems. Despite having high per capita water availability, Bhutan continues to face challenges related to equitable access, water quality, infrastructure limitations, sectoral fragmentation, and increasing climate-induced risks. Rapid urbanisation, evolving consumption patterns, and the growing impacts of climate change highlight the urgent need for an integrated and strategic approach to water resources management. Addressing these challenges requires all stakeholders to develop a shared understanding of key issues and work collaboratively to manage Bhutan's water resources.

This need for coordinated action was formally recognised in the Water Act of 2011 and the Water Regulations of 2014. In this context, the preparation of the National Integrated Water Master Plan (NIWMP) has emerged as a critical national priority. To support this process, the Guiding Tool for the Development of the NIWMP has been prepared, providing a structured, comprehensive, and practical framework for integrated water planning. The guiding tool emphasises evidence-based decision-making, inter-sectoral coordination, stakeholder engagement, and climate resilience, ensuring alignment with national policies while addressing local realities.

The guiding tool is structured around six interlinked modules, namely: Baseline Diagnosis; Policy and Regulation Assessment; Data Management; Capacity Building; Monitoring and Evaluation; and Finance. Together, these modules provide systematic methodologies, checklists, and analytical guidance to assist planners, practitioners, and stakeholders throughout the NIWMP development process. The modular and adaptable design of the tool allows for its application at national, regional, and local levels.

This guiding tool is intended to serve as a key reference for government agencies, development partners, consultants, and other stakeholders engaged in water sector planning and management. By promoting coordinated action and informed planning, it lays the foundation for the preparation of a robust National Integrated Water Master Plan that supports sustainable development and enhances resilience to future water-related challenges.

As Bhutan advances towards achieving its Water Vision 2025 and broader sustainable development goals, this guiding tool is expected to play an important role in shaping inclusive, resilient, and sustainable water management strategies. The NIWMP, developed using this guiding framework, will contribute to safeguarding water resources, strengthening climate resilience, and ensuring the well-being of both people and the environment for present and future generations.

Finally, I would like to commend the hard work of the Consultant and my colleagues in the Department of Water for coming up with this Guiding Tool for the Development of the National Integrated Water Master Plan. It is hoped that this guiding tool will serve as a valuable framework for the preparation of National and Dzongkhag Integrated Water Master Plans, and will contribute to improved water management through a more cohesive, integrated, and sustainable approach.

(Dechen Yangden)
Director
Department of Water
Ministry of Energy and Natural Resources.

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Acronyms and Abbreviations

ACREWAS	Advancing Climate Resilience of the Water Sector
BCC	Behavior Change Communication
BSB	Bhutan Standards Bureau
Capex	Capital Expenditure
CBA	Cost-Benefit Analysis
DGPC	Druk Green Power Corporation
DMDF	Department of Macro-Fiscal and Development Finance
DoA	Department of Agriculture
DoE	Department of Energy
DoECC/DECC	Department of Environment and Climate Change
DoID	Department of Infrastructure Development
DoW	Department of Water
DoW	Department of Water
GCF	Green Climate Fund
GEF	Global Environment Facility
GIS	Geographic Information System
GLOFs	Glacial Lake Outburst Floods
IEC	Information, Education & Communication
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technology
KPIs	Key Performance Indicators
LD	Liters per Day
M&E	Monitoring and Evaluation
MLD	Million Liters per Day
MoEA	Ministry of Economic Affairs
MoENR	Ministry of Energy and Natural Resources
MoICE	Ministry of Industry, Commerce, and Employment
MoIT	Ministry of Information and Technology
NAP	National Adaptation Plan
NCHM	National Center for Hydrology and Meteorology
NGO	Non-Government Organization
NIWMP	National Integrated Water Master Plan
NSSC	National Soil Services Center
O&M	Operation & Maintenance
Opex	Operational Expenditure
PRA	Participatory Rural Appraisal
RGoB	Royal Government of Bhutan
UNDP	United Nations Development Programme
WHO	World Health Organization
WMP	Water Master Planning
WUAs	Water User Associations
WWTP	Wastewater Treatment Plant

Section 1: Background

A. Background and Context

Access to water and sanitation are recognized by the United Nations as human rights – fundamental to everyone's health, dignity, and prosperity. The global context underscores the pressing need for equitable access to this essential resource, as it underpins health, development, and environmental sustainability. Regionally, the challenges are magnified by varying climatic, geographical, and socio-economic conditions, which affect water availability and quality. Locally, Bhutan presents a unique case. Despite its high per capita water availability, the country faces significant hurdles in ensuring accessible, safe, and affordable water for all its citizens. Bhutan's Water Vision 2025 reflects a comprehensive understanding of water's value as a crucial natural and economic asset, emphasizing the critical need for sustainable management to benefit both present and future generations without compromising ecological integrity.

The water scenario, from a global to a local level, reveals a complex tapestry of challenges and opportunities. Globally, the increasing demand for water, exacerbated by population growth and economic development, is leading to stress on water resources, making sustainable management more critical than ever. Regionally, South Asia faces its own set of challenges, including the impacts of climate change, which contribute to erratic rainfall patterns and water scarcity. Within Bhutan, these global and regional trends manifest in unique ways. The nation's geographic diversity and varying climate conditions add layers of complexity to water resource management. Issues such as inadequate infrastructure, poor governance, and the effects of urbanization further complicate the scenario, affecting the equitable distribution and quality of water resources. These challenges are further intensified by climate change, which leads to unpredictable water flows and extreme weather events, disrupting the balance between water supply and demand.

Addressing these challenges requires an integrated approach that considers the interplay of economic, social, disaster risk reduction and ecological factors at every level. It involves improving water infrastructure, enhancing quality through better management practices, and anticipating the impacts of climate change and population growth. In recognition of the critical importance of water security for its agricultural, industrial, tourism, hydropower and other allied sectors, Bhutan is urged to develop a National Integrated Water Master Plan (NIWMP).

The project "Advancing Climate Resilience of the Water Sector (ACREWAS)" assumes a critical role in enhancing the resilience of Bhutan's water sector in response to climate change, a vital consideration for the nation's sustainable economic development. The significance of formulating comprehensive policies and strategies at both local and national levels is underscored in this initiative, aligning with Bhutan's National Adaptation Plan (NAP). The project employs a holistic approach, consisting of four essential components: Component 1 focuses on water governance and institutions; Component 2 emphasizes nature-based solutions for sustainable and climate-resilient watersheds, supporting livelihood enhancement; Component 3 addresses efficient, adequate, and sustainable water supply, distribution, and utilization; and Component 4 centers on knowledge management. This project is part of Component 1 where the primary outcome is to strengthen water governance, institutions, and financing mechanisms in support of climate-resilient water management. Under component 1, output 1.1 talks about relevant national and local policies and strategies aligned with sustainable and climate resilient water management, under Activity 1.1.1. it is Development of guiding tool for preparation of Water Master Plan, Activity 1.1.2. Undertake participatory assessment of water resources and water issues within local watersheds and Activity 1.1.3. Water master plan for Gasa, Punakha and Tsirang Dzongkhags.

Section 2: Overview of Guiding Tool

B. Need for the Guiding Tool

Bhutan's water resources are foundational to its socioeconomic activities, yet ensuring access to safe, adequate, and sustainable water is a persistent challenge. Key factors contributing to this include the nation's complex topography, scattered settlements, and the limitations of source management and governance, compounded by a sector-based approach to water management systems. Urban growth, alongside limited urban planning, has led to suboptimal water resources, stormwater, and wastewater management, and challenges in meeting environmental discharge norms. Furthermore, climate change exacerbates these issues by impacting the predictability and reliability of water resources, calling for resilient adaptations in water sector planning and management.

The identification of critical challenges highlights the need for an innovative approach to water master planning in Bhutan. Based on interactions with various experts and departments, these challenges include, but are not limited to, forest degradation, drinking water issues, water-related disaster management, institutional and governance obstacles, and the impacts of climate change—such as increased temperatures, erratic rainfall, and glacial melt. The details of the stakeholder meeting and key discussion points are mentioned in Annexure B.

The conventional Water Master Planning (WMP) often follows a siloed approach, which may not adequately address the multifaceted nature of the country's water-related challenges. In contrast, an Integrated WMP, as depicted Table 1, employs a holistic framework. It emphasizes coordination among various sectors, incorporates climate resilience, and ensures that water governance is adaptable to future climatic uncertainties and socioeconomic shifts.

Table 1: Difference in Conventional and Integrated Water Master Plan.

	Conventional WMP	Integrated WMP
Focus	Siloed, addressing water-related issues individually, often neglecting broader environmental trends.	Holistic, considering water management as interconnected within a larger system, specifically including the anticipated impacts of climate change on water resources.
Planning	Fragmented, with different agencies responsible for different aspects.	Collaborative, with different agencies working together to develop a comprehensive plan that considers all aspects of water resources management.
Decision Making	Primarily based on engineering and economic factors, with less emphasis on environmental and social considerations.	Inclusive of engineering, economic, and notably environmental and social factors, with strategies adjusted for resilience against climate variability and change.
Outcome	Can lead to inefficiencies, conflicts, and unsustainable water management practices.	Leads to sustainable practices, adaptive to climate change, improving resilience, and minimizing conflict over water resources.

The guiding tool is intended to support in development of NIWMP in improving water management by developing a more cohesive and sustainable approach. Its development reflects the realistic and necessary steps towards enhancing resilience and ensuring equitable water distribution, with a focus on practical application and adaptability to future demands.

C. Framework of the Guiding Tool

The guiding tool for NIWMP is organized into six interlinked modules shown in Figure 1. In the framework indicated in Figure 2, each module is systematically transitioned into the next, ensuring an integrated and comprehensive planning methodology. The first module, Baseline Diagnosis, establishes a foundation by cataloging the current state of water resources. The insights gathered here are crucial for informing the subsequent Policy and Regulation Assessment, which examines and outlines the

governance framework necessary for water resource management. The Data Management module ensures the accuracy and management of data collected which provides insights for the Capacity Building module, focusing on enhancing the skills and capabilities of the stakeholders. This progression ensures that the human resources required for implementation are well-prepared and informed by accurate, up-to-date data. Subsequent to Capacity Building, the Monitoring and Evaluation module employs the developed capacities and data to track progress and appraise the effectiveness of strategies put in place, enabling informed adjustments to be made. Integral to the entire framework is the Finance module, which underpins the execution of the plan with sustainable economic strategies. Stakeholder feedback is solicited and integrated at every stage of the process, serving as a vital component that ensures the plan remains adaptable and in concurrence to the requirements of the NIWMP. This iterative feedback loop is instrumental in the refinement of the plan, resulting in creation of well-crafted NIWMP.

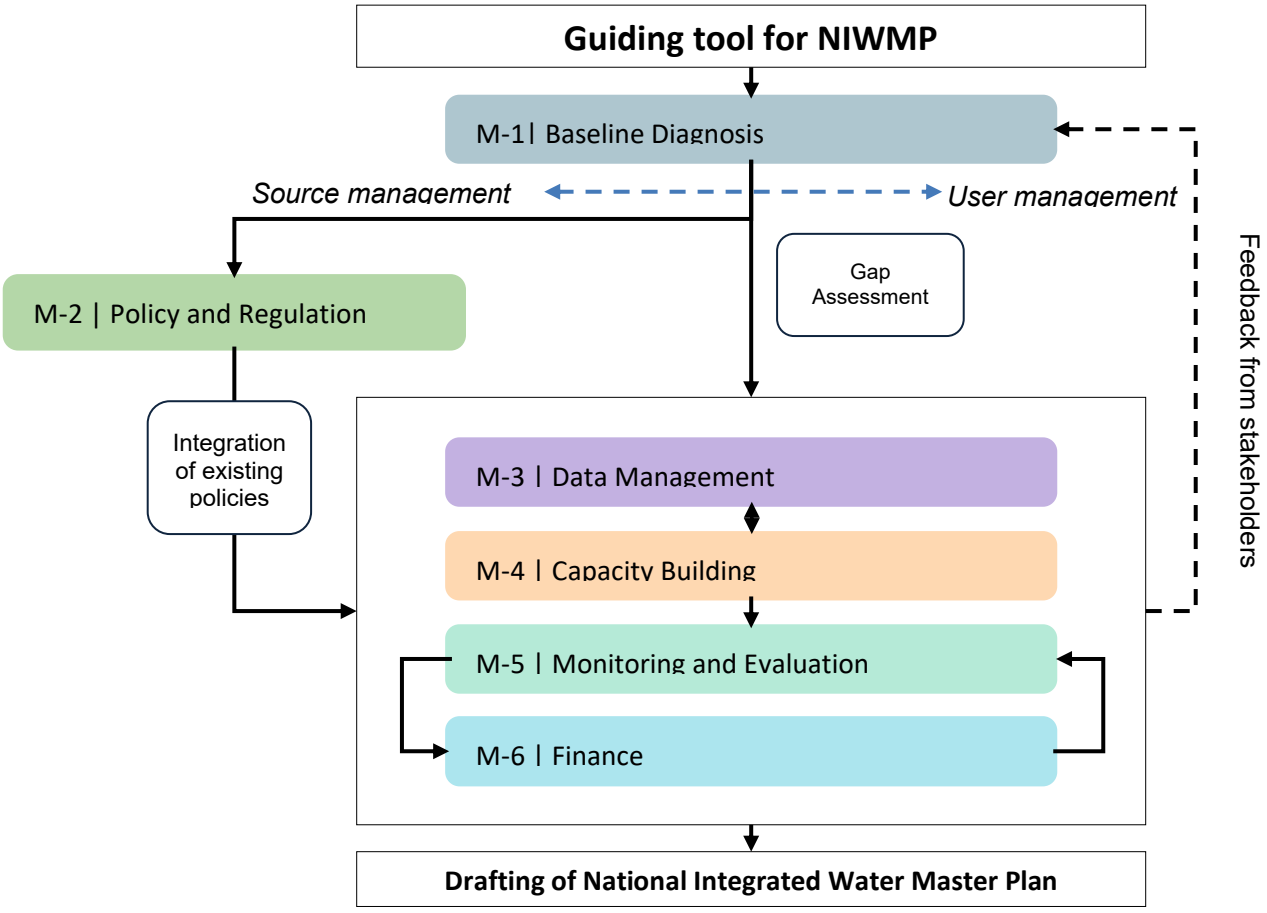


Figure 1: Framework of Guiding tool for NIWMP

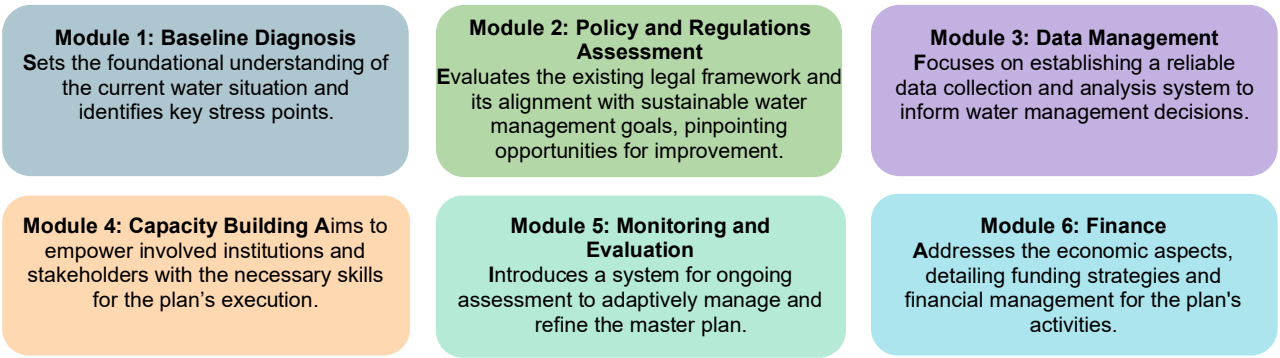


Figure 2: Overview of modules of Guiding tool.

D. User groups of the Toolkit

The guiding tool aims to support target users categorized into four key groups: 1) Department of water, Government of Bhutan; 2) Developer/ firm comprising of experts from different sectors, for development of NIWMP; 3) International development partners; 4) Allied departments. Further classification of users is explained in

Table **2** alongside their roles and responsibilities for developing NIWMP. Additionally, the toolkit can be a good resource for water sector professionals, planners, civil societies, researchers, the general public, and planning consultants. The content of this toolkit is beneficial for independent reading as well.

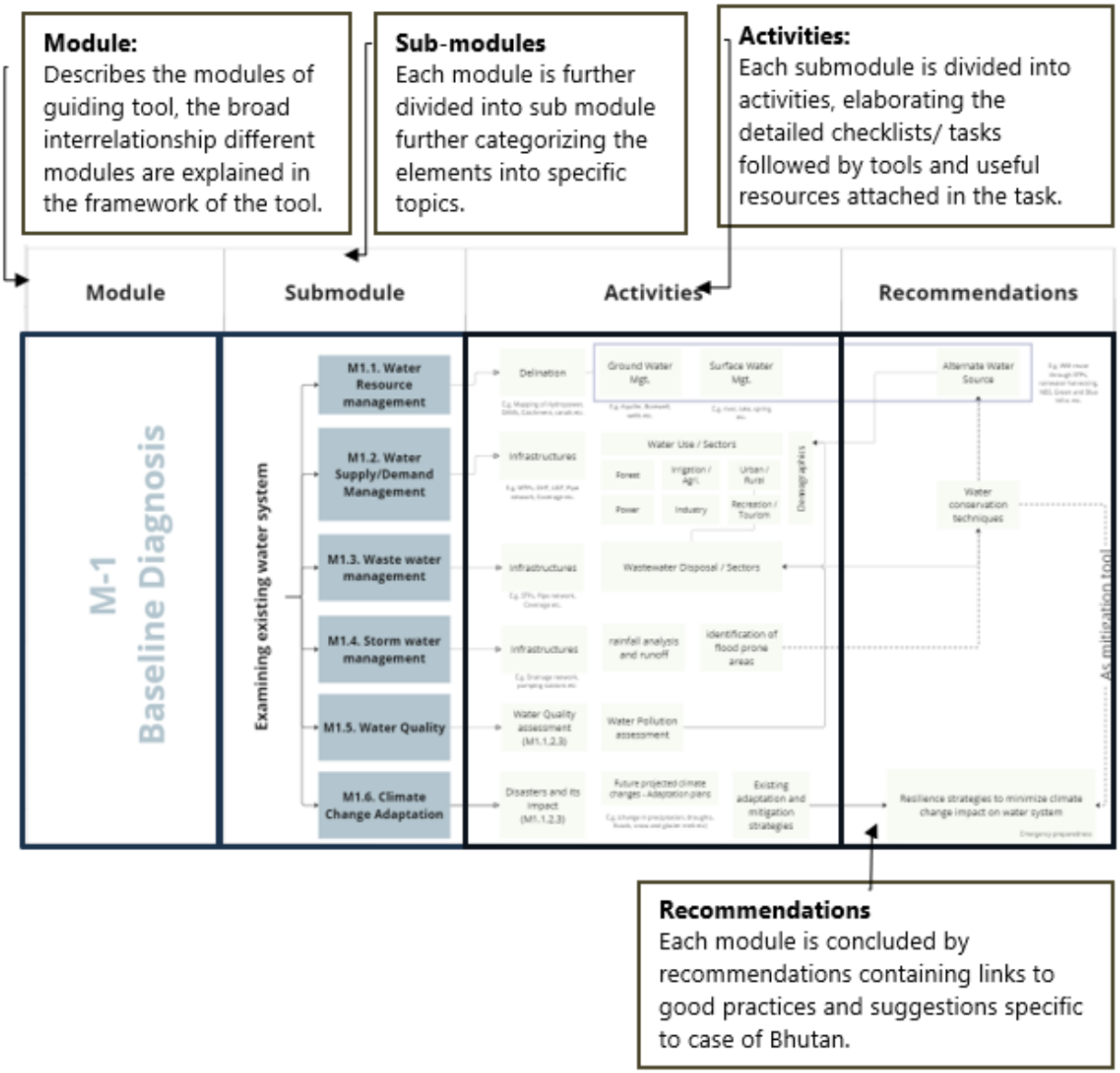
Table 2: User classification and responsibility matrix for Development of NIWMP.

Department of Water, Bhutan	**Allied Departments**	**Developer / Firm comprising of experts from different sectors, for development of NIWMP**								**International development partners**
Finance / M&E / Regulatory	**Support / Data Fetching**	**Technical**								**Finance / M&E**
Head of Dep. / Officials	**Dept. Head**	**Hydrologist/ Water planner**	**Agriculture/ irrigation expert**	**Environment & biodiversity expert**	**GIS Expert**	**Planners**	**IT Expert**	**Economist**	**Capacity building & BCC expert**	**Designated Representative**
Roles and responsibilities										
Policy / Regulations	•Provide data for water needs (supply and demand) •Department such as disaster management, finance, Hydropower, Energy, Tourism etc.	•Assessment of Water resources: Source and Quantity •Flood estimation and management •Climate Change Adaptation Assessment •Matching with demand side •Planning of a water resource •Conveyance and transportation planning •Last mile distribution •drainage plan	•Planning of agricultural development •Assessment of water needs for the above	•Assessment of environmental impact due to various interventions (at supply and user level) •Mitigation strategy for such environmental impacts •Strategize conservation and enrichment of forest and biodiversity of the country	•Supporting hydrologist and water planner with latest GIS and remote sensing techniques	•Assessment and fulfilment of urban water demands including domestic supply •Assessment and mitigation of flood risks in urban area	•Providing support of Analysis and design tools for various domain experts, •Providing support of decision support system •Providing support of management information tool •Providing support for overall project monitoring	•Assessment of water demand for industries and other economic activities, synchronies with national sustainable goal of economic development •Economic evaluation of master plan and its various components, and exploration of alternatives	• Stakeholder Analysis and Engagement • Capacity Building, Develop and deliver training programs • BCC strategy development, Community mobilization	Support in finance, monitoring, and evaluation

E. User guide – Module, Sub-Module and Activity

Sample Module template:

The "User Guide for the Guiding Tool" of Bhutan's National Integrated Water Master Plan (NIWMP) outlines a clear and structured approach to water management planning. It is organized into modules and sub-modules, each containing specific activities complete with detailed checklists, tools, and data sources. These components are designed to ensure effective execution and integration across various aspects of water management. Each activity is color-coded and includes comprehensive descriptions and objectives to enhance understanding and connectivity between different elements of the plan. This guide equips stakeholders with all necessary resources to implement the NIWMP effectively, fostering sustainable water management practices across Bhutan.



Activity sheet template:

Objective:
Every activity is clearly defined by the objective statement.

Activity:
Activities within each submodule with alpha numeric code indicating their submodule.

Submodule:
Submodules are color coded for clear distinction.

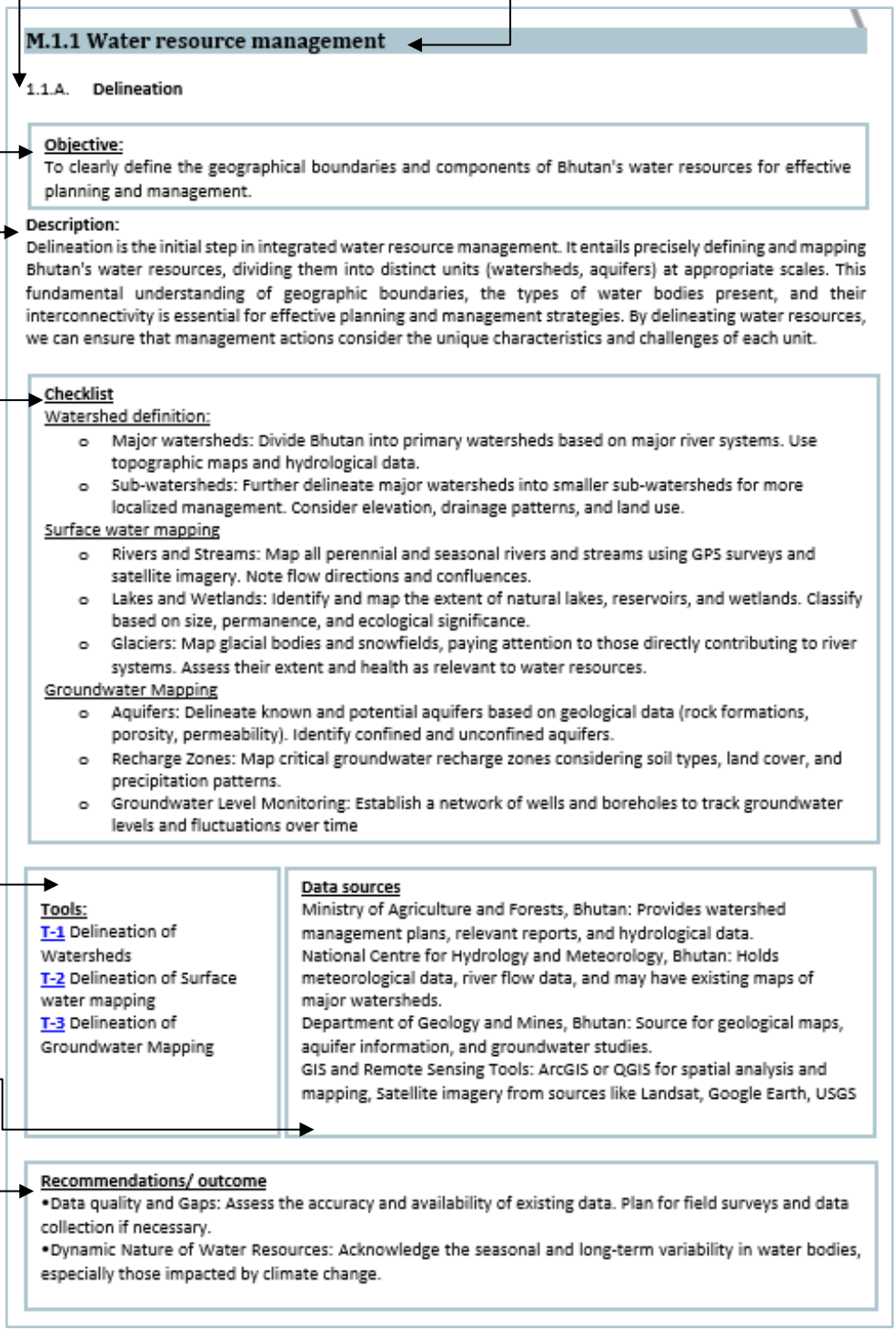
Description:
Each activity as a brief description providing an overview and its linkage with other modules giving a clear understanding to the user/ stakeholder about the task.

Checklist:
Activity is further categorized into a detailed checklist.

Tools:
In each activity sheet a dedicated tool section is provided supporting the checklist these can be tables, excel calculation, manuals, pdfs to full fill the respective tasks, these can be accessed by simply clicking on the Tool code.

Data sources:
In this section all the possible data sources are provided for the users to fulfill the checklist.

Recommendation:
Good practices/ recommendations and possible output of the activity is listed here.



M.1.1 Water resource management

1.1.A. **Delineation**

Objective:
To clearly define the geographical boundaries and components of Bhutan's water resources for effective planning and management.

Description:
Delineation is the initial step in integrated water resource management. It entails precisely defining and mapping Bhutan's water resources, dividing them into distinct units (watersheds, aquifers) at appropriate scales. This fundamental understanding of geographic boundaries, the types of water bodies present, and their interconnectivity is essential for effective planning and management strategies. By delineating water resources, we can ensure that management actions consider the unique characteristics and challenges of each unit.

Checklist

Watershed definition:
- Major watersheds: Divide Bhutan into primary watersheds based on major river systems. Use topographic maps and hydrological data.
- Sub-watersheds: Further delineate major watersheds into smaller sub-watersheds for more localized management. Consider elevation, drainage patterns, and land use.

Surface water mapping
- Rivers and Streams: Map all perennial and seasonal rivers and streams using GPS surveys and satellite imagery. Note flow directions and confluences.
- Lakes and Wetlands: Identify and map the extent of natural lakes, reservoirs, and wetlands. Classify based on size, permanence, and ecological significance.
- Glaciers: Map glacial bodies and snowfields, paying attention to those directly contributing to river systems. Assess their extent and health as relevant to water resources.

Groundwater Mapping
- Aquifers: Delineate known and potential aquifers based on geological data (rock formations, porosity, permeability). Identify confined and unconfined aquifers.
- Recharge Zones: Map critical groundwater recharge zones considering soil types, land cover, and precipitation patterns.
- Groundwater Level Monitoring: Establish a network of wells and boreholes to track groundwater levels and fluctuations over time

Tools:
T-1 Delineation of Watersheds
T-2 Delineation of Surface water mapping
T-3 Delineation of Groundwater Mapping

Data sources
Ministry of Agriculture and Forests, Bhutan: Provides watershed management plans, relevant reports, and hydrological data.
National Centre for Hydrology and Meteorology, Bhutan: Holds meteorological data, river flow data, and may have existing maps of major watersheds.
Department of Geology and Mines, Bhutan: Source for geological maps, aquifer information, and groundwater studies.
GIS and Remote Sensing Tools: ArcGIS or QGIS for spatial analysis and mapping, Satellite imagery from sources like Landsat, Google Earth, USGS

Recommendations/ outcome
- Data quality and Gaps: Assess the accuracy and availability of existing data. Plan for field surveys and data collection if necessary.
- Dynamic Nature of Water Resources: Acknowledge the seasonal and long-term variability in water bodies, especially those impacted by climate change.

Section 3: Module-wise Description of the Guiding Tool

F. M.1 BASELINE DIAGNOSIS

Introduction:
The Baseline Diagnosis module is a critical component of the National Integrated Water Master Plan (NIWMP). It aims to establish a comprehensive understanding of Bhutan's current water resources, demands, challenges, and management practices. This comprehensive assessment serves as the foundation for crafting evidence-based water management strategies within the NIWMP.

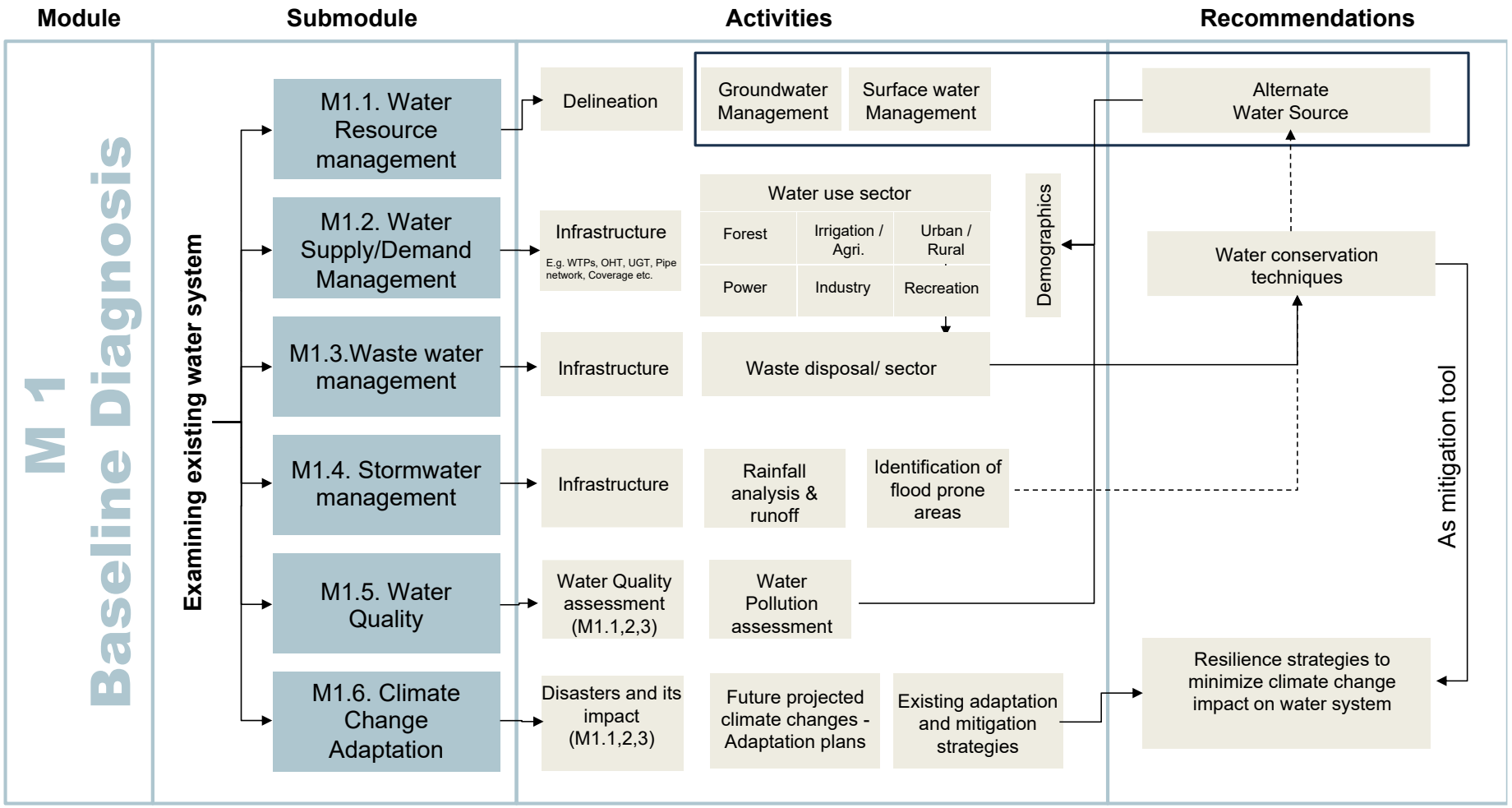
Key Areas of Focus:

- **Water Resource Management:**
  - Delineating watersheds, aquifers, and surface water bodies will create the spatial framework for integrated management.
  - Assessing the quantity and quality of surface and groundwater resources, in the context of climate change impacts, is essential for sustainable supply-side planning.
  - Exploring alternative water sources (rainwater harvesting, reuse, etc.) can increase resilience, especially in water-stressed areas.
- **Water Supply/Demand Management:**
  - Evaluating existing water infrastructure across sectors will highlight capacity gaps and inform future investments.
  - Analyzing water use patterns in agriculture, industry, urban/rural areas, hydropower, and tourism will pinpoint areas for targeted efficiency measures.
  - Demographic studies and population projections are needed to link future water needs and anticipated population trends.
- **Wastewater and Stormwater Management:**
  - Assessing wastewater generation, treatment, and disposal will identify pollution sources and infrastructure needs for protecting water quality.
  - Rainfall analysis, runoff calculations, and mapping of flood-prone areas will guide disaster risk reduction measures related to water.
- **Water Quality and Climate Resilience:**
  - Establishing a water quality monitoring network will track the health of rivers, lakes, and aquifers, allowing for targeted interventions to address pollution.
  - Analyzing past disaster impacts and integrating climate change projections into water scenarios is essential to ensure infrastructure and planning are robust enough for a changing climate.

Objective:
This module goes beyond simply identifying problems. It will reveal areas where Bhutan's water management is already strong, and where the NIWMP should focus interventions. Data-driven insights from the baseline diagnosis will ensure that the NIWMP proposes solutions tailored to Bhutan's specific water realities.

Target users
The Baseline Diagnosis module is crucial for the technical experts developing NIWMP. It provides hydrologists, water planners, sector specialists (agriculture, environment, urban development), and the GIS expert with the quantitative and spatial data they need to assess water availability, demand patterns, and existing infrastructure. This will be a foundation for the subsequent steps on water allocation, infrastructure planning, environmental impact assessments, and designing targeted interventions. Additionally, the module's findings will be valuable for those involved in project financing, monitoring, and potentially, regulatory reform.

Flow chart: Interlinkage between sub-modules of Baseline module.



M.1.1 Water resource management

1.1.A. Delineation

Objective:
To clearly define the geographical boundaries and components of Bhutan's water resources for effective planning and management.

Description:
Delineation is the initial step in integrated water resource management. It entails precisely defining and mapping Bhutan's water resources, dividing them into distinct units (watersheds, aquifers) at appropriate scales. This fundamental understanding of geographic boundaries, the types of water bodies present, and their interconnectivity is essential for effective planning and management strategies. By delineating water resources, we can ensure that management actions consider the unique characteristics and challenges of each unit.

Checklist

Watershed definition:

- Major watersheds: Divide Bhutan into primary watersheds based on major river systems. Use topographic maps and hydrological data.
- Sub-watersheds: Further delineate major watersheds into smaller sub-watersheds for more localized management. Consider elevation, drainage patterns, landuse and transboundary nature, assess water shed condition (forest cover, types etc.).

Surface water mapping

- Rivers and Streams: Map all perennial and seasonal rivers and streams using GPS surveys and satellite imagery. Note flow directions, confluences, and transboundary nature.
- Lakes and Wetlands: Identify and map the extent of natural lakes, reservoirs, and wetlands. Classify based on size, permanence, and ecological significance.
- Glaciers: Map glacial bodies and snowfields, paying attention to those directly contributing to river systems. Assess their extent (transboundary if applicable) and health as relevant to water resources.

Groundwater Mapping

- Aquifers: Delineate known and potential aquifers based on geological data (rock formations, porosity, permeability). Identify confined and unconfined aquifers and conduct volumetric assessment of the aquifer. Consider transboundary nature if applicable.
- Recharge Zones: Map critical groundwater recharge zones considering soil types, land cover, and precipitation patterns.
- Groundwater Level Monitoring: Establish a network of wells and boreholes to track groundwater levels and fluctuations over time.

Tools:	**Data sources**
T-1 Delineation of Watersheds T-2 Delineation of Surface water mapping T-3 Delineation of Groundwater Mapping	• Ministry of Energy and Natural Resources (MoENR): Key source for data on hydropower, dams, reservoirs (DoE), watershed and river basins (DoW). • DoID (under MoIT) for major treatment plants, and urban water supply infrastructure. • GovTech agency for remote sensing and GIS data. • Dzongkhag Administrations: Contact for information on district-level water systems, boreholes, and rural water schemes. • Municipal Authorities (Thromdes): Provide data on urban water distribution networks, metering, leakage rates, and major water users. • MoICE water-intensive industries for data on their water use and on-site treatment systems. • Existing Assessments: Consult RUB (Royal University of Bhutan), NGOs working on water projects, and relevant academic studies for any prior infrastructure assessments.

Recommendations/ outcome

•Data quality and Gaps: Assess the accuracy and availability of existing data. Plan for field surveys and data collection if necessary.

•Dynamic Nature of Water Resources: Acknowledge the seasonal and long-term variability in water bodies, especially those impacted by climate change.

1.1.B. Ground water management

Objective:

To provide in-depth information on Bhutan's groundwater systems and their vulnerability, to support sustainable and integrated water resource management planning. This sub-module builds upon the initial delineation of aquifers completed in Sub-Module A.

Description:

This sub-module involves a detailed characterization of Bhutan's aquifers, including their geological formations, permeability, recharge/discharge dynamics, and connectivity with surface water systems. Data on groundwater levels, trends, water extraction patterns, and quality will be collected and analyzed. This assessment aims to identify areas of abundant groundwater resources, those under stress, and those with high vulnerability to contamination.

Checklist

Aquifer Characterization

- Aquifer type: Identify as confined, unconfined, semi-confined, or fractured rock aquifers.
- Dominant geological formation: Describe the main rock types or soil formations where the aquifer is found (e.g., alluvial deposits, sandstone, limestone).
- Permeability: Indicate if high, medium, or low, based on geological data and if possible, pumping test results.
- Connectivity to surface water: Note if the aquifer interacts with rivers (gaining or losing stream?), lakes, or wetlands. Mapping these connections is crucial.
- Transboundary nature: Specify if the aquifer extends across borders; collaborative management may be needed.

Recharge & Discharge

- Zone type: Designate each mapped zone as primarily recharge or discharge.
- Geographic area: Clearly delimit zone boundaries on maps.
- Primary mechanism: Describe how recharge occurs (diffuse infiltration through permeable soil, focused recharge via sinkholes, etc.).
- Permeability: Indicate the permeability of surface materials within the zone.
- Estimated water balance contribution: If data allows, provide a rough volume estimate of annual recharge/discharge for the zone.
- Sensitivity to change: Assess if the zone is vulnerable to land-use change (affecting infiltration), or changes in precipitation patterns (climate change).

Groundwater Levels & Trends

- Monitoring well ID & map reference: Ensure each well has a unique code, and is precisely located on maps.
- Depth, screened interval: Specify the total well depth, and the depth range where water enters the well.
- Data period, trends: Ideally have at least 5 years of data, show graphs of water level fluctuations (seasonal and long-term).
- Impact of pumping: Note if groundwater levels in the well are significantly impacted by nearby high-volume pumping wells.

Well Yields, Pumping Tests & Water Use

- Well ID & map reference: Link each well to maps.
- Owner, primary use: Specify if the well is for domestic use, irrigation, industrial, etc.
- Pumping test results: Summarize key findings (sustainable yield, drawdown rate).
- Estimated extraction: Provide the best available volume estimates for annual water withdrawal from the well.
- Regulatory status: Indicate if there's a permit for the well, and what restrictions it may have.

Groundwater Quality & Vulnerability

- Sampling location/well ID: Clearly link each sample to a well.
- Sampling dates: Note seasonal variations in testing, if possible.
- Parameters tested: List all water quality parameters analyzed (pH, salinity, nitrates, heavy metals, etc.).
- Results compared to standards: Specify which standards are used (Bhutanese, WHO), and highlight any exceedances.
  Vulnerability assessment: Indicate the method used (DRASTIC index, or another), and map the results.

Tools:	**Data Sources -**
T-4 Aquifer Characterization T-5 Recharge & Discharge (Water Balance Focus) T-6 Groundwater Levels & Trends T-7 Well Yields, Pumping Tests & Water Use T-8 Groundwater Quality & Vulnerability	• Department of Geology and Mines, Bhutan: Geological maps • DoW - Aquifer data, potential existing well logs. • National Centre for Hydrology and Meteorology (NCHM), Department of Water (DoW): Precipitation data, monitoring of springs and their relationship to groundwater. •Thromde / Dzongkhag Administrations: holds records of well permits, water use data. •Stakeholder engagement and consultation with relevant department is advised for data validation and updation while preparing master plan.

Recommendations

- Groundwater Modelling: (Software if available, scenarios, as per the delineated areas).
- Risk Analysis: Highlight risks to quantity and quality.

1.1.C. Surface water management

Objective:

To establish a comprehensive understanding of Bhutan's surface water resources, encompassing their distribution, dynamics (flow patterns), quality, and current utilization. This information is crucial for informing effective management and planning strategies for integrated water resource management and water demand analysis.

Description:

This sub-module builds upon the initial delineation of water bodies (Sub-Module A). It includes a detailed inventory of surface water bodies, noting their uses and health indicators. Streamflow monitoring stations will be mapped, and available flow data analyzed. Water quality testing will provide baseline data on pollution risks. Importantly, water infrastructure (dams, hydropower plants, irrigation systems) will be mapped and linked to specific water bodies, highlighting the interconnectedness of Bhutan's water system.

Checklist

Surface Water Body Inventory

- Water Body Name/ID: Link to IDs used in delineation maps.
- Type: Be specific (first-order stream, high-altitude lake, etc.).
- Sub-basin: Use names from watershed delineation.
- Average Size/Volume: If data permits, else note 'estimated'.
- Primary Uses: List all that apply (irrigation, drinking, industrial, etc.)
- Health Indicators: Use rapid visual protocol if no quality data.

Streamflow Monitoring

- Gauging Station ID: Link to a map location.
- River/Stream Name: Use established official names.
- Location Coordinates: Precise data for revisits.
- Period of Record: Crucial for knowing data reliability.
- Data Type: Not just daily/monthly, but how it's measured (staff gauge, etc.).
- Key Flow Statistics: Minimum, average, high flow (specify timeframe).

Surface Water Quality

- Sampling Location: ID linked to map, not just the water body name.
- Dates of Sampling: Essential for seasonality analysis.
- Parameters Tested: Start with basics, expand if pollution is suspected.
- Results: Tabulate against Bhutan's or WHO standards.
- Potential Sources: Link to observed land uses upstream.

Water Infrastructure

- Structure ID: Unique code, linked to map.
- Type: Be specific (run-of-river hydropower, diversion weir, etc.).
- Water Body / River: Official name of the associated water feature.
- Capacity/Design Flow: In relevant units (m3/s, or storage volume).
- Primary Purpose: Avoid overlap in 'Uses' from the inventory section.
- Operator/Owner: Government agency, private sector, etc.

Condition Assessment: Simple scale (good, fair, needs urgent repair).

Tools:	**Data Sources -**
T-9 Surface Water Body Inventory T-10 Streamflow Monitoring T-11 Surface Water Quality T-12 Water Infrastructure	• DoW and NCHM - Streamflow records, meteorological data for water balance, possibly some water quality data. • Department of Energy (DoE) / Druk Green Power Corporation Limited (DGPC): Information on dams, hydropower facilities, and their operations. • Ministry of Agriculture and Livestock (DoA) and MoIT (DoID): Data on irrigation infrastructure, water withdrawals from surface water sources. • Thromde / Dzongkhag Administrations: for smaller water bodies or traditional water use systems.

Recommendations

• Mapping: Emphasize the visualization of this data. Integrate with the maps from the Delineation Tool.

• Water Balance Modelling If streamflow and water use data allow, include a section for a basic water balance model.

• Ecosystem Health assessment: it is recommended to note the health of aquatic ecosystems connected to surface water sources (presence of key species, habitat condition etc.).

• Links to Subsequent Modules: This data feeds into water allocation, infrastructure planning, pollution control, and environmental protection strategies.

1.1.D. Alternate water sources (detailed in recommendation section)

Objective:
To assess the potential of supplementing Bhutan's traditional water sources (rivers, groundwater) with rainwater harvesting, wastewater reuse, and innovative technologies. This aims to increase water security and resilience, particularly in areas facing water stress or climate variability.

Description:
This sub-module builds upon the knowledge of water availability (Sub-Modules A, B, C) and demand analysis (Module 1.2). It requires analyzing rainfall patterns, potential catchment areas, and existing wastewater flows. The suitability of advanced water technologies is explored in the context of their cost, energy needs, and Bhutan's technical capacity.

Checklist

Rainwater Harvesting Potential

Consider the prospect of utilizing rainwater as an additional water source through an assessment of precipitation trends, possible collection sites, and storage requirements.

i. Rainfall Analysis:
- To identify suitable areas for rainwater harvesting, it's essential to analyses long-term average rainfall, seasonal distribution, and intensity patterns. Regions with consistent and well-distributed rainfall, along with the potential for capturing runoff during intense precipitation events, are ideal for effective rainwater harvesting systems.

ii. Catchment Characterization:
- Urban: Rooftop types, materials (suitability for collection), average building footprints.
- Rural: Schools, community buildings, agricultural structures (rooftops, ground catchment potential).
- Mapping Tool: GIS or simple mapping software to visualize potential catchment areas.

iii. Storage Requirements:
- Estimate potential harvest volume based on rainfall and catchment size.
- Assess storage needs: household tanks, community reservoirs, integration with existing water networks.
- Best Practice: Refer to "Bhutan Green Building Design Guidelines", 2013.

Wastewater Reuse Potential

i. Inventory Wastewater Sources:
- Municipal Treatment Plants: Volume, existing treatment level, effluent discharge locations.
- Industrial Facilities: Identify major water-using industries, their wastewater characteristics.
- Data Sources: Bhutan Water Partnership, Municipal Authorities, targeted industry surveys.

ii. Reuse Standards:
- Reference Bhutanese water quality standards for specific reuse applications (irrigation, restricted urban use, indirect recharge, etc.).
- Best Practices: Investigate case studies of successful wastewater reuse projects in similar regional contexts.

iii. Treatment Technologies:
- Assess current treatment levels against reuse standards.
- Research suitable treatment upgrades or advanced technologies (membrane filtration, constructed wetlands, etc.)

3. Innovative Technologies
- Contextual Suitability: Fog/Dew Harvesting (suitability for specific Bhutanese microclimates); Advanced Aquifer Recharge (if groundwater supplies are suitable).
- Parameters Tested: Start with basics, expand if pollution is suspected.
- Results: Tabulate against Bhutan's or WHO standards.
- Potential Sources: Link to observed land uses upstream.

Tools:	**Data Sources -**
T-13 Rainfall Analysis T-14 Catchment Characterization T-15 Wastewater Reuse Assessment; Water Quality Considerations	National Centre for Hydrology and Meteorology (rainfall data). Department of Water, DoID, Thromde / Dzongkhag Administrations (potential existing reuse initiatives). NGOs, Research Institutions (potential existing reuse initiatives) Thromde / Dzongkhag Administrations, DoID (wastewater volumes, treatment info). MoICE: Industries (self-reported water use and wastewater data). International Water Association (IWA) and similar research platforms.

Recommendations

•Prioritized Mapping: Identify areas with the highest rainwater harvesting or reuse potential.

•Feasibility Focus: Highlight options likely to be cost-effective and within existing technical capacity.

•Targeted Pilot Projects: Recommend specific locations for demonstrating these technologies at an appropriate scale.

•Links to Subsequent Modules: This data informs infrastructure planning, adaptation strategies (climate resilience), and potential regulatory changes to incentivize reuse, etc.

M.1.2 Water supply/demand management

1.2.A. Infrastructure

Objective:
This tool maps and evaluates Bhutan's wastewater management infrastructure. The NIWMP needs this baseline information to identify gaps, priorities enhancements, and establish wastewater treatment and disposal strategies to maintain water quality.

