Adapting to Climate Change through IWRM

Technical Assistance No.: ADB TA 8623 BHU
Kingdom of Bhutan

WANGCHHU BASIN MANAGEMENT PLAN 2016

April 2016

Egis in joint venture with

Royal Society for Protection of Nature

Bhutan Water Partnership

FOREWORD by the Chairman of the Wangchhu Basin Committee

ACKNOWLEGEMENT

NECS, ADB and TA

DISCLAIMER

Any international boundaries on maps are not necessarily authoritative.

Acronyms

ADB	Asian Development Bank
AWDO	Asian Water Development Outlook
BCCI	Bhutan Chamber of Commerce and Industries
BhWP	Bhutan Water Partnership
BLSS	Bhutan Living Standard Survey
BNWRI	Bhutan National Water Resources Inventory
BTFEC	Bhutan Trust Fund for Environmental Conservation
CD	Capacity Development
CDTA	Capacity Development Technical Assistance
CFO	Chief Forestry Officer
CMIP5	Coupled Model Inter-comparison Project Phase 5
DLO	Dzongkhag Livestock Officer
DAO	Dzongkhag Agricultural Officer
DDM	Department of Disaster Management
DEC	Dzongkhag Environment Committee
DEO	Dzongkhag Environment Officer
DES	Department of Engineering Services
DG	Director General
DGM	Department of Geology and Mines
DHPS	Department of Hydropower & Power Systems
DMF	Design & Monitoring Framework
DOA	Department of Agriculture
DOFPS	Department of Forest & Park Services
DHMS	Department of Hydro Met Services
DRC	Department of Revenue and Customs
DWS	Drinking Water Supply
ESD	Environment Service Division of NECS
FAO	Food & Agricultural Organization (of the United Nations)
FEMD	Flood Engineering Management Division (MOWHS)
FGD	Focus Group Discussion
GIS	Geographical Information System
GLOF	Glacier Lake Outburst Flood
GNHC	Gross National Happiness Commission
GNHCS	Gross National Happiness Commission Secretariat
HP	Hydropower Plants
IEC	Information, Education and Communication
IT	Information Technology

IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KPI	Key Performance Indicator
KRA	Key Result Area
MASL	Meter above sea level
MOAF	Ministry of Agriculture & Forest
MOEA	Ministry of Economic Affairs
MOF	Ministry of Finance
MOH	Ministry of Health
MOHCA	Ministry of Home & Cultural Affairs
MOWHS	Ministry of Works & Human Settlements
MPR	Monthly Progress Report
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
NIIS	National Irrigation Information System
NIMP	National Irrigation Master Plan
NIWRMP	National Integrated Water Resources Management Plan
NLC	National Land Commission
NWRB	National Water Resource Board
ODE	Organizational Development Exercise
PES	Payment for Environmental Services
PHED	Public Health Engineering Division
PlaMS	Plan Monitoring System
PPT	Power Point (Presentation)
RBC	River Basin Committee
RBMP	River Basin Management Plan
RCSC	Royal Civil Service Commission
RGOB	Royal Government of Bhutan
RNR	Renewable Natural Resources
RSPN	Royal Society for Protection of Nature (Bhutan)
TA	Technical Assistance
TAC	Technical Advisory Committee (advising WRCD, NECS)
TNA	Training Needs Assessment
TOR	Terms of Reference
UNESCO	United Nations Educational, Scientific and Cultural Organization
WBMP	Wangchhu Basin Management Plan
WEAP	Water Evaluation And Planning, tool for water accounting
WMD	Watershed Management Division
WQMS	Water Quality Monitoring Section of WRCD
WRCD	Water Resources Coordination Division of NECS
WUAs	Water Users Associations

GLOSSARY

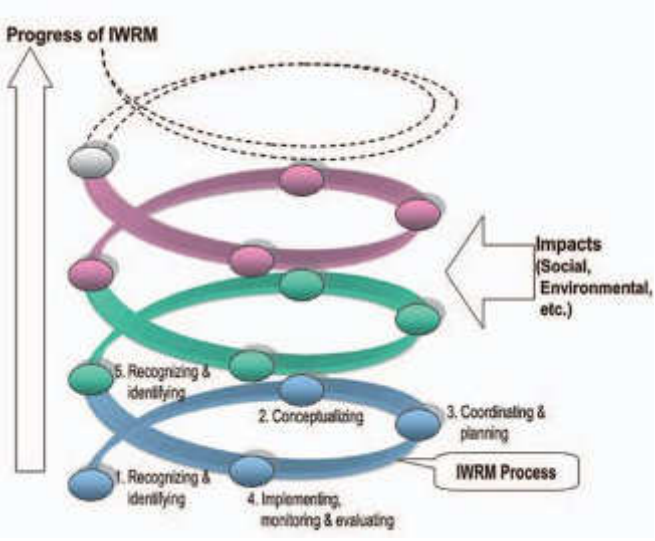
Drainage basin	A drainage basin or catchment basin is an extent or an area of land wherein all surface water from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join another body of water, such as a river, lake, reservoir, estuary, wetland, sea, or ocean.[1] Or, a drainage basin or catchment basin is an extent or an area of land where all surface water from rain, melting snow, or ice converges to a single point at a lower elevation.
Falkenmark index	According to the Falkenmark Water Stress Indicator, a country or region is said to experience "water stress" when annual water supplies drop below 1,700 cubic metres per person per year. At levels between 1,700 and 1,000 cubic metres per person per year, periodic or limited water shortages can be expected. When water supplies drop below 1,000 cubic metres per person per year, the country faces "water scarcity"[2]
Hydrological water balance	Any water entering a system (via precipitation) must be transferred into either evaporation, surface runoff (eventually reaching the channel and leaving in the form of river discharge), or stored in the ground as groundwater and on the ground as snow or ice. This balance requires the system to be a closed hydrological unit.[3]
Integrated Water Resources Management (IWRM)	IWRM is defined as 'a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems'.[4]
IWRM components	The components of IWRM are as follows: **1. Managing water at the basin or watershed level** This includes integrating land and water, upstream and downstream, groundwater, surface water, and coastal resources. **2. Optimizing supply** This involves conducting assessments of surface and groundwater supplies, analysing water balances, adopting wastewater reuse, and evaluating the environmental impacts of distribution and use options.