Description:
This sub-module builds upon the knowledge of water sources and users established earlier in Module 1. A detailed infrastructure inventory will cover treatment plants, major sewer pipelines, septic systems (if widespread), and any decentralized wastewater systems. The age, condition, and operator of each asset will be noted. This data is mapped to visualize spatial patterns and highlight service disparities.

Checklist

Supply-Side Infrastructure

- Dams/Reservoirs: These structures play a critical role in Bhutan's water management, providing hydropower, irrigation water, and potentially flood control. Understanding their capacity, age, operating condition, and the interplay of multiple uses is crucial for assessing if supply can meet current and projected demand. Note any specific concerns impacting a reservoir's function, such as sedimentation reducing its storage capacity.
- Water Treatment Plants: Ensuring access to clean water is fundamental. This section details the location, treatment technology, and capacity of plants, highlighting their ability to match the service area's needs. It also emphasizes the importance of water quality monitoring, as treatment effectiveness is directly linked to the condition of the source water (whether a river, lake, or groundwater).
- Major Pipelines and Canals: This vital network dictates how water travels from source to users. Data on the type, length, capacity, and condition of these conveyances is essential. Note challenges such as leakage, insufficient flow in older canals, or damage-prone sections to inform maintenance and system improvements.

Demand-Side Infrastructure

- [Here you would add similar paragraphs focused on the specific challenges and data needs associated with Irrigation Infrastructure, Urban Distribution Networks, and Industrial Water Systems. Key themes include efficiency, equity of distribution, and environmental compliance.] (detailed out in tool T-17).

User Management

- This section goes beyond infrastructure itself, focusing on how water use is tracked and managed at the consumer level. Accurate metering is fundamental for demand forecasting, revenue generation for water utilities, and encouraging conservation behaviors. Additionally, pressure management (where applicable) and active leak reduction programs are essential for maximizing the efficiency of existing infrastructure and reducing water waste. (Detailed out in tool T-18).

Tools:	**Data Sources -**
T-16 Inventory of Supply side Infrastructure T-17 Inventory of Demand-side Infrastructure T-18 Inventory for User management	• DoE, MoENR/DGPC (Druk Green Power Corporation Limited): Key source for data on dams, reservoirs, hydropower. • DoID and Thromde / Dzongkhag Administrations: major treatment plants, and urban water supply infrastructure. • Dzongkhag Administrations: Contact for information on district-level water systems, boreholes, and rural water schemes. • Municipal Authorities (Thromdes): Provide data on urban water distribution networks, metering, leakage rates, and major water users. • MoICE (DoI): Major Industries: other water-intensive industries for data on their water use and on-site treatment systems. • DoA and DoID: Agriculture and Irrigation water related infrastructures. • Existing Assessments: Consult the RUB (Royal University of Bhutan), NGOs working on water projects, and relevant academic studies for any prior infrastructure assessments.

Recommendations/ Outputs

•Vulnerability Mapping: Areas with aging infrastructure, known leaks, or demand exceeding capacity can be highlighted on maps for targeted interventions.
•Prioritization: Maps highlight areas needing urgent upgrades, or those lacking any service.
•Capacity vs. Demand: Identify areas where treatment capacity is strained by population growth or industrial loads.
•Bottleneck Identification: Whether it's irrigation canals losing water, or undersized urban pipes, the tool can pinpoint where efficiencies are lost.
•Policy Links: Data supports regulations setting effluent standards, or targeting pollution hotspots.
•Links to Subsequent Modules: Feeds into pollution load analysis, infrastructure planning, and aligns with water quality goals.

1.2.B. Water use/ sectors

Objective:

To quantify and analyze water use across Bhutan's economic and social sectors. This establishes a detailed understanding of current water demands, their source reliance (surface vs. groundwater), seasonal patterns, and links to national water policy priorities.

Description:

This sub-module builds upon the knowledge of water sources and infrastructure (Sub-Modules A, B, C). It delves into sectoral water use data for urban/municipal, rural supply, irrigation, fisheries, industry, hydropower (with a focus on its non-consumptive nature), and recreation/tourism. This analysis highlights areas of high-water stress, potential conflicts between users, and where efficiencies could be gained. It directly supports policy considerations in line with country's established water use priorities.

Checklist

Urban & Municipal Water Use

- Target Urban Areas: List specific cities/towns included.
- Residential: Source Water: Surface (% volume), Groundwater (% volume); Metering: Coverage (%); Average Consumption: (Liters per capita per day, or other metric used); Seasonality: Peak months, if any.
- Commercial: Source Water: (if different from residential); Major Users: Industry types, if known; Estimated Consumption: (by business type, or metered if possible).
- Municipal: Parks: Estimated volume; Other: Cleaning, etc., estimate if not metered.
- Unaccounted-for-Water: System-wide leakage (%).

Rural Water Supply

- Dzongkhag: Specify which districts are included.
- Domestic: Piped Systems: Population served, source water; Boreholes: Number, average users/borehole; Seasonality/Scarcity: Yes/No, note specific months.
- Livestock: Animal Types: Focus on most common; Water Sources: Streams, ponds, etc.; Estimated use: Liters per animal type per day.
- Community: Schools, health centers: Note source, if separate from domestic.

Agriculture (Irrigation)

- Geographic Scope: By Dzongkhag or major watershed.
- Government Schemes: Area Irrigated (ha); Water Source: River, reservoir, groundwater; Crop Types: Categorize broadly (rice, other grains, vegetables); Irrigation Method: Flood, furrow, sprinkler, etc.
- Community-Managed Irrigation: Estimate of Area: Even if rough, this is important; Water Sources: Note reliance on small streams, rainfall capture.

Fisheries

- Aquaculture: Types: Fish species raised; Water Volume: Annual, for ponds/tanks; Source: River intake, groundwater pumping.
- Inland Fisheries: Rivers/Lakes: Major ones supporting fishing; Catch Data: If available, even estimates are useful.
- Ecosystem Needs: Protected Areas: Note any with fishing restrictions.

Industrial Water Use

- Target Industries: Based on water intensity.
- Individual Facility Data: Water Source: River intake, groundwater, municipal; Process Use: Breakdown by major steps; Consumption: Annual volume, if possible; Discharge: Volume, treatment (if any), release point; Efficiency/Recycling: Any measures in place.

Hydropower

- Power Plants: Name/ID; River; Reservoir Capacity (if applicable); Estimated Flow Rates: Based on average generation; Seasonality: Reservoir level changes.

Recreation/Tourism

- Sites: List high-use destinations.
- Water-Based Activities: Rafting, hot springs, etc.
- Seasonality Restrictions: Water level, wildlife concerns.
- Management: Permits for Operators: Yes/No; Pollution Controls: Any in place, especially fragile sites.
- **Eco-Tourism Focus: Sensitive Sites: Any with monitoring for overuse.**

Forest and Biodiversity Water Use

- **Geographic Scope: Highlight key forested areas and biodiversity hotspots reliant on specific water sources.**
- **Water Sources: Document primary sources like rivers and wetlands in protected areas.**
- **Seasonal Water Availability: Note variations affecting ecosystems.**
- **Conservation Efforts: Outline measures like reforestation to enhance water retention.**

Human Impact: Assess effects of logging, tourism, and development on water sources.
Spiritual Water Use

- **Geographic Scope: Key religious sites near water bodies across Bhutan.**
- **Water Source: Sacred springs and rivers used in rituals.**
- **Ritual Use: Water used for purification rites and ceremonial purposes.**
- **Seasonality: Increased use during religious festivals.**
- Conservation Efforts: Practices promoting water conservation linked to religious teachings.

Tools:	**Data Sources -**
T-19 Urban & Municipal Water Use T-20 Rural Water Supply T-21 Agriculture (Irrigation) Water Use T-22 Fisheries T-23 Industrial Water Use T-24 Hydropower (Note: Primarily non-consumptive use) T-25 Forest and Biodiversity Water Use T-26 Spiritual Water Use	• Dzongkhag Administrations (rural water schemes): Dzongkhags play a key role in managing water infrastructure at the district level; they'll have data on rural water supply systems (boreholes, community piped systems, etc.) and local water use patterns. • Municipal Authorities (Thromdes): Source for water use data, leakage rates, and metering coverage in urban areas; they may also track water use by major industries within town limits. • Ministry of Agriculture and Livestock (MoAL) (irrigation, livestock): Crucial for data on irrigation schemes, fisheries, area irrigated, crop types, and livestock water requirements. • Department of Forest and Park services, Department of Tourism: water-based recreation activities, fishing etc. • DoW: ecosystem needs, water quality requirements for maintaining healthy aquatic ecosystems, and any water allocations earmarked specifically for environmental needs. • Department of Culture: Therapeutic Water use (Tshachus and Menchus of Bhutan. • Ministry of Industry, Commerce and Employment (MoICE): Industries (especially large water users): Data on water use in manufacturing, processing industries, and other high-consumption sectors needs to be acquired directly from industries. • DoE: The essential source for data on hydropower generation, water flow volumes through turbines (which are primarily non-consumptive), seasonal variations in reservoir levels, and any environmental flow releases mandated downstream of dams.

Recommendations/ Outputs

- Demand hotspots: Highlight areas of concern.
- Source vulnerability: Identify reliance on overused sources.
- Leak reduction focus: Urban areas with high 'unaccounted for' water.
- Policy fit: Assess if water allocation aligns with policy priorities.
- Links to Subsequent Modules: Feeds into forecasting, infrastructure needs, pollution control. (industrial discharge), and ensuring ecosystem water needs are met.

1.2.C. Demographical study

Objective:

To establish reliable population data and forecasting methods to inform water demand across various sectors within the NIWMP.

Description:

This sub-module establishes a demographic baseline using the most recent census data. It analyzes population distribution by district, urban vs. rural trends, and household size. Importantly, it includes

growth rate analysis, both overall and with an urban/rural lens. Projections for different time horizons (short, medium, long-term) provide a framework for the Master Plan's timeframe.

Checklist

Gather Baseline Population Data:

- Acquire the most recent national population figures from the National Statistics Bureau of Bhutan.
- Obtain population breakdowns by Dzongkhag (district) for a clear understanding of geographic distribution.
- Separate urban and rural population data to identify areas with centralized water systems (urban) and those relying on boreholes or community supplies (rural).

Analyze Population Growth:

- Calculate the national decadal growth rate from census data to establish a baseline for future projections.
- Analyze decadal growth rate differences between urban and rural areas to predict potential pressure on distinct infrastructure types.

Project Future Population:

- Utilize the decadal growth rate and any known development plans to create short-term population projections (e.g., 5 years).
- Develop mid-term projections (e.g., 10-15 years) considering the lead time required for water infrastructure projects.
- Create long-term projections (e.g., 25 years) to align with the Master Plan's scope.

Account for Household Size:

- Determine the average household size from National Statistics Bureau data to estimate per capita water demand.
- Investigate trends in household size (increasing or decreasing) to anticipate future water use patterns.

Consider Migration Patterns:

- If possible, obtain net migration figures (immigration minus emigration) to understand how population shifts might impact specific regions.
- Analyze labor statistics or immigration records to identify potential localized or seasonal variations in population due to migration.

Evaluate Seasonal Population Fluctuations:

- Estimate the peak season influx of tourists or other temporary residents using data from the Department of Tourism. Factor these seasonal variations into water system planning to address potential stress during peak periods.

Tools:	**Data Sources -**
T-27 Demographic study	• National Statistics Bureau of Bhutan (NSB): The NSB serves as the central repository for demographic and socioeconomic data in Bhutan. They conduct regular censuses, household surveys, and other studies that provide essential population figures, growth trends, and insights into household composition. • Department of Tourism (MoICE): Understanding seasonal fluctuations in population is crucial for areas where tourism plays a significant role in water demand. The Department of Tourism tracks visitor numbers, peak seasons, and the popularity of specific destinations. This data can help identify areas where water infrastructure may need to accommodate temporary surges in usage. • Ministry of Industry, Commerce and Employment (MoICE): Their data on employment trends might reveal sectors with a high reliance on migrant workers, indicating localized population shifts relevant to water planning. • Local Governments (Dzongkhag/Thromde/Gewogs): One of the important data sources as they maintain latest population & household details.

Recommendations/ Outputs

- Demand Estimates: This data feeds directly into all demand forecasts.
- Infrastructure Needs: Growth areas are highlighted.
- Policy Considerations: Manage growth sustainably, ensure underserved areas are included.
- Links to Subsequent Modules: This sets the stage for water allocation, infrastructure planning, and ensuring water access across all sectors as Bhutan develops.

M.1.3 Wastewater management

1.3.A. Infrastructure

Objective:

To comprehensively map and assess Bhutan's current wastewater treatment and disposal infrastructure. This data provides a critical baseline for the NIWMP, guiding gap analysis, investment prioritization, and the development of strategies to align wastewater management with water quality protection objectives.

Description:

This sub-module focuses on both centralized and decentralized wastewater systems. Data is gathered on wastewater treatment plants (location, capacity, treatment level), sewer network extent, and outfall locations. Importantly, informal systems like septic tanks and pit latrines are estimated where data allows. This provides an overview of service levels and helps target areas lacking adequate infrastructure.

Checklist

Wastewater Treatment Plants (WWTPs):

- Gather data on location (reference map coordinates or Dzongkhag) for all WWTPs in Bhutan. This information can be obtained from municipal records or environmental agencies. Marking these locations on a map will be crucial for visualization.
- Determine the type of treatment employed at each WWTP (primary, secondary, or tertiary). This information, typically found in municipal records or design documents, influences the quality of the effluent discharged from the plant.
- Find out the designed capacity of each WWTP, typically measured in liters per day (LD) or million liters per day (MLD). Municipal records or original design documents will be helpful here. This designed capacity can then be compared to the current volume of wastewater being generated to identify potential shortfalls.
- Assess the current operational status of each WWTP (functional, non-functional, or partially functional) through reports from municipal operators or site inspections. This helps prioritize urgent repairs or upgrades.

Sewer Networks:

- If sewer network maps exist, determine the total extent of the network in kilometers. Municipal records or utility maps are good sources for this information. In the absence of maps, describe the major areas served by the sewer network.
- Conduct a visual condition assessment (where feasible) of the sewer network, categorizing its state as good, fair, or poor. Inspection reports or municipal records can provide clues, otherwise on-site inspections may be necessary. This assessment helps prioritize areas requiring repairs or complete replacement.

Identify Outfall Locations:

- Collaborate with environmental agencies or review environmental permitting data to pinpoint the locations of major wastewater discharge points from WWTPs.
- Plot these outfall locations on the same map used to display WWTPs. This facilitates a visual understanding of the entire wastewater management system.

Assess Informal Sanitation Systems:

- In areas lacking centralized sewer systems, conduct local surveys (if data is unavailable) to estimate the percentage of households relying on septic tanks. Septic tanks provide some level of wastewater treatment before discharge to the ground.
- Similarly, estimate the percentage of households using pit latrines, the most basic form of sanitation.

Tools:	**Data Sources -**
T-28 Waste water treatment plant T-29 Sewer Networks T-30 Outfalls T-31 Informal Systems	• Thromdes, DoID: Contact relevant municipal authorities within major urban centers to obtain data on wastewater treatment plants, sewer network extent, and known discharge points. • Dzongkhag Administrations: Collaborate with Dzongkhags in areas with smaller towns, semi-urban settlements, or significant rural populations to gather information on informal sanitation systems (septic tanks, pit latrines) and any localized wastewater management infrastructure. • Department of Environment & Climate Change (DECC)/ DoW: to access any wastewater discharge permits, treatment plant monitoring data, and records of water quality testing near outfall locations.

Recommendations/ Outputs

- Gaps and Hotspots: Map underserved areas, overloaded infrastructure.
- Priority Investments: Guide decisions on upgrades vs. new infrastructure.
- Environmental Links: Align treatment levels with vulnerability of receiving waters.
- Links to Subsequent Modules: Feeds into pollution load analysis, regulatory change, infrastructure expansion plans.

1.3.B. Wastewater disposal systems

Objective:

To estimate the volume and characteristics of wastewater generated by different sectors (domestic, commercial, industrial, agricultural) within Bhutan. This data is essential for designing appropriate treatment systems and pollution control strategies as part of the NIWMP.

Description:

This sub-module builds upon the knowledge of demographics, water use, and existing infrastructure established in previous sections. It involves analyzing water consumption patterns to estimate wastewater outputs, while also differentiating between domestic and non-domestic sources. The focus is on identifying the types of contaminants likely to be present in wastewater, as this dictates the level of treatment needed.

Checklist

Domestic Wastewater:

- Analyze domestic water supply records (especially from metered areas) or utilize utility estimates and surveys to estimate the daily wastewater volume generated per household or per capita. This domestic wastewater typically represents the largest single source.
- Conduct household surveys or gather data from municipal records to determine the predominant sanitation systems used (sewers, septic tanks, etc.). This information is crucial because it influences how wastewater is collected and disposed of.

Commercial Wastewater:

- Identify major commercial establishments that generate significant wastewater volumes, such as hotels, restaurants, and markets. Business licenses, tourism data, and industry surveys can be helpful in compiling this list. Once the key establishments are identified, estimate their potential wastewater generation volumes.
- Develop a system to categorize commercial establishments by their wastewater output (e.g., small, medium, or large). Industry associations or best practice guides might offer reference points for these classifications. While some estimation may be required, this categorization will provide a basic understanding of wastewater generation patterns within the commercial sector.

Industrial Wastewater:

- Consultation with Concern department and industry records to create a comprehensive list of major industrial facilities throughout Bhutan, categorized by district or city. Focus on industries known for high wastewater output.
- Gather information on the types of wastewaters produced by each industry (process water, contaminated water, etc.) Environmental permits and industry reporting can be helpful for this purpose. Understanding the types of contaminants present is essential for designing appropriate wastewater treatment systems.
- Estimate the total daily or annual wastewater volume generated by each industry type. Industry reports or environmental permits might contain this data. This information is crucial for sizing wastewater treatment plants to handle the anticipated industrial wastewater loads.

Agricultural Wastewater:

Collaborate with the Ministry of Agriculture and Livestock to understand livestock waste disposal practices in Bhutan. Categorize these practices as manure management systems, lagoon use, or direct runoff into waterways. This information helps assess the potential impact of agricultural activities on nearby water bodies.

Tools:

T- 32 Waste water disposal system

Data Sources –

Water supply/utility records (for metered areas, domestic):

- Thromdes: Municipalities managing piped water will likely track consumption to some degree. Focus on urban areas or those with centralized water systems, as metering is less common in rural settings.
- Dzongkhag Administrations: May have some bulk water use data for small piped systems they manage in rural communities.

Industry associations and self-reporting:

- DoI and DECC May have some member data relevant to waste water disposal, especially for larger operations.
- Direct Surveys: Likely needed, as self-reporting on water use may not be standard practice. Collaborating with the Ministry of Industry, Commerce and Employment (MoICE) for outreach to industries would be helpful.

Ministry of Agriculture and Livestock (for livestock, farm practices):

- Department of Livestock: Will be able to provide data on the number of animals by type and district. They may have guidance on manure reuse practices by region.
- Agriculture Extension Services: Have on-the-ground knowledge of irrigation practices, fertilizer use trends, and any water quality concerns linked to farming.

Environmental permits (especially for industry):

- Department of Environment & Climate Change/ DoW: Issues permits that may stipulate wastewater discharge limits or monitoring requirements. This is a very valuable source of qualitative information on the pollution potential of different industries.

Recommendations/ Outputs

- Targeted Treatment: Understanding wastewater composition guides technology choices.
- Hotspots: Identify areas with heavy industrial or agricultural impacts.
- Prioritize Growth Sectors: If expansion is planned, estimate that future pollution load.
- Links to Subsequent Modules: Feeds into treatment plant design, pollution regulation, and any non-point source pollution control efforts in agriculture.

M.1.4 Storm water management

1.4.A. Infrastructure

Objective:
To map and assess the capacity of Bhutan's existing stormwater management infrastructure, including both traditional engineered systems and any green infrastructure elements. This analysis identifies vulnerabilities, prioritizes upgrades, and informs resilient planning to mitigate flood risks.

Description:
This sub-module expands on the understanding of precipitation patterns and flood-prone locations identified in earlier sections of the Baseline Diagnosis. (e.g., M1.1 Climate and Rainfall). Here, we examine the mix of natural drainage systems (streams, channels) and engineered systems (ditches, culverts, pipes) used to manage stormwater runoff. The extent, materials, and overall condition of these systems are assessed. Importantly, it also includes detention/retention structures (basins, ponds) for temporary storage of stormwater, flood control structures like levees and embankments, and any existing green infrastructure elements like permeable pavements or bioswales. Overlaying this infrastructure data with maps of flood risk zones created in M1.1 will be essential to identify areas where existing infrastructure may be insufficient and prioritize upgrades.

Checklist

Drainage Network Assessment:

- Identify areas relying on natural drainage (streams, etc.) versus areas with engineered systems (ditches, pipes). Mapping is ideal, otherwise describe major areas served by each.
- Note pipe/channel materials (concrete vs. earth) as this impact's maintenance needs.
- Assess overall condition (Good/Fair/Poor) using any available inspection reports or visual surveys. This helps target priority areas for upgrades.

Detention/Retention Structures:

- Map the location of all detention basins and ponds.
- Find out their designed storage capacity (in cubic meters) from original design documents, if possible.
- Assess current condition, noting if silt build-up has reduced their effective capacity.

Flood Control Structures:

- Map the location and length of any levees, dikes, or embankments built for flood protection.
- Do the same for floodwalls, noting their location and extent.

Green Infrastructure Assessment:

- If tracked by the municipality, map areas with permeable pavements and note their size.
- Locate any green roofs or bioswales in use, even if pilot projects. These newer solutions should be included.

Tools:	**Data Sources –**
T-33 Drainage Networks T -34 Drainage Detention and Retention Structures	Municipal Records (Especially Urban Areas): • Thromdes: Contact municipal engineering departments or public works offices. These departments may hold records of stormwater drains, culverts, detention ponds, and other related infrastructure within their jurisdiction.

T-35 Drainage Flood Control Structures T -36 Drainage Green Infrastructure	• Dzongkhags (For Smaller Settlements): Dzongkhag administrations might maintain information on rural drainage systems, flood protection measures in smaller towns or villages, and traditional irrigation canals that might also play a role during heavy rain events. River Management or Flood Control Agencies: • NCHM and Department of Local Governance & Disaster Management: The department likely maintains records of major flood events, maps of flood-prone areas, and data on critical flood control structures such as embankments, levees, or upstream dams if they serve a flood mitigation purpose. • DoW for Watershed Management: data on natural channels, erosion control measures, and localized flood protection works undertaken in specific watersheds. Environmental Agencies (For Newer Green Infrastructure): • DoW, DoID and Thromde/ Dzongkhag may have records of pilot projects or planning documents that promote green infrastructure techniques for stormwater management. Check for guidelines encouraging permeable pavements, bioswales, or other nature-based solutions. • NGOs might be collaborating with Thromde/ Dzongkhag on small-scale green infrastructure initiatives. They could be a valuable resource for identifying any emerging practices in this field.
Recommendations/ Outputs • Gaps and Hotspots: Map underserved or vulnerable areas • Resilience Strategies Guide mix of engineered vs. nature-based solutions. • Data Limitations: Lack of stormwater maps is itself a key finding. • Links to Subsequent Modules: Feeds into flood modeling (M1.5), infrastructure expansion plans, and climate change adaptation plans (as rainfall patterns may change.	

1.4.B. Rainfall Analysis and Runoff calculations

Objective:
To analyze historical rainfall data in Bhutan, focusing on spatial and seasonal patterns as well as extreme events. This data is then used to estimate potential runoff volumes across different catchments, informing flood risk assessment and stormwater infrastructure design.

Description:
This sub-module leverages data and knowledge from previous sections of the Baseline Diagnosis report to create a comprehensive picture of rainfall patterns and potential runoff volumes in Bhutan. For instance, the Watershed Delineation sub-module (M1.2) established catchment areas, which are crucial for runoff calculations. Land use data, potentially gathered in the Land Use and Land Cover Change sub-module (M1.1), helps determine how much rainfall infiltrates the ground versus running off as surface water. Understanding these factors together with historical rainfall patterns (from the Meteorological Department) provides a strong foundation for estimating runoff volumes and assessing flood risks. Even with relatively basic runoff models, this analysis can inform the design of appropriate stormwater infrastructure (M1.4) and flood control measures (M1.5) across Bhutan.

Checklist

Rainfall Data Acquisition:

- Collaborate with the National Center for Hydrology and Meteorology (NCHM) to obtain rainfall data.
- Identify the locations of all rainfall gauging stations across Bhutan. Ideally, map these stations to visualize their network density.
- Determine the historical record length (number of years) available for each gauging station. Longer records allow for more robust trend analysis.

Rainfall Analysis:

- Analyze the historical rainfall data to identify spatial variations in average annual rainfall across different locations in Bhutan.
- Investigate seasonal rainfall patterns, determining the percentage of rainfall occurring during the monsoon season and the distribution throughout the year.
- If available, acquire rainfall intensity data (millimeters per hour) which is crucial for understanding storm events and potential flash flood risks.

Runoff Calculations (Preparation):

- Work with previous sub-modules (e.g., M1.2 Watershed Delineation) to obtain delineated catchment areas for different zones in Bhutan. These catchments are essential for runoff calculations.
- Gather land use/land cover data (e.g., forest, urban areas, agriculture) for each catchment. Remote sensing data or land use agencies can be helpful sources for this information. The land cover data helps determine how much rainfall infiltrates the ground versus running off as surface water.
- If soil survey data is available, classify the soil types within each catchment based on their infiltration potential. Clay-rich soils will have different runoff characteristics compared to sandy soils.

Runoff Calculations (Methods):

- Depending on available resources and expertise, choose a method to estimate potential runoff volumes from each catchment. This might involve using established runoff coefficients for different land cover types (obtained from engineering handbooks or incorporating local studies if available).

Tools:	**Data Sources –**
T-37 Rainfall Data T-38 Drainage Runoff Analysis	• The National Centre for Hydrology and Meteorology (NCHM) is your primary source. They maintain rainfall gauging stations and hold the historical records needed for analysis. • DoW / Research Institutions may have their own smaller-scale weather monitoring stations. Land Use Maps: • The National Land Commission will have land use maps, potentially derived from satellite imagery (remote sensing). Soil Surveys: • The National Soil Services Centre (NSSC) would be the main agency holding detailed soil maps and classification data.

Recommendations/ Outputs

- Infrastructure Sizing: Rainfall extremes drive stormwater design needs.
- Vulnerability Mapping: Steep slopes + high rainfall = flood risk.
- Changing Land Use: Show how this might increase runoff over time.
- Links to Subsequent Modules: Feeds into flood modeling (M1.5), stormwater infrastructure planning, and climate change adaptation plans (as rainfall patterns may shift).

1.4.C. Identification of Flood-Prone Areas

Objective:
To analyze historical flooding data, terrain characteristics, and vulnerability factors in Bhutan. This data will be used to create comprehensive flood hazard maps that inform infrastructure design, guide responsible land-use planning, and communicate risks to the public.

Description:
This sub-module builds upon previous sections of the Baseline Diagnosis. It integrates historical flood records with spatial data such as elevation maps (from M1.1), river networks (M1.2), land use patterns (M1.1), and population density. Together, this data reveals the interplay of natural and human factors contributing to flood hazards. Maps become powerful visual tools, depicting zones of low, medium, and high flood risk. These maps allow stakeholders to identify critical infrastructure at risk and help communities understand where precautionary measures are most needed.

Checklist

Historical Flood Data Collection:

- Collaborate with the Department of Local Governance & Disaster Management to acquire records of past flood events in Bhutan.
- These records should ideally include details like location, year of the event, and any existing reports or maps that depict the extent of flooding.
- Supplement official records with local knowledge from district authorities (Dzongkhags) and affected communities. Their firsthand accounts of past floods can provide valuable insights.

Terrain Analysis:

- Obtain elevation data (Digital Elevation Model or DEM) for Bhutan. Remote sensing data or topographical surveys can be helpful sources for this information. A good understanding of the basic topography is crucial for flood hazard mapping.
- Work with Hydrological agencies, such as the NCHM, to acquire river network maps. These maps should show the major and minor rivers and streams throughout Bhutan. The location of rivers is often a strong indicator of potential flood origins.
- Using GIS software, analyze the slope of the terrain in Bhutan. This can be derived from the elevation data (DEM) and categorized as gentle, moderate, or steep slopes. Steeper slopes generally contribute to faster rainwater runoff, increasing flood risk in those areas.

Vulnerability Assessment:

- Collaborate with the National Land Commission Secretariat or explore remote sensing data options to acquire land use maps for Bhutan. Ideally, these maps should categorize areas as urban, agricultural, forests, etc. Land-use patterns significantly influence flood risk, with impervious surfaces in urban areas leading to higher volumes of runoff.
- Work with district records or municipal maps to identify the location of critical infrastructure in Bhutan. This includes hospitals, schools, power plants, and other essential services. Knowing where these assets are positioned helps assess their vulnerability to flooding.
- Consult with the National Statistics Bureau of Bhutan to obtain population density maps. The maps display the population density of Bhutan in individuals per square kilometer. Areas with high population density and elevated flood risk have the potential to cause significant impact on communities during flood occurrences.

Tools:	**Data Sources –**
T-39 Historical Flood Data T-40 Terrain Analysis T-41 Vulnerability Factors	• Department of Local Governance & Disaster Management: Primary source for historical flood data (event records, reports, inundation maps). • Local authorities (Thromde / Dzongkhags) and communities: 'Informal' records of past floods. • DoID, DHS: Flood prone mapping. • NCHM: Rainfall, river flow data, river channel shapes. • DoW: Monitors smaller rivers and streams. • National Land Commission Secretariat: Land-use maps, Satellite imagery for land cover analysis, remote sensing. • National Soil Services Centre: Detailed soil maps. • National Statistics Bureau: Population density maps, household size data. • Universities/Researchers: Local studies on migration or population trends.

Recommendations/ Outputs

- Risk-Reduction Strategies: Prioritize flood protection measures for critical infrastructure, such as power plants and hospitals, to safeguard essential services during flood events.
- Spatial Planning for Resilience: Guide development away from high-risk zones and encourage flood-resilient construction practices in lower-risk areas to minimize potential damage.
- Community Preparedness Programs: Distribute flood hazard maps and utilize them for educational outreach programs to raise awareness and preparedness among communities. This can involve flood evacuation drills and stockpiling of emergency supplies in high-risk areas.

M.1.5 Water quality

1.5.A. Water quality assessment

Objective:
To compile and analyze available water quality data within Bhutan. This analysis identifies key pollutants, assesses adherence to water quality standards.

Description:
This sub-module builds upon previous elements of the Baseline Diagnosis such as the identification of major rivers, lakes, and groundwater sources (M1.2) and the mapping of water use patterns (M1.3A). The goal is to understand how water quality affects both human uses of water (drinking, irrigation) and the health of aquatic ecosystems. Historical records of water quality data, if available, allow for trend analysis. Mapping these results provides a visual overview of water quality hotspots, guiding targeted interventions.

Checklist

National Regulations and Standards:

- Identify the relevant water quality standards established by the Department of Environment & Climate Change and other related agencies in Bhutan. These standards typically establish acceptable limits for various water quality parameters based on designated water uses (drinking water, irrigation, aquatic life).

Water Quality Monitoring Programs:

- Collaborate with the DECC, Royal Centre for Disease Control (RCDC) and relevant agencies (e.g., Department of Public Health, NCHM to understand their existing water quality monitoring programs. This includes:
- The specific water bodies (rivers, lakes, groundwater wells) where water quality is currently monitored. Ideally, a map can be created to visualize the geographic coverage of these monitoring efforts.
- The frequency of water sample collection. Knowing if sampling is sporadic or follows a regular schedule (monthly, quarterly, etc.) is crucial for assessing trends.
- The laboratory methods used for water quality analysis. Consistency in these methods ensures the reliability and comparability of data over time.

Data Acquisition and Analysis:

- Work with water utilities or service providers (Thromdes, rural water supply schemes) to obtain any water quality data they maintain. Their data might focus on raw and treated water quality within their service areas, particularly for assessing suitability for drinking water.
- Reach out to universities or research institutions in Bhutan to identify any ongoing research projects that involve water quality monitoring. Their data might provide valuable insights into specific watersheds or regions, but it's important to confirm the methods used for data collection and analysis to ensure compatibility with national standards.

Data Gaps and Needs:

- Analyze the spatial coverage of existing water quality monitoring programs. Highlight areas in Bhutan where no water quality data is currently collected.
- Identify any important water quality parameters that are not being monitored in some areas. This might include specific pollutants of concern or parameters crucial for assessing the health of aquatic ecosystems.

Tools:	**Data Sources –**
T-42 Monitoring Parameters T-43 Sampling & Analysis T-44 Water Quality Standards T-45 Data Availability	• Royal Centre for Disease Control (RCDC): Key mandate of this organization is to Conduct surveillance on diseases of public health importance. Conduct outbreak investigation and response. Provide reference laboratory services for public health important diseases. Monitor food and water for public health safety. Monitor the quality of medicinal products. Test narcotic and psychotropic substances. Provide information on poison and its management. Ensure quality assurance of laboratory services. Conduct basic and applied research. Develop the capacity of health professionals in laboratory science and epidemiology. • The DoW is the primary water regulatory body in Bhutan. They are likely responsible for setting water quality standards, conducting monitoring programs (especially for priority rivers and lakes). • The DoW and NCHM could be a source for any water quality data linked to their hydrological monitoring networks. This might include basic parameters like turbidity related to sediment load in rivers. • In urban areas serviced by water treatment plants, Thromdes and DoID are likely to track raw and treated water quality. Their data might focus heavily on drinking water suitability. • Rural water supply schemes often rely on simpler water sources (springs, boreholes). Data on these might be more sporadic or focused on bacteriological contamination rather than a wider range of parameters. • RUB and NGOs may have water quality data relevant to specific regions.

Recommendations/ Outputs

- Water Quality Suitability: Categorize water bodies based on their suitability for drinking water, irrigation, aquatic life, etc., according to national standards. This highlights areas where treatment or pollution control measures are needed.
- Pollution Hotspot Mapping: Identify areas with severe pollution levels using GIS. This spatial analysis helps prioritize cleanup efforts and target interventions where they can have the most significant impact.
- Data Collection Recommendations: Highlight any gaps in current water quality monitoring efforts, including areas where data is entirely lacking or where important parameters are not being analyzed. This information is crucial for informing the design of a more comprehensive water quality monitoring program.
- Links to Subsequent Modules: This analysis feeds into pollution load analysis (M1.6), planning for water treatment infrastructure upgrades or expansion (M1.4), and any potential regulatory changes to protect water quality.

1.5.B. Water pollution

Objective:

To identify and characterize both point and non-point sources of water pollution in Bhutan. This characterization will include the types of pollutants originating from each source and the water bodies most likely affected. This information will guide the development of targeted mitigation strategies and inform regulatory interventions within the NIWMP.

Description:

This sub-module focuses on pollution sources that threaten water quality across the country. It builds upon the water quality assessments (M1.5 A) and your understanding of major water uses (M1.3A). Point sources, like factories or treatment plants, are easier to pinpoint. Conversely, non-point sources (agricultural runoff, urban stormwater) are more diffuse, requiring a broader analysis of land use patterns. Mapping suspected or known pollution sources will visualize hotspots alongside sensitive water bodies.

Prioritizing pollutants of concern (based on industry types, land-use practices) tailors the pollution control strategies within the Master Plan.

Checklist

Industrial Point Sources:

- Collaborate with the Ministry of Industry, Commerce and Employment (MoICE), particularly the Department of Industry, to acquire a list of major industries across Bhutan. Ideally, this list should include:
- Their location by Dzongkhag (district).
- Categorization by industry type (textiles, manufacturing, food processing, etc.).

Department of Cottage and Small Industry (CSI):

- While not major industries, these smaller, dispersed operations can contribute to localized pollution. Reach out to the CSI to see if they maintain records of licensed cottage industries.

Environmental Permits and Monitoring:

- Work with the MoEA's Department of Industry to obtain any environmental permits or recent inspection records for major industries. These documents often detail.
- The types of wastewaters these facilities discharge.
- The volume of wastewater discharged.
- The Department of Environment & Climate Change is the primary environmental protection agency in Bhutan. They likely maintain some water quality monitoring data. Request any historical data they have available, including Sampling locations across Bhutan; Specific water quality parameters measured; Historical results for trend analysis.

Regulations and Standards:

- The DECC is also responsible for establishing environmental regulations. Obtain copies of relevant environmental standards and regulations, particularly those related to: Wastewater discharge permits; Pollution limits for different industries.

Royal Centre for Disease Control (RCDC):

- Key mandate of this organization is to Conduct surveillance on diseases of public health importance. Conduct outbreak investigation and response. Provide reference laboratory services for public health important diseases. Monitor food and water for public health safety. Monitor the quality of medicinal products. Test narcotic and psychotropic substances. Provide information on poison and its management. Ensure quality assurance of laboratory services. Conduct basic and applied research. Develop the capacity of health professionals in laboratory science and epidemiology.

Ministry of Agriculture and Livestock (MoAL):

- Collaborate with the Department of Agriculture to understand Bhutan's agricultural practices. Request: Maps of predominant crop types cultivated in different regions; Information on fertilizer and pesticide usage patterns, ideally broken down by crop type and region.

Livestock Management:

If large-scale animal farming exists in Bhutan, inquire with the Department of Livestock about.

- Maps showing livestock density across different regions.
- Existing policies or regulations on manure management and disposal practices.

Municipal Sanitation Systems:

- Start with Thromde Offices in larger urban areas. Request: Maps of existing sewer networks and wastewater treatment plants (if applicable); Data on the quality of treated effluent discharged from these plants; Reports on areas lacking formal sanitation systems, relying on septic tanks or pit latrines.

Rural Sanitation and Waste Disposal:

Collaborate with Dzongkhag (district) and rural authorities to estimate:

- The portion of the rural population not connected to piped water systems.
- Areas with high densities of pit latrines or inadequate solid waste disposal.

Tools:	**Data Sources –**
T-46 Point Sources T-47 Non-Point Sources T-48 Specific Pollutants of Concern T-49 Observed Water Quality Impacts	• MoICE: Key Data: Industry lists (location, type), permits (wastewater discharge), enforcement actions. • DECC/DoW: Water quality data, pollution reports, environmental standards. • Possibly Relevant: Public Health (drinking water data) - RCDC, NCHM (hydrological data). • MoAL: Crop maps, fertilizer/pesticide use data, sustainable agriculture programs. Livestock density maps, manure management practices. • Thromdes: Sewer network maps, treatment plant data, informal sanitation surveys. • Dzongkhags/Rural Authorities: Rural water supply coverage, sanitation practices, solid waste disposal challenges.

Recommendations/ Outputs

- Source Control: Highlight areas needing upgrades, treatment, or stronger regulation.
- Prioritized Monitoring: Focus data collection where gaps exist.
- Ecosystem Focus: Link pollution types to the sensitivity of receiving waters (drinking supply vs. less pristine streams).
- Links to Subsequent Modules: Feeds into any regulatory reforms, infrastructure planning for pollution control, and the design of non-point source management programs.

M.1.6 Climate change adaptation

1.6.A. Disasters and their Impact

Objective:
To analyze historical disaster data in Bhutan, documenting the frequency and severity of different disaster types – particularly those with direct or indirect impacts on water resources and infrastructure. This analysis will highlight Bhutan's vulnerability to water-related disasters and inform climate change adaptation planning for the water sector.

Description:
This sub-module builds upon the knowledge established in previous sections of the Baseline Diagnosis by integrating disaster information with data on water systems. It examines floods, landslides, droughts, and other relevant hazards in the country's context. The focus is on gathering evidence of past impacts to water supply infrastructure, disruptions to essential water services, contamination of water sources, and broader economic losses stemming from water-related disasters. GIS-based overlays of vulnerable areas alongside critical water infrastructure will visually showcase where disaster risks are highest.

Checklist

Department of Local Governance & Disaster Management, National Center for Hydrology and Meteorology (NCHM):

- Collaborate with the Department of Local Governance & Disaster Management to acquire historical data on natural disasters in Bhutan. Focus on events that have impacted water resources and infrastructure, including: Floods (both pluvial and fluvial floods); Landslides; Droughts; Other relevant hazards specific to Bhutan, such as glacial lake outburst floods (GLOFs).

Disaster Impact Details:

- For each historical disaster event, obtain details from the Department of Local Governance & Disaster Management or relevant agencies on: The date and location of the event; The severity or scale of the event (e.g., flood water levels, landslide size).

Water Utility and Service Provider Records:

- Reach out to water utilities and service providers (Thromde offices, rural water supply programs) to collect data on: Damage to water treatment plants, pipelines, wells, or other infrastructure caused by past disasters; The duration of water service outages experienced by customers following disasters.

Environmental Agencies and Health Departments:

- Collaborate with environmental agencies or the Ministry of Health to acquire data on: Water quality impacts following disasters, such as contamination events caused by flooding or landslides.; Any spikes in waterborne illnesses that might be linked to water service disruptions after disasters.

Ministry of Industry, Commerce and Employment (MoICE):

- Partner with the Ministry of Industry, Commerce and Employment (MoICE), particularly the Department of Agriculture, to estimate: Economic losses in water-dependent sectors (agriculture, tourism) due to past disasters.

Vulnerability Mapping:

- Work with the Department of Local Governance & Disaster Management to utilize their existing hazard maps that depict areas prone to flooding and landslides.
- Using GIS software, overlay these hazard maps with a map showing the location of critical water infrastructure (treatment plants, major pipelines, etc.). This visual analysis will highlight areas where water infrastructure is most at risk from various disasters.

Tools: T-50 Types of Disasters T-51 Historical Impacts T-52 Vulnerability Mapping	**Data Sources –** DECC, DoW, Department of Local Governance & Disaster Management and National Center for Hydrology and Meteorology: • Master list of disaster types: They likely track the major categories affecting Bhutan (floods, landslides, GLOFs, droughts, etc.). • Historical records: This is your core data – dates, locations, and severity descriptions for each past disaster event. • Incident reports: These often detail immediate impacts, such as infrastructure damage and population displaced, giving you a starting point for the water sector impacts. • Hazard maps: If the Department of Local Governance & Disaster Management has produced any flood zone or landslide susceptibility maps, these are vital. • Rainfall data: Both historical averages and data on extreme rainfall events relevant to flooding. • Drought indices: If they track dryness or have crop failure records linked to rainfall deficits. • Weather forecasts/warnings: Understanding their system helps evaluate if water utilities get timely alerts. • Watershed-level maps: Steep slopes, erodible soils – these factors make localized flooding worse, even in a moderate rainfall event. • Land use change studies: If deforestation or development is linked to higher landslide risk, this data is very relevant. • GLOF monitoring: If certain glacial lakes are deemed unstable, this specialized threat should be highlighted. • Thromde: Their own incident logs: Likely more detailed than Department of Local Governance & Disaster Management's for water-specific damage and outage duration. • Asset maps: Knowing where the easily disrupted parts of their system lie is crucial (a single intake, etc.). • Water quality data (if collected): Especially if there's data from AFTER landslides or floods, showing a spike in pollution. • MoICE: Industrial disruption reports: Tied to floods etc., helps quantify economic impact beyond just fixing pipes. • MoAL: Crop loss data: If attributed to drought, gives scale to the water scarcity problem. • Insurance corporations and sector: May have better private-sector data on disaster losses, helps build your case for adaptation funding. • Department of Geology and Mines, Department of Local Governance and Disaster management: Information on earthquake and its impacts on water infrastructure systems.

Recommendations/ Outputs

- Resilience Investments: Prioritize areas for upgrades or protection.
- Early Warning Focus: Where damage is recurrent, improving early warning systems for water providers is key.
- Cost-Benefit of Adaptation: Quantified losses support budget requests for climate adaptation measures.
- Links to Subsequent Modules: Feeds into infrastructure design (higher flood standards), land-use planning, and emergency response plans for water utilities.

1.6.B. Future Projected Climate Changes

Objective:
To assess credible climate projections for Bhutan and translate those projections into anticipated impacts on water resources.

Description:
This sub-module focuses on potential future challenges due to a changing climate, utilizing the best available research. The emphasis is on identifying projected changes in precipitation patterns, temperatures, droughts, floods, and glacial melt (if significant in Bhutan). While some uncertainty is inherent in climate modeling, it's important to communicate potential ranges of change along different time horizons. The goal is to understand how climate change might alter hydrological cycles, with implications for water availability and disaster risk.

Checklist

Finding Credible Studies:

- Prioritize research focused specifically on Bhutan's unique geography and climate patterns. Start by contacting the NCHM, the DECC, and relevant universities like the RUB.
- Explore recent scientific publications on Bhutan-related climate modeling, with an emphasis on water resources.

Key Parameters to Analyse:

- Examine projected changes in temperature (average, maximum, minimum) across different timescales (e.g., by 2030, 2050). Look for studies that present this both seasonally and annually.
- Analyze projected changes in total precipitation, but also its distribution across the year (wet season vs. dry season) and the intensity of rainfall events (more frequent heavy downpours, etc.).
- Look for any projections on the frequency or severity of extreme weather events relevant to Bhutan, such as floods, droughts, heatwaves, or storms.

From Climate to Water Impacts:

- Collaborate with NCHM or universities with water resources expertise. Their insights are crucial for translating climate projections into specific water-related impacts.
- Assess how projected changes in temperature and precipitation patterns could affect river flows, hydropower generation potential, and water availability for irrigation and domestic use.
- If glaciers are a significant water source in any Bhutanese watersheds, work with glaciologists to understand how projected changes in glacial melt could impact downstream water systems.

Uncertainty Management:

- Identify studies that use multiple climate models. Look for a range of projections (low, medium, and high emissions scenarios), if available. This helps avoid over-reliance on a single number.
- Communicate clearly that climate projections are tools to guide planning but that some inherent uncertainty exists. This approach encourages flexible and adaptable strategies as the NIWMP is implemented.

Tools:	**Data Sources –**
T-53 Climate Projections T- 54 Water-Specific Impacts T-55 Adaptation Planning	• NCHM, DoW: Historical weather data: Rainfall, temperature, extreme events, climate projections. • Department of Environment & Climate Change: Environmental Policies & Risk Assessments: Collaborate with DECC to understand existing environmental policies and access vulnerability assessments to identify areas at risk. • Royal University of Bhutan and other research institute for relevant research on climate change and water resources. Relevant International Climate Data Portals: • World Bank Climate Change Knowledge Portal: (https://climateknowledgeportal.worldbank.org/). Provides access to global climate data and downscaled climate projections and has a country-specific data section for Bhutan. • The Intergovernmental Panel on Climate Change (IPCC) Data Distribution Centre: (https://www.ipcc-data.org/). Makes IPCC assessment reports and data available for climate change research.

Recommendations/ Outputs

- Adaptation Framework: Formulate strategies based on climate projections to strengthen water resources adaptation measures.
- Policy Updates: Revise water management policies to incorporate climate projections and ensure sustainable resource use.
- Awareness Programs: Implement educational initiatives to inform the public about climate impacts and promote conservation efforts.
- Research Investment: Support ongoing research to refine climate impact projections on water resources.
- Links to Subsequent Modules: Utilize climate data to inform planning and interventions in water resource development, conservation, and disaster management activities.

1.6.C. Existing adaptation and mitigation strategies

Objective:
To identify and evaluate Bhutan's current strategies, policies, and actions related to climate change adaptation and mitigation with a specific focus on the water sector.

Description:
This sub-module examines actions at different scales – from national plans down to localized initiatives. While mitigation (reducing greenhouse gas emissions) is essential, this module primarily addresses adaptation, or building resilience to the impacts of climate change on water resources. It reviews policies, infrastructure investments, changes in water management practices, and any community-driven solutions. The goal is to understand the existing landscape of adaptation efforts, their successes, and limitations, helping the NIWMP integrate with ongoing initiatives.

Checklist

Department of Environment & Climate Change

- Climate change policies, adaptation plans (especially water-related).
- Bhutan-specific climate studies and projections for water impacts.
- Environmental regulations related to water sources or pollution.

Relevant Ministries

- Ministry of Agriculture and Livestock: Irrigation plans, data on water use by crops, watershed management policies, and drought resilience programs.
- DoE, MoENR/ DGPC: Hydropower data, industrial water uses and regulations, water-related economic assessments.
- MoIT: Urban water infrastructure, leak reduction efforts, demand management programs.

<table>
<tr><td colspan="2">Department of Local Governance & Disaster Management
o Records of historical floods, landslides, and their impact on water systems.
o Disaster risk maps, especially highlighting water infrastructure vulnerability.
o Information on existing early warning systems, if applicable.
Municipalities and Water Utilities
o Thromdes: Maps of water/sewer networks, water quality data, vulnerability hotspots, and demand management efforts.
o Rural Water Programs: Data spread across local levels, focus on well depth, drought experiences, and piped system coverage.
NGOs/Community Organizations
o Localized knowledge on traditional water practices and perceived changes.
o Examples of successful small-scale adaptation or watershed protection projects.
o Insights on the effectiveness of existing government-led programs.</td></tr>
<tr><td>Tools:
T-56 National Level
T-57 Sectoral Strategies
T-58 Localized & Community-Led Actions</td><td>Data Sources –
• Department of Environment & Climate Change: Key Data: National Adaptation Plans (NAPs), Climate Change Policy documents, any water-specific policies or regulations, environmental impact assessment reports relevant to water projects.
• DoW: Gather data on adaptation and mitigation efforts linked to watersheds protections.
• Ministry of Agriculture and Livestock: Data on crop types, irrigation practices, drought-resistant cultivation programs, livestock water needs.
• DoE, MoENR/ DGPC: Data on hydropower (generation, planned dams), industrial water use, water-related economic assessments, any mitigation efforts tied to industry (emissions, efficiency).
• Thromde / DoID: Datasets on urban water infrastructure (coverage, leakage),
• DHS: building codes (water efficiency).
• Department of Local Government and Disaster Management: disaster-resilient construction guidance.
• Department of Local Governance & Disaster Management: Key Data: Historical disaster records (emphasis on floods, landslides impacting water infrastructure), hazard maps, early warning systems (if any), post-disaster assessments. Their focus will be on immediate response and damage, but they may have insights on where weaknesses in water systems are repeatedly exposed during disasters.
• Thromdes: Water supply systems (coverage maps), sanitation infrastructure, water quality records (if monitored), leakage data, demand management programs, localized flood/landslide vulnerability.
• Dzongkhag Administration - Rural Water Programs: Data may be less centralized, likely held at Dzongkhag level or by specific schemes. Data on well depth, piped systems, drought impacts, etc., will reflect rural challenges.
• NGOs/Community Organizations - Key Data: Highly dependent on the specific groups. Look for watershed protection groups, those working on irrigation, and anyone doing localized disaster response. They often have on-the-ground knowledge not captured in government datasets.
• NGOs offer valuable insights on traditional water practices, local water changes, and successful small-scale adaptation projects.</td></tr>
</table>

Recommendations/ Outputs

- By strategically scaling up successful existing adaptation efforts in other vulnerable areas, Bhutan can significantly improve water resilience across the country. This ensures best practices are widely adopted.
- Targeted Gap-Filling: The report recommends identifying critical gaps in adaptation efforts through vulnerability assessments. By prioritizing these areas for intervention, the NIWMP can ensure it addresses the most pressing water challenges.
- Cross-Sector Collaboration: The report calls for fostering stronger communication and collaboration among stakeholders involved in water adaptation. This collaborative approach can create a more unified and strategic national response to managing water resources in a changing climate.
- Links to Subsequent Modules: This analysis directly informs infrastructure priorities, policy changes, and capacity-building plans within the Master Plan.

M.1.7 Good Practices and Recommendations

Case Study 1

Hydrogeological Action Research for Spring Recharge& Development and Hill-top Lake Restoration in parts of Southern District, State of Sikkim, India–ACWADAM:

In the Sikkim Himalayas, a project was launched to address a growing concern: the decline of natural springs, a vital source of water for many communities. Recognizing the importance of these springs and the challenges they faced, the project adopted a comprehensive approach that married scientific expertise with community-driven action. Researchers collaborated closely with residents to meticulously map and document the springs. This involved not just pinpointing their locations but also understanding their seasonal variations in flow rate. Through this collaborative effort, they were also able to delve into the root causes of the springs' decline, such as land-use changes and deforestation. Armed with this comprehensive knowledge, the project then transitioned to its action phase. Working alongside community members, the project implemented measures to recharge the springs and protect the delicate ecosystems surrounding them. This ensured the long-term sustainability of these critical water sources.

Read more: Reviving-dying-springs-Sikkim, Climate Change Adaptation Experiments From the Sikkim Himalaya

This case study directly aligns with several key submodules within Module-1. Its focus on mapping and measuring groundwater resources provides essential data for submodule M1.1 (Water Resource Management). The community-driven mapping approach helps illuminate informal water sources and their user groups under M1.2 (Water Supply/Demand Management). Finally, the participatory nature of the project offers a valuable model for data collection and collaborative water governance as outlined in M4.1 (Understanding Water Governance).

Case Study 2

MARVI – Community-Driven Groundwater Management:

The MARVI project in India's Gujarat and Rajasthan states demonstrates the power of combining local participation with technological tools for improved groundwater management. With a focus on Hardrock aquifer regions, the project trained local "Bhujal Jaankars" (water experts) to monitor groundwater levels in numerous wells. Alongside this community-based data collection, they also monitored check dams to understand their role in enhancing groundwater recharge. To streamline data management, the MARVI project developed a user-friendly SMS system and smartphone app

(My Well) for data entry and visualization. This approach ensures data accessibility and facilitates informed decision-making.

Read more: Managing Aquifer Recharge and Groundwater Use through Village-level Intervention

The MARVI project offers valuable lessons for Bhutan's NIWMP. Its emphasis on groundwater monitoring and recharge aligns with Module 1.1 (Water Resource Management). The innovative combination of community-based data collection, sensors, and mobile apps provides models for data acquisition and processing (Module 3). The training of "Bhujal Jaankars" links to capacity building (M4.2), while the project's community engagement approach likely contributes to increased awareness of groundwater issues (M4.3).

Case Study 3

Participatory Rural Appraisal (PRA) for Water Management

PRA techniques offer a bottom-up approach to resource assessment, empowering communities traditionally excluded from decision-making. Methods like mapping, transect walks, and focus group discussions help communities generate localized data on water sources, usage patterns, access issues, and potential solutions. By directly involving community members, PRA processes build trust and ensure the data reflects actual ground conditions and challenges. This locally-sourced information is invaluable for identifying problems and designing appropriate interventions with higher chances of community support and buy-in.

Read more: A Participatory Rural Appraisal (PRA) based Assessment, Participatory Rural Appraisal (PRA) Manual

Participatory Rural Appraisal enhances the baseline diagnosis (Module 1) by adding community-sourced knowledge about informal water sources, seasonal variations, and traditional practices (M1.1), and by uncovering inequities in water access (M1.2). PRA data must be integrated into official datasets (Module 3), requiring protocols to combine qualitative and quantitative information. Importantly, PRA builds community capacity for water governance (M4.2) and fosters awareness for sustainable water use (M4.3). Skilled facilitators are crucial to ensure understanding between communities and NIWMP's technical framework.

Case Study 4

Climate Change and Urbanization: Building Resilience in the Urban Water Sector– A Case Study of Indore, India

The Indore study highlights the challenges faced by a rapidly growing Indian city struggling with insufficient and unreliable water supplies. The research emphasizes the coping mechanisms residents have adopted, including self-supply through groundwater extraction or reliance on water tankers. However, the report underscores the inequities of this system, where low-income communities are often unable to secure the water, they need. Faced with growing pressures from urbanization and a changing climate, the study focuses on to develop a resilience strategy to make Indore's water system more sustainable and adaptable.

Read more: Building Resilience in the Urban Water Sector– A Case Study of Indore, India

The Indore case study offers insights for Bhutan's NIWMP. It stresses the need for a baseline assessment (Module 1) that includes the state of water resources (M1.1) and supply-demand imbalances (M1.2). Indore's experience highlights how a critical review of existing policies is needed to ensure they support sustainable growth and equitable access to water (Module 2). Finally, the case

emphasizes the importance of public awareness campaigns (Module 4.3) to promote water conservation and a shared understanding of the challenges faced.

Case Study 5

Case Study: Tertiary Wastewater Treatment in Surat

The Surat Municipal Corporation (SMC) has built a tertiary treatment plant (TTP) to reuse treated sewage water and provide industrial grade water to Pandesara Industrial Estate [1]. This innovative project reduces reliance on freshwater sources for industrial purposes, potentially lowering the pressure on freshwater resources in the city. The treated wastewater can also reduce the environmental impact of industrial activities. The project demonstrates how wastewater treatment can contribute to a more sustainable and water-secure future for Surat.

Read more: Building Resilience in the Urban Water Sector– A Case Study of Indore, India

Surat's TTP project offers insights for Bhutan's NIWMP. It emphasizes the need to assess wastewater treatment capacity within the baseline diagnosis (Module 1). Cost-benefit analyses for advanced treatment are crucial (Module 6). Continuous monitoring of the treated wastewater is essential to ensure it meets the required standards for reuse (Module 3).

Case Study 6

SCADA for Water and Wastewater Management

SCADA (Supervisory Control and Data Acquisition) systems revolutionize water and wastewater management. At their core, SCADA systems use sensors, communication networks, and software to monitor and control various components of a water system in real-time. They can remotely operate pumps, valves, and treatment processes, collect data on water levels, pressures, and quality, and issue alerts in the case of malfunctions. This optimized control leads to increased efficiency and improved responsiveness to issues.

Read more: Improved Water & Wastewater Systems Monitoring and Automation with SCADA

SCADA systems provide numerous benefits to the NIWMP. Enhancing the foundational evaluation (Module 1) with up-to-date information regarding water resources, consumption, and system efficacy. The effective administration of substantial quantities of SCADA data necessitates the implementation of robust protocols (Module 3). It is critical to incorporate investments in SCADA into a comprehensive cost-benefit analysis, considering potential cost reductions resulting from leak detection and operational enhancements (Module 5, 6).

Case Study 7

The Kuhls of Himachal Pradesh

Kuhls are traditional gravity-fed irrigation channels found in the mountainous regions of Himachal Pradesh, India. These community-managed systems tap into streams and glaciers, distributing water equitably through a network of channels. Kuhls are a remarkable example of sustainable water management, reflecting centuries of local knowledge and cooperation.

Read more: Kuhl, Kohli of Himachal Pradesh

The Kuhl case study offers insights for Bhutan's baseline assessment (Module 1), emphasizing the value of documenting traditional water management systems. It highlights the importance of community governance and capacity building for maintaining such systems (Module 4). Reviving Kuhls likely involves adapting them to current needs while respecting their core principles, requiring ongoing monitoring and evaluation (Module 5).

G. M.2 POLICY AND REGULATION ASSESSMENT

Introduction:
Module-2 'Policy and Regulation Assessment' builds upon the comprehensive water resource assessment of Module 1: Baseline Diagnosis. It examines country's existing laws, regulations, and institutional arrangements for water governance, aiming to identify strengths, weaknesses, and opportunities for improvement. This analysis will provide a clear picture of the current policy environment surrounding water in Bhutan, informing the development of the NIWMP by strengthening its policy and regulatory framework.

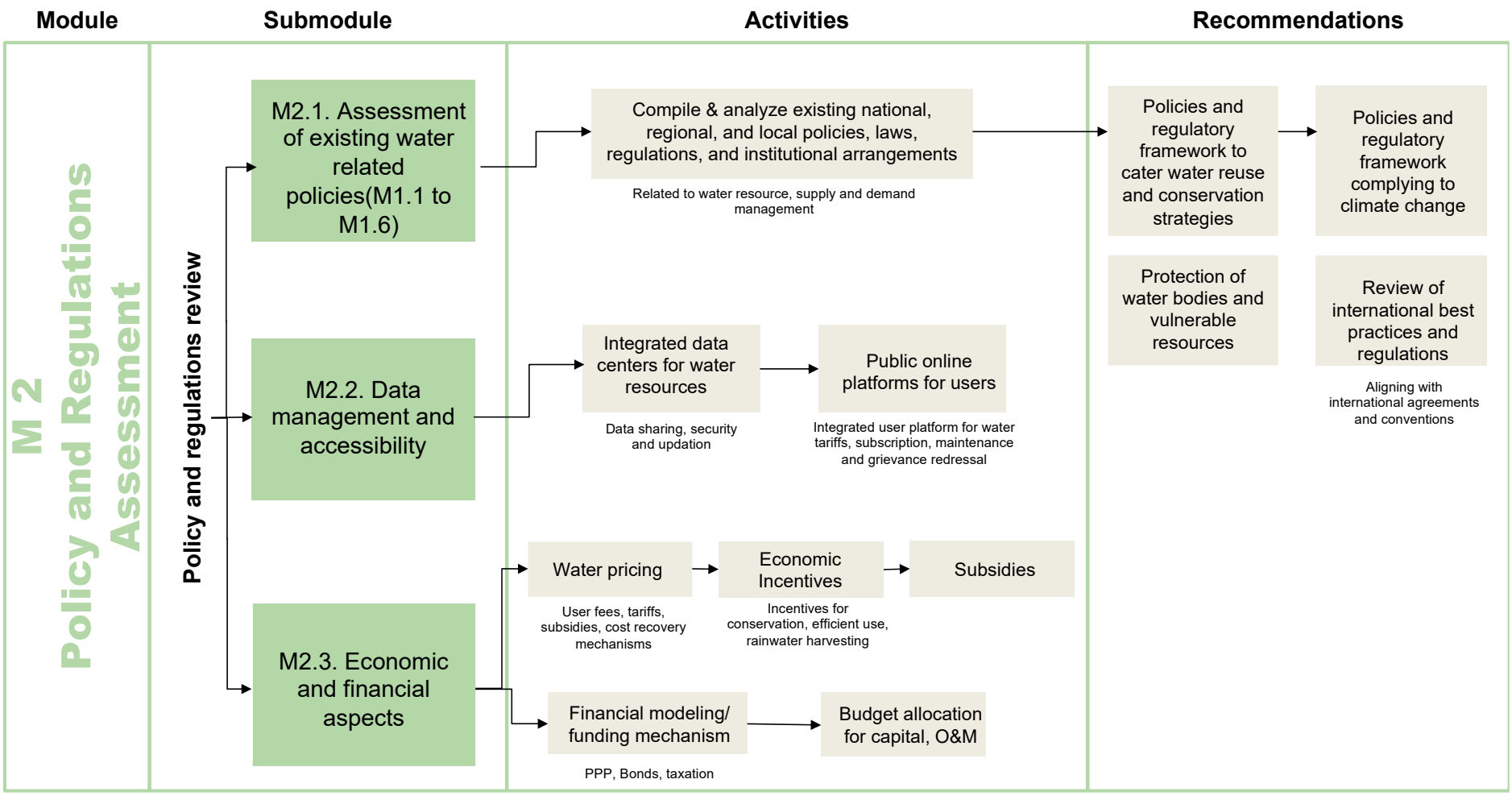
Key Areas of Focus:

- **Institutional Assessment:**
  - This module examines the roles and responsibilities of the various agencies and organizations involved in water management in Bhutan.
- **Policy Review:**
  - Existing water-related policies, laws, and regulations at all governmental levels (national, regional, and local) are compiled and analyzed.
- **Data Governance:**
  - Effective policymaking and adaptive water management rely on access to reliable data.
- **Economic and Financial Sustainability:**
  - A key facet of policy analysis is how water management is financed.

Objective:
The aim of this module is to establish a comprehensive and future-oriented policy framework that aligns with international standards for the protection of water bodies and promotes the economic sustainability of water services.

Target users
This module is crucial for policymakers and legal advisors shaping the regulatory landscape of Bhutan's water sector. It provides them with insights to support the reform of existing policies and development of new ones, ensuring alignment with the NIWMP's goals. Additionally, the module is relevant for technical experts across disciplines (water resources, environment, planner, GIS) as it demonstrates the extent to which policy facilitates the scope. The module's policy analysis will be beneficial for those financing water-related initiatives, helping them establish funding methods that align with Bhutan's sustainable water management objectives.

Flow chart: Interlinkage between sub-modules of Policy and regulation assessment.



M.2.1 Assessment of existing water related policies (M1.1 to M1.6)

2.1.A. Compilation and Analysis of Policies, Laws, and Institutional Arrangements

Objective:
To critically analyze Bhutan's current water-related policies, laws, and regulations, along with the institutional arrangements for water management. This analysis aims to reveal strengths to build upon, weaknesses to address, and potential overlaps or gaps in authority among water management institutions.

Description:
This sub-module is the foundation for aligning policy with action. Beginning with a thorough compilation of relevant policies, it assesses both their scope and effectiveness. Special attention is paid to how agencies are structured, their mandates, and their capacity to carry out those responsibilities. Further, it examines the role of water user associations to understand the balance between centralized and grassroots management. This analysis builds upon the Baseline Diagnosis (M1), offering a policy 'lens' through which to view the water resource data and challenges identified in the previous module.

Checklist

Compile Policies & Regulations:

- Create a comprehensive list of water-related policies at different levels (national, regional, local). Identify the issuing agency or ministry for each policy.
- Categorize policies by their focus area (e.g., water conservation, water quality standards, water allocation procedures, hydropower development guidelines).
- Consider including a summary of each policy's key provisions. This will aid in later analysis of strengths, weaknesses, and potential overlaps.

Analyze Institutional Landscape:

- Identify the key government agencies with mandates related to water management in Bhutan. This may include the Department of Water, Department of Environment & Climate Change, Ministry of Agriculture and Livestock, DoE - MoENR (Department of Hydropower), Ministry of Infrastructure and Transport, and Dzongkhag Administrations.
- Map the roles and responsibilities of each agency. Look for potential overlaps or gaps in authority that could create confusion or hinder effective water management.
- Assess the capacity of each agency to fulfill its water management responsibilities. This includes considering staffing levels, expertise, financial resources, and access to necessary data.
- Evaluate mechanisms for inter-agency coordination on water issues. Are there formal or informal structures in place to ensure different agencies work together effectively?

Assess Policy Effectiveness:

- Go beyond simply reviewing the content of policies. Where possible, try to assess how well they are being implemented and enforced on the ground.
- Consider factors such as:
- Are there clear mechanisms for monitoring and enforcement?
- Have there been any evaluations of the policy's effectiveness in achieving its objectives?
- Are stakeholders (including water users) aware of the policy and its implications?
- Have there been any challenges or unintended consequences associated with the policy's implementation?

Water User Associations:

- Identify the different types of Water User Associations (WUAs) that exist in Bhutan (e.g., irrigation channel WUAs, drinking water supply WUAs, watershed protection committees).
- Examine the legal status of WUAs (registered entities or informal committees).
- Assess the role of WUAs in various aspects of water management, such as water allocation, infrastructure maintenance, conflict resolution, and fee collection.

- Evaluate the effectiveness of WUAs in their roles. Consider factors like their level of autonomy, decision-making processes, financial sustainability, and capacity to represent the interests of their members.
- Identify any challenges or constraints that WUAs face in carrying out their functions.

Tools:	**Data Sources –**
T-1 Water Management Institutions and Their Roles T-2 Water related policies and regulations T-3 Water User Associations (WUAs) and Their Involvement	• Department of Water & Department of Environment & Climate Change: Policies, regulations, coordination mechanisms, water quality standards, adaptation plans. • Ministry of Agriculture and Livestock: Irrigation policies, project reports. • DoE, MoENR (Hydropower): Hydropower regulations, water use data, feasibility studies. • Ministry of Infrastructure and Transport: Local area plan, urban water plans. • Ministry of health: Water safety guidelines, public health standards. • Legal Databases/Government Websites: Access to primary legal texts. • Dzongkhag Administrations: Local plans, community-level water data, insights into implementation challenges. • Water User Associations: Bylaws, meeting records, financial data (if accessible).

Recommendations/ Outputs

- The report will reveal where existing policies are strong and can be leveraged for the NIWMP, and highlight areas where reforms, new policies, or stronger enforcement are needed.
- The analysis will highlight where better institutional coordination may be needed, or where clearer lines of authority will enhance water management.
- Community-Level Insights: Understanding the role of WUAs will shape Master Plan recommendations regarding participatory water management.
- Links to Subsequent Modules: This submodule feeds into all the later stages of the NIWMP. Having a clear picture of policy constraints and enablers is crucial when designing infrastructure, pricing models, conservation measures, etc.

M.2.2 Data management and accessibility

2.2.A. Integrated data centers for water resources

Objective:
This sub-module conducts an evaluation of Bhutan's water resource data infrastructure, encompassing the processes of data collection, storage, sharing, and security. The analysis aims to ensure that the NIWMP is informed by robust data and is aligned with existing data management policies.

Description:
This sub-module explores the presence of a centralized data system in Bhutan for water-related information. The checklist explores data types, accessibility (both within government and to the public), and protocols for updating and ensuring data quality from a policy and regulation perspective. This analysis expands on Module 1 (Baseline Diagnosis) by assessing not only the presence of data, but also its usability for developers in water master planning. In addition, it will bring attention to any significant data gaps that require attention.

Checklist

Centralized Data:
- Do centralized water data centers or platforms exist?
- Determine their scope (hydrology, quality, etc.) and governing agency.

Data Inventory:
- Map the specific types of water data collected (hydrology, quality, infrastructure).
- Note the frequency of data collection (real-time, periodic) and if historical records exist.

Data Sharing:
- Assess if formal data-sharing agreements guide inter-agency exchange.
- Note any barriers to data access (fees, approval processes).
- Identify the preferred formats for data sharing.

Security and Protection:
- Evaluate measures to prevent data loss or unauthorized access, especially for sensitive water data.

Quality and Updates:
- Examine protocols for data accuracy, equipment calibration, and quality control procedures.
- Determine the frequency of data updates and if there is real-time monitoring.

Tools:	**Data Sources –**
T-4 Integrated data centers for water resources	DoW: • Water quality monitoring data, revealing compliance with standards. • Watershed health data for land-use policies affecting water resources. • Groundwater data to inform licensing and sustainable use policies. DECC, NCHM: • Climate change data informing adaptation policies. • Insights into existing data-sharing protocols and past data integration efforts. Ministry of Agriculture and Livestock: • Irrigation data for water allocation and irrigation master plans. NCHM: • Rainfall and hydrological data for designing resilient infrastructure and setting water use rules. Ministry of Infrastructure and Transport: • Urban water infrastructure and water quality data for service standards and regulations. Ministry of Energy and Natural Resources (MoENR) (Hydropower): • Datasets informing hydropower licensing conditions, transboundary water policy Research Institutions:

	• Localized data to fill gaps in government monitoring. • Studies evaluating effectiveness of past water policies.

Recommendations/ Outputs

- The assessment determines whether Bhutan's water data is well-integrated across sectors or remains siloed within different agencies.
- Understanding whether data is openly available informs decisions about potential online platforms or data sharing agreements within the NIWMP.
- Recommendations can be made to bolster data protection measures, especially if transboundary water data will be included.
- Links to Subsequent Modules: This analysis is crucial for infrastructure planning (if data is poor, more monitoring stations may be needed), water allocation scenarios, and potentially for future modelling of climate change impacts on water resources.

2.2.B. Public online platforms for users

Objective:

To evaluate the current state of public-facing water platforms in Bhutan, identifying gaps and best practices to guide recommendations within the NIWMP on integrated, user-friendly online services for water users.

Description:

This sub-module focuses on how the public currently interacts with water service providers, utilities, or regulatory agencies online. It examines existing websites or portals for functionality, ease of use, and transparency. This analysis links back to the previous sub-module on data management, as coherent back-end data systems are often needed to support user-friendly online platforms.

Checklist

Platform Audit: Identify existing websites of utilities, municipalities, or agencies relevant to water. Assess their features.
Tariff Transparency: Specifically check if water tariffs are published online with clear explanations.
Service Management: Determine if users can manage water connections, report issues, or track grievances online.
Accessibility Focus: Check if platforms are in multiple languages, designed with disability access in mind.
Assess Integration: If multiple water-related platforms exist, determine if they are linked or work in silos.

Tools:	**Data Sources –**
T-5 Public online platforms for users	• Utility and Municipal Websites: Websites of water utilities serving urban or rural areas. • Ministry Websites: DoW, Websites of ministries managing water resources, urban development, or agriculture. • National E-Governance Portals: Central or sector-specific government e-service portals • Customer Surveys: Past surveys by utilities or agencies addressing public perceptions on water services. • NGOs: International or local NGOs with water projects, as they may have online tools for communities.

Recommendations/ Outputs

- User-Centric Design: The assessment will inform Master Plan recommendations on the design of online platforms tailored to the specific needs of Bhutanese water users.
- Transparency: Recommendations can address how online tools can improve public understanding of water tariffs, billing, and quality standards.
- Data for Utilities: The assessment can suggest ways in which online platforms could aid utilities in collecting data (leak reports, consumption patterns) to improve service delivery.
- Links to Subsequent Modules: This analysis feeds into Module 6 (Economic and Financial Aspects), especially if the NIWMP will explore online payment gateways or usage-based billing.

M.2.3 Economic and financial aspects

2.3.A. Water pricing

Objective:
To critically examine Bhutan's current water pricing policies and mechanisms. The goal is to assess their effectiveness in ensuring financial sustainability, incentivizing conservation, and addressing equity concerns within water service delivery.

Description:
This sub-module focuses on the economics of water. It reviews whether a cohesive national water pricing policy exists or if diverse regional approaches are used. It analyzes tariff structures (flat fees vs. usage-based) for different sectors (domestic, agriculture, hydropower). Importantly, this sub-module links back to the physical water resource assessment of Module 1, as a region with severe scarcity might justify higher pricing tiers.

Checklist

- Policy Framework: Review national water act & regulations for pricing policy. If no national policy, examine individual utility/Thromde pricing approaches.
- Tariff Structures: Obtain water tariff schedules from major towns or Thromdes. Analyze structure (flat rate, block tariffs, volumetric pricing) and categories (domestic, commercial, industrial, agricultural).
- Cost Recovery: Assess if tariffs recover full-service provision costs (reports from utilities or government agencies).
- Affordability Analysis: Investigate social safety nets or targeted subsidies for low-income households (reports, research).
- Conservation Incentives: Examine tariffs for inclining block rates or penalties for wastage (utility records or enforcement reports).

Tools:	**Data Sources –**
T-6. Water pricing	Water-related legislation and regulations: • Water act and regulation of Bhutan. • National water tariff guideline. • Payment for ecosystem services framework. • Bylaws of relevant water utility authorities (Thromdes, Gewogs, district) - may include specific tariff details not outlined in national policy. Water utility billing documents or published tariff schedules: • Obtain these directly from water utilities in major towns (Thimphu, Phuentsholing, etc.) or from Thromde websites if available online. • Rural Water Supply Schemes: If you have contact with NGOs or local government officials overseeing rural water schemes, request copies of their user fees or tariff structures. Government budget allocations or reports on water subsidies: • Ministry of Finance (Bhutan): Budget documents or reports that might mention allocations for water sector subsidies. • Ministry of Infrastructure and Transport, DoW: Reports or budgetary data specific to urban water supply programs, which might reveal subsidy levels. Research studies on affordability of water services in Bhutan: • National Statistics Bureau of Bhutan: Publications or reports on household income surveys or living standards assessments that touch upon water affordability, especially for low-income groups. • RUB and other research institutions: Look for these, research papers, or NGO reports focused on water access and affordability in Bhutan.

Recommendations/ Outputs

- Financial Viability: The assessment will highlight if water providers are financially self-sufficient, or chronically reliant on external funding that may be uncertain.
- Conservation Signals: Recommendations can address whether pricing reforms are necessary to encourage responsible water use and discourage waste.
- Equity and Affordability: Analysis will reveal if affordability is a barrier to service for some citizens, informing potential targeted subsidy programs or social safety net interventions within the NIWMP.
- Link to Financial Modeling: This analysis is crucial for Module 6 and M2.3.D, especially if the NIWMP explores new infrastructure investments, demand management strategies, or climate adaptation plans with cost implications.

2.3.B. Economic incentives

Objective:

To identify and evaluate the use of financial incentives in Bhutan for promoting water conservation, pollution control, and sustainable water management practices across sectors. The analysis aims to recommend improvements or can introduce new incentive mechanisms within the NIWMP.

Description:

This sub-module focuses on the intersection of financial tools and water policy. It investigates whether Bhutan relies solely on regulations, or if it also employs incentives to encourage individuals, industries, and farming communities to protect water resources. Importantly, this analysis links back to the physical resource assessment (Module 1) and water quality findings (Module 1), as incentives are often tailored to address specific environmental challenges.

Checklist

- Technological Support: Assess if subsidies, tax benefits, or other incentives exist for water-efficient technologies in irrigation, households, or industry.
- Pollution Focus: Examine if polluters are financially penalized, or if incentives exist for exceeding basic environmental standards.
- Ecosystem Protection: Determine if there are payments for ecosystem Services (PES) programs in place to compensate for watershed protection activities.
- Market-Based Tools: Examine any experimental water banking or trading programs, especially in water-stressed areas. Requires reviewing water laws and innovative pilot projects.
- Behavioral Change: Assess public campaigns focused on the economic benefits of conservation or any utility-level rewards for conservation.

Tools:	**Data Sources –**
T-7 Economic incentives	• Ministry of Finance (tax regulations, subsidy, incentive programs). • Ministry of Industry, Commerce and Employment (MoICE) (industrial policies). • DoW for environmental regulations and payment for water related ecosystem service schemes. • Water utilities or service providers (if they offer any conservation incentive programs). • Universities or research centers focused on resource economics.

Recommendations/ Outputs

- Conveys Bhutan's reliance on a mix of regulatory and economic instruments for water management, or a heavy emphasis on regulations.
- Sectoral Targeting: Identifies sectors where incentives are lacking, hindering water stewardship efforts.
- Data Gaps: Reveals where data on the effectiveness of existing incentives might be missing.
- Financial Sustainability: Informs Module 6, and Submodule M2.3.D on potential budgetary implications of introducing new incentive programs within the NIWMP.

2.3.C. Subsidies

Objective:
To analyze existing water-related subsidies in Bhutan, evaluating their rationale, effectiveness, and potential unintended consequences. The assessment will inform recommendations for targeted subsidy reforms or alternative approaches to achieve water policy objectives.

Description:
This sub-module explores the financial side of water provision in Bhutan. It examines whether the full cost of water services is recovered through user fees, or if various forms of subsidies exist that bridge the gap. The analysis explores the rationale behind these subsidies, such as improving affordability for low-income households or boosting agricultural productivity. Critically, the assessment considers the potential link between over-subsidization and water overuse, particularly in regions facing water related issues (identified in Module 1's physical resource assessment).

Checklist

- Identifying Subsidies: Map the types of subsidies (direct payments to utilities, infrastructure grants, below-cost tariffs).
- Rationale and Evidence: Investigate the original goal of each subsidy and seek evidence to show if it is achieving that goal.
- Unintended Consequences: Examine whether subsidies promote waste, distort water prices, or harm the long-term financial health of service providers.
- Equity Considerations: Assess whether subsidies fairly support those in greatest need or primarily benefit large-scale users.
- Explore Alternatives: Consider if more targeted subsidies, incentive-based schemes, or demand management strategies could achieve the same policy objectives more effectively.

Tools:	**Data Sources –**
T-8 Subsidies	• Ministry of Finance and DoW in collaboration with other departments (budget allocations for water sector subsidies, irrigation support programs). • Research institutions or NGOs with publications on water affordability and equity.

Recommendations/ Outputs

- Subsidies in Context: Reveals the extent to which Bhutan's water sector relies on subsidies, impacting pricing decisions.
- Determines where subsidies might hinder conservation efforts, or create unsustainable user expectations.
- Reform Opportunities: Proposes alternative policy tools or smarter subsidy designs linked to the Master Plan's objectives.
- Links to Subsequent Modules: This analysis directly impacts Module 6, and Submodule M2.3.D especially if exploring infrastructure or new conservation programs that require accurate cost projections.

2.3.D. Financial modelling/ funding

Objective:
To assess Bhutan's existing capacity for water-related financial modelling and its strategies for securing funding to implement infrastructure projects and management plans. This analysis aims to inform the NIWMP's financial sustainability recommendations.

Description:
This sub-module focuses on the practical "how will we pay for this?" aspect of water projects. It examines if financial projections are realistic, if diverse funding sources are being explored, and if the technical capacity exists to secure funding. The analysis links back to earlier modules, as projects identified in Module 1 need to be financially feasible. Further, the subsidy analysis (M.2.3.C) informs how much can reasonably be recovered through tariffs vs. reliance on government funding.

Checklist

- Financial Forecasting: Determine the level of sophistication in financial modelling used by water utilities, ministries, or for Master Plans. Do the models take long-term costs or climate impacts into consideration?
- Costing Accuracy: Assess if standard procedures are followed to estimate the full lifecycle costs of infrastructure, or if there's a tendency to underestimate.
- Mix of Funding: Map the current funding landscape: what is the balance between government grants, loans, community contributions, and private investment?
- Public-Private Partnerships: PPPs are an option, analyze country's policy framework towards it
- Capacity Assessment: Determine if sufficient in-house expertise exists on the financial side, or if external consultants are generally needed.

Tools:	**Data Sources –**
T-9 Financial modelling/ funding	Ministry of Finance (MoF), DoW • Budget documents & reports (national, sectoral) for water allocations, public debt, fiscal sustainability. • Public Enterprises Division (PED) for SOE financial data (if applicable). • Financial statements (annual reports) for revenue streams, operational costs, investment expenditures. • Project financial models (if available) for cost projection details. Past project reports/evaluations: • MoF and line departments completed projects (budgets, final costs, financing). • Implementing agencies (NGOs) for project reports (costs, funding sources). Donors/development banks (project funders): • Documents from international financial institutions on water projects related loans (economic/financial analyses).

Recommendations/ Outputs

- Highlights the need for more robust financial modeling to avoid underfunded projects or unrealistic tariff expectations.
- Investment Needs: Quantifies the investment gap, informing whether the financing strategy in the NIWMP is sufficient.
- Alternative Funding: The Master Plan can suggest innovative approaches to mobilize financial resources beyond traditional sources.
- Capacity Building: Recommends any needed training or institutional support to improve the financial side of water management (Module 4).
- Links to Subsequent Modules: Feeds directly into Module 6 (Financial Modeling) and guides the implementation strategy later in the Master Plan.

2.3.E. Budget allocation for Capital, Operation & Maintenance (O&M)

Objective:

To analyze Bhutan's current water-related budget allocations, examining the balance between capital investments (new infrastructure) and funding for O&M The goal is to determine if budgetary priorities align with both the real needs identified in Module 1 (Baseline Diagnosis) and with the policy goals outlined in existing water-related legislation.

Description:

This sub-module conducts a detailed examination of Bhutan's water sector budget allocations. It analyzes trends in budgetary allocations over time to assess whether water sector funding is keeping pace with the nation's water security and sustainability objectives as outlined in relevant policy documents. Furthermore, the sub-module investigates the distribution of water sector funding, determining the relative allocations between capital expenditures for new infrastructure projects and operations and

maintenance (O&M) activities for existing systems. A critical link is established to Module 1's water infrastructure condition assessment.

Checklist

- Sectoral Share: Determine the overall share of the national budget dedicated to water-related investments and programs.
- Budget Trends: Analyze budget documents over several years to identify any increases, decreases, or stagnation in water sector funding.
- Capital Vs. O&M: Examine the balance between investments in new infrastructure versus spending on operations and maintenance.
- Agency Breakdown: Map how funding is split between different ministries/agencies involved in water management (urban vs. rural supply, irrigation, hydropower, etc.).
- Policy Alignment: Compare declared policy priorities (Water Act, etc.) with real budgetary allocations.
- Budgeting Process: Assess if budget needs are determined by utilities (bottom-up) or imposed by the Ministry of Finance (top-down).

Tools:	**Data Sources –**
T-10 Budget allocation for capital, O&M	Ministry of Finance • National budget documents (annual budget reports or budget statements). • Sectoral budget allocations. • Public investment program documents (PIP) - details of capital projects. Line Ministries & Agencies: • MoIT, MoENR, Ministry of Agriculture and Livestock. • Relevant water utilities (Thromdes). Past water sector plans or investment studies.

Recommendations/ Outputs

- Funding Mismatches: Reveals gaps between policies and budget allocation.
- Need vs. Allocation: Highlights underfunded areas despite their importance in the Baseline Diagnosis (Module 1).
- O&M Neglect: Flags the risk of under-investing in maintenance, leading to future system failures and higher costs later.
- The analysis can recommend greater transparency or more participatory approaches in determining water budgets.
- Links to Subsequent Modules: This analysis directly informs Module 6, M.2.3.D, as any proposed project needs realistic cost assumptions, including long-term O&M.

M.2.4 Good Practices and Recommendations

Case Study 8

Redeveloping Institutional Framework and Policy Making for Water, Myanmar

Faced with growing water demands from industrialization and agriculture, Myanmar has recognized the need for institutional and policy reform. The country has developed a new framework based on four pillars: standards and compliance, data-informed decision-making, water services and products, and education and training. Extensive capacity-building programs support the implementation of new policies. Crucially, this effort emphasizes a people-centered approach by creating decision support systems that foster civil society engagement, potentially supported by World Bank initiatives. It also envisions NGOs playing a "watchdog" role in monitoring and enforcing water regulations. The overarching aim is to achieve sustainable water use aligned with broader national development goals.

Read more: Development of institutional frameworks for the management of transboundary water resources.

Myanmar's water governance reforms offer key insights for Bhutan's NIWMP. Their focus on establishing water standards, compliance systems, and policy development aligns directly with Module 2. The emphasis on data-driven decision-making supports data collection and analysis initiatives outlined in Module 3. Myanmar's prioritization of capacity building mirrors Module 4.2, while its participatory approach involving civil society and NGOs exemplifies Module 4.1's focus on inclusive water governance. Additionally, the case study highlights potential links to technological tools for data-driven management (M3) and the long-term goal of sustainable resource use which ties back to the baseline assessment in Module 1.

Case Study 9

Murray-Darling Basin Plan: A Case Study in Integrated Water Resource Management

Australia's Murray-Darling Basin Plan (MDBP) offers a valuable example of how to integrate multiple policies and regulations for comprehensive water resource management. This is particularly relevant for Bhutan, considering its diverse water needs.

The MDBP focuses on restoring the health of the Murray-Darling Basin, a critical resource for agriculture, industry, and the environment. It achieves this through a multi-pronged approach:

- Limiting water extraction: The plan sets limits on the amount of water that can be withdrawn from the basin, ensuring a sustainable balance.
- Environmental water recovery: Allocated water entitlements are being strategically purchased or recovered to restore environmental flows in the basin.
- Improving water management efficiency: The plan also includes measures to improve irrigation practices and reduce water losses throughout the system.

Effective implementation of the MDBP necessitates collaboration between various stakeholders. This includes government agencies, water users, and indigenous communities. The plan acknowledges the potential social and economic impacts of water recovery efforts, highlighting the need for mitigation strategies.

Read more: Murray-darling basin plan, Murray–Darling Basin policy

The case study underscores the importance of a policy assessment for NIWMP. It highlights the need to identify any conflicting or fragmented water policies that could hinder integrated management (M2.1). The plan's success depends on comprehensive data regarding water availability., usage, and environmental needs (M2.2). Additionally, Bhutan must consider the economic impacts of water management decisions, potentially including compensation mechanisms or exploring innovative financing structures for plan implementation (M2.3).

Case Study 10

The Wastewater Reuse Policies in Gujarat, India

In response to Gujarat's water conservation efforts and climate sensitive approach, the state has prioritized the reuse of treated effluent whenever possible. The state has a dedicated Wastewater Reuse Policy, promoting its safe utilization for non-potable purposes in various sectors like agriculture, industries, and urban landscaping. This policy likely includes guidelines and standards for water quality to ensure health and environmental safeguards. Gujarat's approach recognizes treated wastewater as a valuable resource rather than solely waste, helping reduce pressure on freshwater supplies.

Read more: Reuse of Treated Water: Lessons from Gujarat, Gujarat State Waste Water Recycling Policy

Gujarat's wastewater reuse policies offer valuable Considerable insights for NIWMP, particularly within the framework of Module 2. A comprehensive assessment of existing water policies is essential under M2.1 to identify areas where they may not fully recognize treated wastewater as a valuable resource. Effective policy implementation hinges on robust data on wastewater treatment capacity, quality, and potential reuse applications, as highlighted in M2.2. Incorporating economic incentives or financing mechanisms within the policy framework can further promote the adoption of reuse technologies by offsetting upfront costs (M2.3).

Case Study 11

Mumbai Climate Action Plan (MCAP)

Mumbai, India, has taken a proactive approach toward climate change mitigation and adaptation through its MCAP launched in 2022. The plan outlines actions across six key sectors: sustainable mobility, energy and buildings, **urban flooding, waste management, urban greening,** and air quality. Recognizing the geographical vulnerability of the city, the MCAP prioritizes resilience-building alongside efforts to reduce carbon emissions. It is a comprehensive and integrated strategy addressing the interconnected challenges posed by climate change.

Read more: Mumbai Climate Action Plan, A Plan To Fight Climate Change: MCAP

The case study underscores importance of policy integration in Bhutan's NIWMP. Developing the MCAP likely involved evaluating existing policies across sectors for alignment with climate objectives (M2.1). Moreover, its implementation hinges on reliable data related to emissions, infrastructure, and vulnerability, mirroring the NIWMP's data needs (M2.2). Finally, the MCAP may require regulatory changes or planning updates to facilitate climate-resilient infrastructure, offering relevant insights for Bhutan (M2.4).

Case Study 12

Ladakh's 24 x 7 Water Supply Initiative

Ladakh, with its unique terrain and climatic conditions, faces water scarcity and often intermittent supply. The administration has launched an ambitious plan to provide 24 x 7 water access in Leh and Kargil. This likely involves improving existing infrastructure, potentially harnessing new water sources, installing smart meters, and constructing storm water drainage systems for flood resilience. This project aims at ensuring reliable water access across domestic, commercial, and agricultural sectors.

Read more: 24×7 water supply and Storm Water Drainage in Leh and Kargil towns

Ladakh's water supply project highlights key aspects of Bhutan's NIWMP. It reinforces the need for a comprehensive baseline assessment (Module 1) to understand water resources, infrastructure, and demand patterns. Policy frameworks must support the project's financial viability, including sustainable funding and tariff mechanisms (Module 2). Thorough cost-benefit analyses are crucial to justify the investments (Module 6).

H. M.3 DATA MANAGEMENT

Introduction:

Data management plays a crucial part in the development of NIWMP. It creates a standardized framework for collecting, processing, and governing water-related data. This extensive dataset serves as the foundation of the NIWMP, enabling the baseline evaluations (Module 1) and driving policy development (Module 2). By providing the smooth integration of data throughout all phases of the NIWMP, this module also helps capacity building, monitoring and evaluation, and financial planning within following modules. In this way, meticulous data management supports the decision-making process at every level of water resource management, subsequently reflecting the 'One Nation One Water' concept.

Key Areas of Focus:

The module includes the following components:

- **Data Acquisition:**
  - This section focuses on the systematic collection of hydrometeorological and hydrological data, along with the maintenance of comprehensive asset inventories.

- **Data Processing and Integration:**
  - It emphasizes the importance of data integrity, ensuring that all gathered data meets quality standards, is properly integrated using GIS technology, and is effectively visualized for analysis.

- **Data Governance and Accessibility:**
  - The module aims to set up a secure infrastructure for data storage and advocates for open data policies to ensure transparency and ease of access, facilitating the wide application of data in water management practices across the nation.

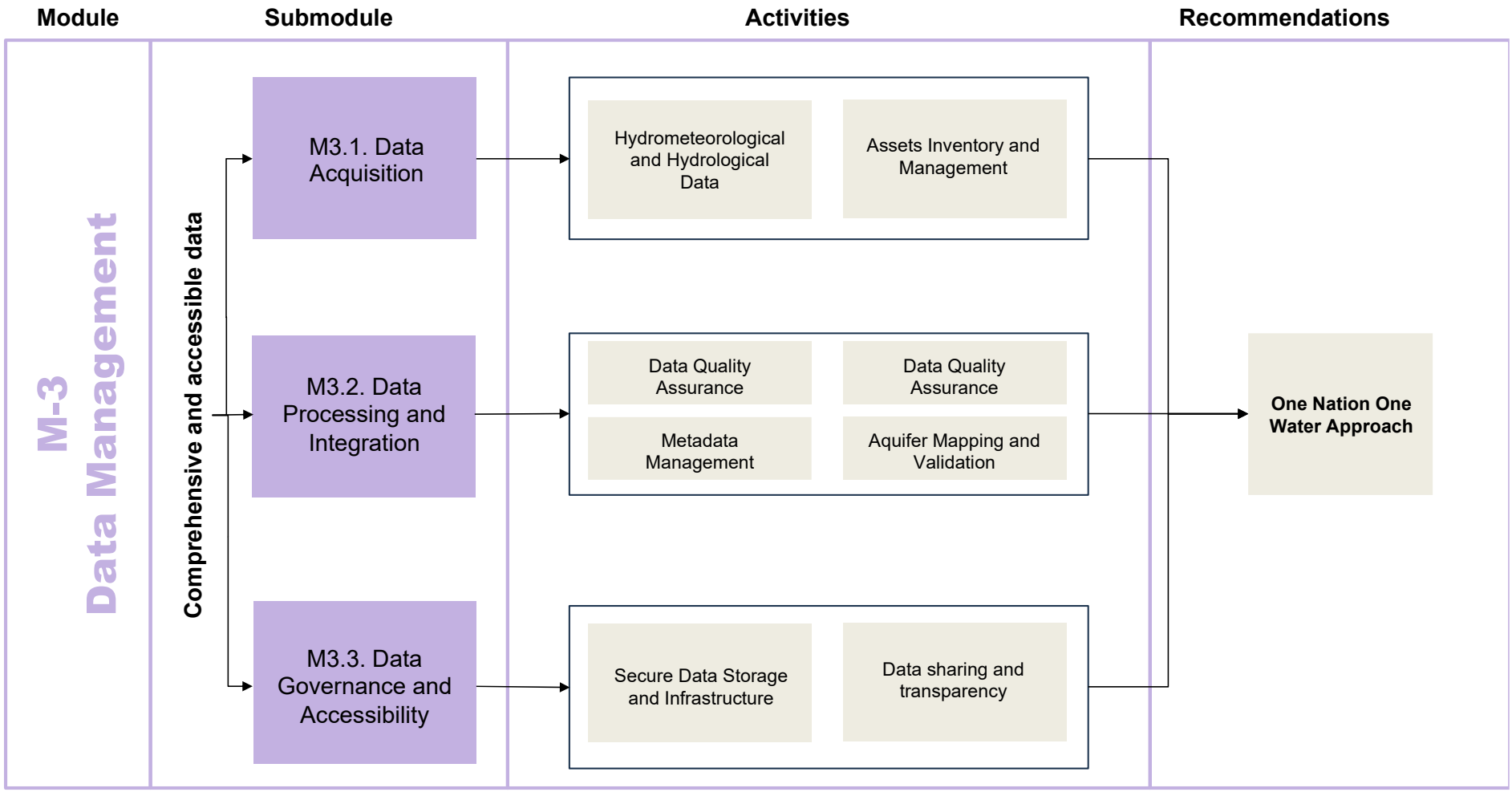
Objective

The objective of Module 3 is to establish a comprehensive and integrated data management system that enhances the accuracy and accessibility of water-related data. It aims to create an effective governance structure that ensures data integrity and supports strategic planning and operational decision-making.

Target Users

The users of this module span a wide spectrum, including departmental heads and officials within the Department of Water, Bhutan, who oversee water governance. Technical experts, such as hydrologists and GIS specialists, depend on this data for detailed resource mapping and analysis, while planners and economists apply it to strategic planning and economic assessments. Capacity builders and communication experts also rely on the insights derived from this data to engage with communities effectively and drive behavioral change, while financial analysts use it to align water resource management with Bhutan's economic development goals.

Flow chart representing Interlinkage between sub-modules of Data Management module:



M.3.1 Data acquisition

3.1.A. Hydrometeorological and hydrological data

Objective:
To comprehensively assess Bhutan's hydrometeorological and hydrological data collection systems, identifying strengths, weaknesses, and areas for improvement. This analysis is crucial to ensure the NIWMP is built upon a foundation of robust and reliable data to inform effective water management decisions.

Description:
This sub-module examines the backbone of water resource planning, advising the NIWMP on Bhutan's network of weather stations, river gauges, and any water quality monitoring sites. It assesses their adequacy to support the Baseline Diagnosis (M1) by revealing spatial gaps or limitations on the types of data collected. The analysis delves into equipment reliability, data transmission, storage, quality control, and accessibility. Close collaboration is necessary with stakeholders involved in Modules 1.1 (Water Resource Management) and 1.5 (Water Quality).

Checklist

Network Assessment:
- Map the locations of weather stations, river gauging stations, and any groundwater monitoring wells.
- Analyze the density of the network across different regions of Bhutan, considering factors like elevation gradients that can impact precipitation patterns.
- Assess if the network provides sufficient coverage in critical basins important for hydropower generation, irrigation withdrawals, or flood risk management (consider findings from Module 1.1 on Water Resource Management).

Data Types:
- Examine what data is being collected at each monitoring station type (e.g., rainfall stations collect precipitation amounts, while river gauges measure water levels and flow rates).
- Evaluate if the types of data collected align with the needs identified in Module 1. For example, does the data include parameters necessary for flood forecasting (rainfall intensity, river levels), irrigation planning (seasonal precipitation patterns, potential evapotranspiration), or drought assessments (precipitation deficits, soil moisture levels)
- Data on drinking water or domestic use, water balance information, data on wetlands, glaciers, irrigation etc.

Equipment & Tech:
- Map the types of equipment used at the monitoring stations (manual readings vs. automated telemetry systems).
- Assess the age and condition of the equipment to identify any potential maintenance or replacement needs.
- Determine if spare parts and calibration services are readily available to ensure the ongoing accuracy of the data collection systems.

Data Flow:
- Analyze how data is transmitted from the field stations to a central database. This may involve manual recording of data sheets, transmission via satellite, or real-time telemetry systems.
- Assess the security measures in place to protect the data during transmission.
- Verify that there are well-established backup procedures to prevent data loss in case of technical failures.

Quality Control:
- Determine if the NCHM or other responsible agencies have standard protocols in place for checking the quality of the collected data.
- This should include procedures for flagging errors, outliers, and data gaps.

- Investigate if there are established processes to investigate and correct any data quality issues that are identified.