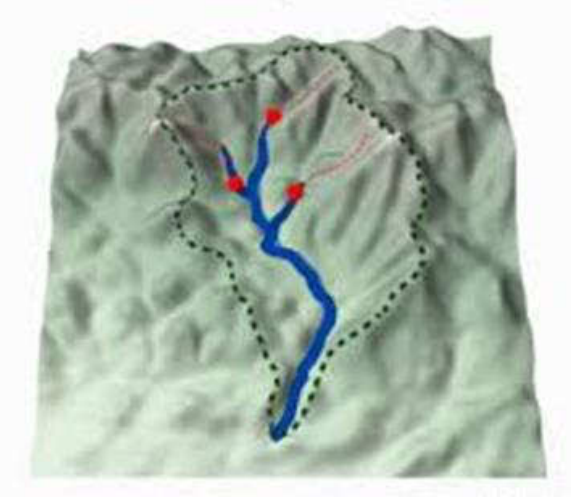
[1] https://en.wikipedia.org/wiki/Drainage_basin

[2] https://en.wikipedia.org/wiki/Water_scarcity

[3] https://en.wikipedia.org/wiki/Water_balance

[4] Global Water Partnership: http://www.gwp.org/The-Challenge/What-is-IWRM/

	3. Managing demand This includes adopting appropriate water/scarcity pricing and investment cost recovery policies, utilizing water-efficient technologies, and establishing decentralized water management authorities. **4. Providing equitable access** This may include support for effective water users' associations, involvement of marginalized groups, and consideration of gender issues. **5. Establishing policy** Examples are implementation of the polluter-pays principle, water quality norms and standards, and market-based regulatory mechanisms. **6. Inter-sectoral approach** Utilizing an inter-sectoral approach to decision-making, where responsibility or authority for managing water resources is coordinated well and stakeholders have a share in the process.
IWRM pillars	The three IWRM pillars relate to: (i) enabling environment (suitable policies, strategies, and legislation); (ii) capable institutional mechanisms; and (iii) management instruments.
IWRM spiral	The traditional one-track approach of "predict→plan→control" is no longer appropriate. Rather, an approach that incorporates iterative learning and flexibility is needed to make water development plans robust to an uncertain future faced with a variety of change drivers and challenges. This can be achieved within the context of IWRM, in particular through a process of continual evolution and improvement – which in the IWRM literature is referred to as the "**spiral approach"**, see figure below. 

	From AWDO, 2013 Each spiral describes the cycle of (1) recognizing/ identifying the issues at stake; (2) conceptualizing the mitigating strategies; (3) coordination & planning of activities; (4) implementing, monitoring and evaluation. Each cycle typically takes about 5 years, and thus corresponds well with the five-year planning practice of the GNHC in Bhutan. Conclusions from the evaluation of previous round of activities will lead to renewal or adjustment of plans in the next cycle.
River basin	A river basin can be defined as:[5] The geographical area determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus (cf. Helsinki Rules, International Law Association, 1966, article II). Or A river basin is the portion of land drained by a river and its tributaries. It encompasses the entire land surface dissected and drained by many streams and creeks that flow downhill into one another, and eventually into the river and exiting the area at one point, see figure below.  Schematic presentation of a river basin NB: A (drainage) basin is basically the same as catchment area or watershed. The distinction is mainly based on the scale of the area being referred to.
The Dublin principles for IWRM	IWRM strategies are based on the four principles formulated at a water conference in Dublin in 1992 (referred to as the Dublin Principles of IWRM) and presented to world leaders at the World Summit in Rio de Janeiro in 1992. The four principles are: (i) water is finite and vulnerable resource; (ii) need for

[5] https://docs.google.com/a/universitywatersectorpartnership.org

	a participatory approach in water management; (iii) the role of women is stressed; and (iv) water has social and economic value. Later, a fifth principle is added: (v) integration of the three E's: economic efficiency – social equity – environmental sustainability.
Water accounting	The systematic study of the current status and future trends in water supply, demand, accessibility and use within a given spatial domain.[6]
Water availability	The hydrologic capacity of a water source (surface water body, groundwater, municipal water) to sustain additional water demands after considering other current water uses and water conditions. (GEMI, 2012) [7] In the context of this basin plan the water availability in an area has been determined as runoff generated from precipitation within the concerned area augmented with the inflow from upstream areas after deducting consumption.
Water security	Defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."[8] Water security may be viewed in physical or economic terms. Physical water security is a situation wherein water is abundant enough to meet all demands, whereas economic water security depends on providing adequate investments in water infrastructure and services delivery.
Watershed	A geographic area of land, water and biota within the confines of a drainage divide. Watershed boundaries define the aerial extent of surface water drainage to a point. Watershed boundaries always follow the highest ridgeline around the stream channels and meet at the bottom or lowest point of the land where water flows out of the watershed. The boundary between watersheds is defined as the topographic dividing line from which water flows in two different directions. However, the scale at which the land scape is examined is relevant for identifying and defining watersheds. A watershed may be small and represent a single tributary within a larger system, or be quite large and cover thousands of miles (i.e. Mississippi River Watershed).[9]

[6] Godfrey, J. and K. Chalmers (editors). Water Accounting: International Approaches to Policy and Decision-making. Edward Elgar Publishing, 2012.

[7] http://www.iadclexicon.org/water-availability/

[8] UN-Water: http://www.unwater.org/topics/water-security/en

[9] http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1042207.pdf

Wetlands	"Wetland" is a generic term for all the different kinds of wet habitats--implying that it is land that is wet for some period of time, but not necessarily permanently wet.10 There are various definitions, they usually highlight three aspects: (i) the hydrological regime (depth of flooding or soil saturation; (ii) the type of plant growth (hydrophytes); and (iii) Soil development (hydric soils). Not all definitions include deep permanent lakes and/or glaciers. Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favour the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils. [11] Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation and other factors, including human disturbance. Inland wetlands, like in Bhutan, are non-tidal and can comprise floodplains along rivers and streams; isolated depressions surrounded by dry land along the margins of lakes and ponds, and in other low-lying areas where the groundwater intercepts the soil surface or where precipitation sufficiently saturates the soil (vernal pools and bogs); marshes and wet meadows dominated by herbaceous plants, swamps dominated by shrubs, and wooded swamps dominated by trees. NB: Perennially irrigated areas are not necessarily defined as wetlands under this generic definition.