Data Access:

- Review existing policies or guidelines regarding who can access hydrometeorological data in Bhutan.
  Consider if there are any barriers that limit data access, such as fees associated with obtaining data or a lack of user-friendly online data portals.

Tools:	**Data Sources –**
T-1 Assessment of Hydro-Meteorological Data Infrastructure and Management in Bhutan	NCHM: • Operates weather stations throughout Bhutan. • Collects data on precipitation, temperature, humidity, wind speed, etc. • Maintains stream gauges that monitor river water levels and flow rates. • May operate water quality monitoring stations on rivers, lakes, or glacial meltwater sources. • Focuses on parameters like pollution levels or sediment loads. • May collect data on rainfall and flood events within urban drainage networks. • Stream gauging in rivers relevant to flood risk management. Ministry of Agriculture and Livestock (MoAL): • Department of Agriculture Services: May collect data on irrigation water use or agricultural drought conditions. • Department of Forests and Park Services: May manage some stream gauging stations or monitor snowpack in critical watersheds. Other Potential Sources • Research institutions or universities: RUB, Bhutanese academic institutions may conduct localized hydrometeorological or water quality monitoring projects that can provide valuable supplemental data. Examples include the College of Natural Resources under the Royal University of Bhutan. • ICIMOD/global database.

Recommendations/ Outputs

- Coverage Gaps: Highlight areas where more monitoring is needed to support findings from Module 1, specifically M1.1 (Water Resource Management) and 1.5 (Water Quality).
- Tech Upgrades: The analysis may guide the NIWMP on modernizing equipment or improving transmission reliability for real-time water management.
- Data Quality Focus: May reveal a need for stronger quality control, staff training, or investment in data analysis tools – any deficiencies here will impact M1.
- Accessibility and Sharing: The analysis informs potential policies for open data access or data-sharing agreements to maximize the benefits of hydromet information for other actors (water utilities, researchers). These issues are also closely tied to M2.2 (Data Management and Accessibility).
- Link to Subsequent Modules: This sub-module is the foundation for later modeling work in Module 4 (Water resources Assessment) and Module 5 (Water Allocation). It will also contribute to climate vulnerability assessments in M1.6 (Climate Change Adaptation) by evaluating historical climate data.

3.1.B. Asset inventory and management

Objective:

To create a comprehensive and accurate picture of Bhutan's water infrastructure. This knowledge enables informed decision-making about maintenance, upgrades, and future water system expansion.

Description:
This submodule focuses on understanding the types, locations, and conditions of Bhutan's existing water infrastructure assets. It outlines the creation of a database (if it doesn't exist) to store asset information, as well as regular assessment and updating procedures. The submodule helps identify data gaps, potential system bottlenecks, and areas where asset information informs planning.

Checklist

Scope
- Asset Types: Define all water infrastructure assets to be included.
- Categorization: Create a clear asset hierarchy (by type, location, etc.).

Database
- Existing System: Assess if a database exists, and its capabilities.
- New Database: If needed, outline key requirements for the system.

Data Collection
- Forms/Surveys: Create standardized templates for field data collection.
- Historical Records: Locate and utilize relevant construction records.

Updates
- Frequency: Determine how often the inventory should be updated.
- Procedures: Set processes for adding new assets, repairs, and decommissioning.

Condition Assessments
- Schedule: Establish a regular assessment schedule for all assets.
- Methods: Use or develop standardized condition assessment protocols.
- Integration: Ensure assessments are linked to asset records in the database.

Data Usage
- Maintenance: Use the inventory to drive proactive maintenance planning.
- Investment: Guide capital budgeting and infrastructure decisions.

Tools:

T-2 Evaluation Framework for Water Infrastructure Asset Management in Bhutan

Data Sources –

- Water utilities or DoIT officials: Dzongkhag and Thromde.
- Relevant government ministries: Ministry of Agriculture and Livestock (MoAL), Ministry of Infrastructure and Transport, Department of Local Governance & Disaster Management.
- Infrastructure plans and project documents: Bhutan Water Policy (2007), Rural Water Supply Schemes (RWSS) plans, Hydropower project documents.
- Historical engineering records (if available): Ministry of Infrastructure and Transport archives, project completion reports from relevant agencies.
- Ministry of Health can be added for quality control aspects.

Recommendations/ Outputs

- Create or improve database systems for water asset information.
- Develop standardized procedures for data collection, condition assessments, and regular updates.
- Use inventory data for decision-making related to infrastructure investment, maintenance planning, and identifying future needs.
- Integrate asset data and insights with risk analysis (Module: M2), vulnerability assessments (Module: M2), and future water demand projections (Module: M1) for comprehensive planning.

M.3.2 Data Processing and Integration

3.2.A. Data quality assurance

Objective:
To assess Bhutan's existing practices for ensuring the accuracy, reliability, and suitability of water-related data. This analysis will highlight areas for strengthening data quality to strengthen decision-making processes.

Description:
his submodule delves into Bhutan's approach to quality control (QC) across the data lifecycle: collection, transmission, and storage. It examines data error checking mechanisms, correction procedures, validation methods, and staff capacity for quality assurance. The submodule links back to previous sections on data inventory (M3.1) as reliable data is a prerequisite for an effective inventory.

Checklist

- QC Protocols: Determine the existence of documented QC procedures for different data types. Check if they align with international or respected agency standards.
- Error Checking: Identify methods for detecting outliers, inconsistencies, and missing data.
- Correction Procedures: Investigate processes for handling errors, including flagging, correcting, or documenting limitations.
- Data Validation: Assess the frequency and methods for cross-checking the plausibility of data (e.g., rainfall vs. river flow).
- Training and Capacity: Evaluate whether data-handling personnel receive formal QC training.

Tools:	**Data Sources –**
T-3 Quality Control Tools and Procedures for Hydro-Meteorological Data Management in Bhutan	• NCHM or other relevant agencies. • Water-related research institutions. • International guidelines from the World Meteorological Organization (WMO), World Health Organization (WHO), or others (depending on data type).

Recommendations/ Outputs

- Confidence Level: Indicate the degree of trust Bhutan can place in its data for decision-making.
- Areas for Improvement: Pinpoint specific needs, such as protocol development, technology upgrades, or skill-building.
- Usability of Data: Discuss the integration of quality checks throughout the data management process.
- Emphasize that data quality assurance, as assessed in this submodule and M3.1 (Data Inventory and Management), provides a critical foundation for developing sound recommendations within the NIWMP. Reliable data is essential for accurate modelling, risk evaluation, and strategic planning across all these aspects of water management.

3.2.B. GIS integration and Visualization

Objective:
To evaluate Bhutan's current utilization of Geographic Information Systems (GIS) for water resource management, identify opportunities for improvement, and propose recommendations that can be integrated into the National Integrated Water Management Plan (NIWMP).

Description: This submodule evaluates how well Bhutan integrates water-related data into GIS platforms, the range of spatial analyses conducted, and the use of maps for decision-making and

communication. It builds upon prior sections on data inventory (M3.1) and quality assurance (M3.2), as reliable spatial data is fundamental for effective GIS applications.

Checklist

- Current GIS and remote sensing usage: Determine which agencies (e.g., Gov-Tech, National Land Commission, NCHM, water utilities) utilize GIS and if its use is widespread or project-specific.
- Data Integration: Assess the ease of integrating different data layers (e.g., rainfall maps, infrastructure locations, land use, watershed boundaries) into a GIS. Verify whether datasets are available in compatible formats.
- Analysis Capabilities: Identify the types of spatial analyses performed (e.g., flood risk mapping, water demand projections, site suitability analysis for infrastructure).
- Visualization: Evaluate whether maps and data portals effectively communicate water resource information to decision-makers and the public.
- Software and Skills: Determine the GIS software in use and assess the availability of GIS expertise within relevant agencies. (link to module.4)

Tools:	**Data Sources –**
T-4 Assessment Tool for GIS Application in Water Resources Management in Bhutan	Relevant Bhutanese Agencies: • NCHM - Streamflow data, meteorological data, snow cover maps. • Department of Geology and Mines (DGM) - Geological maps, landslide susceptibility maps. • NLCS - Land use maps, digital elevation models (DEMs). • DoFPS - Protected area boundaries, forest cover maps. • MoIT - Water infrastructure locations, water quality data (if available). • Dzongkhag and Thromde - Local water supply data (if available). • DECC - Environmental vulnerability assessments. • Addition of Local Government and Disaster Management department – understanding about GIS data, Local water supply and wastewater data. Project Reports: Reports from relevant agencies or academic institutions that include GIS components, such as: • Watershed management plans. • Hydropower project feasibility studies or Detailed project report (DPR). • Flood risk assessments. • Water supply network expansion plans. Bhutanese GIS Specialists: Interviews with personnel involved in GIS work within the agencies listed above. IT Procurement Records and Training Programs: Review records maintained by relevant agencies to determine the GIS software licenses currently in use and identify any recent staff training programs related to GIS or spatial data analysis.

Recommendations/ Outputs

- Identify Areas of Strength and Weakness: Highlight where GIS is adding value and where potential improvements lie.
- Data Harmonization: Address challenges with incompatible data formats to enhance integration.
- Capacity Building: Recommend investments in GIS software, data collection, and staff training as needed.
- Linking to Other Modules: Emphasize how GIS can support water demand assessment (M1.2), risk modeling (M1.6), decision-making (M5).

3.2.C. Metadata Management

Objective:

To assess Bhutan's practices in documenting metadata for its water data. Metadata provides essential information about how data was collected, processed, and what its limitations are. This ensures the

data can be understood and used effectively, even by people who were not involved in its original collection and by users in the future.

Description:

This submodule delves into Bhutan's approach to metadata, including the use of established standards, the types of metadata collected, how it's stored, and whether it's integrated into decision-making processes. Metadata management is closely linked with data inventory (M3.1) and data quality assurance (M3.2), as consistent and reliable metadata enhances data reliability.

Checklist

- Metadata Standards: Determine if Bhutan adheres to any national or international metadata standards (e.g., ISO 19115 for geospatial), or if agencies have their own internal guidelines.
- Metadata Content: Examine the typical scope of metadata collected: data source, collection methodology, units, accuracy/limitations, responsible parties, and usage restrictions.
- Metadata Storage: Identify how metadata is stored – with the dataset itself, in a separate catalog, or within a searchable metadata database.
- Workflow Integration: Assess whether metadata creation is a core part of the data collection and processing workflow, or if it's managed separately.
- Metadata Usage: Determine whether decision-makers, researchers, and other data users actively consult metadata before utilizing a dataset.

Tools:	**Data Sources –**
T-5 Metadata Management Evaluation Tool for Bhutan's Geospatial and Environmental	National Data Policies and Guidelines: Review any existing national policies on data management or open data initiatives that might address metadata standards and practices. Relevant agencies: • GovTech - for any national data policies or centralized data infrastructure. • Other agencies identified in previous modules as actively managing water-related data (e.g., NCHM, DGM). Data Portals (if existing): Examine any existing online data portals to check if metadata is made accessible and discoverable. Sample Datasets: Review representative datasets to evaluate metadata availability and comprehensiveness. Interviews: Interview data managers and analysts within relevant agencies to understand their metadata creation and management practices.

Recommendations/ Outputs

- Data Transparency: Evaluate the extent to which a lack of metadata might hinder data sharing and collaboration.
- Long-term Value: Assess whether Bhutanese datasets are at risk of losing usability due to inadequate documentation.
- Master Plan Inputs: The NIWMP may recommend adopting a metadata standard, developing metadata management tools, and integrating metadata practices into training for data-related staff. Effective metadata management will enhance the reliability and decision-support potential of data used in across all modules of the NIWMP.

3.2.D. Aquifer Mapping and Validation

Objective:
To assess Bhutan's understanding of its groundwater resources, including the availability and quality of aquifer data. This knowledge is essential for sustainable groundwater management decisions.

Description:
This submodule focuses on systematic efforts to map Bhutan's aquifers, the types of data used, and the process of validating existing aquifer knowledge. It links back to previous sections on data inventory (M3.1), emphasizing the need for specialized inventories focused on groundwater resources.

Checklist

- Mapping: Investigate past and ongoing aquifer mapping initiatives in Bhutan. Determine their scale (national, regional, or local) and the data sources they employ (geological surveys, borehole data, or a combination of both).
- Mapped Aquifer Characteristics: Examine the specific aquifer parameters included in the maps, such as depth to groundwater, aquifer extent and boundaries, water quality, recharge rates, and potential yields.
- Data Sources for Mapping: Identify the various types of data used to create aquifer maps. This may include well drilling logs, pumping tests, geophysical surveys, and existing well data. Assess how data quality is controlled and ensured.
- Validation Methods: Determine if aquifer maps are validated through ground-truthing practices, such as installing new monitoring wells. Explore if a process exists to update the maps as new information becomes available.
- Applications of Aquifer Maps: Assess how aquifer maps are utilized in water management practices. Examples include using them to guide well permitting decisions, protecting recharge zones, or informing the development of groundwater models.

Tools:	**Data Sources –**
T-6 Aquifer Mapping and Assessment Tool for Groundwater Management in Bhutan	Relevant Agencies • Department of Geology and Mines (DGM) - Geological maps, borehole data. • NCHM - Groundwater level monitoring data. • Dzongkhag and Thromde - Data on water supply wells (location, yield, water quality). Academic Studies: Hydrogeology research carried out by Bhutanese universities or in collaboration with international researchers. Project Reports: Reports on groundwater development or exploration projects, possibly funded by international agencies. Regulations and Policy Documents: Groundwater-related regulations, water master plans, and well drilling guidelines. Interviews: Engage with hydrogeologists and water managers in the relevant agencies to gain insight into available data, mapping practices, and aquifer data applications.

Recommendations/ Outputs

- Groundwater Knowledge: Evaluate the level of understanding and certainty about Bhutan's aquifer systems.
- Data-Driven Management: Assess whether groundwater management is primarily reactive (addressing immediate problems) or proactive (informed by aquifer data).
- Data Gaps: Identify areas needing further investigation, mapping, or monitoring.
- Master Plan Inputs: The NIWMP may recommend investing in aquifer mapping, establishing groundwater monitoring networks, and integrating groundwater knowledge into water demand projections, delineation (M1) and long-term water management strategies (M4, M6).

M.3.3 Data governance and accessibility

3.3. A. Secure data storage and infrastructure

Objective:
To evaluate the effectiveness of Bhutan's water data storage infrastructure, focusing on its ability to withstand technical failures, and other disruptions, while ensuring the security and confidentiality of the data.

Description:
This submodule delves into technical safeguards, disaster recovery plans, and access control measures that protect the nation's water data. It links back to previous sections on data inventory (M3.1) and data quality (M3.2), emphasizing that data security is essential for preserving the results of previous efforts.

Checklist

- Storage Locations: Identify where primary water data and backups are stored (agency servers, cloud services, physical media). Assess if there's geographic redundancy (ideally, backups should be in a different location than the main data).
- Physical Security: For on-site servers, evaluate access controls to the server room and measures for protection against environmental hazards (fire, water, seismic events).
- Cybersecurity: Determine cybersecurity measures: firewalls, antivirus software, intrusion detection, and the use of encryption for data both in storage and during transmission.
- Backup Procedures: Investigate backup frequency, backup locations, and whether backup restoration tests are carried out regularly.
- Disaster Recovery Plan: Examine if a specific and tested disaster recovery plan exists for critical water data and the associated software needed to work with that data.
- Access Controls: Review user permissions for accessing, modifying, and deleting data. Determine if data access logs are maintained for security and accountability purposes.

Tools:	**Data Sources –**
T-7 Water Data Security and Management Assessment Tool for Bhutan	Relevant Bhutanese Agencies: • GovTech - May hold overall infrastructure and cybersecurity policies. • Agencies responsible for water data management (NCHM, DGM) - To understand their server and data handling practices. IT Policies and Procedures: Review documentation pertaining to data security, access control, server management, backup procedures, and disaster recovery. Infrastructure Assessments: Examine server rooms (if applicable), network architecture, and physical security protocols. Interviews: Engage with IT and data management personnel from relevant agencies.

Recommendations/ Outputs

- Vulnerability Assessment: Evaluate the overall risk to data from accidental deletion, hardware failure, natural disasters, or cyberattacks.
- Data Integrity: Assess the level of protection in place to ensure water data remains accurate and uncompromised. Determine if current security measures support user confidence in the reliability and integrity of the data.
- Master Plan Inputs: The NIWMP may recommend enhancements to IT infrastructure, the development of comprehensive data security protocols, disaster recovery planning, and staff training in data security best practices. Secure data is essential for reliable water demand projections (M1), and informed decision-making across other modules.

3.3. B. Data sharing and transparency

Objective:
To assess how openly Bhutan shares water-related data with various stakeholders within and outside the government and evaluate existing mechanisms for data access and transparency.

Description:
This submodule delves into whether relevant policies exist, the presence of central data portals, user-friendliness, and the process for accessing non-published datasets. It builds upon the previous submodules on data quality (M3.2) and data security (M3.6), as transparent sharing is only valuable if data is reliable, and only worthwhile if appropriate security measures are in place.

Checklist

- Open Data Policy: Investigate if there's a national or sector-specific open data policy in place, as well as any guidelines for proactively sharing non-sensitive datasets.
- Data Portals: Determine if a centralized online portal exists for accessing water-related data. Assess the portal's usability, data search functionality, and ease of downloading data.
- Data Licensing: Examine if data is published under clear usage licenses (Creative Commons, Open Data Commons, etc.).
- Data Formats: Check if data is available in machine-readable formats (CSV, JSON, XML), or if it's primarily restricted to non-editable formats (PDFs, scanned documents).
- Restrictions and Transparency: Identify if there are legitimate restrictions on certain datasets, with clearly explained reasons (e.g., national security, personally identifiable information, protection of sensitive ecological data).
- Data Request Process: For data not openly published, determine if there's a formal process to request specific datasets. Assess if there's clarity on response timelines and whether any associated fees are transparently communicated.

Tools:	**Data Sources –**
T-8 Open Water Data Policy and Accessibility Assessment Tool for Bhutan	Relevant Bhutanese Agencies: • GovTech - May hold overall infrastructure and cybersecurity policies. • Agencies responsible for water data management (NCHM, DGM) - To understand their server and data handling practices. IT Policies and Procedures: Review documentation pertaining to data security, access control, server management, backup procedures, and disaster recovery. Infrastructure Assessments: Examine server rooms (if applicable), network architecture, and physical security protocols. Interviews: Engage with IT and data management personnel from relevant agencies.

Recommendations/ Outputs

- Accessibility: Evaluate overall ease of access to water data for the public, researchers, NGOs, and the private sector.
- Integrate with existing system, Centralized water data repository system
- Transparency: Assess the level of clarity around data restrictions and limitations.
- Barriers: Identify obstacles, such as lack of policy frameworks, outdated technology infrastructure, or reluctance toward making data public.
- Master Plan Inputs: The NIWMP may recommend establishing an open data framework, building accessible data portals, and setting clear guidelines for data sharing across relevant agencies. Proactive data access supports informed decision-making throughout the modules of the plan, enhances public engagement, and can drive innovation.
- It is advisable to link the transparency and data sharing framework with existing system in Bhutan.
- Centralized water data repository, case study 14 and 16 good practices can be referred.

M.3.4 Good Practices and Recommendations

Case Study 13

Manual on Aquifer mapping - CGWB, GoI

The Indian Central Ground Water Board (CGWB) has taken a significant step towards sustainable groundwater management through its National Aquifer Mapping Project. This project focuses on mapping and understanding groundwater systems (aquifers) at a localized level (50-100 sq. km). Recognizing that effective water management often requires a more granular understanding of resources than available at the national or state level, the project has developed a detailed manual to guide this mapping process.

The manual likely provides standardized methodologies for data collection, including:

- Hydrogeological Surveys: Analyzing surface features, landforms, and soil types to infer underground water-bearing formations.
- Geophysical Investigations: Using techniques like resistivity surveys to "see" the subsurface and map aquifer structure.
- Exploratory Drilling: Collecting direct samples to confirm aquifer presence, depth, and water quality.

Read more: Manual aquifer mapping, GOI, Central Ground Water Board

India's CGWB Aquifer Mapping Manual offers direct guidance for strengthening data management within Bhutan's Module 3. The manual provides systematic methods for acquiring key groundwater data (M3.1), and the resulting aquifer maps aid in data analysis and visualization (M3.2). Importantly, the manual itself serves as a tool for the dedicated aquifer mapping activities in M3.4. While Bhutan will need to tailor the specific techniques to its geology, the overarching principles of the program can enhance Bhutan's groundwater data collection and management capabilities.

Case Study 14

WISE: A Model for Water Data Management

The Water Information System for Europe (WISE) is an impressive collaboration between the European Commission and the EEA, providing a centralized platform for comprehensive water-related data. It goes beyond basic water quality and quantity monitoring by encompassing data on water pressures (factors that adversely affect water resources, such as pollution or climate change) and the effectiveness of water management policies across Europe. This rich tapestry of information empowers decision-makers at all levels with the knowledge needed to develop and implement more sustainable water management practices. Additionally, WISE makes this data publicly accessible, promoting transparency and enabling informed decision-making by stakeholders like researchers, businesses, and even individual citizens.

Read more: Water Information System for Europe (WISE), Freshwater Information Platform (FIP), EU

The WISE platform could serve as a beneficial model for Bhutan's Module 3. It offers insights into standardized data collection, innovative monitoring techniques, and the integration of diverse datasets (M3.1). WISE's data processing, visualization, and analytical tools could serve as models for Bhutan (M3.2). Further, WISE's emphasis on open data and robust metadata protocols highlights best practices for structuring Bhutan's National Water Resources Inventory, enhancing transparency, accessibility, and data quality (M3.3, M3.4). While WISE operates at a larger regional scale, its core

principles of standardization, integration, and accessibility are directly applicable to Bhutan's water data management.

Case Study 15

Strengthening multi-hazard risk information systems Bhutan – Towards Resilience, CDRI

The "Mountain DRI Dialogue 1" document details a project aimed at enhancing Bhutan's resilience through strengthening multi-hazard risk information systems. Key components include developing an online portal for risk data management, performing a national multi-hazard risk assessment, and building capacity for disaster risk management. These elements are highly pertinent to the NIWMP in Bhutan, as they focus on creating a comprehensive, data-driven understanding of water-related risks, an essential aspect of informed water management planning and decision-making in the face of climate change.

Read more: CDRI and UNDRR support data-informed decision-making to improve infrastructure resilience in Bhutan

This project's methodologies and outcomes are closely related to several modules of Bhutan's NIWMP guiding tool. The data management strategies, the emphasis on technological infrastructure like the DRM Portal, and the participatory approach to risk assessments intersect with Module 3 (Data Management) and Module 5 (Monitoring and Evaluation) of the guiding tool. They exemplify practical applications of data systems and collaborative processes that are essential for effective monitoring, evaluation, and adaptive management within Bhutan's water sector.

Case Study 16

Centralized water data repository

WARIMS is envisaged to be a cloud based digital platform (Decision Support System) for management of water resources and allied themes in an integrated manner. The platform would be capable of handling large amount of hydro-meteorological and hydrogeological data to bring meaningful insights to decision-making processes.

Read more: National Water Informatics Centre, WARMIS

This project's methodologies and outcomes are closely related to several modules of Bhutan's NIWMP guiding tool. The data management strategies, the emphasis on technological infrastructure like the DRM Portal, and the participatory approach to risk assessments intersect with Module 3 (Data Management) and Module 5 (Monitoring and Evaluation) of the guiding tool. They exemplify practical applications of data systems and collaborative processes that are essential for effective monitoring, evaluation, and adaptive management within Bhutan's water sector.

I. M.4 CAPACITY BUILDING (Institutions and other stakeholders)

Introduction:

Module 4 of Bhutan's water management guiding tool focuses on capacity building, a crucial aspect of strengthening institutional and stakeholder knowledge in water governance. This module aims to enhance understanding of water governance principles, foster collaborative capacity, and promote community involvement. It bridges the gap between the data management strategies outlined in Module 3 and the implementation and oversight activities detailed in the subsequent monitoring, evaluation, and finance modules.

Key Areas of Focus:

The focus areas of Module 4 are centered around:

- **Institutional Capacity Building**
  - Department of Water (DoW) and Allied Departments: Training programs and expert talks aim to enhance technical expertise, governance skills, and the ability to effectively utilize the data and tools developed in earlier modules of the NIWMP. This ensures the agencies responsible for water management are well-equipped to implement the plan.

- **Knowledge Sharing and Technological Innovation**
  - Stakeholder Collaboration: Facilitating workshops, forums, and knowledge exchange platforms for diverse stakeholders, including WUAs and other relevant agencies. This promotes collaboration, reduces potential conflicts, and disseminates best practices.

- **Community Engagement and Participatory Governance**
  - Citizen Forums and Planning Process Involvement: Establishing platforms for public dialogue, involving citizens in decision-making, and conducting awareness campaigns about responsible water use. Active community participation cultivates a sense of ownership of water resources and encourages behavior changes that support the NIWMP's sustainability goals.

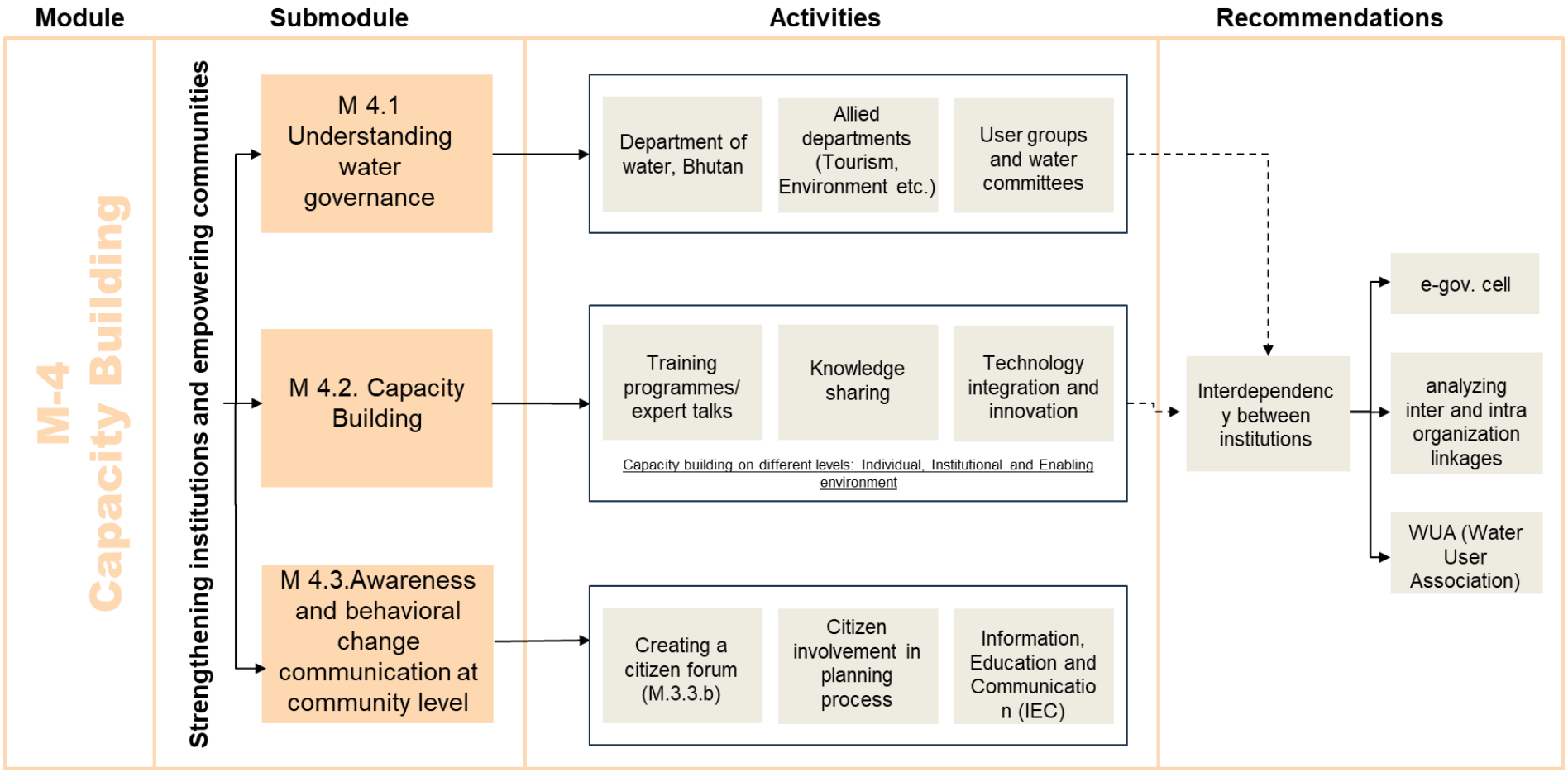
Objective

The primary objective of Module 4 is to elevate the proficiency of individuals and institutions involved in water resource management. This entails equipping them with the necessary skills, knowledge, and tools to effectively govern, manage, and conserve water resources within the framework of the NIWMP.

Target Users

The target users for this capacity-building module include officials from the Department of Water, Bhutan, alongside experts in hydrology, agriculture, environmental science, GIS, planners, and IT. By integrating capacity-building efforts with e-governance initiatives and the WUAs, this module ensures a cohesive approach to managing Bhutan's water resources across various departments and stakeholder groups. It emphasizes the importance of cross-functional collaboration and community engagement to successfully implement the NIWMP in a way that is sustainable, inclusive, and adaptable to future challenges.

Flow chart representing Interlinkage between sub-modules of Capacity building module:



M.4.1 Understanding water governance

4.1.A. Department of water, Bhutan

Objective:
To equip stakeholders involved in the NIWMP development with a comprehensive understanding of the Department of Water - its mandate, structure, policies, and ongoing water management initiatives.

Description:
This submodule focuses on the primary institution responsible for Bhutan's water resource management. Understanding its functions, legal basis, and current activities promotes effective communication and alignment of the NIWMP with existing structures and initiatives. This understanding connects to the broader assessment of laws and regulations (M4.2) and stakeholder identification across sectors (M4.3).

Checklist

- Organizational Structure: Review the Department's divisions, hierarchies, responsible personnel, and any regional or decentralized branches.
- Mandate and Functions: Clearly define the Department's authority and scope of responsibility regarding water resources, covering areas such as planning, allocation, regulation, development, and monitoring.
- Policies and Regulations: Examine the policies, regulations, and legislative frameworks that directly shape the Department's actions. This might include the Bhutan Water Act, the National Water Policy, and specific regulations on water quality, abstraction, allocation, or environmental protection.
- Ongoing Initiatives: Investigate the current projects and programs the Department is undertaking. Consider initiatives in water infrastructure development, conservation, resource monitoring, data collection, and community engagement or capacity building.

Tools:
T-1 Comprehensive Checklist for Understanding the Department of Water's Role in country's Water Resource Management

Data Sources –

- Bhutan Water Act (2011): The primary legal document outlining the Department's establishment and responsibilities.
- Department of Water, Bhutan Website: Official website containing organizational charts, policy statements, and project information.
- Departmental Reports and Publications: Project reports, annual reports, and other documents detailing past and current water management activities.
- NCHM: Operates weather stations throughout Bhutan, collects data on precipitation, temperature, humidity, wind speed, etc., Maintains stream gauges that monitor river water levels and flow rates.

Recommendations/ Outputs

- Knowledge Base for Stakeholders: Ensure all stakeholders involved in the NIWMP have a strong understanding of how the Department of Water functions and how it interacts with water resource management responsibilities within other agencies.
- Collaboration and Integration: Identify opportunities for effective collaboration between the Department and other stakeholders involved in developing and implementing the NIWMP.
- Master Plan Alignment: The NIWMP recommendations should align with the Department's existing mandate, policies, and ongoing initiatives, aiming to strengthen ongoing efforts rather than proposing incompatible changes. Recommendations within the NIWMP may also suggest capacity building for the Department of Water in terms of personnel, technical resources, or new legal mandates to effectively implement the plan (M4.5).

4.1.B. Allied departments (tourism, environment, etc.)

Objective:
To identify government departments and agencies beyond the core water sector that have a significant role in water resource management. The goal is to promote cross-sectoral collaboration for the integrated water management approach of the NIWMP.

Description:
This submodule recognizes that water cuts across traditional sectoral boundaries. It involves mapping stakeholders, analyzing their water-related activities, and identifying potential areas for collaboration and points of potential conflict. This module builds on the understanding of water institutions specifically (M4.1) and leads into establishing participatory mechanisms (M4.3).

Checklist

- Identification of Allied Departments: Create a comprehensive list of ministries, departments, and agencies whose actions have a potential impact on water resources or that depend on reliable and clean water for their functions.
- Define Roles and Responsibilities: For each identified stakeholder, clearly outline their specific mandate and how it relates to water resources management (whether direct or indirect).
- Assess Water-related Initiatives: Identify each department's current projects and programs with a relation to water resources. Consider areas like water infrastructure, environmental protection, agricultural water management, and disaster risk reduction.
- Analyze Collaboration & Conflict: Identify areas where water-related goals align across sectors and where potential conflicts might arise (e.g., economic development vs. environmental protection).
- Establish Communication: Determine optimal communication channels (formal and informal) between water sector agencies and allied sectors to facilitate integrated water management.

Tools:
T-2 Strategic Framework for Inter-Departmental Collaboration in Water Resource Management in Bhutan
T-3 Key Ministries and Departments Involved in the National Integrated Water Master Plan (NIWMP) of Bhutan: Roles and Contributions

Data Sources –

- Official Government Websites Explore websites of relevant ministries and departments. Key ones include:
  - Ministry of Agriculture and Livestock.
  - Department of Environment & Climate Change.
  - DMDF (For policy integration).
  - Ministry of Industry, Commerce and Employment (MoICE).
  - Relevant departments within the Ministry of Infrastructure and Transport (especially Urban Development).
- Policy Documents: National policies, sector-specific plans, and water-related legislation.
- Project Reports and Evaluations: Documents from ongoing or completed water sector projects may provide insight into collaborations or challenges.
- Stakeholder Consultations: Interviews and workshops with representatives across sectors.

Recommendations/ Outputs

- Stakeholder Mapping: Visualize the water-related linkages between institutions, highlighting key dependencies.
- Collaboration Opportunities: Identify concrete areas where shared goals and joint activities can improve water management outcomes.
- Managing Conflict: Develop mechanisms to address potential conflicts between sectors, ensuring that water resource protection is a shared priority.
- Master Plan Integration: The NIWMP needs to propose actions not just for the water sector but also for allied agencies to create a truly integrated water management approach. This ensures the plan is feasible and supported by a broad base.

4.1.C. User groups and water committees

Objective:
To evaluate the capacity of WUA to engage in participatory water management approaches and actively contribute to the implementation of the NIWMP.

Description:
This submodule recognizes the essential role of water user groups in decentralized water management. It examines their understanding of water issues, awareness of their rights, technical skills, organizational structure, and linkages with water authorities. This assessment builds upon understanding the broader legal framework for water governance (M4.2).

Checklist

- Awareness of Rights and Roles: Determine if water user groups understand their legal rights regarding water access and their potential role in water resource management as outlined in water policies.
- Understanding of Water Issues: Assess group members' knowledge of local water resources (sources, seasonal variability), water use patterns, challenges related to availability or quality, and how their own actions impact the larger water system.
- Technical Skills: Evaluate if the groups have any training related to water-saving techniques, simple water quality monitoring, routine maintenance of small-scale water infrastructure, or other practical skills.
- Leadership and Organization: Analyze if the groups have a clear organizational structure, designated leaders, and established processes for decision-making and resolving internal conflicts.
- Inclusivity and Representation: Assess whether the groups ensure participation from diverse members of the community, ensuring representation across various genders, socioeconomic groups, and upstream–downstream user interests.
- Linkages to Government: Determine if there are clear communication channels between the groups and government water agencies, and whether the concerns raised by groups are acknowledged and acted upon.

Tools:	**Data Sources –**
T-4 Assessment of Community Engagement and Capacity in Water Management Practices	• Interviews with Group Representatives: Engage in direct discussions with members and leaders of water user groups or committees. • Participatory Rural Appraisal (PRA) Techniques: Use PRA methodologies (focus group discussions, community mapping) to gain insight into community dynamics and water issues. • Review of Policies and Guidelines: Examine policies such as the Bhutan Water Act (2011) for provisions relating to water user groups. • Project Reports and Case Studies: Review documentation from projects supporting water user groups or participatory water management. • Relevant agencies: Engage with agencies that may have a track record of interacting with or supporting water user groups.

Recommendations/ Outputs

- Capacity Gap Analysis: Identify areas where water user groups may require further training or support to strengthen their engagement.
- Strengthening Participation: Propose mechanisms to enhance the two-way communication between these groups and water authorities.
- Master Plan Integration: The NIWMP needs to include specific recommendations on promoting the formation of water user groups where they don't exist, defining their roles and responsibilities, and building their capacity to effectively participate in water resource management. Capacity building is crucial to ensure the plan's recommendations are implemented successfully.

M.4.2 Capacity building

4.2.A. Training programmes / expert talks

Objective:

To design and implement effective capacity-building initiatives that enhance knowledge, skills, and adoption of best practices at the individual, institutional, and wider enabling environment levels within Bhutan's water sector.

Description:

This submodule focuses on targeted training and knowledge-sharing to build the capacity needed for successful NIWMP implementation. It recognizes that capacity needs exist for water professionals, user groups, and the broader public affected by water management. This builds on previous assessments of existing institutions (M4.1 and M4.2) and the specific needs of user groups (M4.3).

Checklist

- Target Audience Identification: Clearly define the specific groups who would benefit from training. Consider technical staff, agency decision-makers, members of water user groups, and potentially even the general public for awareness programs.
- Curriculum Development: Outline the core topics for training, aligning them with the identified capacity gaps within relevant institutions. Tailor the content to the target audience and ensure it's relevant to the Bhutanese context.
- Trainer and Expert Selection: Identify trainers or speakers with suitable expertise and experience in water management fields. Consider a mix of local and international experts, ensuring the ability to translate complex concepts into the local context.
- Training Logistics: Determine the optimal format, location, duration, and resources required for training. Balance budget considerations with accessibility and inclusivity.
- Monitoring and Evaluation: Design assessment tools (pre- and post-training surveys) to gauge knowledge gains and program effectiveness. Gather participant feedback, and be open to adjusting the curriculum or delivery methods for future iterations.

Tools:	**Data Sources –**
T-5 Framework for Designing and Implementing Water Management Training Programs	• Prior Capacity Needs Assessments: Review any existing assessments carried out by agencies or as part of past projects. • Relevant agencies: ○ Department of Local Governance and Disaster Management (DLGDM), RCSC and MoICE: May track professional development needs. ○ Identify local experts. ○ Bhutan Water Partnership: May connect stakeholders with international training resources. • International Knowledge Networks: Explore networks specializing in water management capacity-building. • Stakeholder Consultations: Interviews and focus group discussions to gather direct input on training needs from diverse groups within the water sector.

Recommendations/ Outputs

- Comprehensive Capacity Building Plan: Design a multi-year plan outlining priority training areas linked directly to the implementation needs of the NIWMP.
- Knowledge Sharing and Collaboration: Facilitate platforms for expert talks and knowledge exchange to foster a learning culture within the water sector.
- Master Plan Integration: The NIWMP should go beyond technical solutions and include explicit recommendations on human resource development, knowledge management systems, and continuous learning to ensure the plan is well-implemented and adaptable in the long term.

4.2.B. Knowledge sharing

Objective:

To establish effective mechanisms for sharing water-related knowledge, best practices, and lessons learned. This promotes a culture of continuous learning and innovation within the water sector.

Description:

This submodule focuses on moving beyond data collection (M3), toward the proactive sharing and contextualization of knowledge. It helps bridge gaps identified in previous capacity assessments (M4.1 through M4.4), creating a collaborative environment for water professionals. Effective knowledge-sharing supports informed decision-making at all levels.

Checklist

- Identify Knowledge Sources: Map out existing knowledge resources, including internal datasets, agency reports, research papers, case studies from other regions, and knowledge held by traditional water managers.
- Knowledge-Sharing Strategy: Develop a plan outlining objectives, target audiences (technical staff, public, decision-makers), mechanisms (platforms, workshops), and how this will contribute to the NIWMP's specific goals.
- Knowledge Platform: Select appropriate platforms for sharing, balancing accessibility with data security needs. Consider online portals, collaborative workspaces, regular newsletters, or knowledge-exchange conferences.
- Content Development: Prepare knowledge products in accessible formats (visual summaries, case study briefs, training manuals). Tailor content to different audiences, and consider translation into local languages where needed.
- Promote Participation: Design participation mechanisms to encourage contribution to the growing knowledge base. Implement feedback mechanisms and reward those who actively share their expertise or lessons learned.

Tools:	**Data Sources –**

T-6 Strategic Plan for Enhancing Knowledge Sharing in Water Management	• Relevant agencies:
	  ○ GovTech: For identifying existing technology infrastructure.
	  ○ Identifying traditional knowledge sources.
	  ○ Royal University of Bhutan (RUB) or other academic institutions: For research collaboration.
	• Project Reports (Water-related): Examine documentation from past water sector projects to extract lessons learned and best practices.
	• International Partners: Consult with international organizations active in water knowledge management and capacity-building.
	• Stakeholder Consultations: Gather input on knowledge needs and preferred mechanisms for sharing information.

Recommendations/ Outputs

- Knowledge Hub: Establish a centralized knowledge repository or portal (if one does not exist) with well-structured navigation and intuitive search features.
- Collaboration Culture: Foster collaboration between water agencies, researchers, and practitioners to ensure knowledge flows.
- Master Plan Integration: The NIWMP should go beyond technical solutions and explicitly recommend investing in knowledge management systems, knowledge exchange platforms, and incentives to reward collaboration. This ensures the plan is not only technically sound but also adaptable based on new knowledge.

4.2.C. Technology integration and innovation

Objective:

To build the capacity of Bhutanese water institutions to effectively adopt and leverage relevant technologies. This promotes innovation, aiming to enhance data collection, analysis, decision-making, and the efficiency of water management practices.

Description:

This submodule recognizes that technology is a tool for better water management, focusing on the skills and enabling environment to select and properly utilize appropriate technologies. While some technology might be imported, this module is also about fostering a local culture of innovation in the water sector and potentially creating tech-driven solutions for Bhutan's unique challenges. It builds on the previous data management submodules (M3).

Checklist

- Technology Landscape Assessment: Evaluate the existing technology used by water management agencies, including hardware, software, data collection sensors, and analytical tools. Identify strengths and areas for upgrade or expansion.
- Technology Needs Identification: Determine specific areas where technology can address water management challenges. Explore technologies for data collection, modeling, real-time monitoring, and decision support systems.
- Innovative Solutions Research: Investigate emerging technologies and innovative solutions globally. Consider remote sensing tools, AI-based predictive models, water-saving technologies for agriculture and infrastructure, and community-based monitoring systems.
- Technology Integration Plan: Develop a roadmap for adopting selected technologies, including procurement guidelines, infrastructure upgrades (if needed), data integration, and change management within institutions.
- Training and Support: Provide comprehensive training to staff on the use of new technologies. Establish technical support systems for troubleshooting and knowledge sharing.

Tools:	**Data Sources –**
T-7 Technology Assessment and Integration Framework for Water Management	• Relevant agencies: ○ GovTech: For understanding national IT infrastructure and policies. ○ Agencies actively working with water data (especially NCHM): For their current capacity and needs. ○ Technical institutes: For research and potential collaboration. • Industry Partnerships Examine partnerships between the water sector and Bhutanese technology companies/startups. • Project Reports (Water-related): Review past projects for successful or unsuccessful technology adoption case studies. • International Knowledge Networks: Explore networks specializing in water management technologies and innovation in developing country contexts.

Recommendations/ Outputs

- Technology Roadmap: Create a clear plan for phased technology adoption aligned with the priorities of the NIWMP.
- Promoting Innovation: Establish mechanisms (grants, innovation challenges) to encourage water-tech solutions tailored to Bhutanese needs.
- Master Plan Integration: The NIWMP should consider investment in technology as essential, not optional. It should include specific technology-related capacity-building programs to ensure successful implementation of the plan.

M.4.3 Awareness and behavioral change communication at community level

4.3.A. Creating a citizen forum (M.3.3.b)

Objective:
To empower communities to actively participate in water-related decision-making and adopt sustainable water management practices. This involves setting up representative citizen forums and utilizing effective communication strategies for awareness-raising and behavioral change.

Description:
This submodule recognizes that top-down water management approaches often fail. It focuses on building social capital and ensuring communities understand the benefits of proposed changes. The citizen forum provides a platform for gathering local insights and concerns, improving decision-making, and aligning actions with community needs. This submodule builds upon the earlier stakeholder mapping exercises (M4.1 and M4.2).

Checklist

- Community Stakeholder Identification: Map the diverse groups within a community who are impacted by water management decisions. Consider geographic sub-divisions, water user groups, marginalized populations, women-led groups, and youth leaders.
- Forum Objectives: Collaboratively define the role of the forum. Will it be primarily consultative, or will it have decision-making power in specific areas (e.g., local water allocation). Clearly define its scope to manage expectations.
- Forum Structure: Design the forum's membership, ensuring inclusivity and representation. Decide on leadership selection (election or rotation system). Establish basic rules for conducting meetings and respectful participation.
- Communication Channels: Choose communication methods suited to the community's preferences and existing infrastructure. Consider a mix of open meetings, local notice boards, text alerts, newsletters, or community radio, depending on the context.
- Regular Engagement: Schedule regular forum meetings with clearly defined agendas. Employ facilitation techniques to ensure all voices are heard. Create channels to communicate forum inputs to formal water management decision-making bodies.

Tools:	**Data Sources –**
T-8 Guidelines for Establishing Citizen Forums in Water Management	• Thromde Thuemis and Gewog representatives: Consult community leaders to understand existing community structures, traditional communication practices, and potential stakeholders for the forum. • Local NGOs and Community-Based Organizations: Investigate existing citizen-led groups or those working in water-related areas to understand local awareness of water issues and social dynamics. • Academic Studies: Research community participation models in Bhutanese water projects. • Focus Group Discussions: Engage directly with diverse community members to gather input on forum structure and communication preferences.

Recommendations/ Outputs

- Design forum structure and communication strategies specifically for each community based on their unique characteristics and needs.
- Build trust between the community and water management authorities through consistent two-way communication via the citizen forum.
- Master Plan Integration: The NIWMP should go beyond technical solutions and have explicit recommendations on supporting citizen forums (capacity-building resources, funding for activities). This ensures that community-level engagement doesn't end with the completion of the NIWMP but becomes an ongoing governance practice.

4.3.B. Citizen involvement in planning process

Objective:
To ensure that community needs, priorities, and local knowledge are effectively integrated into the development of Bhutan's National Integrated Water Master Plan (NIWMP). This promotes a sense of ownership and increases the likelihood of the plan's successful implementation.

Description:
This submodule goes beyond mere awareness-raising, actively involving citizens in shaping aspects of the NIWMP. It recognizes that communities possess valuable insights into water challenges, and their participation leads to more equitable and sustainable solutions. Building upon earlier stakeholder analysis exercises (M4.1 and M4.2), this submodule focuses on creating mechanisms for meaningful two-way exchange.

Checklist

- Stakeholder Mapping: Identify relevant groups within the community (water user groups, marginalized communities, village councils, etc.) who have a stake in water management decision-making.
- Awareness-Raising: Conduct initial awareness sessions to inform the community about the NIWMP development process, its objectives, and why their participation matters. Tailor materials and delivery methods to the local context.
- Gathering Community Input: Employ participatory tools (focus group discussions, mapping exercises) to solicit community feedback on water challenges, priorities for the NIWMP, and potential local solutions. Ensure that sessions are inclusive and accessible.
- Sharing Information: Make water-related information and draft plan components accessible to the community in easily understandable formats. Provide summaries in local languages, visual aids, and utilize both digital and physical channels for information sharing.
- Feedback Mechanisms: Establish multiple channels (hotline, suggestion boxes, representative in citizen forums) to gather community feedback on plan proposals. Implement systems to track, respond to, and integrate feedback where feasible.

Tools:	**Data Sources –**
T-9 Community Engagement Strategy for Water Master Plan Development	• Thromde Thuemis and Gewog representatives: Consult local leaders to map community structures, identify potential participants for focus group discussions, and understand local communication channels. • Local NGOs and Community-Based Organizations: Collaborate with existing groups to gain trust, identify potential stakeholders, and tap into existing community networks. • Previous Water Project Reports: Review past participatory assessments or feedback processes to learn what worked well and what could be improved upon. • Academic Studies: Research community participation models previously used in Bhutan.

Recommendations/ Outputs

- Transparent and Responsive Planning Process: Demonstrate that community input is considered meaningfully, and adjust plan proposals where feasible and justified.
- Locally-Owned Solutions: Include locally driven adaptation or infrastructure proposals (if sound) to increase buy-in.
- Master Plan Integration: The NIWMP should go beyond technical solutions and have explicit recommendations on supporting participatory planning (resource allocation, guidelines for agencies, tools) to ensure this approach becomes the norm for future water projects.

4.3.C. Information, Education and Communication (IEC)

Objective:

To raise awareness, change attitudes, and promote positive behavioral changes related to sustainable water use and management amongst the Bhutanese public. IEC supports widespread understanding and participation in implementing the goals of the NIWMP.

Description:

This submodule focuses on translating complex water management concepts for different audiences, from schoolchildren to rural communities. IEC builds upon community engagement efforts (M4.6 and M4.7). It ensures that knowledge doesn't stay just within water agencies but reaches the broader public, creating a broader culture of responsible water stewardship.

Checklist

- Baseline Knowledge Assessment: Conduct surveys, interviews, or focus group discussions to understand the existing levels of public awareness around water issues, common misconceptions, and how water is connected to their lives.
- Tailor IEC Materials and Campaigns: Develop educational materials addressing identified knowledge gaps and promoting positive water practices. Use local languages, culturally relevant examples, and visual aids for maximum impact.
- Multi-Pronged Delivery: Utilize diverse channels for IEC interventions. These include community workshops, school programs, campaigns on local media, collaborations with religious or cultural leaders, and informational signage in public spaces.
- Monitoring and Evaluation: Track the reach of IEC campaigns, gather feedback from participants, and conduct pre- and post-intervention surveys to assess knowledge gains and behavioral changes. Adjust messaging or delivery methods based on results.

Tools:	**Data Sources –**
T-10 Implementation and Evaluation of Information, Education, and Communication (IEC) Initiatives for Water Management	• National Statistics Bureau (NSB): May have data on community awareness of environmental issues. • Department of Media, Creative Industry, and Intellectual Property: Consult media houses to understand potential formats for IEC campaigns. • School Curriculum and NGOs Working in Education: Collaborate with the Ministry of Education and Skills Development and educational NGOs to identify opportunities for integrating water awareness programs into schools. • Local Religious Leaders and Cultural Traditions: Explore incorporating water stewardship messages into religious practices or through traditional storytelling.

Recommendations/ Outputs

- Sustained and Targeted IEC: IEC shouldn't be a one-off activity. Budget for ongoing campaigns that adapt to changing needs and priorities.
- Partnerships for Reach: Collaborate with NGOs, community groups, and the media to amplify IEC efforts.
- Master Plan Integration: The NIWMP should go beyond technical solutions and have a strong section on IEC strategies. This may include recommendations for funding community-led campaigns, supporting water education in schools, or establishing a dedicated unit for public information within water agencies.

M.4.4 Good Practices and Recommendations

Case Study 16

Case Study: The Parabs of Bhuj – Building Local Water Expertise:

In the water-stressed Bhuj region of India, a unique program transforms local citizens into "Parabs," or para-professionals specializing in groundwater management. This collaborative initiative, led by an NGO (ACT), empowers community members through a rigorous 45-day training. Combining classroom-based learning in geology, water harvesting techniques, and government programs with extensive field experience, the curriculum builds both technical and community engagement skills. This holistic approach ensures practical application and a deep understanding of local contexts.

Upon completion, Parabs are encouraged to become self-employed consultants, offering their expertise to their own communities and beyond. The formation of Parab Water Management Pvt. Ltd. formalizes their services, boosting credibility, and allowing them to partner with organizations like the Reliance Foundation, IL&FS, and government agencies like WASMO. The Parabs' success lies in the trust they've built within communities, effectively bridging the gap between local water needs and technical solutions.

Read more: Sahjeevan annual report 2010

The Bhuj Parab initiative illustrates the capacity-building objective of the NIWMP. It demonstrates the power of empowering local stakeholders through training, fostering community-driven water management as outlined in M4.1 and M4.2. While focused on groundwater, the Parab program likely enhances broader water resource understanding (M1.1) and facilitates communication about sustainable practices (M4.3). Additionally, their expertise could potentially contribute to infrastructure planning (M6) and the successful implementation of water-related policies (M2).

Case Study 17

Case Study: Gujarat Jal Sewa Training Institute

Gujarat's Jal Sewa Training Institute (GJTI) plays a pivotal role in building capacity in the water and sanitation sector across the state and beyond. The institute offers a range of training programs, seminars, and workshops to address the diverse needs of stakeholders. Their target audience likely includes government officials responsible for water management, technical staff, NGOs, and potentially even community-level water committees. Their focus on knowledge sharing emphasizes collaboration and continuous learning in the sector.

Read more: Case study in community participation, Gujarat Jal Seva training institute (gjti)

The Gujarat Jal Sewa Training Institute demonstrates Module 4's emphasis on enhancing capabilities. Its programs enhance knowledge of water governance principles and technical skills for stakeholders, directly aligning with M4.2. By fostering collaboration and knowledge sharing, it also strengthens broader understanding of water governance (M4.1). This can promote sustainable water practices within communities, supporting the behavioral change goals of M4.3.

Case Study 18

PUB Water Academy- Singapore

Singapore's PUB Water Academy reflects the country's commitment to building a strong water-specialized workforce. The Academy offers diverse training programs for water professionals, covering technical aspects of water management, advanced technologies, and policy issues. This focus on knowledge and skill development has been critical for Singapore's success as a water-secure nation. A similar institution in Bhutan could foster local expertise, preparing Bhutanese professionals to address complex water challenges.

Read more: City Water Stories: Singapore, Singapore's national water agency, PUB

- Advanced & Tailored Training: Singapore's Academy offers highly specialized courses on cutting-edge technologies (water reuse, desalination, etc.) and complex policy topics. Bhutan's Academy could identify priority areas like climate-resilient infrastructure or nature-based solutions and create similarly focused training.
- Global Linkages and Partnerships: Singapore's Academy likely collaborates with international institutions for knowledge sharing, curriculum development, and exchange programs. Bhutan's Academy could explore similar partnerships to tap into global expertise and best practices.
- Multi-Stakeholder Approach: While primarily for water professionals (M4.2), Singapore's Academy likely has public outreach components (M4.3). Bhutan could expand its capacity building scope to involve community groups, policymakers, the private sector, and students in tailored programs.
- Focus on "Soft Skills": Beyond technical aspects, Singapore likely emphasizes leadership, communication, and innovation in its training. Bhutan's Academy could integrate these elements to build holistic water management capacity.

A dedicated water academy for Bhutan would be instrumental in capacity building (M4.2) by offering technical and policy-focused training programs for water professionals. It could also serve as a hub for public outreach and awareness campaigns focused on water conservation and sustainability (M4.3). Importantly, the Academy could play a key role in developing a deep understanding of water governance frameworks that integrate climate change challenges and sustainable practices (M4.1).

J. M.5 MONITORING AND EVALUATION

Introduction:

Module 5 of the NIWMP, centered on Monitoring and Evaluation, is essential for ensuring that the initiatives taken are not only implemented but also yielding the desired outcomes. It is a strategic approach to tracking the performance of water services, evaluating infrastructure efficiency, and financial sustainability. By integrating analytical tools like GIS mapping and benchmarking best practices, this module systematically observes user-based components such as water access, quality, and supply-demand dynamics, which are critical for continuous improvement.

Key Areas of Focus:

The module is composed of:

- **Monitoring for Informed Decision-Making**
  - User-Based Water Component Assessment: Regularly monitoring water supply coverage, service quality, user satisfaction, and the condition of water infrastructure. This data is critical for identifying areas where service delivery is falling short and prioritizing interventions.

- **Data Analysis and Feedback**
  - Interpretation and Benchmarking: Analyzing the collected data, comparing it against national and international standards, and seeking insights from stakeholders (surveys, focus groups, etc.). This analysis reveals gaps between the current state of water services and the desired outcomes and helps shape improvement strategies.

- **Adaptive Improvement Cycle**
  - Performance Evaluation and Innovation: Continuous assessment of progress against NIWMP goals, identifying successes and failures. This includes incorporating adaptive management techniques to trial new solutions and embracing innovation for continual optimization of services in line with changing needs and evolving technologies.

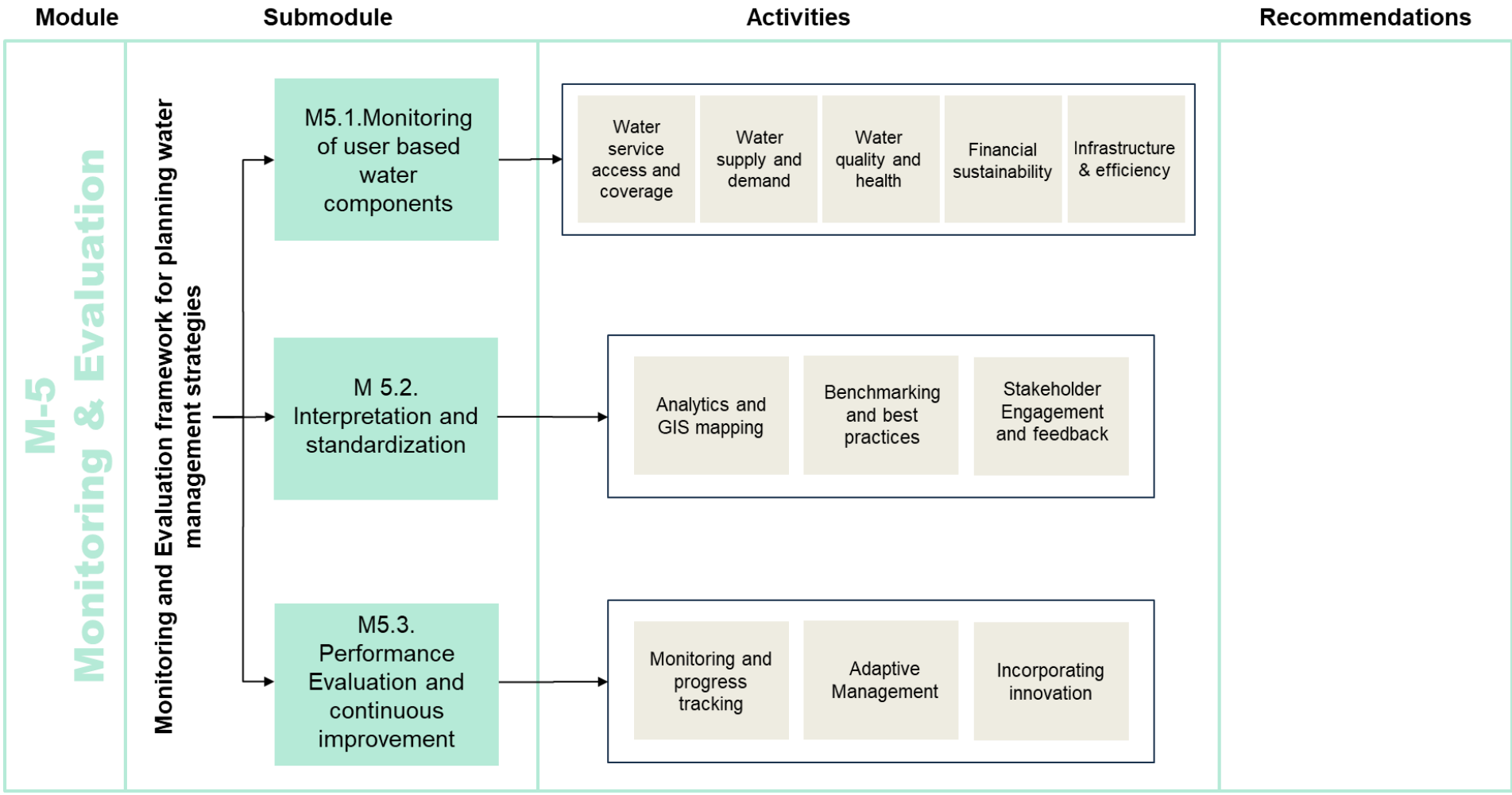
Objective

Module 5 aims to establish a culture of continuous vigilance and adaptability in water management practices. Through diligent monitoring and regular evaluations, the module aims to identify areas for improvement and ensure that the strategies employed are both effective in the present and sustainable in the long term.

Target Users

The intended users of this module include officials from the Department of Water, Bhutan, technical experts like hydrologists and GIS analysts, and professionals in agricultural planning and urban development. It is also crucial for financial analysts and capacity building specialists, as it provides them with valuable data and insights needed for effective resource allocation, stakeholder engagement, and educational programs. These users are vital for creating a responsive and dynamic framework for managing Bhutan's water resources effectively.

Flow chart representing Interlinkage between sub-modules of Monitoring and Evaluation module:



M.5.1 Monitoring of user-based water components

5.1.A. Water service access and coverage

Objective:
To establish a robust system for tracking progress in expanding water service access, improving service quality, and ensuring equity in the distribution of water benefits. This data will inform decision-making and course correction as needed.

Description:
This submodule focuses on measuring key aspects of water service delivery from the user's perspective. Emphasis is placed on identifying underserved areas, evaluating service reliability and quality, and ensuring that vulnerable populations have equitable access. Building on baseline data collection in earlier modules (M1, M3), it puts in place the systems for ongoing performance assessment.

Checklist

- Mapping Service Areas: Utilize GIS tools to visualize current service boundaries and compare them with population density maps to pinpoint areas lacking access.
- Calculating Population Served: Cross-reference service area data with census figures to determine what percentage of the population is currently served and where gaps exist.
- Assessing Service Quality: Track indicators such as service hours, disruptions, water pressure, and water quality through a mix of technical measurements, user surveys, and analysis of service logs.
- Addressing Equity: Conduct studies to identify marginalized groups who may face barriers to accessing water services. Develop targeted interventions to improve access for these groups.
- Planning Expansion: Integrate data on unserved populations and service quality to prioritize areas for infrastructure extension. Conduct feasibility studies and draft expansion plans.
- Community Engagement: Hold consultations with communities to incorporate their preferences, needs, and feedback into service expansion plans.

Tools:	**Data Sources –**
T-1 Comprehensive Strategy for Enhancing Water Service Coverage and Quality in Bhutan	•Department of water, Bhutan, and Thromde/Dzongkhag Water Service Providers: Customer records, service logs, infrastructure maps. •GIS and Remote Sensing Tools: For spatial analysis. •National Statistics Bureau: Population data, maps, rural water supply schemes, irrigation etc. •Community-level surveys: To capture user perceptions and experiences.

Recommendations/ Outputs

- Data-Driven Expansion Prioritize infrastructure investment in areas with the greatest need or potential for quick wins.
- Service Improvement Plans: Use monitoring data to identify bottlenecks and target actions to improve service reliability and quality.
- Equity Focus: Develop specific action plans to address barriers faced by marginalized communities, ensuring water service benefits are accessible to all.
- Links to Other Modules: Performance data on service access informs water demand projections (M1) and highlights areas where water conservation measures (M1) may be especially critical. It also guides the design of infrastructure upgrades in a manner that meets user needs.

5.1.B. Water supply and demand

Objective:
To establish a system for continuously tracking water supply availability against current and projected demands. This aims to identify potential water shortages, inform infrastructure investment decisions, and promote water conservation across all sectors.

Description:
This submodule goes beyond a snapshot assessment, focusing on setting up ongoing monitoring to inform adaptive management. It emphasizes regular data collection and analysis to track changes in water availability due to factors like climate variability, as well as shifts in water demand due to population growth and changing consumption patterns. Building upon baseline data collection (M1) and demand projections (M1), it translates theoretical water balance assessments into actionable information for decision-makers.

Checklist

- Water Supply Monitoring: Regularly assess yields from surface water sources (rivers, lakes) and groundwater aquifers. Track seasonal and inter-annual variations, and calibrate against climate models to assess long-term trends.
- Demand Monitoring: Disaggregate water use data by sector (domestic, industrial, agricultural). Establish metering systems where feasible, and update demand projections as economic development and demographic changes occur.
- Water Balance Analysis: Calculate the balance between available supply and overall demand at different geographic scales (dzongkhag, thromde, catchment level) and for different time periods (monthly, dry season vs. wet season) to pinpoint areas of stress.
- Efficiency Promotion: Track the adoption of water conservation practices and technologies. Evaluate their impact on reducing per capita demand, especially in sectors identified as high-water users.
- Policy Monitoring: Assess the effectiveness of water pricing measures, conservation incentives, and other regulatory tools in influencing water demand patterns.
- Adaptive Management: Use the data to adjust water allocations, prioritize infrastructure investments (storage, efficiency improvements), and refine demand management strategies to maintain a sustainable water balance.

Tools:	**Data Sources –**
T-2 Strategic Approach to Balancing Water Supply and Demand in Bhutan	• NCHM: For hydrological data, climate projections, and water resource assessments. • DoW, DoFPS, DoT DoID and Thromde/Dzongkhag Water Service Providers: Water abstraction and consumption records, forestry and biodiversity water requirement, tourism. • Department of Agriculture and Livestock: Data on irrigation water demand. • DoE, DGPC: hydropower water supply and demand. • Ministry of Industry, Commerce and Employment (MoICE): Industrial water use data and economic development projections. • National Statistics Bureau: Population data and projections.

Recommendations/ Outputs

- Infrastructure Planning: Data on supply/demand gaps will inform the prioritization of new dams, water transfers, or water efficiency investments.
- Drought/Flood Preparedness: Monitoring data will support early warning systems and proactive management during extreme events.
- Demand Management: Identify sectors or regions where targeted water conservation campaigns or regulatory changes are most needed.
- Links to Other Modules: Water supply/demand data is essential for risk assessments (M2), water quality monitoring (M1.5), and financial planning (M6) within the NIWMP.

5.1.C. Water quality and health

Objective:
To establish a robust system for monitoring water quality parameters, tracking water-related health outcomes, and assessing the effectiveness of interventions aimed at protecting public health and ensuring water safety.

Description:
This submodule recognizes the intrinsic link between water quality and human well-being. It focuses on establishing baseline water quality conditions, detecting emerging contaminants, and linking epidemiological data (disease outbreaks) to water quality issues. It builds upon the water quality assessment done earlier (M1.5), setting in place ongoing monitoring to inform interventions.

Checklist

- Water Quality Monitoring: Design and implement a comprehensive water quality monitoring program covering drinking water sources, treated water supplies, rivers, and water bodies used for recreation. Analyze parameters such as turbidity, microbial contamination, heavy metals, pesticides, and emerging contaminants of concern.
- Health Data Tracking: Collaborate with the Ministry of Health to collect and analyze data on waterborne disease incidence (diarrhea, typhoid, etc.). Map disease hotspots to investigate potential correlations with compromised water quality.
- Public Education: Develop and disseminate educational materials on the relationship between water quality and health, safe water handling practices, and household water treatment options.
- Source Protection: Implement watershed protection plans to address pollution from agriculture, industry, and wastewater discharge. Enforce land-use regulations around critical water sources.
- Water Treatment Assurance: Conduct regular s of water treatment plants. Upgrade or expand treatment infrastructure as needed, and promote the use of point-of-use treatment options in areas where centralized systems are inadequate.
- Multi-Sectoral Coordination: Foster collaboration between the DoW, Local Water Service Providers, the Ministry of Health, and the Department of Environment & Climate Change to address water quality issues holistically.

Tools:	**Data Sources –**
T-3 Water Quality Management and Health Impact Strategy	• DoW, DECC: for environmental monitoring and can provide water quality data and analysis. • DoW and Thromde/Dzongkhag Water Service Providers: Responsible for the quality of drinking water supplies. • RCDC: Maintains records on waterborne diseases and epidemiological data. • NCHM: May have data on water quality trends in rivers.

Recommendations/ Outputs

- Targeted Interventions: Monitoring data will guide investments in treatment upgrades, source protection campaigns, or public health interventions in areas with the greatest need.
- Early Warning Systems: Water quality monitoring can support early detection of contamination events, preventing widespread health impacts.
- Behavior Change: Public awareness campaigns can drive the adoption of safe water practices, reducing the burden of illness.
- Links to Other Modules: Water quality data is essential for risk assessments (M2), understanding the impacts of pollution and climate variability (M1.6), and informing infrastructure decision-making throughout the NIWMP.

5.1.D. Financial sustainability

Objective:
To establish a system for tracking the financial viability of water service providers, identifying revenue shortfalls, and assessing the long-term affordability of water infrastructure investments.

Description:
This submodule recognizes that water is not a free good, and that sustainable service delivery requires sound financial management. It focuses on monitoring financial indicators to ensure that revenues generated through tariffs, fees, and other sources are adequate to cover the full cost of providing water services over their lifecycle. Building upon earlier financial assessments (M6), this submodule puts ongoing tracking in place.

Checklist

- Revenue Tracking: Regularly monitor revenue collection from water tariffs, connection fees, industrial water charges, and other potential income streams. Disaggregate revenue by source and by user type.
- Expenditure Analysis: Track operational expenses (energy, staff salaries, chemicals), maintenance costs, debt service, and capital investments. Categorize spending to identify areas where cost efficiencies might be possible.
- Cost Recovery Evaluation: Calculate the ratio of total revenues to total costs. Assess the extent to which current tariff structures allow for the recovery of the full cost of providing water and sanitation services.
- Sustainability Indicators: Develop and monitor a set of financial indicators relevant to the water sector, such as debt-to-equity ratio, operating ratio, and reinvestment ratio.
- Affordability Analysis: Track affordability metrics, considering water bills as a percentage of household income, especially for low-income groups. Assess if tariffs need to be better tiered to balance cost recovery and equity.
- Financial Forecasting: Develop financial models to project future revenue needs, operation and maintenance costs, and capital investments required for infrastructure expansion or upgrades.

Tools:	**Data Sources –**
T-4 Financial Sustainability Strategy for Water Services Management	• Department of Water, Local Water Service Providers: Financial statements, tariff schedules, billing records. • Ministry of Finance: May track data on subsidies or transfers to water service providers. • National Statistics Bureau: Data on household income levels for affordability analysis.

Recommendations/ Outputs

- Tariff Adjustments: Data may indicate the need to revise tariffs or fees to achieve greater cost recovery while maintaining affordability.
- Operational Efficiency: Identify areas where operational costs can be reduced or where revenue leaks can be fixed.
- Investment Planning: Financial projections will inform the prioritization and timing of infrastructure projects, balancing ambition with fiscal realities.
- Links to Other Modules: Financial sustainability is essential for implementing all NIWMP recommendations. It is intertwined with infrastructure planning, water conservation efforts, and the overall affordability of services to citizen.

5.1.E. Infrastructure and efficiency

Objective:
To establish a system for continuously assessing the condition of water infrastructure, measuring water use efficiency, and tracking progress toward minimizing losses and optimizing resource use.

Description:
This submodule focuses on the physical components of the water system and how effectively they are operated. Regular inspections, audits, and performance metering are essential to identify leaks, reduce energy consumption, and prioritize investments in upgrades or replacements. It builds upon the baseline infrastructure inventory conducted earlier (M1) and sets up a process for ongoing evaluation.

Checklist

- Asset Condition Assessment: Conduct scheduled inspections of critical infrastructure (pipelines, treatment plants, pumps) to document deterioration, leaks, or potential failure points. Utilize visual inspection, condition surveys, and non-destructive testing where possible.
- Water Loss Assessment: Quantify non-revenue water through a combination of metering, system modeling, and leak detection programs. Disaggregate non-revenue water into components like physical leakage, meter errors, unauthorized consumption, etc.
- Efficiency Benchmarking: Compare performance metrics like water losses per km of pipe or energy use per cubic meter of water treated to industry benchmarks. Identify areas where the system lags and where performance gains are possible.
- Infrastructure Renewal Planning: Based on condition assessments and efficiency analysis, prioritize repairs, replacements, or upgrades of key infrastructure assets. Develop a capital improvement plan with budget estimates and a timeline for implementation.
- Technology Evaluation: Research and assess the suitability of new technologies for water leak detection, smart metering, energy-efficient pumping systems, and other aspects of infrastructure management and operation. Consider pilot projects to test the feasibility and cost-benefit of innovative technologies.
- Capacity Building: Provide training to operations staff on infrastructure maintenance, preventative maintenance practices, leak detection techniques, and principles of operating an efficient system.

Tools:	**Data Sources –**
T-5 Strategies for Enhancing the Efficiency and Resilience of Water Infrastructure	• DoID, DoA, Local Water Service Providers: Maintenance records, asset inventories, pump station operational data. • DoE: may have records for energy use in treatment and pumping of water. • BSB (Bhutan standard Bureau), Bhutan schedule of rates have water efficiency standards or benchmarks for equipment. • Private Engineering Consultants: Can be contracted to conduct specialized asset inspections or efficiency audits.

Recommendations/ Outputs

- Data-Driven Investments: Monitoring results will inform decisions about where to prioritize infrastructure rehabilitation or replacement to maximize reliability and efficiency gains.
- Leak Reduction Campaigns: High non-revenue water may trigger leak detection programs, meter upgrades, or public awareness campaigns.
- Energy Savings: Tracking energy consumption can pinpoint areas to target for efficiency upgrades in pumping or treatment processes.
- Links to Other Modules: Infrastructure data is critical for water supply/demand forecasting (M1), links to financial sustainability analysis (M6), and informs adaptation planning in the face of climate change (M1.6).

M.5.2 Interpretation and standardization

5.2.A. Analytics and GIS mapping

Objective:

To establish a comprehensive and effective system for collecting and managing spatial data, leveraging geospatial analysis techniques, and creating insightful visualizations that empower informed decision-making for water resource management.

Description:

This submodule recognizes the power of location-based data to reveal patterns, trends, and interrelationships that might be missed in spreadsheets or reports. It focuses on leveraging GIS tools to visualize complex datasets, support scenario modeling, and identify areas needing attention. This submodule builds upon earlier data collection efforts (M3) and provides the analytical backbone for several other aspects of the NIWMP.

Checklist

- Data Standardization: Collect spatial data (water infrastructure locations, water body boundaries, land use/land cover, etc.) from various sources and ensure it is georeferenced and formatted consistently for integration within a GIS environment.
- GIS Basemap Development: Create a comprehensive basemap of Bhutan's water resources, including layers for rivers, aquifers, watersheds, water intake points, treatment plants, distribution networks, and critical hydrological infrastructure.
- Demand Mapping: Overlay population density data, economic activity data, and water use records onto the basemap to visualize patterns of water demand and pinpoint areas of high consumption.
- Risk Mapping: Integrate climate data, flood hazard maps, and land use change data to identify areas prone to water scarcity, pollution events, or conflicts over water.
- Resource Allocation Modeling: Employ GIS tools for analytical tasks like optimizing routes for water tankers during emergencies, siting new infrastructure based on demand forecasts, or prioritizing watershed restoration efforts.
- Public Information Portal: Develop a user-friendly online map viewer providing access to key water resource information for the public and stakeholders. This promotes transparency and engagement.

Tools:	**Data Sources –**
T-6 GIS-Driven Approach for Advanced Water Management and Planning	• National Land Commission Secretariat (NLCS): Land use maps, topographic data, cadastral data. • Department of Water (DoW), Local Water Service Providers, DoID: Location and attributes of water infrastructure assets. • NCHM: Rainfall data, watershed boundaries, hydrological data. • DoW, Department of Geology and Mines (DGM): Groundwater data, aquifer boundaries. • National Statistics Bureau (NSB): Population data, land use information.

Recommendations/ Outputs

- Informed Decision-Making: GIS analysis allows for data-driven decisions on infrastructure investments, demand management strategies, and conservation measures.
- Risk Mitigation: Maps of vulnerable areas support proactive planning and the implementation of climate adaptation measures.
- Transparency and Engagement: Sharing GIS outputs with the public builds awareness and can encourage participation in water resource protection.
- Links to Other Modules: GIS supports nearly every aspect of the NIWMP – data collection, infrastructure planning (M6), assessing the impacts of pollution (M1.5), and more.

5.2.B. Benchmarking and best practices

Objective:

To establish a systematic process for comparing Bhutan's water management performance to established standards, identifying proven best practices from around the world, and adapting them to drive continuous improvement in water resource management across all sectors.

Description:

This submodule recognizes that there's no need to reinvent the wheel. By looking beyond Bhutan's borders, water managers can learn from the successes and failures of others. It focuses on identifying relevant performance metrics, researching comparable case studies, and creating a culture of striving for continuous improvement. This submodule builds on the foundation laid by earlier data collection (M1 and M3) and performance monitoring efforts.

Checklist

- KPI Development: Define clear and measurable Key Performance Indicators (KPIs) for aspects such as water use efficiency, water quality compliance, customer satisfaction, infrastructure reliability, and financial sustainability.
- Benchmarking: Compare Bhutan's KPIs to national targets, regional benchmarks, or international standards set by organizations like the International Water Association (IWA). Identify areas where performance lags.
- Best Practice Search: Conduct thorough research of academic journals, technical reports, and online case study repositories to uncover successful water management strategies worldwide, with a focus on contexts similar to Bhutan's.
- Applicability Assessment: Critically evaluate the relevance of best practices to Bhutan's unique conditions (legal, cultural, environmental). Consider the need for adaptation before adoption.
- Pilot Projects: Implement promising best practices on a small scale to test their effectiveness in the local context and gather data for a full-scale rollout decision.
- Continuous Improvement: Regularly review performance against benchmarks and best practice standards. Update strategies and action plans to continually improve water management practices.

Tools:	**Data Sources –**
T-7 Framework for Implementing Best Practices in Water Management	• Department of Water (DoW), Local Water Service Providers: Operational data for KPI tracking. • Ministries and Agencies in other sectors: Data relevant to water-related KPIs in agriculture, energy, tourism, etc. • International Water Association (IWA) and other professional bodies: Benchmarking resources, performance standards. • World Bank, Asian Development Bank: Water management case studies, reports with international data. • Academic Literature: Research papers and case studies relevant to Bhutan's context. • BSB (Bhutan standard Bureau), Bhutan schedule of rates have water efficiency standards or benchmarks for equipment.

Recommendations/ Outputs

- Targeted Improvement Plans: Benchmarking pinpoints areas needing attention, leading to focused investments and capacity-building programs.
- Innovation Mindset: Exposure to global best practices helps challenge the status quo and spurs innovation in finding locally appropriate solutions.
- Links to Other Modules: Best practices can influence water use efficiency efforts (M1.2), set higher standards for water quality (M1.5), and inform infrastructure investments (M6).

- Global Partnerships: Benchmarking can open doors for collaboration and knowledge exchange with international experts or leading institutions.

5.2.C. Stakeholder engagement and feedback

Objective:
To establish inclusive and effective channels for communication and collaboration between water managers, diverse stakeholders, and the affected public, ensuring the NIWMP is informed by a wide range of needs and perspectives, enhancing the plan's acceptance and long-term success.

Description:
The NIWMP's success depends on broad stakeholder support. Effective engagement ensures everyone with a stake in Bhutan's water resources has a voice in the planning process. Building relationships, actively soliciting feedback, and demonstrating responsiveness to input fosters trust and ownership. This approach is essential from the early planning stages (informed by baseline data collection in M1) through implementation (to address issues raised during monitoring and evaluation in M5.3). Effective stakeholder engagement can also help identify data gaps (feeding back into M3.1) and ensure the chosen best practices (M5.5) are culturally appropriate and socially acceptable.

Checklist

- Stakeholder Mapping: Create a comprehensive list of all individuals, groups, organizations, and government agencies with a stake in water resources in Bhutan. Categorize them by their type of interest or influence.
- Outreach Strategy: Design a plan specifying how and when different stakeholder groups will be engaged. Select engagement methods (workshops, interviews, surveys, online forums) that are appropriate for each group and inclusive of diverse voices.
- Clear and Accessible Communication: Disseminate information about the NIWMP's goals, progress, and proposed actions using plain language through multiple channels (websites, newsletters, community meetings) ensuring accessibility for people with varying levels of literacy and technical knowledge.
- Multiple Feedback Channels: Establish formal mechanisms for stakeholders to submit comments, concerns, and suggestions – both online and in-person where appropriate.
- Transparent Response: Document all feedback received and demonstrate how it was considered. Where feasible, modify the NIWMP in response to input, and communicate these changes. When ideas cannot be implemented, examine the cause.
- Iterative Engagement: Don't treat engagement as a one-time event. As the NIWMP is implemented and revised, plan for ongoing opportunities for stakeholder input and review.

Tools:	**Data Sources –**
T-8 Stakeholder Engagement Plan for Water Resource Management	• Thromde/Dzongkhag Administrations: Records on community groups, local NGOs, businesses with a major water footprint. • Sectoral Departments (Agriculture, Industry, Tourism etc.): May have their own stakeholder networks relevant to water issues. • NSB: Census data and demographics studies: Can help identify marginalized groups to ensure their voices are included. • Feedback forms, meeting minutes, etc.: Documentation of the public participation process.

Recommendations/ Outputs

- Broad-Based Support: Effective engagement helps to build consensus for the NIWMP, potentially reducing conflicts and easing implementation hurdles.
- Locally Relevant Solutions: Input from the community can highlight place-specific problems or potential solutions that technical experts may not be aware of.

- Links to Other Modules: Meaningful stakeholder engagement can provide crucial input about water demand patterns (M1.2), concerns around water quality (M1.5), and can influence public awareness campaigns (M4.3).

M.5.3 Performance evaluation and continuous improvement

5.3.A. Monitoring and progress tracking

Objective:
To establish a comprehensive system for tracking progress against the NIWMP's goals, analyzing outcomes, identifying areas for improvement, and adapting strategies to ensure water management initiatives remain effective and impactful over time.

Description:
This submodule recognizes that the NIWMP is not a static document, but a living roadmap. It emphasizes regular assessment against key performance indicators, gathering feedback from diverse stakeholders, and using those insights to drive adjustments. This ensures the plan stays aligned with changing needs and that successful innovations are scaled up. It builds upon all prior data collection and monitoring activities.

Checklist

- KPI Tracking: Establish clear Key Performance Indicators (KPIs) linked to the NIWMP's goals (water supply expansion, quality improvement, conservation gains, etc.). Regular monitoring is essential to reveal if targets are being met.
- Progress Reporting: Produce regular reports that summarize progress against goals, highlight milestones achieved, and identify areas where performance is lagging. These reports should be accessible to all stakeholders.
- Outcome Analysis: Conduct in-depth analysis at planned intervals (annually or bi-annually) to understand the root causes of both successes and failures. Go beyond just KPIs to look at how well actions are serving the broader intent of the NIWMP.
- Review Meetings: Hold structured meetings with stakeholders from government agencies, the private sector, and the community to discuss progress, challenges, and potential course corrections.
- Adaptive Management: Explicitly incorporate mechanisms for adjusting plans, budgets, or project timelines based on monitoring and evaluation findings.
- Learning Culture: Encourage a culture of openness within implementing agencies where problems are seen as opportunities to learn and improve, rather than failures to be hidden.

Tools:	**Data Sources –**
T-9 Framework for Effective Monitoring and Adaptive Management in Project Implementation	•Department of Water (DoW), Local Water Service Providers, DoID: Data on infrastructure performance, service levels, water quality. •Department of Environment & Climate Change: Environmental monitoring data that may reflect the impacts of water management practices. •Ministries and Agencies in other sectors: Data relevant to water-related KPIs and outcomes in agriculture, public health, etc. •Stakeholder surveys, interviews, focus groups: Qualitative and quantitative feedback about the perceived impact of the NIWMP and its actions.

Recommendations/ Outputs

- Data-Driven Decision-Making: Monitoring data should directly inform the reallocation of resources or the modification of programs.
- Enhanced Efficiency: Tracking reveals where efforts are paying off and where processes can be streamlined.
- Stakeholder Confidence: Transparent reporting builds trust, showing that the NIWMP is held accountable and responsive.
- Links to Other Modules: This submodule ensures that lessons learned lead to improvements in data collection (M3), infrastructure design (M6), policy (M2), and ultimately overall water resource outcomes (M1).

5.3.B. Adaptive management

Objective:

To establish a culture of continuous learning and responsiveness within Bhutan's water management sector, promoting the ongoing refinement of strategies and recognizing that the NIWMP is a living document, not just a plan that is set in stone.

Description:

This submodule focuses on moving beyond rigid adherence to the original plan and being open to making changes as new information arises, challenges emerge, or technologies evolve. It emphasizes structured experimentation, learning from pilot projects, and incorporating stakeholder feedback to guide improvements. This submodule builds upon earlier monitoring activities (M5.2, M5.6) by putting the resultant data to practical use.

Checklist

- Problem Identification: Use monitoring data, stakeholder feedback, and insights from staff to pinpoint specific areas where performance is suboptimal or new opportunities have emerged.
- Brainstorming Solutions: Hold workshops that bring together technical experts, community members, and relevant stakeholders to develop a range of potential solutions, fostering creativity beyond the usual approaches.
- Piloting and Evaluation: Select the most promising improvements to test on a small scale before full implementation. Carefully monitor pilot results using pre-defined metrics.
- Gathering Feedback: Solicit input from participants in the pilot project and the wider community about the effectiveness and acceptability of the tested changes.
- Scaling or Refinement: Based on pilot results and feedback, make decisions about scaling up successful improvements, iteratively refining them, or abandoning changes that don't work as intended.
- Knowledge Sharing: Document the process, including challenges and lessons learned, and share these case studies both internally across government agencies and externally with the public.

Tools:	**Data Sources –**
T-10 Continuous Improvement Process for Project and Program Improvements	• DoID, Department of Water (DoW), Local Water Service Providers: Operational data and staff insights on bottlenecks and potential innovations. • Stakeholder feedback channels (surveys, meetings, etc.): Concerns, ideas, and positive experiences from water users. • Academic institutions and research centers in Bhutan: May be sources of new water management technologies or pilot project partners. • Pilot project data: Specific outcomes and performance metrics from the testing of improvements.

Recommendations/ Outputs

- Resilient and Responsive Systems: This approach helps to make the NIWMP robust even in the face of unexpected shocks or a changing environment.
- Enhanced Innovation: Encouraging adaptive management stimulates a culture of problem-solving and continuous improvement.
- Links to Other Modules: Adaptive management can lead to the refinement of data collection (M3), infrastructure design (M6), policy (M2), and ultimately, the overall success of the NIWMP in achieving its goals for Bhutan (M1).

5.3.C. Incorporating innovation

Objective:
To ensure that Bhutan's water management sector actively seeks out, evaluates, and adopts new technologies and practices that have the potential to improve efficiency, resilience, and sustainability, avoiding stagnation and maximizing the benefits of the NIWMP.

Description:
This submodule recognizes that the water challenges faced today might not be best solved with the tools of yesterday. Integrating innovation involves remaining on the lookout for new approaches, from advanced water treatment systems to community-driven conservation programs. This often requires building partnerships with universities, the private sector, and looking for inspiration from other countries. It builds upon problem identification within other monitoring modules (ex: if water quality issues persist, look beyond traditional solutions).

Checklist

- Innovation Scouting: Establish mechanisms for staying updated on global water innovations (conferences, research journals, online platforms).
- Applicability Assessment: Critically evaluate the relevance of emerging innovations to Bhutan's specific needs, environmental conditions, and resource capabilities.
- Pilot Projects: Implement promising innovations as small-scale pilots, collecting comprehensive data on their performance, cost-effectiveness, and social acceptability.
- Stakeholder Engagement: Integrate feedback from water users, local communities, and experts throughout the innovation cycle.
- Scaling Up: Develop plans to transition successful pilot projects to full-scale implementation, incorporating lessons learned during the testing phase.
- Monitoring and Refinement: Continue to monitor the performance of adopted innovations to ensure they remain effective in the long run and to identify areas for further adjustment.

Tools:
T-11 Innovation Integration Strategy for Enhancing Water Management Systems

Data Sources –

- International Orgs: IWA, World Water Council, ADB Water Knowledge Hub, GWP etc.
- Case Study Platforms: SuSanA, The Water Channel, Circle of Blue.
- Innovation Hubs Imagine H2O, Isle Utilities.
- DHI (Druk Holding and Investment).
- RUB and research centers.

Examples and Best Practices (Global)

- Nature-based Solutions: Mimicking natural systems in stormwater capture, flood control, and water treatment.
- Smart Metering and Leak Detection: Reducing water loss and enabling data-driven water management.
- Decentralized Systems: Small-scale treatment and reuse options for areas where central infrastructure is less feasible.
- Participatory Water Governance: Innovative decision-making models that give communities a stronger voice.

Recommendations/ Outputs

- Innovation-Friendly Policies: Review policies to ensure they don't create unnecessary barriers to adopting new approaches, and may even provide incentives to spur innovation.
- Collaboration Hubs: Consider establishing formal partnerships or innovation hubs between government agencies and research institutions to accelerate the adoption of new technologies in Bhutan.
- Links to Other Modules: Innovation is vital for nearly every aspect of the NIWMP, finding new water resources (M1), more efficient infrastructure(M6), and better ways to engage the public (M4).

M.5.4 Good Practices and Recommendations

Case Study 19

Performance Assessment System (PAS), developed by CEPT

CEPT University's PAS initiative is a notable effort to enhance data-driven management of urban water and sanitation services (UWSS) in India. The system provides a comprehensive framework for assessing service delivery in alignment with the government's Service Level Benchmarking (SLB) goals. PAS offers cities an online platform to input data and calculate key performance indicators (KPIs), enabling them to set targets and track progress. The system facilitates benchmarking, allowing for comparisons between cities. Importantly, PAS makes this data widely accessible through annual datebooks and interactive dashboards on their website, promoting transparency and informed decision-making.

Read more: PAS Project - Center for Water and Sanitation

PAS initiative directly supports Module 5 by standardizing KPIs for urban water management (M5.2), enabling performance tracking and benchmarking (M5.3, M5.7). The focus on making data publicly accessible empowers stakeholders and facilitates feedback mechanisms, both of which are crucial for continuous improvement within the sector (M5.6).

Case Study 20

SLB-Connect for Citizen Feedback

The SLB-Connect tool aligns with Service Level Benchmarks (SLB) initiative aimed at improving urban service delivery. It offers a streamlined solution for gathering citizen feedback about water and sanitation services through mobile-based surveys. The tool boasts a user-friendly web dashboard for real-time monitoring, analysis, and visualization of survey results. Its "traffic light" display system simplifies interpretation, with red highlighting areas of poor performance and green indicating areas where services meet expectations. Further enhancements include customizable analysis, map views, and tailored reports for city managers, aiding in more targeted decision-making.

Read more: SLB connect for urban water supply and sanitation

The SLB-Connect tool supports Module 5's focus on monitoring and evaluation. It provides a platform for gathering user-centric feedback on water services (M5.1), and likely standardizes survey questions and data visualization for easier interpretation (M5.2). Its emphasis on citizen participation aligns with stakeholder feedback goals (M5.6), while the focus on identifying areas for improvement supports continuous service enhancement (M5.7).

Case Study 21

Mekong Integrated Water Resources Management Project (IWRM)

The Mekong IWRM Project is a multilateral effort between the countries of the Mekong River Basin (Cambodia, Laos, Thailand, Vietnam) focused on transboundary water management. It emphasizes collaboration and data-driven decision-making. Key components include the development of a basin-wide monitoring network and data sharing mechanisms to track water availability, quality, and usage patterns. To ensure data is used effectively, the project also invests in modeling and forecasting tools to understand hydrological trends, predict potential conflicts, and simulate the impacts of different management scenarios. Decision Support Systems (DSS) are being developed to aid

governments and other stakeholders in collaborative planning, incorporating the complex interplay of social, economic, and environmental factors across the basin.
Read more: Mekong Integrated Water Resources Management Project

The Mekong IWRM Project emphasizes data-driven water management, supporting Module 5. Its monitoring of water use across sectors informs the evaluation of water needs (M5.1). Modeling and decision support tools enable the assessment of policies and interventions (M5.3). Its collaborative approach fosters data sharing, aiding in the benchmarking of water management strategies across the basin (M5.5). The focus on regular monitoring and evaluation supports adaptive management in a dynamic transboundary context (M5.7).

Case Study 22

Smart Water Metering- Singapore

Singapore has taken a technology-driven approach to water conservation and leak detection through smart water meters. These meters transmit real-time or near real-time data on household and commercial water use. This high-resolution data allows utilities to pinpoint leaks quickly, reducing water loss. Additionally, consumers can access their usage data through apps or portals, promoting awareness and empowering them to make informed choices about water usage.

Read more: Smart Water Meter, Smart nation Singapore

Smart water metering facilitates the continuous monitoring of water usage across several sectors, directly supporting Module 5 (M5.1). This data streamlines the identification of inefficiencies or leaks (M5.2) and helps evaluate conservation policies and leakage reduction efforts (M5.7). Further, this granular data enhances water demand forecasting (Module 1), aiding in proactive supply management. Additionally, real-time monitoring can pinpoint areas where infrastructure may be strained, informing targeted upgrades or repairs (Module 6).

Case Study 23

Water Evaluation and Planning System (WEAP)

The WEAP software offers a powerful tool for modeling complex water systems, supporting planners and policymakers. It simulates water availability, considering sources like rivers, reservoirs, and groundwater. Simultaneously, WEAP models water demands across diverse sectors (agriculture, industry, domestic). Crucially, it allows users to explore "what if" scenarios by testing the impacts of policy changes, population growth, infrastructure development, or climate change. This scenario-based approach aids in long-term planning and facilitates the comparison of different management strategies to identify those that best meet water needs while ensuring sustainability.

Read more: WEAP ("Water Evaluation and Planning" system)

WEAP can be a valuable tool for Bhutan's NIWMP. It supports the baseline assessment (Module 1) by integrating data on water resources (M1.1) and analyzing current and future water demands (M1.2). WEAP aids in the evaluation of existing water management practices and potential policy or infrastructure interventions (Module 5). Further, the tool can inform financial planning (Module 6) by allowing cost-benefit analysis of different scenarios, considering their long-term impacts on water supply and demand.

K. M.6 FINANCE

Introduction:
Module 6 in the NIWMP framework emphasizes the essential role of finance in water resource management, integrating need assessment, cost estimation, funding sources, and climate finance into a comprehensive financial strategy. Interlinking with data management and capacity building, this module draws on analytics and GIS mapping to quantify current and projected financial demands, ensuring every monetary decision is grounded in solid data and contributes to the master plan's resilience.

Key Areas of Focus:

The module is organized into interconnected submodules:

- **Need Assessment:**
  - It involves evaluating current capital expenditure (Capex), operational expenditure (Opex), user charges, taxes, and conducting cost-benefit analyses.

- **Proposed Cost Estimates:**
  - This involves formulating financial models for recommended initiatives and ensuring they are economically viable and sustainable.

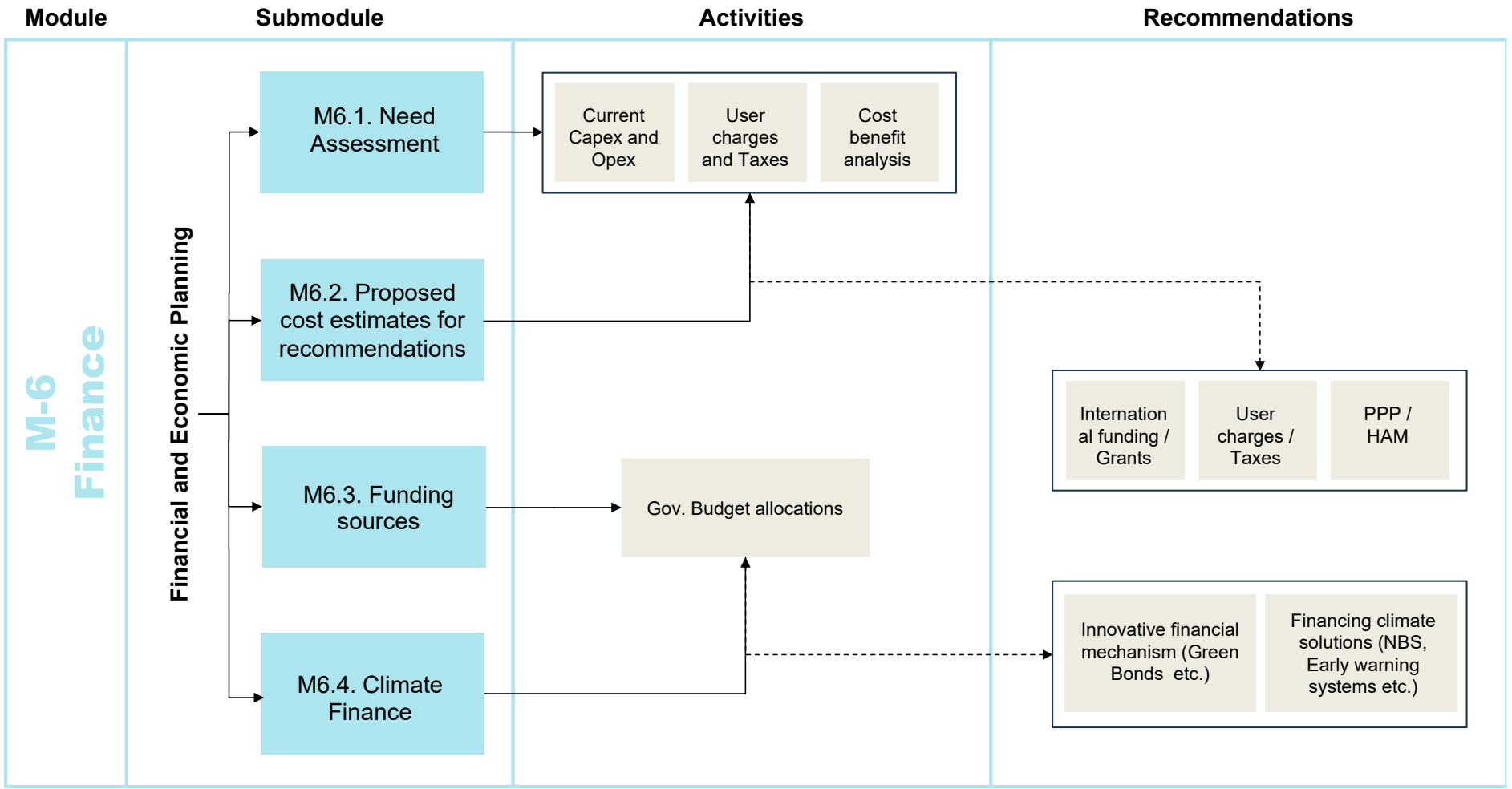
- **Funding Sources:**
  - The module explores government budget allocations, international funding, grants, Public-Private Partnerships (PPP), and innovative financing mechanisms like Green Bonds.