[10] https://water.usgs.gov/nwsum/WSP2425/definitions.html

[11] http://www.epa.gov/wetlands/what-wetland

EXECUTIVE SUMMARY

1. The Wangchhu Basin Management Plan (WBMP) was prepared in accordance with the requirements laid down in the Water Act (2011) and the Water Regulation (2014), giving a prominent role to the River Basin Committee (RBC) to be established in each of the main river basins. Accordingly, an Executive Order was issued on 14 April 2016 establishing the Wangchhu Basin Committee (WBC). The WBC is composed of chairpersons of the district development councils (Dzongkhag Tshogdu*)*, district governors (Dzongdags), district environment officers (DEOs) of the four districts of Chukha, Haa, Paro, and Thimphu and the Environmental Officer and Mayor (Thrompon) of Thimphu city. The position of RBC chairperson will be rotated *annually* among the district governors covered by the basin, and a staff member of the WRCD, NECS will be designated as interim member secretary until the time when the RBCs are able to have their own Secretariat

   The Executive Order, in accordance with the provisions of Water Act, mandates the WBC to *coordinate* water resource management in the basin. In particular, the WBC is a coordinating body responsible for preparation and updating of river basin management plan, integration of priorities in respective district plans, monitoring implementation of plans and reporting on the level of water security in the basin. The structure and institutional linkages of the River Basin Committee is shown in Figure 1.

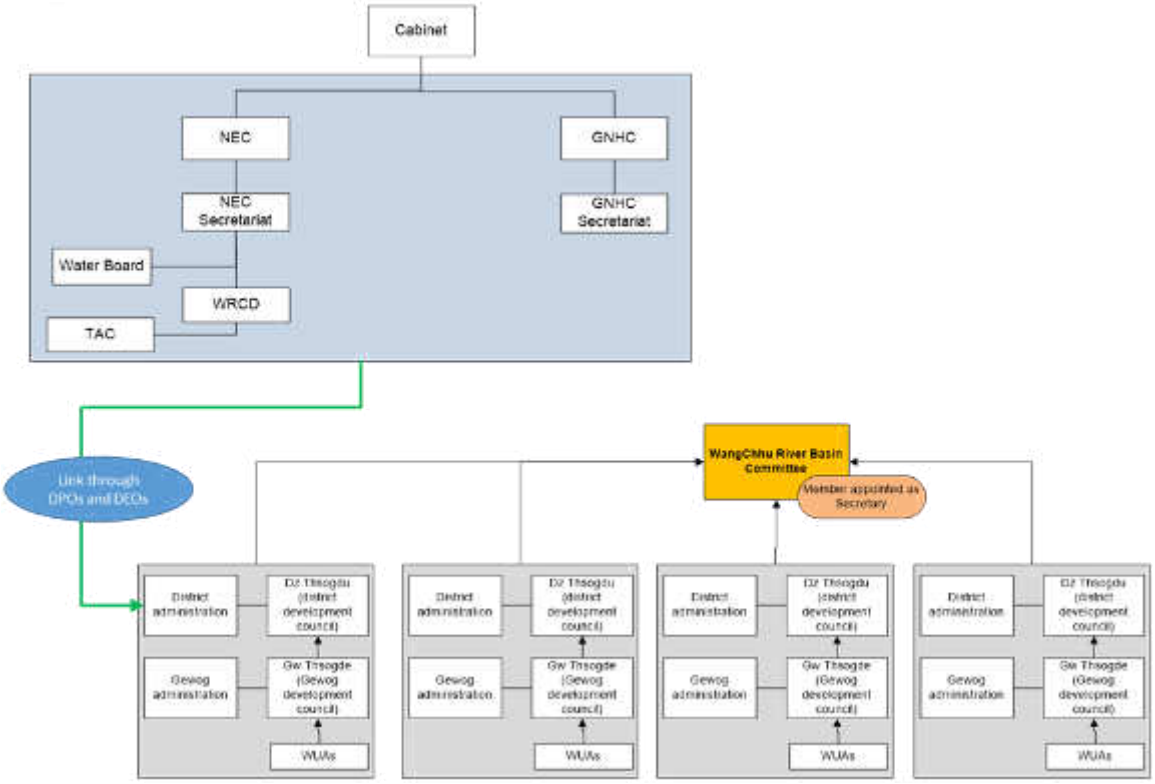


Figure 1: Structure of the RBC

   Prior to formal establishment of the Wangchhu RBC, the designated members of the RBC were involved in the preparation of the WBMP through a series of meetings and workshops. These were held from May 2015 to April 2016 and were facilitated under the Asian Development Bank financed technical assistance project

"Adapting to Climate Change through IWRM."[12] The Wangchhu RBC was formally established by Executive Order of the Prime Minister on 14 April 2016, see Appendix 1

The WBMP was prepared in line with the National IWRM Plan (NIWRMP) as well as the UNESCO guidelines for IWRM at the river basin level. It was endorsed by the RBC in its meeting on 21 April 2016.

2. The overall goal of the WBMP is to increase and sustain water security in Wangchhu basin through improved planning and coordination among agencies involved in water resources management along the framework of the Bhutan Water Security Index System (BWSIS). As with the national level, the BWSIS at basin level comprises five key dimensions: (i) rural drinking water supply and sanitation; (ii) economic water security; (iii) urban drinking water supply, sanitation and drainage; (iv) environmental water security; and (v) resilience to disaster and climate change. Each dimension is scored by an index value in the range from 1 (poor) to 5 (very good), from which an overall average score is obtained. For Bhutan the present average score is 3.08, and for Wangchhu basin the score is 3.34 (Figure 2).