- **Climate Finance:**
  - This focuses on securing funds specifically for climate adaptation and mitigation measures, vital for the long-term sustainability of water resources.

Objective
The main goal of Module 6 is to create a strong financial foundation for the water master plan, balancing financial caution with the requirement for strong, climate-resistant water infrastructure. It strives to provide a transparent financial plan that is in line with Bhutan's developmental and environmental objectives.

Target Users
The primary users of this module include financial and economic experts from the Department of Water, Bhutan, and international funding bodies like the UNDP. These users play a crucial role in shaping the financial landscape of water management through strategic budgeting, identifying funding sources, and ensuring economic sustainability. Their insights and expertise are fundamental to realizing the goals set forth in the National Integrated Water Master Plan.

Flow chart representing Interlinkage between sub-modules of Finance module:



M.6.1 Need assessment

6.1.A. Current Capital expenditure (Capex) and Operating Expenditure (Opex)

Objective:
To establish a comprehensive baseline understanding of current financial allocations and spending patterns for water infrastructure in Bhutan. This includes capital expenditures (construction) and ongoing operating and maintenance costs (Opex).

Description:
This submodule provides a financial snapshot of Bhutan's water sector. It moves from overall inventory done previously (M3.1) to understanding the costs to build and maintain these assets. The data collected will be crucial for comparing funding needs identified in the NIWMP against current spending levels. This module links to earlier data collection on tariffs and cost recovery (M6.2) to assess financial sustainability.

Checklist

- Sectoral Investment Analysis: Utilize the sectoral share insights from M.2 to assess how Capex and Opex are allocated across various water infrastructure projects.
- Historical Budget Review: Align with the budget trends analysis from M.2 to note the trajectory of investments and operational funding in water sector over the past decade.
- Infrastructure Spending Balance: Reflect on the Capital vs. O&M examination from M.2 to critique if current expenditures are favoring new projects over essential maintenance.
- Funding Source Mapping: Correlate with the agency breakdown from M.2 to specify how different water management bodies finance their capital and operational expenses.
- Policy and Budget Congruence: Leverage the policy alignment review from M.2 to ensure Capex and Opex reflect the national water policy objectives.
- Expenditure Mechanisms: Discuss if the budgeting process identified in M.2 is coherent with the funding structures in place for current Capex and Opex, identifying any discrepancies or opportunities for optimization.

Tools:
T-1 Financial Analysis Checklist for Existing Water Infrastructure Management

Data Sources –

- Ministry of Finance (MoF): This is the umbrella ministry overseeing all government spending. Relevant departments within the Ministry of Finance include:
  - Provides a macroeconomic perspective on government budgeting and resource allocation.
  - Focuses on annual government budgets and expenditure allocations across sectors, including water.
  - Maintains records of government expenditure and can provide insights into historical spending patterns on water infrastructure.
  - Collects government revenue and can inform on trends in water-related fees or taxes.
- Dzongkhag and Thromde Water Supply and Sanitation – Operation and maintenance aspects.
- DoE: Hydropower & Power Systems (for hydropower infrastructure).
- DoW: Financial records of the water infrastructure projects.

Recommendations/ Outputs

- Expenditure Trends: Identify whether spending has been mainly on new construction (Capex) or on Opex (maintenance). Evaluate if Opex allocation is sufficient.
- Geographic Disparity Analysis: Disaggregate data by dzongkhag, thromde, or gewog to reveal disparities in funding or challenges specific to certain regions.
- Master Plan Inputs: The NIWMP will likely propose new infrastructure and capacity-building. This submodule provides the baseline against which future financial needs can be estimated.

6.1.B. User charges

Objective:
To analyze existing user charges (water tariffs) for different consumer categories across water supply, wastewater management, and stormwater drainage (where applicable). This submodule evaluates the adequacy and equity of current pricing structures.

Description:
This submodule examines whether the price of water reflects its true value and covers the costs of providing the service. It connects back to the infrastructure inventory (M1) and Opex analysis (M6.1), asking whether revenue raised through tariffs keeps pace with operating and maintenance needs. Equitable tariffs encourage conservation while ensuring that low-income users can still access basic water services.

Checklist

- Tariff Structures: Obtain current tariff schedules for various water services (supply, wastewater, stormwater) disaggregated by user type (residential, commercial, industrial, agricultural, etc.).
- User Base: Determine the number of active paying customers in each water service category and analyze trends over at least the past five years. Identify if connections are metered or charged a flat rate.
- Revenue Collection: Examine the total revenue generated by user charges over the past five years or longer if data is available. Determine if revenue has kept pace with inflation and increased operating costs.
- Cost Recovery: Assess whether user charges are sufficient to cover a significant portion of the Opex for providing water services. Identify any subsidies or reliance on external financing.
- Tariff Policies: Examine the rationale behind current tariff structures. Investigate if they aim to promote water conservation, ensure affordability, or incentivize infrastructure investment.

Tools:	**Data Sources –**
T-2 Revenue Collection Analysis for Water Services: User Charges and Taxes Overview	• Department of Water: plays a significant role in regulating. • Dzongkhag and Thromde Water Supply and Sanitation: Local bodies may have water-related user charges for areas under their jurisdiction. • Agencies responsible for hydropower, irrigation, or other specialized water uses: Obtain tariff information as applicable. • Ministry of Finance and DoW: Provide information on broader policies related to water pricing or taxation of water-intensive industries.

Recommendations/ Outputs

- Financial Sustainability: Evaluate whether tariffs generate sufficient funds to maintain a basic level of service, or if reliance on government funding is unsustainable in the long term.
- Equity Analysis: Consider if tariffs disproportionately burden low-income users or hinder economic development.
- Master Plan Inputs: The NIWMP may recommend tariff revision, introducing tiered pricing, or targeted subsidy mechanisms. Analysis of affordability and willingness-to-pay (from earlier stakeholder engagement) should inform these recommendations.

6.1.C. Cost-benefit analysis

Objective:
To evaluate the financial viability of existing water services by comparing costs (Capex and Opex) against revenues generated from user charges or other sources. This analysis aims to identify services that run deficits and explore potential financing solutions.

Description:
This submodule examines whether water services are recovering their costs and therefore financially sustainable in the long term. It builds upon previous submodules that assessed expenditure patterns (M6.1) and analyzed tariff structures (M6.2). A sound CBA helps justify investment in water infrastructure upgrades or management reforms to achieve greater benefits for society and the environment.

Checklist

- Cost Assessment: Gather data on total costs (Capex and Opex) associated with providing water services over at least the past five years. Disaggregate costs by type of infrastructure (water supply, sanitation, etc.) and service area (dzongkhag, thromde, or gewog).
- Revenue Assessment: Collect revenue data generated through user charges, taxes, or other sources related to water services over the same period as the cost assessment.
- Cost-Benefit Ratio: Calculate the ratio of total costs to total revenues for each category of water service and geographic area. A ratio below 1 indicates that revenues are insufficient to cover costs.
- Sensitivity Analysis: If detailed CBA studies are not readily available, conduct a simplified analysis to test how sensitive revenue is to changes in tariffs, user base expansion, or efficiency improvements.

Tools:	**Data Sources –**
T-3 Annual Financial Overview and Cost-Benefit Analysis for Water Sector	• Ministry of Finance: For understanding current subsidy programs and revenue allocation policies impacting water services. • DoW: Support in preparation of guidelines and analysis at urban and rural areas. • Academic Studies or Consultancies: Research past CBAs conducted for water infrastructure or service delivery models in Bhutan.

Recommendations/ Outputs

- Financial Health Check: This submodule provides a snapshot of which water services are financially viable and where cost recovery is a major challenge.
- Tariff Design: CBA informs tariff reforms by indicating if they need to be raised, made more progressive to protect low-income users, or if new subsidies are needed.
- Master Plan Inputs: The NIWMP may recommend expanding water services. The CBA will establish a baseline of existing costs/benefits, against which the financial implications of the proposed expansion can be analyzed.

M.6.2 Proposed cost estimates for recommendations

Objective:
To assess the financial implications (Capex and Opex) of the various technical, institutional, governance, and public awareness (IEC) solutions proposed in the NIWMP. This submodule ensures that proposed solutions are not only technically sound but also financially viable, supporting the long-term implementation of the plan.

Description:
This submodule bridges the gap between identifying needs and designing solutions. It grounds the recommendations by analyzing associated capital and operating costs. Emphasis is placed on exploring innovative financing models and ensuring that the anticipated benefits justify the investment needed. It builds upon previous submodules that assessed existing costs and financing mechanisms (M6.1, M6.2, and M6.3).

Checklist

- Costing Solutions: For each proposed solution (technology, new institution, regulation change, IEC campaign), estimate the initial capital expenditure (Capex) and projected ongoing operating costs (Opex) over a planning horizon aligned with the NIWMP (up to 2050).
- Funding Sources: Identify potential funding avenues for both Capex and Opex, considering government budgets, external donor support, private sector investment, community contributions, and potential new revenue streams.
- Revenue Potential: If solutions introduce user charges, estimate the potential revenue considering the targeted population, affordability, and willingness to pay.
- Cost-Benefit Analysis (CBA): Conduct a CBA for each major proposed intervention, comparing costs to a wider range of anticipated benefits. These benefits may include direct cost savings, enhanced service efficiency, health benefits, and environmental improvements.
- Alternative Scenarios: Develop at least three alternative funding scenarios for implementing the NIWMP recommendations, with varying levels of government support, private sector involvement, and community participation.

Tools:	**Data Sources –**
T-4 Evaluation and Recommendation Framework for Sustainable Water Management Solutions	• NIWMP Technical Studies: Reference detailed technical feasibility studies to extract cost estimates for proposed infrastructure or technologies. • Vendors and Private Sector: Consult with potential equipment suppliers or technology providers to understand pricing and long-term maintenance costs. • International Case Studies: Research similar water management projects in comparable contexts to benchmark costs and identify innovative financing models. • Ministry of Finance: For accessing macroeconomic projections and understanding the government's fiscal space for future water-related investments.

Recommendations/ Outputs

- Phased Implementation: Outline a financially realistic schedule for phasing in major NIWMP recommendations, balancing ambition with available resources.
- Financing Strategy: Develop a financing strategy that combines traditional sources with exploring innovative mechanisms such as green bonds, water impact funds, or payment for ecosystem services schemes.
- Master Plan Integration: The NIWMP needs a dedicated chapter on financial sustainability, not just technical solutions. This chapter will outline the overall costs of the plan, diverse funding sources, and any necessary changes to policy or financial regulations to enable implementation.

M.6.3 Funding sources

6.3.A. Gov. budget allocations

Objective:
To analyze past and current government budget allocations specifically for the water sector (including water supply, wastewater, and stormwater management). Assess trends in funding, uncover potential cross-sectoral linkages, and identify opportunities for reallocation or new funding streams to support the NIWMP.

Description:
This submodule examines how water is prioritized in Bhutan's national budget. It looks beyond total allocation to understand which types of projects receive funding (infrastructure, capacity-building, etc.). By analyzing spending across ministries, it aims to identify sectors with overlapping needs and scope for collaborative funding. This module links to earlier modules that examined current expenditures (M6.1).

Checklist

- Water Sector Budget Disaggregation: Obtain budget breakdowns for the past five years (if possible), specifically highlighting line items related to water supply, sanitation, stormwater, irrigation, hydropower, or disaster risk reduction associated with floods and droughts.
- Funding Trend Analysis: Examine if budget allocations for the water sector have been increasing, decreasing, or remaining stagnant in real terms (adjusted for inflation).
- Cross-Sectoral Spending: Analyze budget allocations to other ministries (Agriculture, Forestry, Environment, Health, etc.) to identify programs or projects that have a direct or indirect water component.

Tools:	**Data Sources –**
T-5 Comprehensive Budget Analysis for Water Supply, Wastewater, and Stormwater Infrastructure	Ministry of Finance: • Provides detailed annual national budget documents. • Offers a macroeconomic perspective on government spending patterns and fiscal space. • Operationalization of Bhutan Climate fund(BCF). Relevant Line departments: Dzongkhag and Thromde, DoA, DoW, MoIT, DoID and other departments.

Recommendations/ Outputs

- Budget Advocacy: Identify gaps between current funding and the anticipated financial needs outlined in the NIWMP. This can support advocacy for increased budget allocations to the water sector.
- Cross-sectoral Collaboration: Highlight opportunities for ministries to pool resources or jointly design projects that address multiple objectives (water for agriculture, disaster resilience, etc.).
- Master Plan Inputs: The NIWMP may recommend streamlining funding applications or creating dedicated funding mechanisms for integrated water projects to address fragmentation.
- Innovative Financing: Explore innovative financing options such as engaging with banks for loans, developing Public-Private Partnerships (PPPs), adjusting water tariffs to ensure cost recovery and sustainability, and identifying new revenue-generating sources like ecosystem services payments.

6.3.B. Other funding sources

Objective:
To map the spectrum of non-governmental funding sources that have contributed or can contribute to Bhutan's water sector. This includes international grants, loans, and partnerships, aiming to align external financial support with the goals of the NIWMP.

Description:
This activity seeks to chart a comprehensive landscape of international funding bodies, their contributions to Bhutan's water sector, and the alignment of these projects with the country's water management priorities. It will explore opportunities for synergies and additional funding that can enhance the scope and impact of the NIWMP, looking at the variety and suitability of international funds available. This module links to earlier modules that examined current expenditures (M6.1).

Checklist

- International Project Tracking: Document international water-related projects and their funding sources, such as loans and grants, previously or currently active in Bhutan.
- Partner Alignment: Evaluate the alignment of these projects with Bhutan's national water sector priorities and the NIWMP's objectives.
- External Funding Mechanisms: Review the terms, conditions, and impact of financial support provided by international partners like the World Bank, ADB, and various UN agencies.
- Potential for Diversification: Assess the potential for diversifying funding sources, considering the range of international donors including UNDP, EU, SAARC, FAO, WWF, UNFCCC, GEF, GCF, and the Adaptation Fund.

Tools:
T-6 International Funding Overview: A compilation of data related to external funding sources for the water sector in Bhutan.

Data Sources –

- Records of international cooperation and aid for water projects.
- International Partner Publications: Reports from UNDP, EU, SAARC, FAO, WWF, World Bank, ADB, UNFCCC, GEF, GCF, and Adaptation Fund regarding their engagements in Bhutan's water sector.
- Project Reports: Specific reports and evaluations from completed and ongoing projects funded by international bodies.

Recommendations/ Outputs

- Funding Strategy: Develop a strategy to engage with and leverage international funding for the water sector more effectively.
- Partnerships Development: Foster stronger relationships with existing and new international donors to support the implementation of the NIWMP.
- Project Synergy: Identify international projects that can be integrated into the NIWMP for enhanced water resource management, considering climate resilience and sustainable development goals.
- Links to Subsequent Modules: Utilize insights from international funding experiences to inform financial planning and strategy modules within the NIWMP.

M.6.4 Climate Finances

Objective:
To assess Bhutan's past success in accessing climate finance for water-related projects, identify gaps in current funding, and explore innovative financial mechanisms to support the implementation of climate-resilient solutions proposed in the NIWMP.

Description:
This submodule recognizes that water security is inherently linked to climate change. It investigates funding specifically earmarked for projects that enhance water infrastructure resilience, promote nature-based solutions, or implement adaptation measures in the water sector. It builds upon the risk assessment module that will have identified specific climate-related vulnerabilities for Bhutan's water systems.

Checklist

- Inventory of Climate-Funded Water Projects: Compile a list of past and ongoing projects in Bhutan's water sector that were supported through dedicated climate finance mechanisms (multilateral funds, bilateral grants, etc.).
- Funding Sources and Amounts: For each project, identify the specific funding source, the total amount disbursed, and the types of activities that were financed.
- Climate Resilience Focus: Analyze how climate resilience was integrated into project design. Determine what kinds of interventions were prioritized (hard infrastructure, nature-based solutions, early warning systems, capacity building, etc.)
- Impact Assessment: Evaluate the outcomes of climate-funded projects in terms of improved water security, reduced vulnerability to droughts/floods, or other climate-related benefits.
- Access Barriers: Identify any challenges Bhutan may have faced in accessing climate finance, including complex application processes, lack of technical capacity for proposal writing, or mismatch between funder priorities and national needs.

Tools:	**Data Sources –**
T-7 Climate Finance Impact and Assessment for Water Management Projects in Bhutan	• DECC (Technical Department) and Ministry of Finance is the designated national authority for major climate finance mechanisms and can provide information on project pipelines. • Relevant Line Ministries: Agencies implementing water projects may have records of which components were funded through climate-specific finance. • Operationalization of Bhutan Climate Finance (BCF), link to Funding sources. • International Donors and Development Partners: Contact relevant embassies and development agencies active in Bhutan's climate adaptation space.

Recommendations/ Outputs

- Capacity Building for Climate Finance: The NIWMP may recommend establishing a dedicated unit or working group to track climate finance opportunities and develop robust project proposals.
- Innovative Mechanisms: Explore options for mobilizing climate finance through green bonds, water impact funds, or payment for ecosystem services schemes that reward climate-smart water management practices.
- Master Plan Integration: The NIWMP needs to actively highlight the climate resilience aspects of proposed projects to make them attractive to international funders. It shouldn't just be about technical solutions, but about climate-proofing Bhutan's water future.

M.6.5 Good Practices and Recommendations

Case Study 24

Improving services by reducing NRW in Thane, Mumbai

The city of Thane in India faced challenges with poor water service delivery and significant financial losses due to high Non-Revenue Water (NRW). NRW refers to water that is produced but "lost" before reaching the paying customer, due to leaks, theft, or metering inaccuracies. Thane tackled this issue through several measures. They improved billing and collection efficiency, converting illegal connections into legal, billed connections. Crucially, they mapped their water distribution network to pinpoint leak-prone areas. These combined efforts led to a reduction in NRW, improving their services and strengthening their financial position.

Read more: Nonrevenue Water Management in South Asia

Thane's experience emphasizes the financial importance of NRW reduction. Their case underscores the need to quantify NRW as part of financial assessments (M6.1). Cost-benefit analyses must be conducted to justify investments in leak detection and repair (M6.2). Improving revenue generation can increase internal funds for water infrastructure (M6.3). Finally, NRW reduction demonstrates water security and efficiency, which could attract climate-related funding (M6.4).

Case Study 25

Pricing as a Water Demand Management Instrument

Water demand management through the implementation of a tariff structure: the case of Kampala, Uganda

Kampala, Uganda, faced the challenge of balancing water conservation with equitable access for its growing population, including low-income residents. They adopted a demand-responsive tariff structure, setting prices that incentivize conservation. Importantly, they differentiated tariffs by customer type (e.g., household, industrial), with increasing block tariffs for high-volume consumers. Kampala's tariff model adjusts annually for inflation and strikes a balance between conservation and affordability, ensuring basic needs are met for all residents.

Read more: Using tariff structures as a demand management instrument: The case of Kampala

Kampala's tariff approach highlights how financial planning and water conservation are intertwined. Their strategy underscores the need to understand water demand patterns across sectors (M6.1) and carefully assess the costs of water supply for accurate pricing (M6.2). Importantly, revenue from tariffs can sustain infrastructure (M6.3). Kampala's experience offers insights for Bhutan when setting their own water tariffs that balance affordability and conservation goals (M6.5)

Case Study 26

Metering of Water Supply

Bulk Measuring with an Intelligent Operating System in Bangalore

The Bangalore Water Supply and Sewerage Board (BWSSB) recognized the importance of accurate water flow measurement for effective system management. They invested in bulk water meters at key points in their distribution network. However, the real innovation was coupling these meters with an ICT system that allows them to capture, analyze, and use the data generated by these meters. This system likely aids in detecting leaks, identifying areas of high consumption, and better managing supply in response to demand.

Read more: Bangalore, Bulk Metering with Intelligent operating system

The project underscores the financial aspects of water management. It emphasizes the need to carefully assess investments in metering and data analysis (M6.2). Such investments can lead to long-term financial benefits through improved efficiency and leak detection (M6.3). Additionally, the project highlights how accurate water accounting can strengthen the case for climate-related funding (M6.4) by demonstrating transparency and efficient water use.

Case Study 27

Green Budgeting in Assam, India

- Assam's Flood Mitigation Investments: Assam demonstrates how to integrate climate resilience into its budget. Funds are allocated for projects like river embankments, improved drainage, and early warning systems to combat recurrent flooding. To ensure transparency and efficiency in these projects, Assam leverages innovative open contracting approaches.
- Goa's Green Budget: Goa shows how to prioritize climate action through its Green Budget. A dedicated portion of the budget is used for initiatives specifically addressing climate resilience and environmental protection, demonstrating a commitment to sustainable development.

Read more: Green Budgeting in Assam, Improving climate resilience in flood-prone Assam, India

These cases underscore the financial implications of climate resilience. They highlight the need to quantify climate-related risks and the costs of adaptation investments (M6.1). Detailed cost-benefit analyses are vital for justifying such investments (M6.2). Innovations like Assam's open contracting can improve efficiency, while Goa's Green Budget shows how targeted funding prioritizes resilience (M6.3). Crucially, investing in resilience can attract climate-related funding support (M6.4).

Section 4: Conclusion

The National Integrated Water Master Plan (NIWMP) for Bhutan is envisioned as a comprehensive and integrated document that encapsulates various facets of water management, spanning from water supply to wastewater and stormwater management. By interconnecting water with other sectors, it aims to foster collaborative efforts through stakeholder consultations, considering engineering, economic, environmental, and social factors, all aimed at achieving a balanced and sustainable approach to master planning. This initiative seeks to promote more efficient, equitable, and sustainable water management practices, with a keen focus on the long-term well-being of both the community and the environment.

The NIWMP serves as a vital framework for the sustainable sourcing and utilization of Bhutan's water resources to meet future needs. It will undertake detailed assessments (primary and secondary sources) of water availability, demand, and quality, considering current and projected climate risks across various sectors. The plan delineates strategies for efficient water allocation, infrastructure development, and climate change adaptation, with the overarching goal of harmonizing competing demands while preserving ecosystems and biodiversity. Through robust stakeholder engagement and governance mechanisms, the NIWMP endeavors to foster inclusive decision-making and ensure effective implementation. Key priorities include bolstering water infrastructure, advocating for water conservation, and enhancing institutional capacity. By integrating principles of environmental protection, international cooperation, and adaptive management, the NIWMP aims to ensure the enduring resilience and equitable utilization of Bhutan's invaluable water resources for the betterment of present and future generations.

This guiding tool offers crucial support for users in crafting the comprehensive NIWMP, as outlined in section 2. The toolkit is structured into six modules, comprising twenty-four sub-modules, numerous activities, a checklist, and various tools. Designed to be user-friendly and effective, it provides a robust master planning framework for the preparation of the NIWMP. It is imperative for the NIWMP to articulate detailed strategies and actions for short-term, medium-term, and long-term planning, necessitating continuous interaction with stakeholders throughout the development process.

The proposed table of contents for the NIWMP could encompass an executive summary, an introduction detailing the project brief, vision, and scope of work, a baseline diagnosis (M1), the master plan document encompassing policy assessment (M2), data management (M2), capacity building and skill development (M3), monitoring and evaluation (M4), and financial planning including climate financing aspects (M5). Additionally, detailed strategies and action plans, including cost estimates for short, medium, and long-term planning, should be outlined across all modules. Annexures could include stakeholder consultation feedback, inputs from sectoral experts, and other relevant documentation to enrich the NIWMP's comprehensiveness and effectiveness.

Section 5: Annexures

A. Stakeholder Matrix

As outlined in the inception report, the preparation of the NIWMP involves engaging various key stakeholders. A matrix (Figure 3) has been devised to distinguish the levels of responsibility, accountability, and interest among stakeholders in the forthcoming NIWMP preparation.

The Department of Water (DoW) within the Royal Government of Bhutan (RGB) holds a pivotal role in crafting the NIWMP document. Within the Department of Water there are other divisions, such as Water Services Division (WSD), Water Resources & Management Division (WRMD). The DoW, will work in close collaboration with all the 20 Dzongkhag, 205 Gewog, and some of the existing Dzongkhag Water Management Committee, River Basin Committees, and Water Users Associations.

Adherence to policies, laws, and regulations, strategies and plans concerning climate and environmental assessments is imperative in the NIWMP document's formulation. Hence, departments like the Department of Environment and Climate Change and its divisions, (Environment Assessment and Compliance Division, Climate Change Division, Waste Management Division), Ministry of Agriculture and Livestock, development partners, and the Ministry of Finance will hold significant influence for drafting a holistic NIWMP document.

In addition, the Departments/organizations such as the Department of Forests and Park Services, Department of Tourism, Ministry of Agriculture and Livestock, Ministry of Energy and Natural Resources (MoENR), Civil Society Organizations (CSOs), NGOs, development partners, local government and academic institutions should be thoroughly informed and consulted during the drafting process of the NIWMP report. Their inputs and feedback will be instrumental in shaping the final NIWMP document.

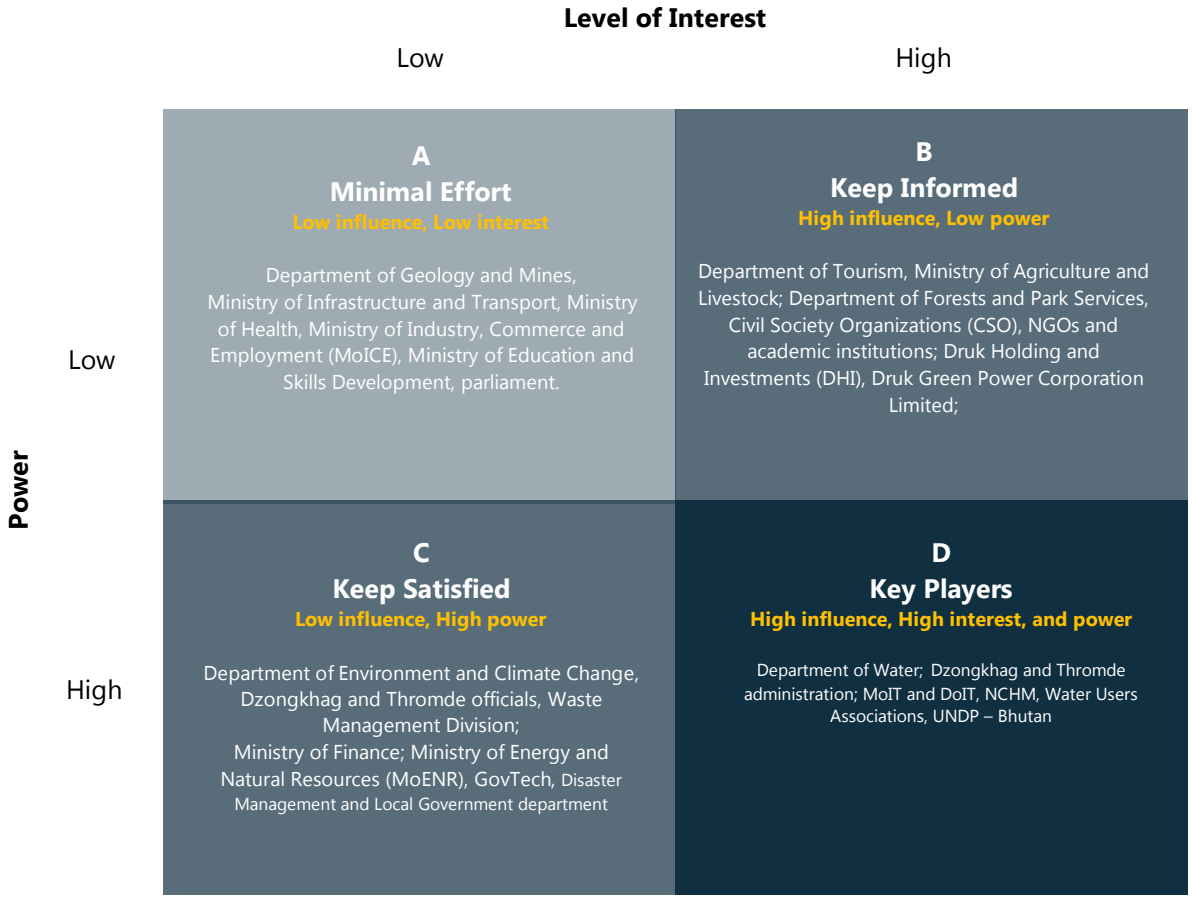


Figure 3: Stakeholder assessment matrix representing stakeholders important to this project

B. Discussion MoM of stakeholders- 1

After the inception workshop which was attended by SNV, Nature Conservation Division, DoFPS Tarayana Foundation, Department of Energy, Druk Green Power Cooperation, Thimphu Thromde Department of Tourism, Department of Infrastructure Development, MoIT, Bhutan Trust Fund for Environment Conservation, Department of Industry, MoICE, Department of Human Settlement, MoIT, Policy and Planning Division, MoENR, Department of Environment and Climate Change, Department of Water and UNDP Team, a survey for feedback regarding the preparation of NIWMP document was conducted among the stakeholders who attended the workshop.

Feedback from stakeholders on need for and importance of NIWMP

Thirteen departments / responses were received from various organizations, with 70% of the respondents representing the Royal Government of Bhutan and the remainder from the UNDP Bhutan team, as well as NGO and CSO representatives as shown in Figure 4.

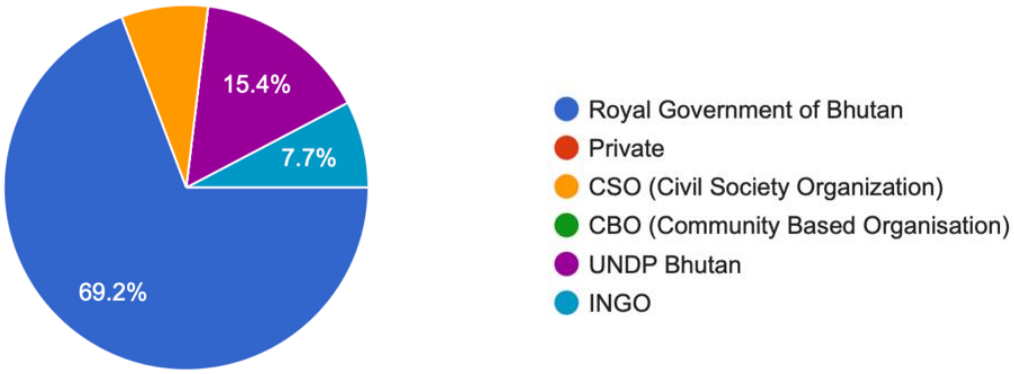


Figure 4: Survey responses from each organisation

Water holds a crucial mandate and significance for most of these organizations and their respective departments. The overarching concern expressed by most stakeholders revolves around the National Integrated Water Master Plan's pivotal role in achieving sustainable development by 2030 (Figure 5).

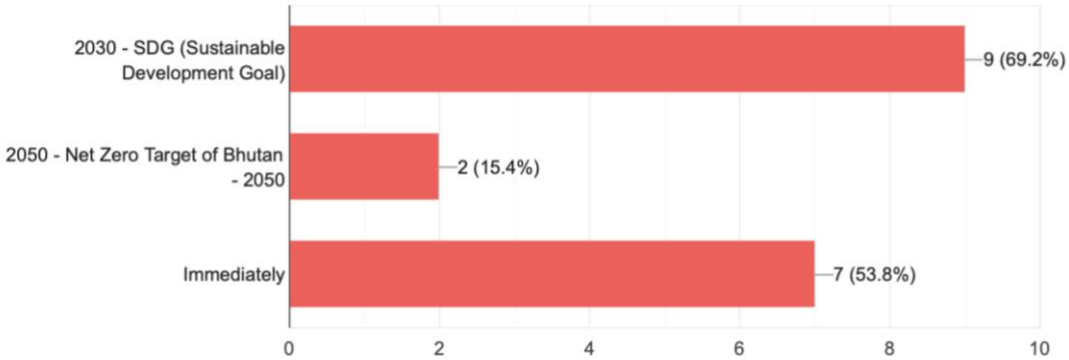


Figure 5: Importance and need for NIWMP.

Stakeholders also voiced three significant reasons necessitating the NIWMP: 1) tackling climate risks in the water sector, 2) preparing for potential water crises, and 3) ensuring equitable allocation of water resources (Figure 6).

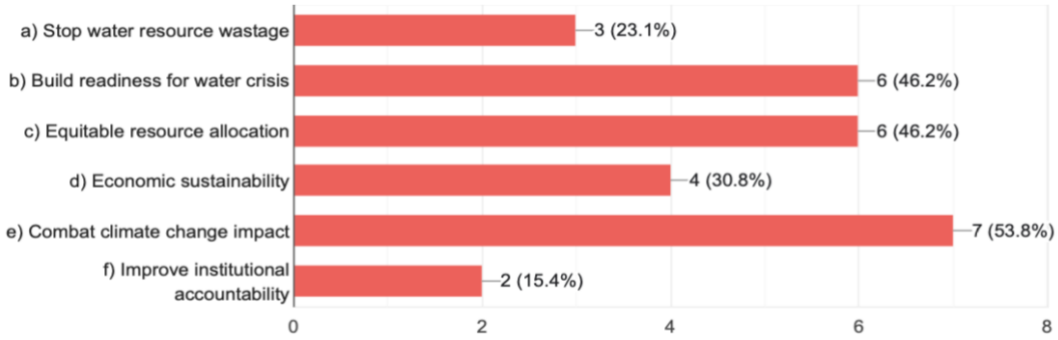


Figure 6: Important reasons for preparation of NIWMP.

The stakeholders in the survey highlighted three key areas of concern that might pose as bottlenecks: 1) the highly diversified features of Water Resource Management (WRM) in Bhutan, 2) lack of experience and preparedness, and 3) inter-departmental disagreements.

Some important points shared in the survey are:

- 'Water for humans and water for ecological use' must be underscored in the guiding tool, so that the NIWMP strikes a perfect balance between water use and conservation.
- The Industrial Park Management Division is tasked with the development and management of industrial parks and having sufficient water flow for all the industries in the parks/estates is a major concern and subject of action.
- Technical experts from the Industrial Park Management Division could be more suited for this project as water management is a concern in the industrial parks.
- It would be great if a sample guiding tool practiced internationally (if any) be shared in the report and with the stakeholders.
- The water sources are being shared within residents of municipality and locality but the proper management of that particular water source has not been mandated to both users. The water source integration is taking place at snail phase by joint sitting with the end users. The municipality authority is being pressurized for demand of water by the developer within the municipality area.

C. Discussions / Data collection for preparing guiding tool

The national consultant for this project, also went to interact with various departments to collect important data / information's and documents related to the project. These stakeholders included Tenzin Khorlo - Chief, Department of Water; Dorji Gyeltshen - Principle Officer, Department of Water; Ugyen Thinley Principle Engineer Ministry of Infrastructure and Transport; Dr. Pema Wangda Executive Director, Bhutan for Life Fund Secretariat; Kinley Tshering Chief Program Officer Bhutan Trust Fund for Environmental Conservation, Kezang L. Dorji Officiating - Chief Environment Officer Thimphu Thromde; Penjor Drukpa, Thimphu Thromde, Ugyen Lhendup - Country Coordinator, Bhutan Water Partnership; Ugyen Rinzin - SNV. All the data collected in given in the link.

A separate Section 6 has been provided in this document to list all the documents referred to, based on the secondary literature reviewed and understood.

D. Stakeholder consultation workshop and bilateral meetings MoM- 2

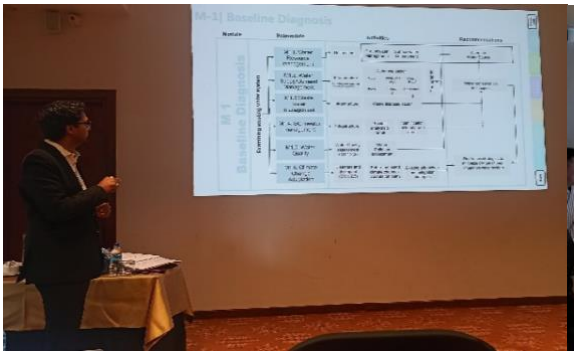
Date: April 8-12, 2024
Location: Thimphu, Bhutan
Attendees: Department of Water (DoW), RGoB, UNDP Bhutan, Taru Leading Edge, and other relevant stakeholders (as mentioned in the agenda).

Day-1 & 2 stakeholder consultation workshops

Participants: Representatives from UNDP, Bhutan; DoW, RGoB, Taru Team and task force members from various from various ministries, departments, and organizations, including DoT, MoICE, DECC, DoFPS, Thimphu Thromde, DoID, DHS, DoA, DoE.

Key highlights: The initial two days comprised a stakeholder consultation workshop, with participation from representatives across various ministries and organizations of Bhutan. Proceedings began with formal introductions, agenda adoption, and an in-depth presentation of the project's background and aims. The Taru team presented the updated guiding tool for NIWMP development, followed by question-and-answer sessions and group activities for in-depth review of guiding tool. Additionally, presentations on the draft ToR and cost estimates for the NIWMP were delivered, leading to constructive discussions.

Outcome : The workshop resulted in the collection of extensive feedback on the guiding tool, ToR, and cost estimates. Stakeholders provided valuable insights and recommendations, highlighting areas for potential improvement in the Guiding tool, ToR, and Cost estimates. This collaborative process set the stage for refining the project deliverables to ensure the NIWMP development plan addresses the needs and priorities of all involved.



Day- 3 Discussion with DoW representatives

Participants: Officials from DoW, Taru team consultants – Jay Shah and Aastha Kirar and representative from UNDP- Tshering Yangtsho.

Key highlights

The third day focused on in-depth discussions between the Taru Team and representatives from the Department of Water (DoW), RGoB. In the bilateral discussion, participants meticulously reviewed the feedback obtained during the workshop, exploring potential solutions and strategies to incorporate stakeholder comments and recommendations.

Outcome

These discussions produced a clear action plan for modifying the guiding tool and integrating stakeholder perspectives. The Taru Team and DoW representatives established an agreement on concrete steps to enhance project deliverables and optimize the overall NIWMP development process.

Day-4 Discussion with UNDP, Bhutan

Participants: UNDP, Bhutan Officials: Sonam Rabgye, Tshering Yangtsho; Taru Team: Jay Shah, Aastha Kirar and Chukey Wangchuk.

Key highlights

Day four centered on a discussion between the Taru Team and UNDP representatives in Bhutan. The emphasis was placed on reviewing revised deliverables and reports, ensuring that project outcomes aligned with UNDP expectations.

Outcome

The discussion adopted a consensus on project deliverables and their alignment with the scope of work. establishing a clear, coordinated approach between the Taru Team and UNDP for the project's successful completion.

Day- 5 Final discussion with DoW and UNDP, and wrap-up

Participants: DoW: Chief Mr. Tenzin Khorlo and other officials, UNDP: Sonam Rabgye, Yangtsho and Taru team: Jay shah and Aastha.

Key highlights

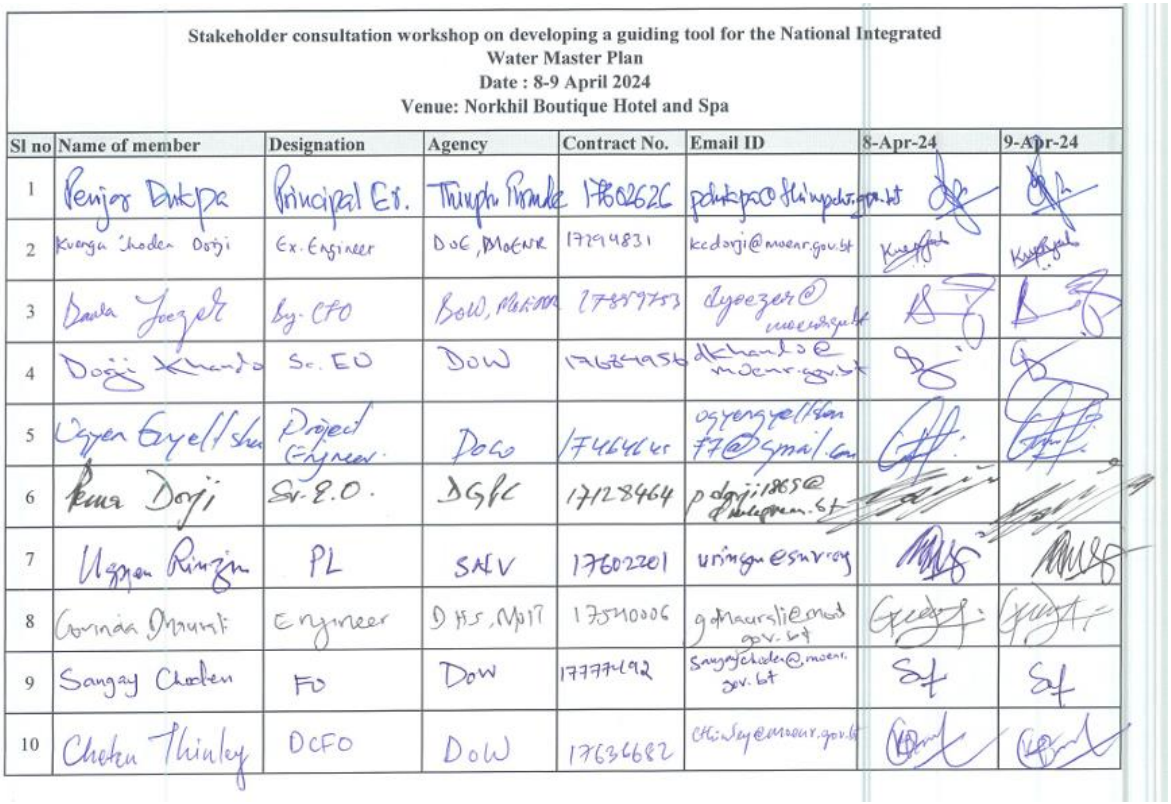
On the final day, the Taru Team presented a comprehensive summary of the discussions and comments received throughout the mission, along with the plan of finalizing the deliverables. This was followed by focused discussions on project closure and the potential for future collaborations. The Taru team, DoW, and UNDP representatives participated in a concluding session and delivered closing remarks.

Outcome

Mission's final day resulted in the formalization of terms, a clear outline of final deliverables, and the establishment of a timeline for project closure. Additionally, all parties reached a shared agreement on a smooth transition and potential avenues for continued partnership in the future.


TOYOTA

Participants list of Day-1 & 2 stakeholder consultation workshops:



Stakeholder consultation workshop on developing a guiding tool for the National Integrated Water Master Plan
Date : 8-9 April 2024
Venue: Norkhil Boutique Hotel and Spa

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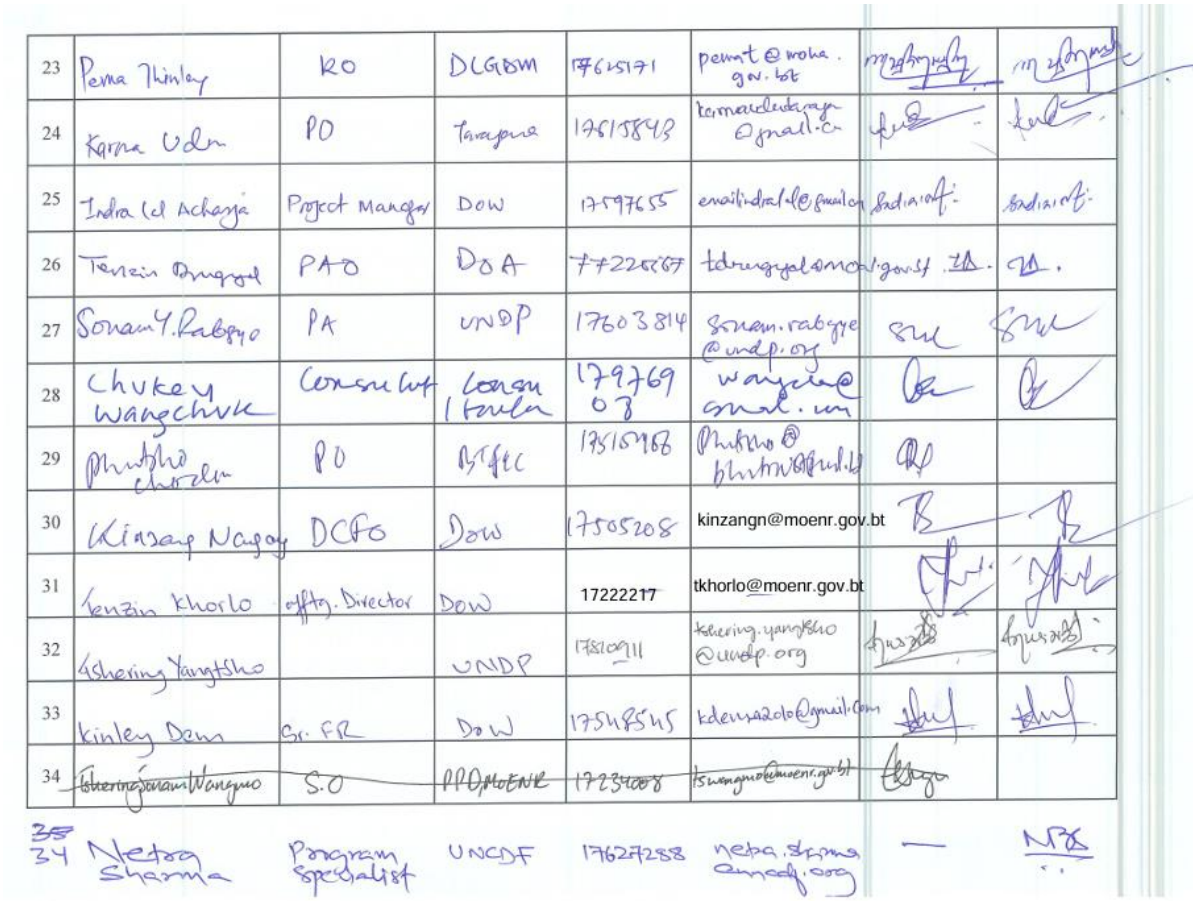

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Participants list of Day-3 Discussion with DoW representatives

Wrap-up meeting with TARU team to discuss the two-day workshop outcome on the development of a guiding tool for the National Integrated Water Master Plan
10, April,2024
Department of Water Conference Hall, Thimphu

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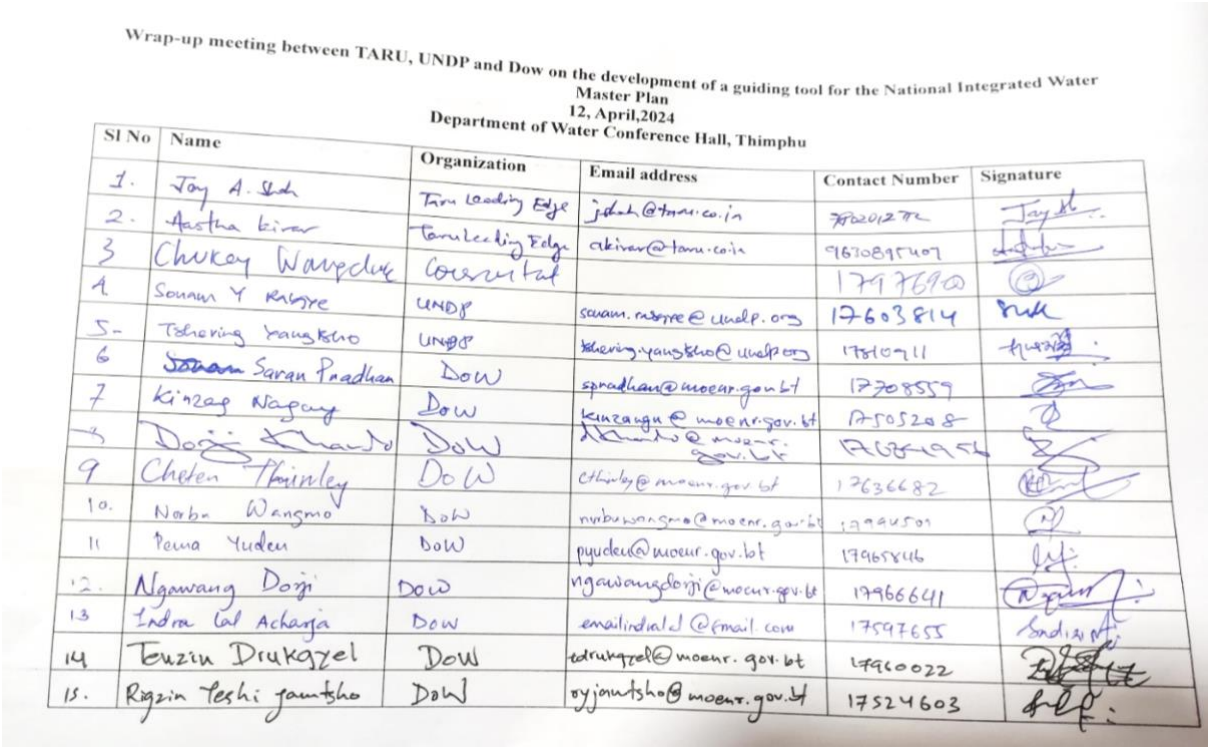
Participants list of Day-4 with UNDP, Bhutan

Participants: UNDP, Bhutan Officials: Sonam Rabgye, Tshering Yangtsho; Taru Team: Jay Shah, Aastha Kirar and Chukey Wangchuk.

Participants list of Day-5 final discussion with DoW and UNDP, and wrap-up



Wrap-up meeting between TARU, UNDP and Dow on the development of a guiding tool for the National Integrated Water Master Plan
12, April,2024
Department of Water Conference Hall, Thimphu

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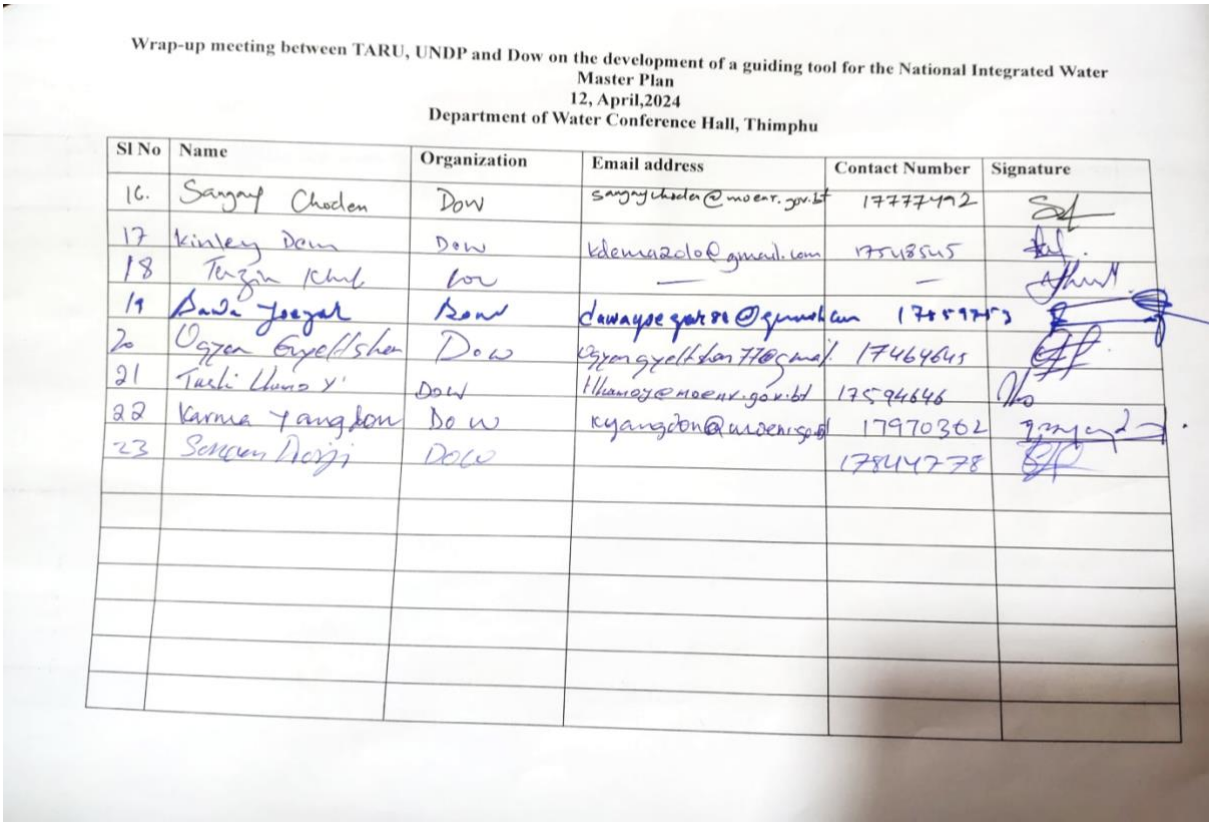

Wrap-up meeting between TARU, UNDP and Dow on the development of a guiding tool for the National Integrated Water Master Plan
12, April,2024
Department of Water Conference Hall, Thimphu

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E. Toolkit for Modules-1 BASELINE DIAGNOSIS

M1.1. WATER RESOURCE MANAGEMENT

M 1.1.A. Delineation

T-1 Delineation of Watersheds

S.no.	Watershed Name	Major river system	Sub-watersheds	Approximate Area (km2)	Mapping required (Yes / No)	Data Source	Transboundary nature (if applicable)	Water condition/ character

*Yes, if delineated maps are not available from data sources mention

T-2 Delineation of Surface water mapping

S.no.	Waterbody Name	Type (River, Lake, Wetland, Glacier)	Coordinates (or Map Reference)	Classification	Mapping required (Yes / No)	Remarks (size, seasonal variations, etc)	Transboundary nature (if applicable)

*Yes, if delineated maps are not available from data sources mention

T-3 Delineation of Groundwater Mapping

S.no.	Aquifer Name/ Identifier	Geological Formation	Mapping required (Yes / No)	Type (Confined/ Unconfined)	Estimated Recharge Zone (Map Reference)	Existing Wells/Monitoring Points	Transboundary nature(if applicable)

M 1.1.B. Ground water management

T-4 Aquifer Characterization

S.NO.	Aquifer Name/Identifier (Refer to Delineation Tool)	Aquifer Type (Confined, Unconfined, Semi-confined, Fractured)	Dominant Geological Formation (Refer to Delineation Tool)	Permeability Assessment (High, Medium, Low)	Connectivity with surface water (See Delineation surface water maps)	Transboundary nature (if applicable - note shared aquifers along borders)

T-5 Recharge & Discharge (Water Balance Focus)

S.NO.	Zone Type (Recharge/ Discharge)	Geographic Area (Map reference - Integrated with Delineation maps)	Mapping required (Yes / No)	Primary Mechanism (infiltration, interaction with rivers/springs, etc.)	Permeability Assessment (High, Medium, Low)	Estimated Volume Contribution/Loss (annual/seasonal)	Sensitivity to change (land-use, climate variability)

T-6 Groundwater Levels & Trends

S.NO.	Monitoring Well ID (Linked to Delineation Map References)	Depth of Well (Screened interval)	Data Collection Period (5+ years is ideal)	Average/Seasonal Water Table Depth & Trends (graphical representation alongside data)	Impact of major pumping wells

T-7 Well Yields, Pumping Tests & Water Use

S.NO.	Well ID (Linked to Delineation Map References)	Owner/Operator	Primary Use	Pumping Test Results	Estimated Annual Water Extraction	Permit/Regulation Status (if applicable)

T-8 Groundwater Quality & Vulnerability

S.NO.	Sampling Location/Well ID (Linked to Delineation Mapping)	Date(s) of Sampling	Parameters Tested (Comprehensive listing)	Results (Compare to Bhutanese and WHO water quality standards)	Vulnerability Assessment (Index or overlay method)

M 1.1.C. Surface Water management

T-9 Surface Water Body Inventory

S.NO.	Water Body Name/ID (Reference Delineation Maps)	Type (River, Stream, Lake, Reservoir, Wetland)	Sub-basin/Watershed (Reference Delineation)	Average Size/Volume (if applicable)	Primary Uses (Irrigation, hydropower, drinking water, etc.)	Health Indicators (visual assessment or basic parameters if data exists)

T-10 Streamflow Monitoring

S.NO.	Gauging Station ID (Link to Delineation Map)	River/Stream Name	Location Coordinates	Period of Record (Start Date - End Date)	Data Type (Daily, monthly, annual flows)	Key Flow Statistics (If calculated - average, high flow, low flow)

T-11 Surface Water Quality

S.NO.	Sampling Location (Water Body ID or Reference Point)	Date(s) of Sampling	Parameters Tested (basic: pH, turbidity, major ions - Expand based on concerns)	Results (Compare to water quality standards)	Potential Pollution Sources (Observed land use)

T-12 Water Infrastructure

S.NO.	Structure ID (Link to Delineation Map if possible)	Type (Dam, Reservoir, Hydropower Plant, Irrigation Canal network)	Water Body / River	Capacity/Design Flow	Primary Purpose Operator/Owner	Condition Assessment (Basic visual rating - Good, Fair, Needs Repair)

M 1.1.D. Alternate water sources

T-13 Rainfall Analysis

- Basic Spreadsheets: Microsoft Excel or Google Sheets.
  Key functions include: AVERAGE, MIN, MAX for rainfall summary statistics
- Charts for visualizing seasonal trends
- Rainfall interpolation (creating smooth maps from point data)
- Rainfall intensity-duration-frequency curve calculations (relevant for extreme events)

T-14 Catchment Characterization

Feature	Google Earth Pro	QGIS	Notes
Catchment Delineation	Basic: Manual drawing of areas	Automated: Uses elevation data (if available) for more precise watershed boundaries	For simple catchments, Google Earth is adequate. Complex terrain needs QGIS
Area Calculation	Built-in tool	Built-in tool	Both provide this essential function
Data Overlays	Can import limited GIS layers (KML, simple shapefiles)	Extensive data compatibility (raster, vector, various formats)	Google Earth is limited if you need to visualize catchment alongside land-use, infrastructure, etc.
Advanced Analysis	None	Hydrology toolsets for flow analysis, stream network calculations, etc.	Only needed if very detailed catchment studies are part of the plan

T-15 Wastewater Reuse Assessment: Water Quality Considerations

Wastewater Source	Likely Pollutants	Relevant Bhutanese Standards	Potential Reuse Applications (if standards are met)	Treatment Upgrade Notes (if standards are NOT met)
Municipal Wastewater (after primary treatment)	High organic matter (BOD, COD), pathogens, nutrients (N, P)	Name specific Bhutanese standards documents or sections	Restricted irrigation (non-food crops), certain urban uses (street cleaning, etc.), indirect groundwater recharge	Advanced secondary treatment (biological processes), possible disinfection
Specific Industries (textiles, food processing, etc.)	Industry-specific pollutants (dyes, heavy metals, etc.), high salt content possible	Reference applicable industrial effluent standards in Bhutan	Irrigation (needs careful matching of crop tolerance to water quality), restricted industrial reuse	May require specialized treatment (membrane filtration, constructed wetlands, etc.) depending on pollutants

How to Use This Table:

- Expand Sources: List major wastewater sources in your target area.
- Research Bhutan's Standards: Fill in the specific standards and the parameters country regulate.
- "Reuse Fit": Based on the quality, brainstorm potential reuse options that are safe.
- Treatment Gap: This column highlights where investment is likely needed.

Additional Considerations:

- Volume: Is the wastewater flow consistent enough for reliable reuse?
- Cost/Benefit: Assess treatment costs vs. the value of the reused water.

M1.2. WATER RESOURCE MANAGEMENT

M1.2.A. Infrastructure

T-16 Inventory of Supply side Infrastructure

Infrastructure Element	ID/Name (Map Reference)	Type/ Capacity	Primary Purpose	Operator/ Owner	Age/Condition (Visual Rating)	Notes
Dams/Reservoirs	Example: Dam Name	Multi-purpose dam	For drinking water supply and irrigation purposes.		Year of construction (Good, Poor condition)	E.g.: Cracks etc.
Water Treatment Plants						
Major Pipelines/Canals						
Groundwater Wells/Boreholes						

T-17 Inventory of Demand-side Infrastructure

Infrastructure Element	ID/Name (Map Reference)	Type/ Capacity	Primary Purpose	Operator/ Owner	Age/Condition (Visual Rating)	Notes
Irrigation Infrastructure	Example: Paro Valley Canal Network	Canals, Gates, Field Channels	Irrigation	Ministry of Agriculture	Varies	Efficiency, Distribution Issues
Dams/ Reservoir	Example: Dam Name	Multi-purpose dam	For drinking water supply and irrigation purposes.		Year of construction (Good, Poor condition)	E.g.: Cracks etc.
Urban Distribution Networks	Example: Thimphu Zone 2 Piping	Pipelines, Storage Tanks	Municipal Supply	Thimphu City Corporation	Varies	Leakage %
Industrial Water Systems	Site-specific	Reuse/Recycling, Effluent Treatment	Industry	Individual Enterprises	Varies	Compliance, Efficiency

T-18 Inventory for User management

Infrastructure Element	ID/Name (Map Reference)	Type/ Capacity	Primary Purpose	Operator/ Owner	Age/Condition (Visual Rating)	Notes
Metering (Residential)	By Zone/Area	Meter Type, Coverage %	Utility/Service Provider		Accuracy, Data Use	
Pressure Management Zones	If Applicable	Control Valves, Monitoring	Utility		Reduction of Leaks	

M1.2.B. Water use/ sectors

T-19 Urban & Municipal Water Use

Water Use Category	Current Water Use Estimate (Annual Volume)	Surface Water (%)	Groundwater (%)	Seasonality	Data Source	Data Reliability (High/Med/Low)
Residential (Domestic)						
Commercial						
Municipal (Parks, cleaning, maintenance etc.)						
Unaccounted-for-Water (Leakage)						

The tool could provide a clear overview of Bhutan's urban and municipal water consumption. This analysis can highlight:

- Which water sources (surface and groundwater) are predominantly used by different sectors.
- Areas of potential water loss (high unaccounted-for-water percentages).
- Seasonal water demand fluctuations.

Furthermore, the exercise could inform policy decisions and infrastructure planning. Potential supporting decision points can be:

- Identifying areas for leak reduction in the water distribution system.
- Justifying investment in rainwater harvesting or surface water storage (depending on the mix of surface and groundwater use).
- Targeting water conservation campaigns during peak usage seasons.

If similar tables are created for multiple regions or cities within Bhutan; comparisons can be drawn to identify best practices in water management.

T-20 Rural Water Supply

Water Use Category	Current Water Use Estimate (Annual Volume)	Surface Water (%)	Groundwater (%)	Seasonality	Data Source	Data Reliability
Domestic						
Livestock						
Community use (schools etc)						

T-21 Agriculture (Irrigation) Water Use

Irrigation Area (Hectares)	Water Source (River, Canal, Groundwater)	Crop Types	Irrigation Method (Flood, Sprinkler, etc.)	Estimated Water Use (Annual Volume)	Seasonality	Data Source	Data Reliability
Region 1							
Region 2							
Region 3							

T-22 Fisheries

Water Use Category	Water Use Estimate (Annual Volume)	Seasonality	Data Source	Data Reliability
Aquaculture (Fish farming)	[Volume in liters or cubic meters]	[Seasonal variation]	Ministry of Agriculture and Livestock	
Inland Fisheries (Rivers, Lakes)	-	[Seasonal variation]	Ministry of Agriculture and Livestock	
Ecosystem Support (Water for Fish Habitat)	-	Year-round	Ministry of Agriculture and Livestock	

T-23 Industrial Water Use

Industry Type	Water Source	Process Use (If known)	Water Recycling/Efficiency Measures	Estimated Water Use (Annual Volume)	Discharge Quality	Data Source	Data Reliability
Example: Food Processing							

T-24 Hydropower (Note: Primarily non-consumptive use)

Hydropower Plant	River	Reservoir Capacity	Generation Capacity	Estimated Flow Rates through Turbines (non-consumptive)	Seasonal Variation	Data Source	Data Reliability

T-25 Forest and Biodiversity water use

Water Use Category	Water Use Estimate (Annual Volume)	Source Water (%)	Groundwater (%)	Seasonality	Data Source	Data Reliability
Forest Ecosystems						
Wildlife Habitats						
Conservation Projects						
Recreational Areas						
Biodiversity Research						

T-26 Spiritual Water Use

Water Use Category	Water Use Estimate (Annual Volume)	Surface Water (%)	Groundwater (%)	Seasonality	Data Source	Data Reliability
Hot Springs (Tshachus)	[Volume in liters or cubic meters]				Department of Culture	
Meditation Sites (Menchus)	[Volume in liters or cubic meters]				Department of Culture	
Therapeutic Uses (Cultural Baths)	[Volume in liters or cubic meters]				Ministry of Health	

M.1.2.C. Demographical study

T-27 Demographic study

S. No.	Description of Data Elements	Unit	Source(s)	Notes
	Total Population (Most Recent Census)	Persons	National Statistics Bureau of Bhutan	Most critical starting point
	Population by District (Dzongkhags)	Persons	National Statistics Bureau of Bhutan	For geographic distribution of water demand
	Urban Population	Persons	National Statistics Bureau	Focus on areas with centralized water systems
	Rural Population	Persons	National Statistics Bureau	Boreholes, community supplies to consider
	Decadal Growth Rate (Overall)	%	National Statistics Bureau	Baseline for projection models
	Decadal Growth Rate (Urban vs. Rural)	%	National Statistics Bureau	Predict pressure on different infrastructure types
	Projected Population (Short-term, e.g., 5 years)	Persons	Calculation	Based on growth rates, any known development plans
	Projected Population (Mid-term, e.g., 10-15 years)	Persons	Calculation	Longer time frame where water projects take time

S. No.	Description of Data Elements	Unit	Source(s)	Notes
	Projected Population (Long-term, e.g., 25 years)	Persons	Calculation	Aligns with the scope of a Master Plan
	Household Size (Average)	Persons	National Statistics Bureau	Helps determine per capita demand
	Household Size Trends (Increasing/Decreasing)	Qualitative	National Statistics Bureau, social surveys	Impacts future water use patterns
	Migration Trends (Into/Out of Bhutan)	Net figures, if possible	Immigration records, labor statistics	Impacts may be localized or seasonal
	Seasonal Population Fluctuations (Tourism, etc.)	Persons (estimated)	Ministry of Tourism	Stress on water systems at peak times

M1.3. WASTE WATER MANAGEMENT

M.1.3.A. Infrastructure

T-28 Waste water treatment plant

S. No.	Description of Data Elements	Unit	Source(s)	Notes
	Location (Map coordinates or district reference)	N/A	Municipal records, Environmental agencies	Mark on a map for visual reference
	Type of Treatment (Primary/Secondary/Tertiary)	N/A	Municipal records, Environmental agencies	Impacts quality of discharged water
	Designed Capacity	Liters/day or MLD	Municipal records, original design documents	Compare to current wastewater generation
	Current Operational Status	Functional/ Non-functional /Partially functional	Municipal operators, Site inspection	Prioritizes repair needs

T-29 Sewer Networks

S. No.	Description of Data Elements	Unit	Source(s)	Notes
	Extent of Network (If mapped)	km	Municipal records, utility maps	Otherwise, describe major areas served
	Pipe Material	Concrete, PVC etc.	Construction records, if available	May affect leakage, maintenance needs
	Condition Assessment (Visual if possible)	Good/Fair/Poor	Inspection reports, municipal records	Prioritization of repair or replacement

T-30 Outfalls

S. No.	Description of Data Elements	Unit	Source(s)	Notes
	Location of Major Discharge Points	Map reference	Environmental permits, monitoring data	Mark on the same map as WWTPs

T-31 Informal Systems

S. No.	Description of Data Elements	Unit	Source(s)	Notes
	Area-wise Estimate of Septic Tank Prevalence	% of households	Local surveys, or estimate if no data	Important if centralized sewers are limited
	Area-wise Estimate of Pit Latrine Use	% of households	Local surveys, or estimate if no data	Even more rudimentary sanitation

M.1.3.B. Waste water disposal systems

T-32 Waste water disposal system

Sector	Description of Data Elements	Unit	Possible Sources	Notes
Domestic	Wastewater volume per household or per capita	Liters/day or MLD (for larger settlements)	Water supply records (if metered), utility estimates, surveys	This is often the largest source
	Type of Sanitation Systems (Sewers, Septic etc.)	% of households	Household surveys, municipal records	Affects whether wastewater is collected
Commercial	Major Establishments generating significant wastewater	Listing: Hotels, restaurants, markets etc.	Business licensing, tourism records, industry surveys	Estimate potential volumes
	Estimate of wastewater volume per business type	Liters/day (or scale: Small/Medium/Large output)	Industry associations, best practice guides	
Industrial	Listing of major industries	By district or city	Ministry of Industry, Commerce and Employment (MoICE), industry records	Categorize industries known for high wastewater output
	Wastewater type	Categorization: Process water, contaminated/chemical, etc.	Environmental permits, industry reporting	Impacts treatment needs
	Estimate of total wastewater volume by industry type	Liters/day or MLD	Industry reports, environmental permits	Crucial for sizing treatment plants
Agricultural	Livestock waste disposal practices	Categorization: Manure management, lagoons, direct runoff	Ministry of Agriculture	Impacts nearby water bodies

M1.4. STORM WATER MANAGEMENT

M.1.4.A. Infrastructure

T-33 Drainage Networks

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Extent of Mapped Network	km of channels/pipes	Municipal records, utility maps	If unmapped, describe areas served instead
	Material of Pipes/Channels	Concrete, earth, etc.	Construction records, visual inspection	Impacts durability and maintenance needs
	Condition Assessment	Good/Fair/Poor	Inspection reports, municipal records	Prioritizes repair and upgrades

T-34 Drainage Detention and Retention Structures

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Location of Detention Basins/Ponds	Map reference	Municipal records, planning documents	Mark these as key features on a map
	Designed Storage Capacity	Cubic meters (m3)	Original design documents, engineering plans	Important for flood mitigation
	Current Condition	Visual assessment, or siltation level	Inspection reports, municipal records	Determines if capacity is reduced

T-35 Drainage Flood Control Structures

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Levees/Dikes/Embankments	Location, length	River management agencies, flood control records	Map these linear features
	Floodwalls	Location, length	Municipal records, engineering plans	Vertical barriers, map accordingly

T-36 Drainage Green Infrastructure

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Permeable Pavement Areas	Location, size (m2)	If tracked by municipality, or pilot areas	Important in newer developments
	Green Roofs/Bioswales	Location/ Number	If tracked by municipality, or pilot areas	Still emerging practices often

M.1.4.B. Rainfall Analysis and Runoff calculations

T-37 Rainfall Data

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Historical Rainfall Records: Length of available data	Years	Meteorological Department	Longer records provide better trend analysis
	Average Annual Rainfall by Location	Millimetres (mm)	Meteorological Department, Hydrological agencies	Spatial variation across Bhutan
	Rainfall Intensity Data (if available)	mm per hour	Meteorological Department (may be less common)	Important for storm events, flash flood risk
	Seasonal Rainfall Patterns	Monsoon season %, Annual distribution	Meteorological Department	Understanding the timing of heaviest rainfall

T-38 Drainage Runoff Analysis

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Catchment Areas (if delineated)	Square kilometers (km2)	Hydrological agencies, Watershed maps	Required for runoff calculations
	Land Use/ Land Cover Data	Forest, Urban, Agriculture etc. (% of catchment)	Remote Sensing (GIS), Land use agencies	Impacts how much rainfall infiltrates vs. runs off
	Soil Type Data	Classification based on infiltration potential	Soil surveys, Agricultural agencies	Clay-heavy vs. sandy soils behave differently
	Runoff Coefficients (if used)	Dimensionless (varies by land cover type)	Engineering handbooks, local studies	Literature values may need adjustment for Bhutan

M.1.4.C. Identification of Flood-Prone Areas

T-39 Historical Flood Data

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Extent of Flooding (if mapped)	Inundation maps (even if basic sketches)	Disaster Management Agency, Relief records	Visual representations are powerful
	Flood Severity	Estimated depth, duration of flooding	Eyewitness accounts, agency reports, news	Even qualitative severity helps prioritize

T-40 Terrain Analysis

S. No.	Description of Data Elements	Unit	Possible Sources	Notes
	Elevation Maps (DEM)	Meters above sea level	Remote Sensing (GIS), Topographical surveys	Basic topography is the foundation
	River Network Maps	Major & minor rivers, streams	Hydrological agencies, Watershed maps	Flood origins often tied to rivers
	Slope Analysis	% slope, or categorical (Gentle/Moderate/Steep)	Derived from DEM in GIS software	Steep areas = faster runoff, flood risk

T-41 Vulnerability Factors

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Land Use Maps	Urban areas, agriculture zones, forests etc.	Remote Sensing (GIS), Land use agencies	Impervious surfaces increase flood risk
	Location of Critical Infrastructure	Hospitals, schools, power etc. (Map)	District records, Municipal maps	What assets are at highest risk of disruption
	Population Density Maps	Persons per sq. km	Census data, National Statistics Bureau	Densely populated areas + flood risk = impact

M1.5. WATER QUALITY

M.1.5.A. Water quality assessment

T-42. Monitoring Parameters

S. No.	Description of Data Elements	Parameters	Unit	Notes
	Chemical Parameters	Dissolved oxygen, Hardness, Nutrients (N, P), Heavy metals etc.	mg/l, ppb, etc.	Env. agencies, water utilities, research
	Biological Parameters	Coliform bacteria, pathogens (if analysed)	Counts/100 ml, or Presence/Absence	Env. agencies, health agencies, water utilities

T-43. Sampling & Analysis

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Sampling Locations	Rivers, lakes, groundwater wells (Map reference)	Env. agencies, water utilities, research	Ensure coverage of different water bodies
	Sampling Frequency	Monthly, quarterly, seasonally etc.	Env. agencies, monitoring protocols	Detecting trends needs regular data

	Laboratory Methods	Standard methods followed (APHA, etc.)	Env. agencies, water utilities, labs	Ensures reliability of results

T-44. Water Quality Standards

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Applicable Standards	Drinking water, surface water etc. (list)	National Environmental Commission, Bhutanese regulations	The benchmark for comparison

T-45. Data Availability

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Geographic Coverage of Monitoring	Districts/sites with regular data	Env. agencies, summarize spatially	Identifies monitored vs. unmonitored areas
	Length of Historical Record	Years	Env. agencies	Longer records = better trend analysis

M.1.5.B. Water pollution

T-46. Point Sources

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Wastewater Treatment Plants	Plant locations, treated effluent quality	Municipal records, utility operators, Env. monitoring data	Even treated effluent can have some impacts
	Other Point Sources	Landfills, mines etc. (if relevant)	Env. permits, site inspection records	Consider location even if not monitored

T-47. Non-Point Sources

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Agricultural Runoff	Predominant crops, fertilizer & pesticide use	Ministry of Agriculture, farmer surveys, local studies	Difficult to quantify, may need estimates
	Urban Runoff	Areas lacking drainage, impervious surfaces	Municipal records, land-use maps, visual observation	Carries pollutants, impacts storm events
	Septic System Leachate	Areas with high septic tank density	Household surveys, local knowledge, water well data	Impacts groundwater if density is high

T-48. Specific Pollutants of Concern

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Known or suspected pollutants based on sources	Heavy metals (industry), nutrients, pathogens etc.	Previous studies, Env. agency focus, global trends	Tailor to Bhutan's context

T-49. Observed Water Quality Impacts

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Downstream of Pollution Sources	Compare water quality above/below discharges	Env. monitoring data (if site-specific)	Confirms pollution is reaching water bodies
	Algal blooms, fish kills etc.	Documented incidents	Env. agencies, local reports (if verifiable)	Signs of ecological stress due to pollution

M1.6. CLIMATE CHANGE ADAPTATION

M.1.6.A. Disasters and their Impact

T-50. Types of Disasters

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Floods (Riverine, Flash Floods)	Frequency (events per year/decade)	Disaster Management Agency, historical records, news archives	Most direct water-related impact
	Landslides	Frequency	Disaster Management Agency, geological surveys	Can disrupt water infrastructure, pollute sources
	Droughts	Frequency and severity (scale or index)	Meteorological Department, agricultural records	Impacts water availability over time
	Other Relevant Hazards	Forest fires, Glacial Lake Outburst Floods (GLOFs) etc.	Specific to Bhutan's context	Tailor this list as needed

T-51. Historical Impacts

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Damage to Water Supply Infrastructure	Treatment plants, pipelines, wells etc.	Disaster Management Agency reports, utility records	Quantify cost of repairs, if possible
	Disruption of Water Services	Duration of outages, population affected	Utility records, public health records (waterborne illness spikes)	Indirect impact, often severe

	Contamination of Water Sources	Due to flooding, landslides etc.	Env. agencies, water quality data post-disaster	May be short-term or persist
	Economic Losses	Water-dependent sectors (agriculture etc.)	Ministry of Industry, Commerce and Employment (MoICE), insurance data (if available)	Shows the broader cost beyond infrastructure

T-52. Vulnerability Mapping

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Areas Prone to Flooding & Landslides	Maps by district/watershed	Disaster Management Agency, risk assessments	
	Location of Critical Water Infrastructure	Overlay with hazard maps	Water utilities, municipal records	Identifies assets at highest risk

M.1.6.B. Future Projected Climate Changes

T-53. Climate Projections

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Sources of Projections	Downscaled Global Climate Models (GCMs), regional models, studies specific to Bhutan	Meteorological Department, DECC, research institutes	Credibility and relevance are key
	Key Parameters	Projected changes in precipitation (amount, intensity), temperature, extreme events	% change, absolute change etc. (vs. a baseline period)	Reports, datasets from projection sources
	Timeframes	Short-term (e.g., 2030s), mid-term (2050s), long-term (end of century)	Studies will offer different time horizons	Planning needs multi-decade thinking
	Uncertainty & Scenarios	If available, projections showing a range (low, medium, high emissions)	Some studies may have this	Avoids overconfidence in a single number

T-54. Water-Specific Impacts

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Changes in River Flows	Projected increases/decreases by season, impacts on hydropower potential	Hydrological research (may be separate from raw climate data)	Crucial for water supply
	Glacial Melt Impacts	If relevant, timing and volume of meltwater changes	Specialized glaciology studies, linked to water models	Only for glacier-fed watersheds

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Drought Risk Projections	Changes in drought frequency, severity, affected areas	Indices like SPI, PDSI, specific to Bhutan	Impacts agriculture & ecosystems
	Flood Risk Projections	Changes in flood magnitude & frequency	Linked to rainfall intensity projections	Impact on infrastructure design

T-55. Adaptation Planning

S. No.	Description of Data Elements	Parameters	Possible Sources	Notes
	Existing Vulnerability Assessments	Any sector-wise or district-level studies	DECC, Ministries, research projects	Avoids redundancy with prior work
	Adaptation Options Considered	Nature-based solutions, infrastructure changes, policy shifts etc.	Literature on climate adaptation specific to water if possible	Wide range of possibilities

M.1.6.C. Existing adaptation and mitigation strategies

T-56. National Level

S. No.	Description of Data Elements	Parameters	Possible Sources
	National Adaptation Plans (NAPs) or Policies	Specific to water, or broader climate action	DECC, relevant ministries
	Disaster Risk Reduction Strategies	How they address water-related disruptions	Disaster Management Agency
	Water-Specific Legislation or Regulations	If measures for conservation, drought preparedness exist	Relevant ministries, legal documents

T-57. Sectoral Strategies

S. No.	Description of Data Elements	Parameters	Possible Sources
	Agriculture	Irrigation efficiency, drought-resistant crops, etc.	Ministry of Agriculture, farm extension programs
	Hydropower	Dam design for resilience, reservoir management plans	Ministry of Industry, Commerce and Employment (MoICE), hydropower operators
	Urban Water Supply	Leak reduction, demand management, backup sources	Municipalities, water utilities

T-58. Localized & Community-Led Actions

S. No.	Description of Data Elements	Parameters	Possible Sources
	Traditional Water Management Practices	If documented anywhere (research, NGOs)	Local knowledge, community groups
	Watershed Protection Initiatives	Forestry, land use changes driven by climate concern	Ministry of Environment, local groups, NGOs
	Early Warning Systems (If any)	For floods, landslides	Disaster Management Agency, local level

F. Toolkit for Modules-2 POLICY AND REGULATION ASSESSMENT

M.2.1 Assessment of existing water related policies (M1.1 to M1.6)

M.2.1.A. Compilation and Analysis of Policies, Laws, and Institutional Arrangements

T-1 Water Management Institutions and Their Roles

Institution/Agency	Mandate/Jurisdiction	Key Responsibilities (Relevant to Water)	Relevant Laws or Policies
Department of Water	Overall water resources planning and management	Lead agency for NIWMP, water allocation, data collection, policy development	Water Act of Bhutan (2011), National Integrated Water Resource Management Plan (NIWRMP, 2016), Bhutan Water Policy (2025), The Water Regulation of Bhutan (2014), WATER Securing Bhutan's Future ADB (2016), National Adaptation Plan (NAP, 2023), Analysis of Historical Climate and Climate Projection for Bhutan (2019), Assessment and mapping of water sources/springs in Bhutan (2021), Assessment of climate risks on water resources for the National Adaptation Plan (NAP) in Bhutan - Priority risks and recommendations for adaptation (2023)
Department of Environment and Climate Change	Environmental protection, policy development	Setting water quality standards, issuing permits, monitoring	Water Act of Bhutan (2011), Environmental Regulations, Biodiversity Act of Bhutan (2022), Biodiversity Rules and Regulations (2023)
Ministry of Agriculture and Livestock	Agriculture, irrigation, watershed management	Irrigation development, water allocation for agriculture, promoting watershed protection	Water Act of Bhutan (2011), Forest and Nature Conservation Act (1995), Cross Case Synthesis: an assessment of the impact of National Irrigation Policy (2017)
DoE, MoENR	Hydropower development and management	Planning and operating hydropower projects, regulating water use for power generation	Electricity Act (2001), Water Act of Bhutan (2011) Act (2001), Water Act (2011); PSMP-2040, Energy Policy/Act (under review), GDHP-2018, E-flow guidelines 2019
Ministry of Infrastructure and Transport	Planning, water supply and sanitation	Provision of drinking water and sanitation infrastructure, setting service standards	Local Government Act (2009), Public Health Engineering Division Guidelines, Integrated Urban Water Management (IUWM) - GWP (2014)

Dzongkhag Administrations	District-level governance and coordination	Implementing water-related policies, local-level water resource planning	Local Government Act (2009), Water Act of Bhutan (2011)

Key considerations:

- Is there clarity regarding roles, or is there a potential for conflict between agencies?
- Do institutions have the necessary staff, funding, and resources to effectively carry out their water-related responsibilities?
- Is there a structured system in place for different agencies to work together on water-related matters?

T-2 Water related policies and regulations

Policy/Law/Regulation Title	Year Enacted	Issuing Agency	Key Provisions Related to Water	Areas of Potential Strength/Weakness
Water Act (2011)	2011	NEC (Renamed as DECC)	Establishes principles of water allocation, licensing, pollution control	Consider comprehensiveness, enforceability
Bhutan Water Policy (2025)	[Year]	Department of Water, Bhutan	Outlines strategic direction for water management, including conservation, equitable access, etc.	Consider alignment with current challenges
National Adaptation Plan (NAP) (2023)	2023	NEC (or relevant) (Renamed as DECC)	Specific water-related adaptation measures for climate resilience	Assess if future-focused, actionable
Regulations on Drinking Water Quality	[Year]	Ministry of Health (or relevant)	Standards for safe drinking water, monitoring requirements	Check if based on WHO guidelines, or if stricter
Environmental Assessment Regulations	[Year]	NEC (Renamed as DECC)	Procedures for projects with potential water impacts	Consider if thresholds are clear, enforcement strong
Watershed Protection Regulations	[Year]	Ministry of Agriculture and Livestock	Guidelines for management of forests, land use in critical watersheds	Assess if connected to water supply plans
Irrigation Management Regulations	[Year]	Ministry of Agriculture and Livestock	Rules governing water user associations, allocation in irrigation systems, efficiency measures	Consider if they promote modernization
Hydropower Licensing Regulations	[Year]	Department of Hydropower & Power Systems	Water use requirements for hydropower, environmental flow considerations, coordination with other sectors	Assess if long-term sustainability is addressed
Groundwater Management Regulations	[Year]	[Relevant Agency]	Permitting for well development, protection of recharge zones, monitoring of groundwater levels	Assess if data-driven management is in place
Disaster Risk Reduction and Water	[Year]	Disaster Management Agency	Plans integrating water infrastructure protection, early warning systems for water-related hazards	Assess if proactive, not just response

Key considerations:

- Are policies comprehensive enough to address supply, demand, quality, ecosystem protection, and climate change?
- Do the alignments match each other and align with Bhutan's overall development objectives?
- Has there been evidence of successful execution, or is it primarily grounded in theory?

T-3 Water User Associations (WUAs) and Their Involvement

WUA Name or Type	Geographic Scope	Legal Status (Registered/Informal)	Role in Water Management	Effectiveness	Challenges
Irrigation Channel WUA	Village / group of villages	May have bylaws or be formally recognized	Allocation, maintenance, conflict resolution, fee collection	Level of autonomy, success rate, capacity	Barriers to operation
Drinking Water Supply WUA	Urban neighbourhood or settlement	May be registered, or community committee	Operation of water source, piped network, tariff setting	Service reliability, financial sustainability, inclusion	Dependence on external support
Watershed Protection Committee	Micro-watershed or sub-basin	Could be informal, or linked to forestry programs	Forest protection, erosion control, promoting water-smart land use practices	Influence on decision-making, long-term impact	Conflicts with other land users
[Add more as needed]					

Key considerations:

- Are policies comprehensive enough to address various aspects such as supply, demand, quality, ecosystem protection, and climate change?
- Do the alignments match each other and align with Bhutan's overall development objectives?
- Is there proof of successful implementation, or is it mostly theoretical?

M.2.2. Data management and accessibility

M.2.2.A. Integrated data centers for water resources

T-4 Integrated data centers for water resources

Aspect	Questions to Consider	Possible Sources	Notes
Existing Data Centres	* Are there centralized water data centres or platforms in Bhutan? * Who operates them (government agency, research institute, etc.)? * What is their scope (e.g., only surface water, or broader)?	DoW, relevant ministries, research organizations	Understand if such a centre exists
Data Types	* What kinds of water data are collected? (Rainfall, river flows, water quality, groundwater levels, water use by sector, etc.) * Temporal resolution of data (daily, monthly, etc.)	Relevant agencies (Meteorological Dept., Hydrology, Water Utilities)	
Data Sharing	* Are there formal data-sharing protocols between agencies? * Is data freely accessible, or are there restrictions or fees involved? * What formats is data shared in (raw data, reports, etc.)?	Policies, data portals (if any), interviews with agencies	
Data Security	* What measures are in place to prevent data loss, corruption, or unauthorized access? * Are there backups, cybersecurity practices, etc.?	IT policies of the data centre, interviews	Especially sensitive for transboundary water data

Data Updation	* How frequently is data updated? Is there real-time monitoring for any parameters? * Are there protocols for data quality checks?	Agency procedures, data centre documentation	

- Data analysis software (for comparing and analyzing tariff data across regions or sectors)
- Geographic Information Systems (GIS) - if geo-coded data on water tariffs and customer demographics is available, GIS can be used to visualize spatial patterns of affordability or price variations
- Utility customer surveys (to assess public understanding and acceptance of tariffs)

M.2.2.B. Public online platforms for users

T-5 Public online platforms for users

Aspect	Questions to Consider	Possible Sources	Notes
Existing Platforms	* Do water utilities or local governments have websites or online portals for users? * What functionalities do they offer (if any)? * Are there separate platforms for different services (drinking water vs. irrigation)?	Websites of utilities, municipal bodies, regulatory agencies	May be basic, or non-existent
Tariff Information	* Are water tariffs published online, with clear explanations? * Are there online calculators to help users estimate their bills?	Utility websites, regulations	Lack of transparency hurts public trust
Subscription/ Connection Management	* Can users apply for new water connections or update their details online? * What is the process like (forms, documentation required, etc.)?	Utility websites, e-governance portals (if any)	Ease of use is crucial
Maintenance Requests & Grievances	* Is there an online system for reporting leaks, service disruptions, or billing issues? * Are response timelines and tracking mechanisms in place?	Utility websites, municipal apps, feedback forms	Responsiveness builds confidence
Accessibility	* Are platforms available in local languages besides Dzongkha? * Are they designed for access by people with disabilities?	Government accessibility standards, testing the platforms	Inclusivity is key
Integration	* If there are multiple platforms, are they linked, or must users go to different sites for different services? * Is there potential for a single user-friendly interface?	Technical assessment of existing systems	Fragmented experience is frustrating

M.2.3. Economic and financial aspects

M.2.3.A. Water pricing

T-6. Water pricing

Aspect	Questions to Consider	Possible Sources	Notes
Pricing Policies	* Does Bhutan have a national water pricing policy or guidelines? * Are tariffs set by utilities, local governments, or a central regulator?	Water Act, tariff regulations, utility bylaws	Look for consistency across regions
Tariff Structure	* Are tariffs volumetric (based on amount used), flat rate, block tariffs, or other? * Are there different tariffs for domestic, irrigation, industrial, or commercial users?	Utility billing documents, regulatory rules	Impacts affordability & conservation signals
Cost Recovery	* Do water tariffs cover the full cost of service provision (operation, maintenance, infrastructure investment)? * If not, what is the level of subsidy?	Utility financial reports, government budget allocations	If costs aren't recovered, service suffers
Affordability	* Are there measures to ensure water remains affordable for low-income households (lifeline tariffs, targeted subsidies)? * Do tariffs account for regional economic disparities?	Social welfare policies, utility documents, customer surveys	Equity is linked to pricing policy
Conservation Incentives	* Do tariff structures encourage water conservation (higher prices for excess use)? * Are there penalties for wastage or illegal connections?	Tariff rules, enforcement records	Price as a demand-management tool

M.2.3.B. Economic incentives

T-7 Economic incentives

Incentive Type	Questions to Consider	Possible Sources	Notes
Water-saving technologies	* Are there subsidies, tax breaks, or rebates for adopting efficient irrigation systems, low-flow fixtures, rainwater harvesting, etc.?	Ministry of Agriculture, Ministry of Finance (tax rules), utility programs	Applicable to both rural & urban
Pollution Control	* Are there "polluter pays" principles in place (fines, effluent charges)? * Are there incentives for industries to exceed minimum pollution standards?	Environmental regulations, industry-specific policies	Can be hard to enforce in practice
Ecosystem Protection	* Are landowners compensated for watershed protection services (PES schemes, etc.)? * Are there incentives for reforestation, or penalties for land-use changes harming water sources? PES - Payment for Ecosystem Services	Forestry policies, land use regulations, potential pilot programs	Often requires careful design
Market-based instruments	* Is water trading or water banking allowed in any form (especially if scarcity is an issue)? * Are there experimental projects testing such approaches?	Water Act, academic studies, innovative pilot schemes	Not common, but future-focused

Behavioural Incentives	* Are there public awareness campaigns linking water conservation to economic savings? * Do any utilities offer rewards for reduced water use?	Public outreach materials, utility programs	Beyond just pricing, targets choices

M.2.3.C. Subsidies

T-8 Subsidies

Aspect	Questions to Consider	Possible Sources	Notes
Types of Subsidies	* Are water tariffs below cost, creating an implicit subsidy? * Are there direct subsidies for irrigation infrastructure, water connection fees etc.? * Are these targeted to specific groups (small farmers, low-income areas)?	Utility financial statements, government budget allocations, agricultural support programs	Subsidies can be hidden or explicit
Rationale	* What is the stated goal of each subsidy? (water access, food security, poverty reduction, etc.) * Is there evidence the subsidies are achieving these goals?	Policy documents, program evaluations (if any)	Good intentions don't always equal good outcomes
Unintended Consequences	* Do subsidies encourage wasteful water use, or disincentivize investment in efficiency? * Do they create financial dependency for water providers on government support?	Sectoral water use data, utility financial health, academic studies	Long-term impacts matter
Equity	* Do subsidies disproportionately benefit certain users (large industries vs. smallholders)? * Are subsidies reaching the most marginalized communities?	Program eligibility criteria, socioeconomic data on water access	Subsidies can worsen inequity if poorly designed
Alternatives	* Could the goals be met through more targeted subsidies, incentives, or demand-management? * Is there political will to phase out or reform fewer effective subsidies?	Comparative policy analysis, stakeholder consultations	Master Plan can suggest a shift, not just cuts

- **Budget analysis:** Scrutinize government budget allocations to various water-related programs and subsidies. This analysis can reveal the total amount spent on subsidies, the specific programs or beneficiaries targeted, and any trends in subsidy levels over time.
- **Policy review:** Comprehensively examine water sector policies, laws, and regulations to understand the stated rationale for subsidies and any policy objectives they are designed to support. Look for consistency between national water policy documents and subsidy programs implemented by different ministries or agencies.
- **Stakeholder consultations:** Engage with a diverse range of stakeholders to gather insights on the perceived effectiveness and potential drawbacks of existing water subsidies. Consultations can involve interviews with government officials from relevant ministries (Finance, Agriculture, Works & Human Settlement), water utility managers, representatives from farmer associations, NGOs working on water access issues, and potentially community members in areas where subsidies are in place

M.2.3.D. Financial modelling/ funding

T-9 Financial modelling/ funding

Aspect	Questions to Consider	Possible Sources	Notes
Financial Planning	* Do water utilities, relevant ministries, or planners use financial models for long-term projections? * Do these models account for operational costs, infrastructure replacement, and potential climate change impacts?	Master Plans, feasibility studies, utility budgets, planning guidelines	Sophistication of models varies greatly
Costing of Investments	* Are there standard practices for estimating the capital costs of water projects (dams, treatment plants, etc.)? * Are lifecycle costs considered, not just initial construction?	Engineering guidelines, procurement documents, past project assessments	Underestimates lead to budget shortfalls
Funding Sources	* What is the mix of funding for water projects (government grants, loans, tariffs, private investment)? * Are there innovative financing mechanisms being explored (green bonds, etc.)?	Ministry of Finance, past project funding records, donor/development bank reports	Diversification is key for resilience
Public-Private Partnerships (if applicable)	* Does Bhutan have a framework for PPPs in the water sector? * Are there any successful (or failed) examples to learn from?	PPP policies or guidelines, specific project case studies	Can be complex, needs clear rules
Capacity	* Is there adequate technical expertise in financial modelling and project finance within relevant agencies?	Staffing of finance units, training programs	Strong plans are useless if funding can't be secured

M.2.3.E. Budget allocation for capital, O&M

T-10 Budget allocation for capital, O&M

Aspect	Questions to Consider	Possible Sources	Notes
Budget Analysis	* What percentage of the national budget is allocated to the water sector? * How has this allocation changed over the past several years (trend analysis)? * Is there a breakdown between capital expenditure (new infrastructure) and O&M?	National budget documents, Ministry of Finance reports, past water sector plans	Look for trends, not just one year's data
Distribution	* How is the water budget split between different agencies/ministries involved in water? * How much goes to urban vs. rural water supply, irrigation, hydropower, disaster management, etc.?	Sectoral budget breakdowns, agency reports	Mismatches between needs and funding are common
Alignment with Plans	* Does the budget allocation reflect the priorities in the Water Act, National Water Policy, or other strategic documents? * Are there underfunded areas despite policy emphasis?	Compare policy goals to budget realities	Good plans are useless if unfunded

O&M vs. Capital Focus	* Is there a tendency to overemphasize new construction at the expense of maintaining existing assets? * Are O&M costs factored into the lifecycle budget of projects?	Examine past project records, utility budgets	Neglecting O&M leads to future system failures
Budgeting Process	* How are water-related budget needs determined (bottom-up by utilities, or top-down)? * Is there a transparent and well-defined process?	Budget guidelines, interviews with agencies	Participation influences outcomes

G. Toolkit for Modules-3 DATA MANAGEMENT

M3.1. Data acquisition

M 3.1.A. Hydrometeorological and hydrological data

T-1 Assessment of Hydro-Meteorological Data Infrastructure and Management in Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
Network Density	* How many rainfall stations does Bhutan have, and what is their spatial distribution (consider elevation gradients, etc.)? * How many river gauging stations measure water levels and flows? Are key catchments well-monitored?	NCHM	Assess if coverage is adequate for different water uses
Data Parameters	* Beyond rainfall, what is measured? (Temperature, evaporation, snowpack if relevant, etc.) * Are water quality parameters monitored, and at what frequency (if linked to hydrometer)? * Data on irrigation can be compiled at present stored in basic excel files.	NCHM records, environmental monitoring agencies	Data types must match management needs
Equipment and Technology	* Are stations manual, or do they have automated telemetry for real-time data? * What is the age and condition of the equipment? Are spare parts and calibration services readily available?	NCHM technical reports, maintenance records	Reliability and uptime are crucial
Data Transmission & Storage	* How is data transferred from field stations to a central location? * Is there a database? Is it backed up, secure, and in a well-documented format?	NCHM data management procedures, IT infrastructure assessment	Data that's lost or inaccessible is useless
Quality Control	* Are there standard protocols for checking data for errors, outliers, and gaps before it's used? * Is there a process to flag and correct issues?	NCHM protocols, interview with staff	Bad data leads to bad decisions
Accessibility	* Who can access this data currently (within government, researchers, etc.)? * Are there any barriers (fees, lack of an online platform)?	NCHM policies, review any existing data portals	Open data benefits the NIWMP and society

M 3.1.B. Asset inventory and management

T-2 Evaluation Framework for Water Infrastructure Asset Management in Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
Scope of Inventory	* What types of assets are included? (Dams, reservoirs, treatment plants, pipelines, irrigation canals, hydropower facilities, etc.) * Is there a clear hierarchy or categorization of assets?	Water utilities, relevant ministries, infrastructure plans	Be as comprehensive as possible
Database or System	* Is asset data stored in a centralized database, or is it fragmented across spreadsheets/paper records? * Does the system track just basic information, or also details like construction date, design capacity, condition assessments?	IT systems in water agencies, engineering records	A good database is the foundation
Data Collection Methods	* How is asset information initially gathered? Are there standard forms and field surveys? * For older assets, do construction records or as-built drawings exist?	Procedures of engineering departments, utility operations	Data quality depends on how it's collected
Updating Process	* How frequently is the asset inventory updated? * Is there a process for recording new infrastructure, major repairs, or decommissioning?	Inventory management guidelines, agency protocols	Outdated inventories can be misleading
Condition Assessments	* Are condition assessments conducted on a regular schedule? * Who carries them out, and are there standardized methods? * Are assessment findings integrated into the assets database?	Maintenance records, engineering reports	Knowing the condition is key to prioritization
Usage of Inventory Data	* Is the asset inventory used for planning maintenance? * Does it inform capital budgeting and infrastructure investment plans?	Interview utility managers, planning documents	