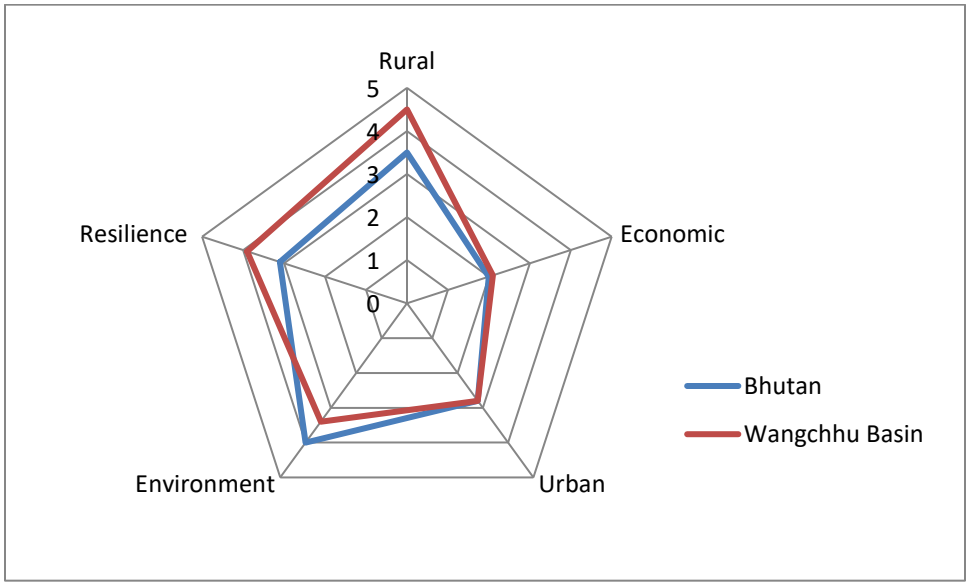


Figure 2: Present Water Security Index for Bhutan and Wangchhu basin

This goal of improved basin water security shall be achieved through iterative and adaptive planning spirals matching the Five Year Plan periods, as illustrated in Figure 3. The time horizon is 2033, which coincides with the end of the 14th FYP.

[12] Adapting to climate change through IWRM, ADB-TA BHU-8623.

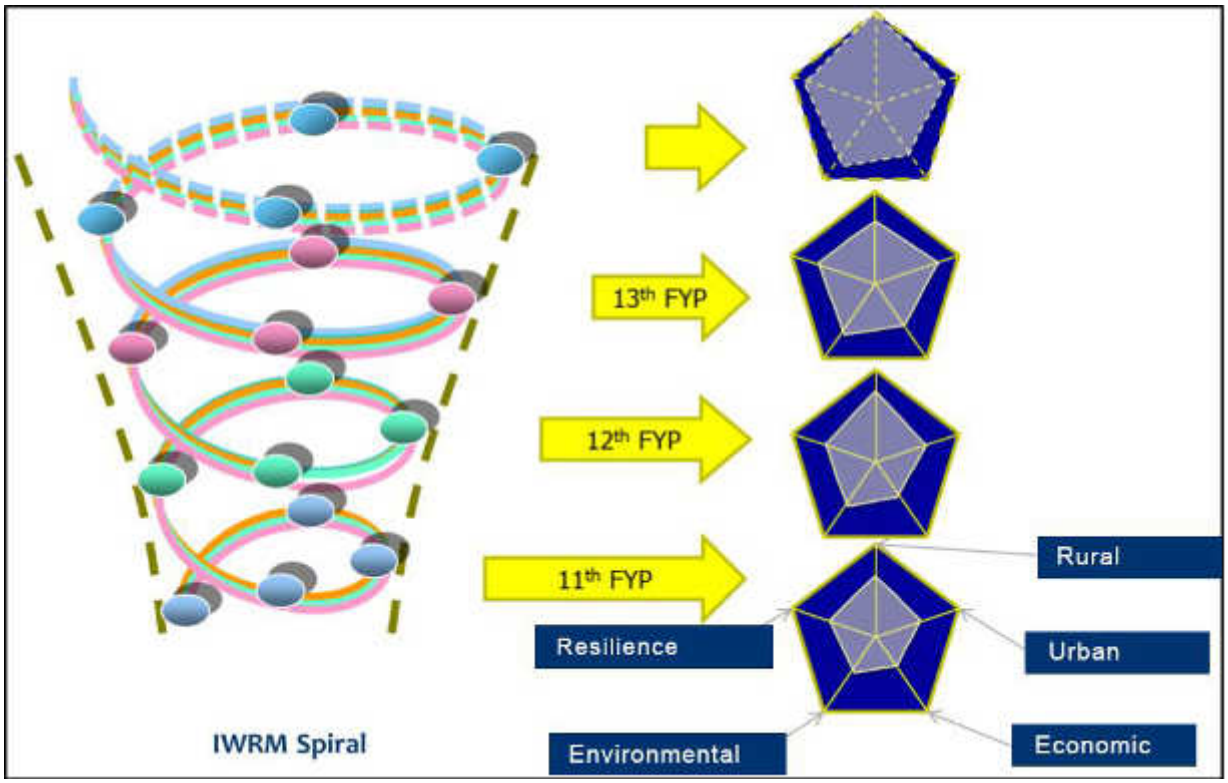


Figure 3: Schematic presentation of the IWRM spiral

(Adapted from Asian Water Development Outlook 2013)

3. The WBMP was prepared on the basis of climatic, hydrological, and socio-institutional assessments as shown in the simplified diagram in Figure 4.

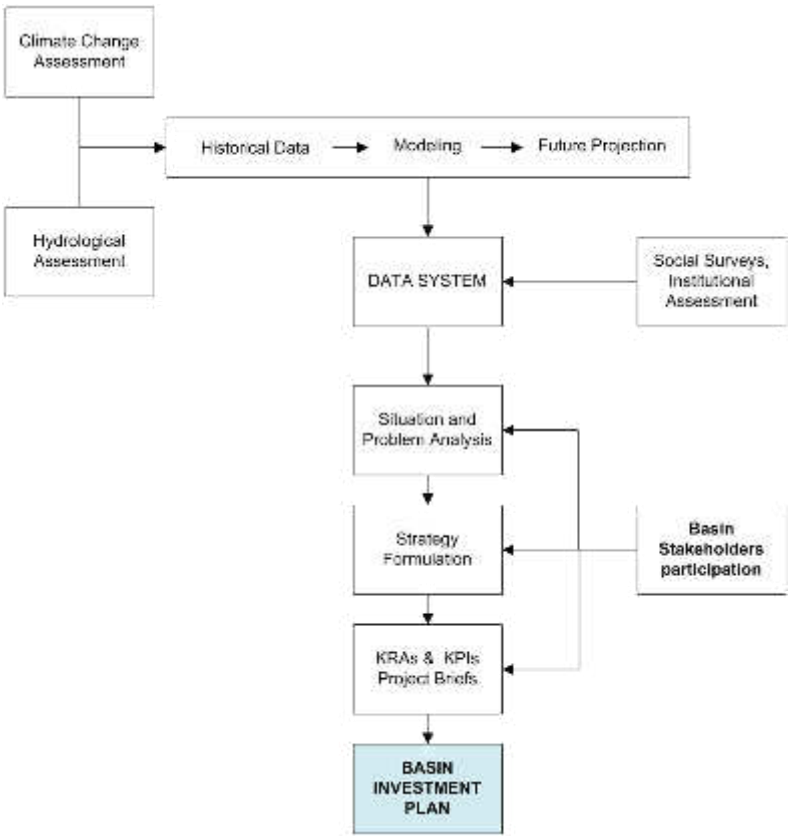


Figure 4: Simplified diagram showing methodology of preparation of the WBMP

4. Wangchhu basin occupies almost 12% of Bhutan's area, and its share in forest land (10.0%), agricultural area (12.1%), wetland (9.2%) and livestock (12.3%), as well as capital outlay (13.1%) is in the same order of percentage. However, the percentage of population relative to the whole country is much higher at 24%. The number of contract firms (19%) and revenue generated from hydropower (47%) are also high for Wangchhu basin. The literacy rate for Wangchhu is about 10% higher than the average for Bhutan.

5. Per the IWRM approach, the Wangchhu basin comprises one drainage basin, which is also considered as one management unit and thus the area of jurisdiction of the River Basin Committee.[13] It was sub-divided into 19 sub-basins for hydrological assessments covering four districts (Chukha, Haa, Paro, and Thimphu) and 30 Gewogs.[14]

6. Monthly water balances were established as the difference between water availability and water consumption at present and in the 2030s for all Gewogs. Potential water shortage was assessed using three criteria: (i) total amount of water resource per capita per year (also known as the Falkenmark Index), (ii) total volume of water available resulting from the monthly water balance per Gewog, and (iii) the monthly ratio of future water

[13] A drainage basin or catchment basin is an extent or an area of land where all surface water from rain, melting snow, or ice converges to a single point at a lower elevation.

[14] Five percent (%) of Dagana district, comprising two Gewogs is also located in Wangchhu basin.

consumption over water availability per Gewog. None of these criteria showed any physical water shortage in the basin. However at village level at least 65 cases of water scarcity were reported by the Gewogs.

The Gewogs of Chang (Thimphu district), Wangchang, Hungrel and Shari (all in Paro district) might develop potential water stress beyond 2033 from increased population and consumptive demand.

7. Climate change modelling projects that temperature and rainfall will increase in Wangchhu basin, resulting in higher monsoon outflows (Figure 5)[15].[16]

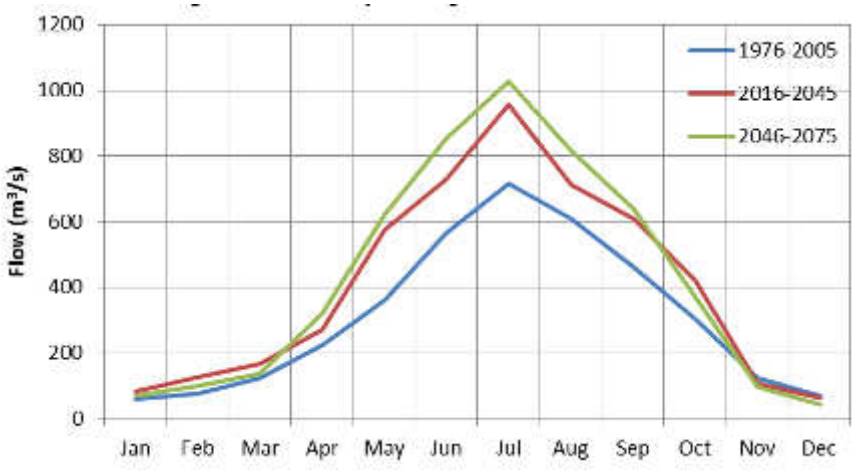


Figure 5: Monthly average maximum flows for RCP 8.5

It follows that the magnitude of the basin outflow with 50-year return period is expected to increase by around a quarter of its present value during the 2060s. This is significant because studies done during the preparation of the WBMP found numerous areas that are prone to flooding, as shown in Figure 6. They include areas in Haa town, near the base of Rimpung Dzong in Paro, and parts of the urban road after the Lingkarna bridge/ royal garage, Centenary farmers market, Chanjji football stadium in Thimphu.

[15] RCP 8.5 stands for a climate change scenario with increased greenhouse gas emissions following 'business as usual'.

[16] From the Coupled Atmosphere-Ocean General Circulation Models (GCM) MRI-CGCM3 and CCSM4 were used for downscaling, using the APHRODITE dataset.

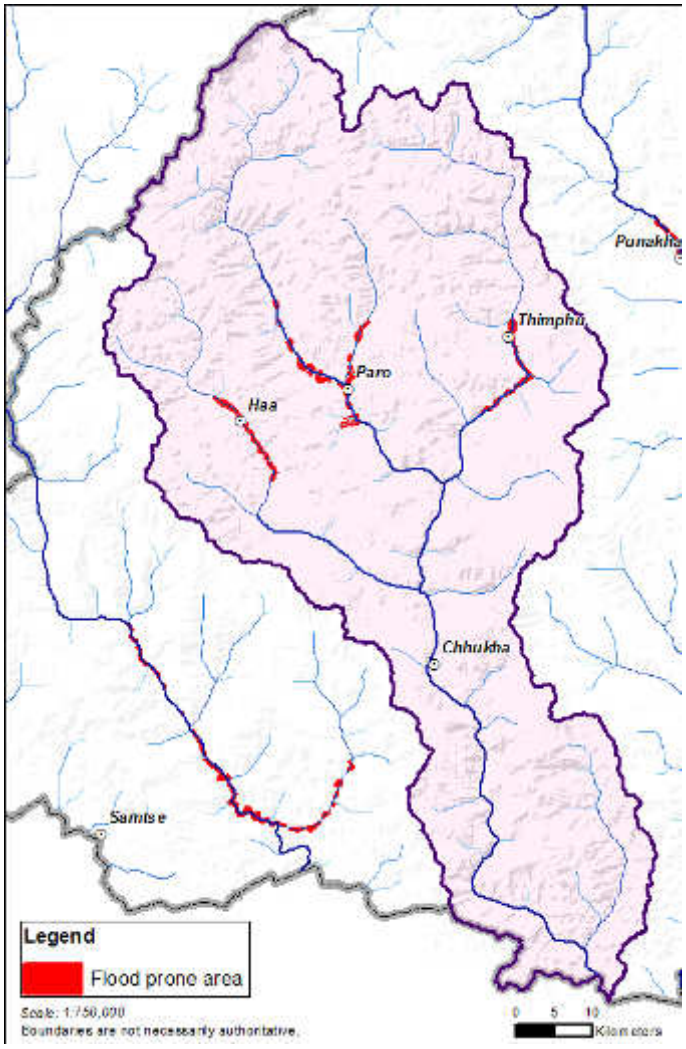


Figure 6: Flood-prone areas in Wangchhu basin

8. Two areas in particular require watershed protection and improvement. The Watershed Management Division (WMD) classified watershed 'Nr. 158', covering 71,000 ha in the lower part of Wangchhu basin as critical. It classified watershed 'Nr. 67' comprising 22,500 ha in and around Thimphu district as 'critical by function' because it provides the urban centre of Thimphu with drinking water.[17] The other watersheds are in good condition and do not require other measures than monitoring.