M3.2. Data Processing and Integration

M 3.2.A. Data quality assurance

T-3 Quality Control Tools and Procedures for Hydro-Meteorological Data Management in Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
Quality Control (QC) Protocols	* Are there documented QC procedures for different data types (hydro met, water quality, etc.)? * Do these cover the entire data lifecycle (collection, transmission, storage)? * Are procedures in line with international standards or those from reputable agencies?	NCHM or other agencies' data manuals, WHO/WMO guidelines (depending on data type)	
Error Checking	* What checks are in place for outliers, inconsistent values, missing data? * Are these manuals, automated, or a mix?	Technical staff interviews, software used for data processing	

Correction Procedures	* If errors are found, is there a clear process for flagging, correcting where feasible, or documenting the issue for users?	QC protocols, data logs	
Data Validation	* Is there a periodic review to ensure data is sensible? (e.g., cross-checking rainfall against river flow in a catchment)	Agency practices, research studies	
Training and Capacity	* Do staff involved in handling data have training in QC, or is it done ad-hoc?	Staff development records, curricula if formal training exists	

M 3.2.B. GIS integration and Visualization

T-4 Assessment Tool for GIS Application in Water Resources Management in Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
GIS Usage	* Is GIS used in water resources management? If so, by which agencies or departments? * Is its use project-specific or institution-wide?	Relevant ministries (hydropower, water supply, etc.), academic studies	
Data Integration	* Can GIS easily integrate: hydrometeorological data, asset data, land use/cover, watershed boundaries, etc.? * Are data layers available in compatible digital formats?	GIS staff interviews, data compatibility standards	
Analysis Capabilities	* What types of spatial analysis are conducted for water management? Examples: flood risk mapping, catchment delineation, water demand hot spot identification, etc.	Project reports, academic collaborations, software licenses held	
Visualization	* Are GIS maps used to effectively communicate data to decision-makers and stakeholders? * Are data portals or web maps available for wider access?	Review existing maps, reports, online platforms	
Software and Skills	* What GIS software is used (ArcGIS, QGIS, etc.)? * Is there adequate GIS expertise (staff numbers, training levels)?	IT procurement records, human resources assessment	

M 3.2.C. Metadata Management

T-5 Metadata Management Evaluation Tool for Bhutan's Geospatial and Environmental Data

Aspect	Questions to Consider	Possible Sources	Notes
Metadata Standards	* Does Bhutan follow any metadata standard (ISO 19115 for geospatial is common, others exist)? * If not, are there agency-specific guidelines on what to document?	National data policies, agency data dictionaries, check headers of existing datasets	
Content	* What metadata is typically collected? Consider: data source, collection date/time, methodology, units of measurement, accuracy/precision, responsible person/agency, any restrictions on use, etc.	Review existing metadata (if any), interview data managers	

Storage	* Is metadata stored with the dataset itself, or in a separate catalogue? * Is there a searchable metadata database?	IT systems within agencies, data portal design	
Workflow	* Is metadata creation integrated into the data collection and processing workflow, or done as an afterthought?	Procedures for field staff and data analysts	
Usage	* Do decision-makers, researchers, etc., actively consult metadata before using a dataset?	Interview data users, look for citations of metadata in reports	

M 3.2.D. Aquifer Mapping and Validation

T-6 Aquifer Mapping and Assessment Tool for Groundwater Management in Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
Mapping Efforts	* Have any systematic aquifer mapping efforts been undertaken? At what scale (national, specific basins)? * Are maps based on geological surveys, borehole data, or a combination?	Water resources agency, geological surveys, academic studies	
Data Types	* What aquifer parameters are mapped? Consider: depth to groundwater, aquifer extent, water quality, recharge rates, potential yields	Hydrogeology reports	
Data Sources	* What data is used for mapping? Drill logs, pumping tests, geophysical surveys, existing well data? * How is data quality assessed?	Agency records, interview with groundwater experts	
Validation	* Is aquifer maps ground-truthed through new drilling or monitoring wells? * Is there a process to update maps as new information emerges?	Project reports, research collaborations	
Usage	* Are aquifer maps used to guide well permitting, protect recharge zones, or for groundwater modelling?	Regulations, planning documents, interview with water managers	

M3.3. Data governance and accessibility

M 3.3.A. Secure data storage and infrastructure

T-7 Water Data Security and Management Assessment Tool for Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
Storage Location	* Where is primary water data stored? (Agency servers, cloud, offsite)? * Are there redundant backups with geographic separation?	IT policies of agencies, server room assessments	
Physical Security	* If data is on physical servers, is the server room access controlled, with protection against fire, flooding, etc.?	Facility inspection, security protocols	
Cybersecurity	* Are there firewalls, antivirus, and intrusion detection systems in place? * Are encryption protocols used for data in transit and at rest?	IT security audits, agency policies	

Backup Procedures	* How frequently is data backed up? Are backup files tested to ensure they can actually restore data?	IT backup schedules, disaster recovery plans	
Disaster Recovery	* Is there a documented disaster recovery plan specifically for critical water data? * Does this include steps to restore not just data, but necessary software to use it?	Emergency plans, past incident reviews	
Access Controls	* Are there clear permissions on who can access, modify, or delete data? * Are logs kept on data access for accountability?	IT systems, user rights management	

M 3.3.B. Data sharing and transparency

T-8 Open Water Data Policy and Accessibility Assessment Tool for Bhutan

Aspect	Questions to Consider	Possible Sources	Notes
Open Data Policy	* Does Bhutan have a national or water sector specific open data policy? * Does it mandate proactive sharing of non-sensitive data?	Government open data portal (if any), review policies, National Statistics Bureau	
Data Portal	* Is there a centralized online portal where water data is published? * How easy is it to find and download data?	Search existing government websites, agency sites	
Data Licensing	* Are datasets published under clear licenses (Creative Commons, etc.) so users understand how the data can be reused?	Check data portals, metadata	
Formats	* Is data available in machine-readable formats (CSV, not just PDFs), or only as images in reports?	Test downloads from portals	
Restrictions	* Are there legitimate restrictions on certain datasets (national security, personally identifiable info)? * Are restrictions explained clearly?	Policies, portal terms of use	
Data Requests	* If data isn't on a portal, is there a process to request it? Is there a response timeline, and are fees, if any, transparent?	Agency websites, past user experiences	

H. Toolkit for Modules-4 CAPACITY BUILDING

M 4.1 Understanding water governance

M 4.1.A. Department of water, Bhutan

T-1 Comprehensive Checklist for Understanding the Department of Water's Role in country's Water Resource Management

Aspect	Checklist Items	Possible Sources	Notes
Familiarity with Organizational Structure:	Understand the hierarchical structure of the Department of Water, Bhutan, including divisions, departments, and key personnel responsible for water resource management.	Bhutan Water Act 2011, Department of Water, Bhutan organizational charts	
Mandate and Functions:	Grasp the department's mandate and its functions concerning water resource management, such as regulation, conservation, and development of water resources.	Bhutan Water Act 2011, Department of Water, Bhutan website	
Policies and Regulations:	Acquire knowledge of existing policies, regulations, and frameworks governing water management in Bhutan, including laws related to water rights, pollution control, and water allocation.	Bhutan Water Policy, Legislative documents	
Ongoing Initiatives:	Stay informed about ongoing water-related projects and initiatives undertaken by the Department, including infrastructure development, research projects, and community outreach programs.	Department of Water, Bhutan reports, Project documentation	

M 4.1.B. Allied departments (tourism, environment, etc.)

T-2 Strategic Framework for Inter-Departmental Collaboration in Water Resource Management in Bhutan

Aspect	Checklist Items	Sources/References
1. Identify relevant allied departments	List all departments with potential impact on water resources (ref table. Below)	o National policies and regulations o Previous water management plans and reports o Stakeholder interviews and consultations
2. Understand roles and responsibilities	Define the specific roles of each department (ref table. Below)	o Government mandates and organizational structures o Existing collaboration frameworks and agreements o Departmental policies and strategies

3. Assess existing water-related initiatives	Identify ongoing projects and programs related to water	○ Government databases and reports ○ Stakeholder consultations ○ Past evaluations and assessments
4. Analyze potential synergies and conflicts	Identify areas of alignment and potential conflicts	○ SWOT analysis ○ Comparative studies with similar contexts ○ Expert consultations and workshops
5. Establish communication channels	Determine formal and informal communication mechanisms	○ Communication plans and protocols ○ Stakeholder mapping and engagement strategies ○ Technology platforms for information sharing

T-3 Key Ministries and Departments Involved in the National Integrated Water Master Plan (NIWMP) of Bhutan: Roles and Contributions

Category	Ministry / Department	Role in NIWMP
Directly Linked	Ministry responsible for Water	Core leadership, integrating water-specific expertise and data
Directly Linked	MoENR / LG	Protecting water sources, addressing ecosystem-water linkages
Directly Linked	MoAL and MoIT	Managing irrigation demand, aligning practices with water sustainability
Directly Linked	NCHM	Integrating hydropower operations into broader water resource planning
Directly Linked	DLGDM	Water-related disaster risk reduction (flood, drought)
Directly Linked	Urban Development / Municipalities	Ensuring sustainable urban water services
Directly Linked	Regulatory Bodies (Water Pricing, Pollution Control, etc.)	Setting and enforcing rules that impact water use and quality
Indirectly Linked	DoT	Sustainable tourism development in the context of water availability
Indirectly Linked	MoICE/MoENR	Balancing industrial water needs, pollution control for water security
Indirectly Linked	MoIT	Safe drinking water and sanitation
Indirectly Linked	NCHM	Providing climate and hydro-met data essential for NIWMP
Indirectly Linked	National Statistics Bureau	Data support for informed water management decisions

M 4.1.C. User groups and water committees

T-4 Assessment of Community Engagement and Capacity in Water Management Practices

Aspect	Questions to Consider	Possible Sources	Notes
Awareness of Rights & Roles	* Do members understand their legal rights to water access? * Are they aware of their expected role in water management, as outlined in policies or plans?	Interviews with groups, review of Water Act, or participatory schemes	
Understanding of Water Issues	* Do group members have a basic understanding of local water resources, challenges (scarcity, quality, etc.), and how their actions impact the system?	Educational programs run by govt or NGOs, focus group discussions	
Technical Skills	* Do groups have any training in water-efficient practices, simple water quality monitoring, or maintaining small-scale infrastructure?	Past capacity-building programs they've attended	
Leadership & Organization	* Are water committees well-structured with clear leadership? * Do they have processes for decision-making and conflict resolution?	Internal rules of the committees, observation of meetings	
Representation	* Do the committees ensure inclusivity across genders, socioeconomic groups, or upstream/downstream users where relevant?	Committee membership records	
Linkages to Government	* Is there a clear channel for the groups to communicate with water agencies? *Are their concerns taken seriously?	Review of institutional mechanisms, case studies of past interactions	

M 4.2. Capacity building

M 4.2.A. Training programmes / expert talks

T-5 Framework for Designing and Implementing Water Management Training Programs

Aspect	Checklist Items	Sources/References
1. Identify target participants	- Specify individuals, institutions, and environmental contexts	- Stakeholder analysis - Sector-specific needs assessments
2. Develop a curriculum	- Outline topics, objectives, and methodologies for training	- Industry best practices and standards - Global benchmarks for water management - Expert consultations and feedback
3. Select qualified trainers/speakers	- Identify experts in water management and related fields	- Academic and professional credentials - Previous successful training programs - Recommendations from industry leaders
4. Establish training logistics	- Determine venue, schedule, and required resources	- Budget constraints and allocations - Accessibility and inclusivity considerations - Technological infrastructure for virtual training
5. Monitor and evaluate training effectiveness	- Implement pre- and post-training assessments	- Participant feedback and satisfaction surveys - Adjustments to the curriculum based on evaluations - Long-term impact assessments on participant performance

M 4.2.B. Knowledge sharing

T-6 Strategic Plan for Enhancing Knowledge Sharing in Water Management

Aspect	Checklist Items	Sources/References
1. Identify knowledge sources	- Identify internal and external knowledge repositories	- Existing databases and documentation - Expert networks and collaborations - Industry publications and research papers
2. Develop a knowledge-sharing strategy	- Define goals, target audiences, and delivery mechanisms	- Institutional strategies and goals - Communication and outreach plans - Lessons learned from previous knowledge-sharing initiatives
3. Establish a knowledge-sharing platform	- Select suitable platforms (online portals, workshops, forums)	- Technological infrastructure and capabilities - Accessibility considerations - Privacy and security measures
4. Create content and learning materials	- Develop user-friendly materials catering to diverse audiences	- Subject matter experts and content creators - Multimedia tools and software - Accessibility and inclusivity considerations
5. Encourage active participation	- Implement interactive sessions, discussions, and forums	- Engagement strategies and incentives - Community-building approaches - Feedback mechanisms and continuous improvement plans

M 4.2.C. Technology integration and innovation

T-7 Technology Assessment and Integration Framework for Water Management

Aspects	Checklist Items	Sources/References
1. Assess current technology landscape	- Evaluate existing technological infrastructure and capabilities	- Technical reports and assessments - Inventory of available technologies - Stakeholder consultations
2. Identify technology needs and gaps	- Determine specific requirements for water management technologies	- Needs assessment surveys - Analysis of technological trends and advancements - Benchmarking with similar projects or initiatives
3. Explore innovative solutions	- Research and identify innovative technologies and approaches	- Academic and industry publications - Case studies of successful implementations - Collaboration with research institutions and technology providers
4. Develop technology integration plan	- Outline strategies for integrating selected technologies	- Project management frameworks - Budget allocations - Risk assessment and mitigation plans

5. Provide training and support for technology use	- Organize training programs for stakeholders on technology usage	- Expert consultations and workshops - User manuals and documentation - Technical support systems

M 4.3. Awareness and behavioral change communication at community level

M 4.3.A. Creating a citizen forum (M.3.3.b)

T-8 Guidelines for Establishing Citizen Forums in Water Management

Aspects	Checklist Items	Sources/References
1. Identify community stakeholders	- Identify key community groups and individuals for forum formation	- Community mapping - Stakeholder consultations
2. Establish forum objectives	- Define the purpose and goals of the citizen forum	- Alignment with water management objectives - Input from community stakeholders
3. Determine forum structure and governance	- Decide on the organizational structure and leadership roles	- Best practices in citizen forum organization and governance - Legal and regulatory requirements
4. Develop communication channels	- Establish methods for communication and information sharing	- Technology platforms (social media, websites, etc.) - Traditional communication channels (meetings, posters, etc.)
5. Conduct regular forum meetings	- Schedule and organize periodic meetings for engagement	- Meeting agendas and protocols - Facilitation techniques

4.3.B. Citizen involvement in planning process

T-9 Community Engagement Strategy for Water Master Plan Development

Aspects	Checklist Items	Sources/References
1. Identify key stakeholders and community groups	- Identify relevant community groups and stakeholders for involvement	- Stakeholder analysis reports from previous water management projects - Community leader consultations - Collaboration with local authorities and community-based organizations
2. Conduct initial community awareness sessions	- Organize community meetings to introduce the water master plan and its objectives	- Presentations and informational materials developed specifically for community engagement - Local media campaigns to announce and promote the sessions - Engage local influencers and opinion leaders to increase attendance
3. Gather community input and preferences	- Facilitate focus group discussions and workshops to gather feedback and ideas	- Prepared discussion guides tailored to specific topics of the water master plan - Utilize participatory tools such as voting boards and idea boards - Translate materials into local languages to ensure inclusivity

4. Provide accessible information on the plan	- Distribute informational materials about the water master plan in accessible formats	- Develop brochures, posters, and fact sheets explaining key aspects of the plan - Utilize digital platforms and social media for information dissemination - Establish information kiosks in public areas for easy access to materials
5. Establish a feedback mechanism	- Set up dedicated channels for community feedback and inquiries	- Establish a hotline or email address for direct communication with stakeholders - Design feedback forms and suggestion boxes for collecting input - Regularly review and respond to feedback received from the community

M 4.3.C. Information, Education and Communication (IEC)

T-10 Implementation and Evaluation of Information, Education, and Communication (IEC) Initiatives for Water Management

Submodule	Checklist Items	Sources/References
1. Conduct a baseline assessment of community knowledge and perceptions related to water management	- Gather data through surveys, interviews, or focus group discussions	- Previous water management reports and studies - Local government records and documents - Expert consultations
2. Develop tailored IEC materials and strategies	- Create educational materials and campaigns in local languages	- Collaboration with education and communication experts - Utilize culturally appropriate messaging and visuals - Ensure accessibility for diverse community members
3. Implement IEC activities	- Organize workshops, seminars, and community events	- Budget allocations - Utilize existing community gatherings for IEC interventions - Engage local influencers and opinion leaders for outreach
4. Monitor and evaluate IEC effectiveness	- Collect feedback and data on the reach and impact of IEC efforts	- Pre- and post-intervention surveys - Focus group discussions to assess perception changes - Observation of community engagement during IEC activities

I. Toolkit for Modules-5 MONITORING AND EVALUATION

M 5.1. Monitoring of user-based water components

M 5.1.A. Water service access and coverage

T-1 Comprehensive Strategy for Enhancing Water Service Coverage and Quality in Bhutan

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Identification of Service Areas	Map current service coverage	1. Collect existing geographic and infrastructure data. 2. Utilize GIS technology to map out current water service areas. 3. Identify gaps in coverage by comparing service maps with population density maps.	Geographic Information Systems (GIS), local water authority records	Use GIS mapping to accurately identify and document areas covered by water services, including differentiation between urban, peri-urban, and rural zones.
Population Served	Calculate the percentage of the population served	1. Use census data to obtain current population figures. 2. Cross-reference population data with service area maps to determine coverage. 3. Calculate the percentage of the population within service areas versus total population.	Census data, water service provider databases	Assess how much of the population has access to water services within identified areas to identify gaps in service coverage.
Service Quality	Evaluate reliability, continuity, and pressure	1. Conduct surveys or utilize sensors to gather data on water service reliability and pressure. 2. Analyse service interruption records for continuity assessment. 3. Implement improvement plans based on evaluation results.	Customer feedback, service logs, field measurements	Assessments should include the regularity and quality of water supply, focusing on reliability (24/7 service), continuity (no interruptions), and pressure.
Accessibility for Vulnerable Groups	Ensure equitable access	1. Identify vulnerable groups through social studies and surveys. 2. Assess current accessibility levels for these groups. 3. Develop targeted strategies to remove barriers and improve access.	Social studies, community surveys	Special emphasis on ensuring that marginalized and vulnerable groups have access to water services, identifying and addressing any barriers to access.
Expansion Plans	Develop plans for extending services	1. Analyse data from service area mapping and population coverage to identify priority areas for expansion. 2. Conduct feasibility studies for infrastructure development.	Strategic development plans, feasibility studies	Outline strategies for expanding water services to unserved and underserved areas, including necessary infrastructure investments and timelines.

		3. Draft detailed expansion plans including timelines, budgets, and required resources.		
Community Participation	Engage local communities in planning	1. Organize community meetings and public consultations. 2. Gather input on local water needs and preferences. 3. Incorporate community feedback into planning and decision-making processes.	Community meetings, public consultations	Facilitate active participation of local communities in the planning and decision-making processes to ensure that services meet their needs and preferences.
Legal and Regulatory Framework	Review and strengthen regulations	1. Review existing water service regulations and policies for gaps or outdated provisions. 2. Propose amendments or new regulations to support sustainable water service delivery. 3. Engage with legal experts and stakeholders for comprehensive policy development.	Legal documents, policy analysis	Examine current legal and regulatory frameworks governing water services, identifying areas for improvement to support service expansion and sustainability.
Technological Solutions	Implement innovative solutions	1. Research and identify technological advancements in water service delivery. 2. Evaluate the applicability and benefits of these technologies for Bhutan. 3. Plan and implement pilot projects for promising technologies.	Industry best practices, technology assessments	Investigate and adopt technological advancements that can improve the efficiency and quality of water service delivery, such as smart water management systems.
Financing Strategies	Identify financing mechanisms	1. Conduct a financial analysis of current funding and expenditure. 2. Explore various financing options, including government funding, loans, grants, and private investments. 3. Develop a sustainable financial model for water service expansion and maintenance.	Financial analysis, potential donor agencies	Explore sustainable financing options for service expansion and maintenance, including government funding, international aid, and partnerships with the private sector.
Monitoring and Feedback	Establish monitoring systems	1. Define key performance indicators (KPIs) for water service delivery. 2. Implement data collection mechanisms, such as customer feedback and sensor data. 3. Regularly review performance data and adjust strategies accordingly.	Performance indicators, customer feedback systems	Set up comprehensive monitoring and feedback mechanisms to continuously evaluate the access and quality of water services and address issues promptly.

M 5.1.B. Water supply and demand

T-2 Strategic Approach to Balancing Water Supply and Demand in Bhutan

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Water Supply Assessment	Evaluate current water sources	1. Inventory existing water sources (rivers, reservoirs, groundwater). 2. Assess the capacity and yield of each source. 3. Analyse historical data to identify trends and variability.	Hydrological studies, water resource databases	Understanding the capacity and reliability of each water source is crucial for long-term planning.
Water Demand Analysis	Estimate current and future demand	1. Collect data on current water use by sector (domestic, agricultural, industrial). 2. Project future demand based on population growth, economic development, and changing consumption patterns. 3. Identify sectors with rising demand.	Census data, economic forecasts, water usage records	Accurate demand projections are essential for ensuring water supply meets future needs.
Water Balance and Gap Identification	Assess supply-demand balance	1. Compare total available water supply with current and projected demands.\ 2. Identify periods and areas of water surplus or deficit. 3. Evaluate the impact of climate change on water balance.	Climate change models, water management plans	Identifying gaps is critical for addressing potential water shortages and planning for demand management or supply augmentation.
Sustainability and Efficiency Measures	Promote water use efficiency	1. Implement water-saving technologies and practices in key sectors. 2. Encourage rainwater harvesting and reuse of treated wastewater. 3. Develop incentives for water conservation.	Best practice guides, policy frameworks	Efficiency measures can significantly reduce demand, contributing to the sustainability of water resources.
Policy and Regulatory Framework	Strengthen water governance	1. Review and update water policies and regulations to support sustainable water use. 2. Ensure policies are aligned with NIWMP goals and objectives. 3. Engage stakeholders in policy development and implementation.	Legal documents, stakeholder consultations	Effective governance is key to managing water supply and demand sustainably.
Monitoring, Reporting, and Adaptation	Establish a robust M&E system	1. Develop indicators for water supply reliability and demand management effectiveness. 2. Regularly collect and analyse data to inform policy and management decisions. 3. Adjust strategies based on feedback and changing conditions.	M&E frameworks, data collection tools	Ongoing monitoring and flexibility to adapt are essential for responsive water resource management.

M 5.1.C. Water quality and health

T-3 Water Quality Management and Health Impact Strategy

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Water Quality Monitoring	Implement comprehensive water quality testing	1. Identify key water quality parameters (e.g., pH, turbidity, contaminants). 2. Develop a schedule for regular sampling and analysis 3. Designate monitoring sites across various water sources and supply systems.	Environmental Protection Agency guidelines, water quality standards	Regular testing is crucial for early detection of pollution and ensuring water safety.
Health Impact Assessment	Monitor water-related health outcomes	1. Track incidence of water-borne diseases. 2. Analyze health data in relation to water quality data. 3. Collaborate with health departments for integrated monitoring.	Health department records, hospital, and clinic reports	Understanding the link between water quality and health is vital for targeted public health interventions.
Public Awareness and Education	Enhance public knowledge on water quality	1. Develop educational materials on safe water practices. 2. Conduct public awareness campaigns. 3. Provide resources for household water treatment and safe storage.	Public health guidelines, community workshops	Educated communities are better equipped to protect their health and advocate for improvements.
Source Protection	Implement strategies to protect water sources	1. Identify potential sources of contamination. 2. Establish protected zones around water sources. 3. Enforce regulations on industrial discharges and agricultural runoff.	Land use plans, environmental regulations	Protecting water sources is fundamental for sustaining water quality and ecosystem health.
Treatment and Remediation	Ensure access to effective water treatment	1. Evaluate the effectiveness of existing water treatment facilities. 2. Upgrade infrastructure as needed to meet quality standards. 3. Implement point-of-use treatment solutions where necessary.	Water treatment technology standards, infrastructure assessment reports	Adequate treatment is essential for removing contaminants and ensuring water is safe for consumption.
Stakeholder Engagement and Collaboration	Foster multi-sectoral partnerships	1. Establish forums for stakeholder involvement in water quality management. 2. Promote collaboration between water sector, health agencies, and communities. 3. Leverage expertise and resources for joint initiatives.	Stakeholder meeting reports, partnership agreements	Collaborative efforts enhance the effectiveness of water quality and public health measures.
Policy Development and Enforcement	Strengthen water quality regulations	1. Review and update policies related to water quality and health. 2. Ensure compliance with national and international standards. 3. Implement enforcement mechanisms for violators.	Legislative documents, policy reviews	Strong policies and enforcement mechanisms are crucial for maintaining high standards of water quality.

M 5.1.D. Financial sustainability

T-4 Financial Sustainability Strategy for Water Services Management

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Revenue Generation	Assess current revenue streams	1. Review tariffs, fees, and other charges. 2. Analyse revenue from water services and permits.	Billing records, financial statements	Ensure revenues cover operational and maintenance costs, reflecting a balance between affordability and sustainability.
Cost Recovery Analysis	Evaluate cost recovery mechanisms	1. Compare revenues against full cost of water services. 2. Identify gaps in cost recovery.	Cost accounting records, financial analysis	Full cost recovery includes operational, maintenance, and environmental costs.
Financial Planning and Management	Develop long-term financial plans	1. Forecast future financial needs. 2. Plan for capital investments and infrastructure upgrades.	Budget documents, strategic plans	Long-term planning is essential for sustainable infrastructure development and service provision.
Efficiency and Affordability	Measure efficiency and control costs	1. Implement measures to reduce water loss. 2. Review tariffs for affordability and equity.	Operational audits, customer feedback surveys	Balancing efficiency with affordability ensures broad access to water services while promoting conservation.
Investment in Infrastructure	Plan and prioritize infrastructure investments	1. Identify critical infrastructure needs. 2. Secure funding for sustainable water system upgrades.	Infrastructure assessment reports, investment plans	Strategic investments are crucial for resilience and sustainability.
External Funding and Partnerships	Explore external funding opportunities	1. Identify and apply for grants and loans. 2. Establish partnerships with private sector and NGOs.	Grant databases, partnership agreements	External funding can complement domestic resources for large-scale projects and innovations.
Sustainability Indicators and Reporting	Establish financial sustainability indicators	1. Develop key financial indicators. 2. Regularly report on financial health and sustainability.	Annual reports, sustainability assessments	Indicators might include cost recovery ratio, operational efficiency, and investment in maintenance.

M 5.1.E. Infrastructure and efficiency

T-5 Strategies for Enhancing the Efficiency and Resilience of Water Infrastructure

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Infrastructure Condition Assessment	Evaluate the physical condition of infrastructure	1. Conduct regular inspections and assessments of water distribution networks. 2. Identify areas of deterioration and risk of failure.	Inspection reports, maintenance records	Early identification of issues allows for timely repairs and reduces the risk of service disruptions.
System Efficiency Analysis	Analyse water system efficiency	1. Measure non-revenue water including physical losses and unbilled authorized consumption. 2. Benchmark efficiency against industry standards.	Water audit reports, performance benchmarks	High levels of non-revenue water indicate areas for improvement in system efficiency and integrity.
Renewal and Upgrading Strategies	Plan for infrastructure renewal and upgrades	1. Prioritize infrastructure projects based on criticality and risk assessment. 2. Develop a schedule and budget for upgrades and expansions.	Capital improvement plans, risk assessments	Systematic upgrading ensures the resilience and capacity of water infrastructure to meet demand.
Innovative Technologies	Integrate innovative technologies and practices	1. Identify and evaluate new technologies for water treatment, distribution, and conservation. 2. Implement pilot projects to test feasibility.	Technology reviews, pilot project reports	Adoption of new technologies can enhance efficiency and service quality.
Energy Efficiency	Improve energy use efficiency	1. Conduct energy audits of water treatment and distribution systems. 2. Implement energy-saving measures and monitor results.	Energy audit reports, operational data	Energy efficiency reduces operating costs and environmental impact.
Capacity Building	Enhance technical and managerial capabilities	1. Identify skill gaps among staff. 2. Provide targeted training programs on system maintenance, emergency response, and efficient operation.	Training needs assessments, workshop reports	Well-trained staff are essential for maintaining high levels of service efficiency and reliability.
Sustainability and Climate Resilience	Ensure infrastructure sustainability and resilience	1. Incorporate climate change projections into infrastructure planning. 2. Implement measures to enhance system resilience to extreme weather events.	Climate studies, resilience strategies	Planning for climate resilience safeguards water supply against future challenges.

M 5.2. Interpretation and standardization

M 5.2.A. Analytics and GIS mapping

T-6 GIS-Driven Approach for Advanced Water Management and Planning

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Data Collection and Management	Compile and standardize spatial data	1. Gather spatial data on water sources, infrastructure, and demand. 2. Standardize data formats for compatibility.	Satellite imagery, field surveys	Consistent data formats ensure ease of analysis and integration across platforms.
GIS Mapping	Develop comprehensive GIS-based maps	1. Map water distribution networks, supply areas, and risk zones. 2. Visualize demographic and ecological data layers.	GIS software, environmental databases	GIS maps provide a spatial understanding of water resources, critical for planning and management.
Analytics for Resource Allocation	Utilize analytics for optimizing resources	1. Analyse water usage patterns and demand forecasts. 2. Identify areas of high stress or potential scarcity.	Usage data, predictive modelling tools	Analytics help in making informed decisions about water allocation and conservation efforts.
Risk Assessment and Management	Apply GIS for risk and vulnerability analysis	1. Identify areas vulnerable to droughts, floods, and pollution. 2. Map potential impacts on water quality and availability.	Climate data, hydrological studies	Understanding environmental risks assists in proactive planning and mitigation strategies.
Infrastructure Planning	Plan infrastructure using GIS insights	1. Analyse spatial data for new infrastructure projects. 2. Optimize locations for treatment plants, reservoirs, and pipelines.	Infrastructure databases, GIS analysis	Spatial analytics support the strategic expansion of water infrastructure to meet future needs.
Public Access and Transparency	Create public-facing GIS portals	1. Develop online platforms to share water resource maps and data. 2. Encourage public engagement and awareness.	Web GIS platforms, public access software	Accessible GIS data promotes transparency and enables community participation in water management.
Continuous Monitoring and Updating	Ensure regular updates to GIS databases	1. Establish protocols for the periodic updating of GIS data. 2. Integrate real-time data feeds where possible.	Remote sensing data, IoT sensors	Up-to-date GIS information is vital for responsive water resource management and adapting to changes.

M 5.2.B. Benchmarking and best practices

T-7 Framework for Implementing Best Practices in Water Management

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Performance Benchmarking	Identify key performance indicators (KPIs)	1. Determine KPIs for water efficiency, quality, and sustainability. 2. Compare against national and international benchmarks.	Industry reports, international water associations	KPIs guide the evaluation of current performance and highlight areas for improvement.
Best Practice Research	Research and document global best practices	1. Review literature on successful water management strategies. 2. Document case studies relevant to similar contexts.	Academic journals, case study repositories	Understanding global successes provides a roadmap for adopting effective practices.
Gap Analysis	Conduct a gap analysis	1. Compare current practices against best practices. 2. Identify discrepancies and areas for enhancement.	Internal assessments, benchmarking studies	Gap analysis pinpoints specific areas needing attention and improvement.
Adoption of Best Practices	Develop an implementation plan for best practices	1. Prioritize best practices based on their impact and feasibility. 2. Outline steps for integration into current operations.	Strategic plans, implementation guides	A structured approach ensures the effective translation of best practices into operational improvements.
Stakeholder Engagement	Involve stakeholders in benchmarking processes	1. Solicit feedback on best practice adoption. 2. Engage stakeholders in setting performance targets.	Workshops, surveys	Stakeholder input enriches the benchmarking process and fosters a culture of continuous improvement.
Continuous Monitoring	Establish a system for ongoing evaluation	1. Regularly monitor the performance against adopted best practices. 2. Adjust strategies based on outcomes and evolving benchmarks.	Monitoring tools, performance dashboards	Continuous monitoring ensures practices remain effective and adapt to changing conditions.
Knowledge Sharing	Promote internal and external knowledge exchange	1. Create forums for sharing successes and lessons learned. 2. Participate in networks for water management excellence.	Conferences, professional networks	Sharing experiences encourages innovation and collective advancement in water management practices.

M 5.2.C. Stakeholder engagement and feedback

T-8 Stakeholder Engagement Plan for Water Resource Management

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Stakeholder Identification	Identify all relevant stakeholders	1. List stakeholders including community members, government entities, businesses, and NGOs. 2. Categorize them by interest and influence.	Stakeholder databases, community meetings	Comprehensive identification ensures all voices are considered in the planning process.
Engagement Strategy	Develop an engagement plan	1. Outline objectives for engagement. 2. Determine methods and timelines for stakeholder interaction.	Communication plans, engagement frameworks	A clear strategy facilitates effective and timely stakeholder interactions.
Information Dissemination	Share information with stakeholders	1. Use diverse platforms to communicate plan details and updates. 2. Ensure information is accessible and understandable.	Newsletters, websites, public forums	Transparent communication builds trust and informs stakeholders of the process and its benefits.
Feedback Mechanisms	Establish channels for receiving feedback	1. Create multiple channels for feedback including surveys, public meetings, and online portals. 2. Actively encourage and facilitate stakeholder feedback.	Feedback forms, digital platforms	Effective feedback mechanisms are crucial for incorporating stakeholder perspectives into the plan.
Incorporation of Feedback	Integrate stakeholder feedback into the plan	1. Review and analyse received feedback 2. Adjust planning and implementation strategies accordingly.	Analysis reports, strategy documents	Responsiveness to feedback demonstrates commitment to stakeholder involvement and plan improvement.
Continuous Engagement	Maintain ongoing stakeholder involvement	1. Provide regular updates on progress and developments 2. Invite stakeholders to participate in review and revision processes.	Progress reports, revision meetings	Ongoing engagement ensures stakeholders remain informed and involved throughout the planning lifecycle.
Evaluation of Engagement Efforts	Assess the effectiveness of engagement activities	1. Conduct surveys or interviews to gauge stakeholder satisfaction. 2. Use findings to improve future engagement efforts.	Evaluation studies, feedback analysis	Regular evaluation helps refine engagement strategies for greater inclusivity and effectiveness.

M 5.3. Performance evaluation and continuous improvement

M 5.3.A. Monitoring and progress tracking

T-9 Framework for Effective Monitoring and Adaptive Management in Project Implementation

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Monitoring Framework	Establish a monitoring framework	1. Define clear objectives and key performance indicators (KPIs). 2. Develop a timeline for regular review sessions.	Project plans, strategic goals	A robust framework is essential for tracking progress and ensuring alignment with overall objectives.
Data Collection and Analysis	Set up data collection systems	1. Identify data needs for each KPI. 2. Utilize appropriate tools and technologies for data collection.	Data management tools, field surveys	Accurate and timely data collection underpins effective monitoring and decision-making.
Progress Reports	Generate regular progress reports	1. Compile data into comprehensible reports. 2. Highlight achievements, challenges, and variances from plans.	Reporting software, templates	Regular reports facilitate transparency, accountability, and informed decision-making.
Review Meetings	Conduct periodic review meetings	1. Schedule and hold meetings with key stakeholders. 2. Discuss progress, obstacles, and potential adjustments.	Meeting agendas, minutes	Meetings offer opportunities for collaborative review and consensus-building on necessary actions.
Adjustment Mechanisms	Implement mechanisms for adjustments	1. Define procedures for making adjustments to strategies or activities. 2. Ensure flexibility to respond to feedback.	Management protocols, policy documents	The ability to adapt to feedback and changing circumstances is crucial for maintaining project relevance and impact.
Performance Dashboards	Develop performance dashboards	1. Create dashboards to visualize progress on KPIs in real time 2. Enable access for relevant stakeholders.	Dashboard software, KPI metrics	Dashboards provide an at-a-glance view of progress, facilitating quick insights and decisions.
Feedback Loops	Establish feedback loops	1. Formalize channels for receiving feedback from stakeholders. 2. Integrate feedback into review and planning cycles.	Surveys, forums	Feedback loops are vital for continuous improvement and stakeholder engagement.

M 5.3.B. Adaptive management

T-10 Continuous Improvement Process for Project and Program Improvements

Aspect	Checklist Item	Detailed Steps	Possible Sources	Notes
Improvement Identification	Pinpoint areas for enhancement	Review data and feedback; prioritize by impact.	Feedback channels, reports	-
Solution Generation	Create and assess solutions	Ideate with stakeholders; evaluate feasibility.	Innovation labs, workshops	Diverse input encourages creative solutions.
Pilot Testing	Test improvements on a small scale	Implement, monitor, and gather feedback on pilots.	Pilot reports	Mitigates risk and informs scalability.
Feedback Integration	Incorporate stakeholder feedback	Adjust improvements based on stakeholder insights.	Surveys, discussions	Ensures alignment with stakeholder needs and expectations.
Iterative Refinement	Continuously refine based on outcomes	Use feedback and results for adjustments.	Improvement logs	Supports ongoing optimization of strategies.
Documentation and sharing	Record and disseminate learnings	Document processes and outcomes; share widely.	Case studies, guides	Facilitates knowledge sharing and institutional memory.

M 5.3.C. Incorporating innovation

T-11 Innovation Integration Strategy for Enhancing Water Management Systems

Aspect	Checklist Item	Detailed Steps	Examples and Best Practices
Innovation Identification	Scout for emerging innovations	Identify technological and methodological advancements	Decentralized water treatment, AI in water management
Feasibility Analysis	Assess applicability and benefits	Evaluate potential impact, costs, and adaptation needs	Rainwater harvesting in urban settings
Pilot Projects	Implement pilot studies	Test selected innovations in controlled environments	Pilot testing of smart water meters
Stakeholder Involvement	Engage stakeholders in innovation	Gather input and support from community and experts	Community-based water management initiatives
Scaling and Integration	Plan for broader adoption	Develop strategies for scaling successful innovations	Nationwide rollout of water-saving technologies
Monitoring and Evaluation	Track performance and adapt	Continuously evaluate the effectiveness and make necessary adjustments	Feedback mechanisms for new water policies
Knowledge Sharing	Disseminate findings and lessons learned	Share successes and challenges widely	Workshops and publications on innovative practices

J. Toolkit for Modules-6 FINANCE

M 6.1 Need Assessment

M 6.1.A. Current Capital expenditure (Capex) and Operating Expenditure (Opex)

T-1 Financial Analysis Checklist for Existing Water Infrastructure Management

S. No.	Checklist	Possible Sources	Notes
	*Existing infrastructures (as derived from M1.1 to M1.5) Capex cost	Department of Water; Department of Macro-fiscal and Development Finance; Department of Procurement and Properties; Department of Treasury and Accounts; Department of Planning, Budget, and Performance; Dept. of Revenue & Custom	Collect data for all infrastructure.
	*Existing infrastructures (as derived from M1.1 to M1.5) Opex. cost		Collect data for all infrastructure.
	*Opex. cost break – (is it PPP contract, who is the agency managing it, is the infrastructure is operated and maintained by gov. department, what is the monthly or annual cost given to the operating agency, staff involved, equipment's and machinery operation and maintenance schedule and costs in last five years, etc.)		Collect data for last five years
	*Opex. issues / challenges face in current financial arrangement		Collect data for last five years
	*Capex. issues / challenges face in current financial arrangement		Collect data for last five years

M 6.1.B. User charges

T-2 Revenue Collection Analysis for Water Services: User Charges and Taxes Overview

S. No.	Checklist	Possible Sources	Notes
	*A. User charges collected giving per connection (water supply, wastewater supply and stormwater) for each user type.	Department of Water; Department of Macro-fiscal and Development Finance; Department of Procurement and Properties; Department of Treasury and Accounts; Department of Planning, Budget, and Performance; Dept. of Revenue & Custom	Last five years data
	*Total no. of users (M1.1. to M1.5.)		Last five years data; Understanding incremental increase and check for 100% connection coverage.
	*A. Total amount of user charges collected for giving connections		Last five years data
	*B. Amount of user charges collected in form of taxes for various services (water supply, wastewater supply and stormwater).		Last five years data
	*A. Total amount of user charges collected in form of taxes		Last five years data

M 6.1.C. Cost-benefit analysis

T-3 Annual Financial Overview and Cost-Benefit Analysis for Water Sector

S. No.	Checklist**	Possible Sources	Notes
	*Understanding total expenses – annually	Department of Water; Department of Macro-fiscal and Development Finance; Department of Procurement and Properties; Department of Treasury and Accounts; Department of Planning, Budget, and Performance; Dept. of Revenue & Custom	Last five years data
	*Understanding total revenues collected annually		Last five years data
	*Gathering information about cost to benefit ratio		Last five years data

***if the said data is not available, they detailed assessment needs to be carried out by experts.*

M 6.2 Proposed cost estimates for recommendations

T-4 Evaluation and Recommendation Framework for Sustainable Water Management Solutions

S. No.	Checklist (Technology / institutional, governance and IEC level) **	Possible Sources	Notes
	*Capex. cost of recommended solutions	Learning from best practices national and international	Solutions should be compiling to SDG 6,7,11, and 13
	*Opex. cost of recommended solutions		Finding Opex. based on interaction with potential Pvt. players or vendors.
	*Cost benefit ratio of revenue vs total expenses (Capex + Opex)		Assessment potential benefits / revenue streams vs cost estimated for solutions
	*Recommending best suitable recommendations based on various options		Minimum three options required

M 6.3 Funding sources

M 6.3.A. Gov. budget allocations

T-5 Comprehensive Budget Analysis for Water Supply, Wastewater, and Stormwater Infrastructure

S. No.	Checklist**	Possible Sources	Notes
	*Budget for Water supply infrastructure components	Department of Water; MoF	Last five years
	*Budget for wastewater infrastructure components		Last five years
	*Budget for stormwater infrastructure components		Last five years
	*Understand the increase or decrease annually w.r.t to various budget heads / allocations		Last five years
	*Identify various options in the overall budget – were there can be potential cross-sectoral linkages.		Last five years
	*Understand past funding sources such as international funding / Grants; User charges / Taxes; PPP / HAM (detailed in the recommendations)		Last five years

***if the said data is not available, they detailed assessment needs to be carried out by experts.*

M 6.3.B. Other funding sources

T-6 International Funding Overview: A compilation of data related to external funding sources for the water sector in Bhutan

S. No.	Checklist	Possible Sources	Notes
	Document external water-related projects	International donor databases, Project reports	Record names, durations, amounts, areas of focus.
	Evaluate project alignment with NIWMP	Strategic planning documents, Partnership MOUs	Ensure consistency with NIWMP goals.
	Review terms of external funding	Financial agreements, MOUs	Note conditions, repayment terms.
	Explore funding diversification	Global environmental and climate funds	Investigate various donor options for water sector support.
	Aggregate data on funding impact	Project evaluations, Donor reports	Assess the effectiveness and alignment with sector needs.
	Strategize partnerships for NIWMP enhancement	Networking events, Stakeholder meetings	Formulate approaches for donor engagement and collaboration.

M 6.4 Climate Finance

T-7 Climate Finance Impact and Assessment for Water Management Projects in Bhutan

Sr.	Checklist**	Possible Sources	Notes
1.	*Breakdown of climate finance allocated to water supply, wastewater, and stormwater related projects	Dep. of Water Bhutan; Learning from best practices	Last five years data
2.	*Funding sources, including public and private investments, grants, and loans for climate related solutions such as Nature based solutions, early warning systems, alerts etc.		Last five years data
3.	*Climate Resilience Metrics: Integration of climate resilience measures in project design and implementation. Data on the adaptability of infrastructure to climate change impacts.		Last five years data
4.	*Impact on Water Security: Changes in water availability and quality post-implementation. Improved water security indicators, such as increased access to clean water.		Last five years data
5.	*Social and economic benefits realized by vulnerable communities w.r.t to current and prosed infrastructures.		Last five years data
6.	*Environmental Impact: Evaluation of the environmental sustainability of water projects. Assessments of any unintended environmental consequences.		Last five years data
7.	*Risk Assessment: Identification and evaluation of potential risks associated with climate finance in water projects. Strategies employed to mitigate and manage risks.		Last five years data

***if the said data is not available, they detailed assessment needs to be carried out by experts.*

Chapter 6: Documents Referred

List of documents referred to while preparing the draft guiding tool for NIWMP:

- National Adaptation Plan (NAP) of the Kingdom of Bhutan, 2023
- National Integrated Water Resource Management Plan (NIWRMP), 2016
- Water Act of Bhutan, 2011
- Bhutan Water Policy, 2025
- Integrated Urban Water Management (IUWM) - GWP (Global Water Partnership), 2014
- Bhutan Water policy, 2007
- Analysis of Historical Climate and Climate Projection for Bhutan - National Center for Hydrology and Meteorology Royal Government of Bhutan, 2019
- Assessment and mapping of water sources/springs in Bhutan, watershed management division December, 2021
- Assessment of climate risks on water resources for the National Adaptation Plan (NAP) in Bhutan Priority risks and recommendations for adaptation, 2023
- The Water Regulation of Bhutan, 2014
- WATER Securing Bhutan's Future ADB, 2016
- Cross Case Synthesis: an assessment of the impact of National Irrigation Policy Volume I: Policy and Planning Division, Ministry of Agriculture & Forests (renamed as Ministry of Agriculture and Livestock) May 2017
- A Roadmap and Strategy for Strengthening Skills Assessment for Climate Change Research in Bhutan 2021 – 2025 National Adaptation Plan (NAP) Formulation Process in Bhutan, November 2020
- Biodiversity Act of Bhutan 2022
- Biodiversity Rules and Regulations 2023
- Secondary towns urban development project-3674 (tariff rationalization) MoWHS (now renamed Ministry of Infrastructure and Transport), RGoB
- Draft Guideline for Water Tariff (NEC now renamed as DECC)
- Thimphu Structure Plan Comprehensive Development Plan for Bhutan 2030 -JICA
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- Assessment of climate risks on water resources for the National Adaptation Plan (NAP) in Bhutan. Deltares. (2021).
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- Population Projections Bhutan 2017–2047; National Statistics Bureau, Bhutan
- National Sanitation and Hygiene Policy 2020, RGoB
- A Roadmap and Strategy for Strengthening Skills Assessment for Climate Change Research in Bhutan 2021 – 2025; November 2020.
- National Forest Policy of Bhutan - Final Draft March, 2010
- Bhutan Drinking Water Quality Standard, 2016

Toolkits referred

- Urban Water Security Planning Toolkit, CEPT University, 2017, https://cwas.org.in/resources/file_manager/urban_water_security_planning_toolkit_compressed.pdf
- Water Security and Cities: Integrated Urban Water Management. Global Water Security Issues (GWSI), UNESCO and i-WSSM. 2023, https://unesdoc.unesco.org/ark:/48223/pf0000388100
- Our City Plans: An Incremental and Participatory Toolbox for Urban Planning, UN- Habitat, 2021, https://unhabitat.org/sites/default/files/2020/07/piup_toolbox_final.pdf
- Toolkits Master Plan Preparation, National Capital Region Planning Board, ADM, 2009, https://www.ncrpb.nic.in/NCRBP%20ADB-TA%207055/index.html#
- Climate proofing toolkit for basic urban infrastructure, with a focus on water and sanitation, UN- Habitat, 2021, https://unhabitat.org/sites/default/files/2021/09/climate_proofing_toolkit_2021_option_b.pdf
- The WASH Basins Toolkit, ARUP, Frank Water, 2022, https://www.frankwater.com/app/uploads/2022/01/WASH-Basins-Toolkit-Global-.pdf
- Guidelines for the preparation of national master water plans, water resources series no. 65, UN, 1989, https://www.ircwash.org/sites/default/files/202.5-89GU-5794.pdf
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- The Multi Use Water Services (MUS) Toolkit, Rockefeller Foundation, IRC, https://www.musgroup.net/node/15
- IWRM Guidelines at River Basin Level (Part 1: Principles and Parts 2.1, 2.2, 2.3: Guidelines for IWRM Coordination, for Flood Management, and for Irrigation), UNESCO,2009, https://unesdoc.unesco.org/ark:/48223/pf0000186417
- Water security planning, USAID, 2018, https://winrock.org/wp-content/uploads/2018/05/20170512_Winrock_SWP_Toolkit-3-2.pdf
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- Aurora Integrated Water Master Plan (IWMP), 2017; https://cdnsm5-hosted.civiclive.com/UserFiles/Servers/Server_1881137/File/Residents/Water/PDFs/Water%20Facts%20and%20Reports/Aurora%20IWMP%20Final_External%20Use_September%202017.pdf
- The Republic Of Kenya - The Project On The Development Of The National Water Master Plan 2030; https://wasreb.go.ke/downloads/National%20Water%20Master%20Plan%202030%20Exec.%20Summary%20Vol.%201%20Main%201.pdf
- The Study on Master Plan on Renewable Water Resource Development in the Southwest Region in the Kingdom of Saudi Arabia, 2010; https://openjicareport.jica.go.jp/pdf/12005732_01.pdf