9. As discussed in the NIWRMP 2016, the institutional capacity for basin management needs to be strengthened with respect to coordination between central agencies and with local administrations. In particular, the River Basin Committee needs to assume its role in basin-level planning and coordination among the districts, but also the District and Gewog administrative units need strengthening in order to cope with the work related to documenting the fragmented water sources and their use, and the formal registration of Water Users Associations (WUAs) as required by upcoming regulations.

[17] This numbering is according to WMD, DoFP, MoAF.

The WUAS will have a major role in local water management at the village level, in particular by looking after the water source, equitably allocating the supply of water among its members as per priorities laid down in the Water Act, resolving conflicts, and maintaining the distribution system.[18]

10. The WBMP formulates in Chapter 4 the strategies and targets for increasing the water security along the indicators defined under the five dimensions of the BWSI. For the Wangchhu basin, the main thrusts are on improving the rural and urban drinking water supply and sanitation, rural water storage, irrigation development, and flood protection measures. Cost estimates were also established for the respective interventions. The total amount until 2033 is estimated at Nu. 112 Billion evenly spread over the 12th, 13th and 14th FYP.

    Once implemented, the plans reflecting the main thrusts above would increase the average score of water security for Wangchhu basin from the present 3.34 to 3.60 by 2033 (Figure 7).

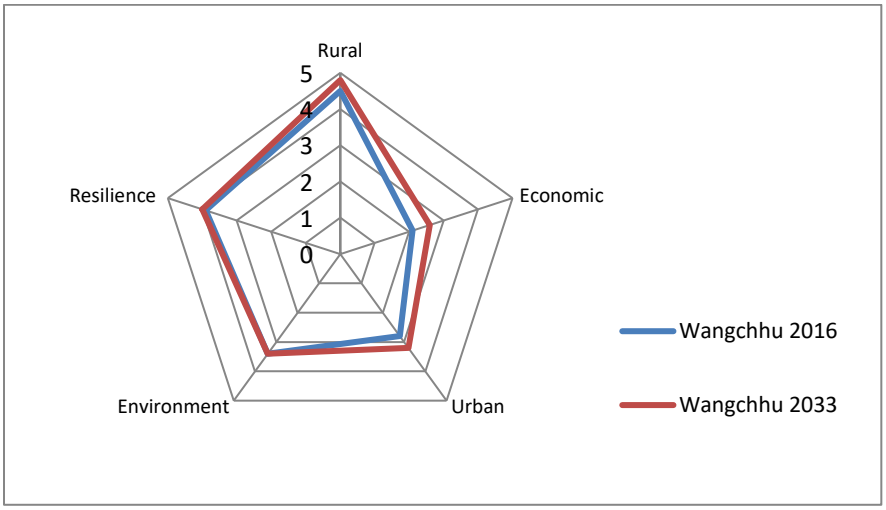


Figure 7: Score of Water Security in Wangchhu basin

11. The priority steps for the RBC are: (i) review and refine the plans described in Chapter 4, and (ii) Incorporation of the WBMP in the 12th FYP in terms of result-based programs of national sector agencies as well as local governments organized by sector.

12. Lastly the implementation arrangements for the WBMP were elaborated in terms of institutional capacity building, coordinated planning, implementation and monitoring of the basin management plans, and financing. ◊

[18] Article 38 of the Water Act states the following priorities in water use: 1. Water for drinking and sanitation, 2. Agriculture, 3.energy, 4. Industry, 5. Tourism and recreation, 6. Other uses

WANGCHHU BASIN MANAGEMENT PLAN 2016

EXECUTIVE SUMMARY

Contents

1. Introduction

1.1 Background

The National Integrated Water Resource Management Plan (NIWRMP), 2016 promulgates the importance of water security as an important development goal for Bhutan. For the purpose of ensuring that this goal is pursued at the level of river basins, the plan defines five management basins namely i) Amochhu, ii) Wangchhu, iii) Punatsangchhu, iv) Mangdechhu and v) Drangmechhu. Drawing on the requirements of the Water Act of 2011 and its regulations, each of these management basins will have a committee to coordinate among the districts and central agencies the planning, implementation, monitoring and reporting progress towards the goal of water security in the basin. The NIWRMP also defines the Bhutan Water Security Index (BWSI) comprised of five dimensions and 57 indicators that provide the framework for coordinated planning, implementation, monitoring and reporting progress.

This Wangchhu Basin Management Plan (WBMP) has been prepared in keeping with the Water Act 2011, the Water Regulation 2014 and the 11th Five Year Plan (FYP) 2013-2018. The plan was prepared by the Wangchhu Basin Committee (WBC) with support from the National Environment Commission Secretariat (NECS).[19] Considering that this is the first river basin management plan for the country, the NEC has availed technical assistance from Asian Development Bank to assist the NECS and the WBC in preparing the plan. As per the requirements of the Water Act and Regulations, the WBC was established in 2016 vide Executive Order of the Prime Minister who is also the Chairman of the NEC. For the purpose of preparing the WBMP, the NECS has i) carried out technical assessment of water resources and issues in the basin and ii) constantly involved the district officials and stakeholders of Wangchhu basin in i) training and orientation to IWRM concepts and ii) consultations for preparation of the WBMP.

Since there is not one agency entirely responsible for the implementation of the plan, it may be noted that the WBMP is still a framework document that will serve as a reference to district administrations and central agencies for integration of the identified interventions in their respective plans. Owing to lack of specific baseline information, this plan must be maintained as a living document with regular updates to baseline information and targets, preferably carried out at least once every five years in time for integration into the next FYP.

1.2 Objectives of the WBMP

Guided by the national goal of water security as per the NIWRMP, the goal of the WBMP is to improve water security in Wangchhu basin through improved planning and effective coordination among district administrations and agencies involved in water resources management in the basin. This will be achieved using the frameworks of both the Bhutan Water Security System and the iterative and adaptive planning cycles or “spirals” of Integrated Water Resources Management (IWRM).

Specific objectives are:

- to assess the current situation and future prospects of water resources of Wangchhu basin

[19] Financed under Asian Development Bank (ADB) Technical Assistance 8623-BHU: Adapting to Climate Change through Integrated Water Resources Management

- to define intervention strategies and targets for the water security indicators for, respectively, the 12th, 13th and 14th Five Year Plans, and to assess the cost involved.
- to propose institutional arrangements for effective implementation of the plan within the overall institutional framework as per NIWRMP and terms of reference of the WBC.

1.3 Methodology followed to prepare the River Basin Management Plan

The formulation of the WBMP was guided by the NIWRMP and follows the Dublin principles of IWRM: (i) water is finite and vulnerable resource; (ii) need for a participatory approach in water management; (iii) the role of women is stressed; (iv) water has social and economic value, and (v) integration of the three E's: economic efficiency – social equity – environmental sustainability.[20] The three pillars of IWRM are also considered: (i) enabling environment (suitable policies, strategies, and legislation); (ii) capable institutional framework; and (iii) management instruments.

The WBMP also follows the UNESCO guidelines for IWRM at river basin level. The basin level approach to water management enables integration of upstream and downstream issues, and to quantify and characterize water resources and their uses based on a water balance approach. This is particularly important when considering the impact of climate change, and the response of the hydrological cycle on the supply side and water demand side resulting from changing land use, urbanization and industrial/ hydropower development. Risk management and climate change adaptation strategies, such as managing extreme floods and droughts, are also taken into consideration. Within an IWRM system, water availability shall be systematically monitored and all major water abstractions shall be registered (based on permits, as provided in upcoming water user regulations). It is essential that different basin stakeholders work together and share information. The roles of the stakeholders are specified in the 2014 Water Regulation further elaborated in the functions of the multi-sectoral river basin committees to be formed, as described in the NIWRMP.

Furthermore the WBMP incorporates the concepts of 'Methodology for Effective Decision-making on Impacts and Adaptation' (MEDIATION), which includes activities such as: (i) analysis of the decision-making context, (ii) inventory, review and further development of methods for impacts and vulnerability analysis, (iii) inventory, review and further development of methods for costing of impacts and adaptation options, (iv) the development of an overarching integrated methodology, (v) the development of a flexible, interactive common platform for knowledge sharing, and (vi) disseminating this knowledge by communication and training program.[21]

It is emphasized that IWRM is an iterative, evolutionary and adaptive process conceptualized as a 'spiral' which builds on understanding of the prevailing conditions, enables immediate action where appropriate, and fosters stakeholder ownership. For Bhutan, each cycle represents a period of five years, corresponding with the government's FYPs. The IWRM process starts with recognizing and examining the present situation under the five key dimensions of water security (pertaining to i) rural household, ii) economic, iii) urban, iv) environment, v) resilience), and then moves to conceptualizing what needs to be done, followed by setting up of coordination mechanisms under which planning is undertaken with sustained stakeholder involvement. This is followed by implementation of water security measures, combined with monitoring and evaluation of progress

[20] These principles were formulated in a water conference in Dublin in 1992, see http://www.gwp.org/en/The-Challenge/What-is-IWRM/IWRM-Principles/

[21] MEDIATION represents new concepts in Europe to reduce vulnerability to climate change in the most cost-effective way. It needs scientific and technical information about climate change impacts, vulnerability and adaptation options.

so as to understand the starting point for the next cycle. Consecutive cycles move the system closer to the goal of water security. The process is depicted in Figure 8.

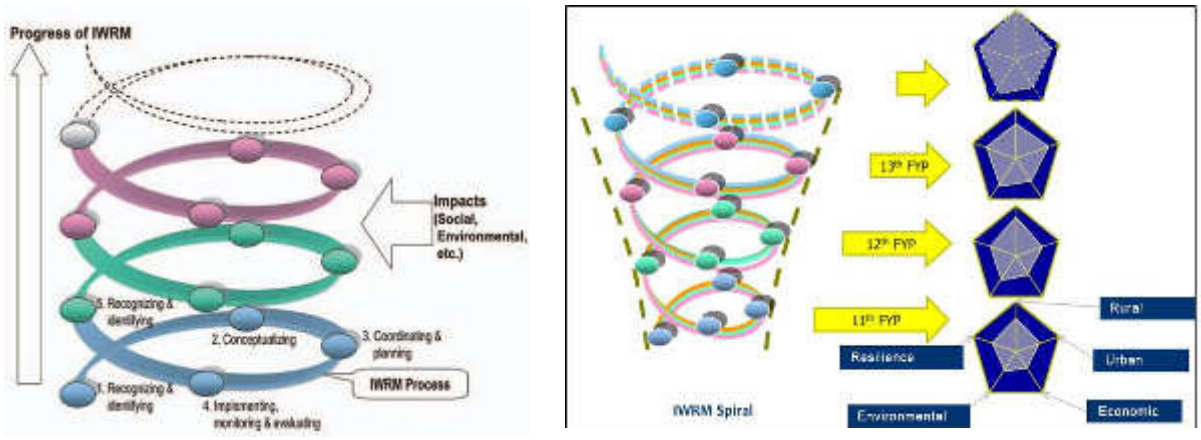


Figure 8: Schematic presentation of the IWRM spiral (Adapted from Asian Water Development Outlook 2013)

The process followed in formulating the RBMP is schematically presented in Figure 9. A brief explanation is given below.

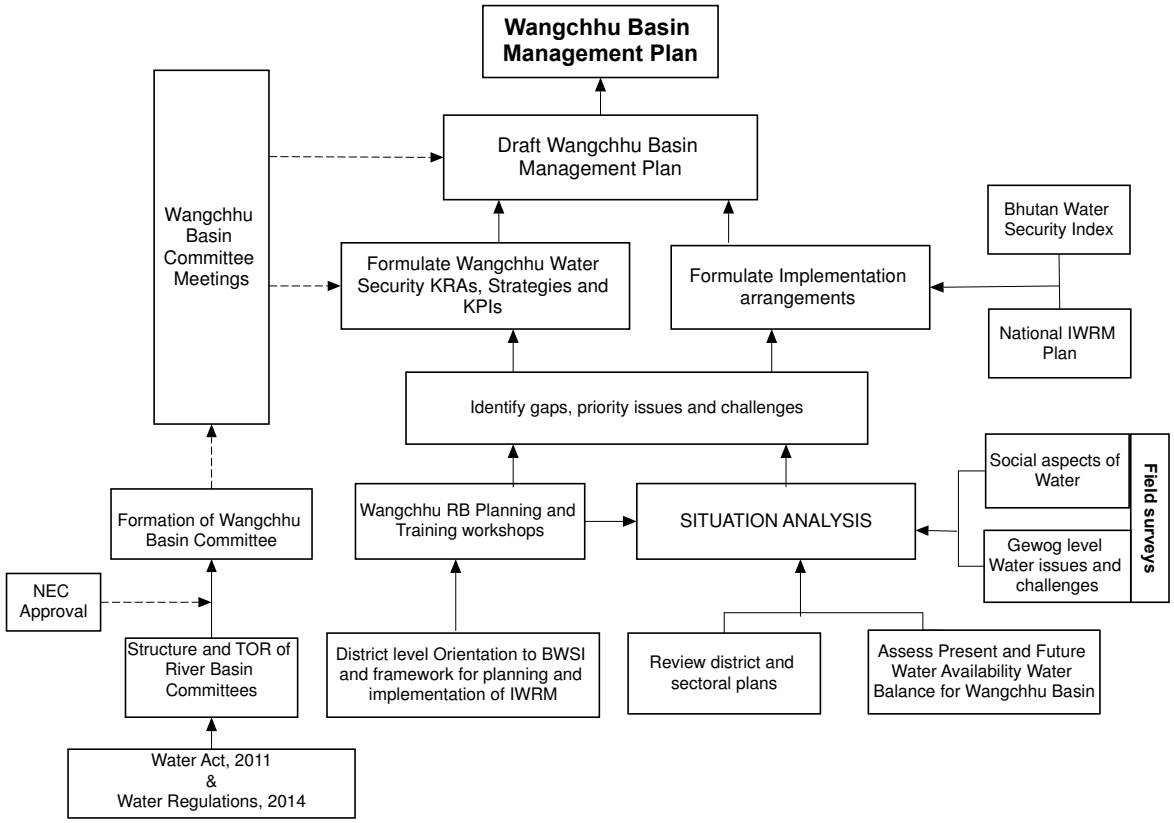


Figure 9: Roadmap for the preparation of the river basin management plan.

According to the Water Act and its regulations, the river basin management plan shall be prepared by the river basin committee. Hence, the fundamental requirement for preparation of river basin management plan is the establishment of river basin committee. For this, the structure and terms of reference for formation of river basin committees was approved by the NEC. For the purpose of facilitating preparation of the WBMP, the NEC established the Wangchhu Basin Committee (WBC) on 14 April 2016 vide Executive Order by Prime Minister who is also the Chairman of NEC. Although the committee was established only in April 2016, the process of preparing the basin plan began a year ago with the constant involvement of the members as well as other stakeholders. The methodology followed in preparing the plan is briefly described below:

Technical assessment of water availability and issues in the basin: River basin modelling was conducted to assess the hydrological status of the Wangchhu basin. Attempts were made to analyse water availability at the Gewog level. Water scarcities as well as 100 year return period floods were assessed. Surveys were also conducted to collect information on water issues at the Gewog level. Further, the eleventh Five Year Plan (FYP) water related interventions for the Wangchhu districts as well as sector plans for Wangchhu basin were reviewed.

Training and consultative planning workshops: The members of the WBC, district planning officers and engineers were oriented to the concept of IWRM and Bhutan Water Security Index (BWSI) as per the NIWRMP. The trainings and planning workshops provided the platform for progressive consultations and participatory planning involvement of the WBC and the stakeholders to assess the situation of water resources, issues, and institutional gaps and identify priority interventions for management of the basin. This entailed group exercises to analyse cause and effects of water issues and converting them to intervention activities and strategies, which form the basis for the proposed plans. Cost analysis and estimates for the proposed interventions were conducted with the assistance of district planning officers and engineer.

Wangchhu basin committee meetings and endorsement of the plan: Although the Wangchhu basin committee was officially established in April 2016, the incumbent members were trained and constantly involved in the consultation process. The draft WBMP was shared and deliberated at the first Wangchhu basin committee meeting held on 20 April 2016. The plan was reviewed and revised over a period of two days and endorsed on 21 April 2016.

1.4 Structure of the plan

Guided by the NIWRMP, this plan provides a comprehensive description of the geographical, social, economic, and environmental context of the Wangchhu basin. Based on climate change and hydrological assessments carried out for the country, the water availability and water balance for the basin have been assessed. This is followed by statement of water related issues based on which interventions, strategies and implementation arrangements are proposed. Detailed description of subsequent chapters is given below:

Chapter 2 introduces the Wangchhu basin providing general description of its geography and climate, administrative boundaries and socio-economic conditions. It also describes the water resources of Wangchhu basin, the status of the Bhutan Water Security Index for the basin, and the composition and role of the Wangchhu Basin Committee.

Chapter 3 focuses on the analyses of issues and stress factors related to water management in Wangchhu basin. The areas covered include basin-specific impact of climate change, water scarcity at Gewog level, flood-prone areas, critical watersheds, limitations and impacts of hydropower development, and water governance issues. The chapter also presents a problem analysis and strategy development based on a participatory logical framework analysis carried out by WBC members and stakeholders.

Chapter 4 presents the plan based on Bhutan Water Security Index (BWSI) and expressed in terms of Key Result Areas and Key Performance Indicators. Baseline values and targets are presented, with an explanation of the next steps to be taken. The latter are expected to be used as a guide to preparing water resource development plans in the series of Five Year Plans (FYPs) formulated by the Gross National Happiness Commission (GNHC) in coordination with competent authorities and local administrations. The WBMP's planning horizon is 2033, the end of the 14th FYP.

Chapter 5 deals with implementation arrangements for implementation of the WBMP. This includes institutional capacity building, financial modalities, and monitoring and reporting mechanisms.

Position of WBMP relative to other documents

Legally, the WBMP is positioned under the NIWRMP as required under the Water Act (Figure 10). Whereas the NIWRMP provides the overall planning and coordination framework of water resources management in Bhutan, the WBMP aims at guiding the formulation of annual and Five Year Plans (FYPs) for the districts and central agencies, per the requirements of the Gross National Happiness Commission (GNHC). As such, the plans and targets laid-out in the WBMP are not binding for the Basin Committee, also because there is no guarantee that the necessary resources for implementation of the plans will be available.

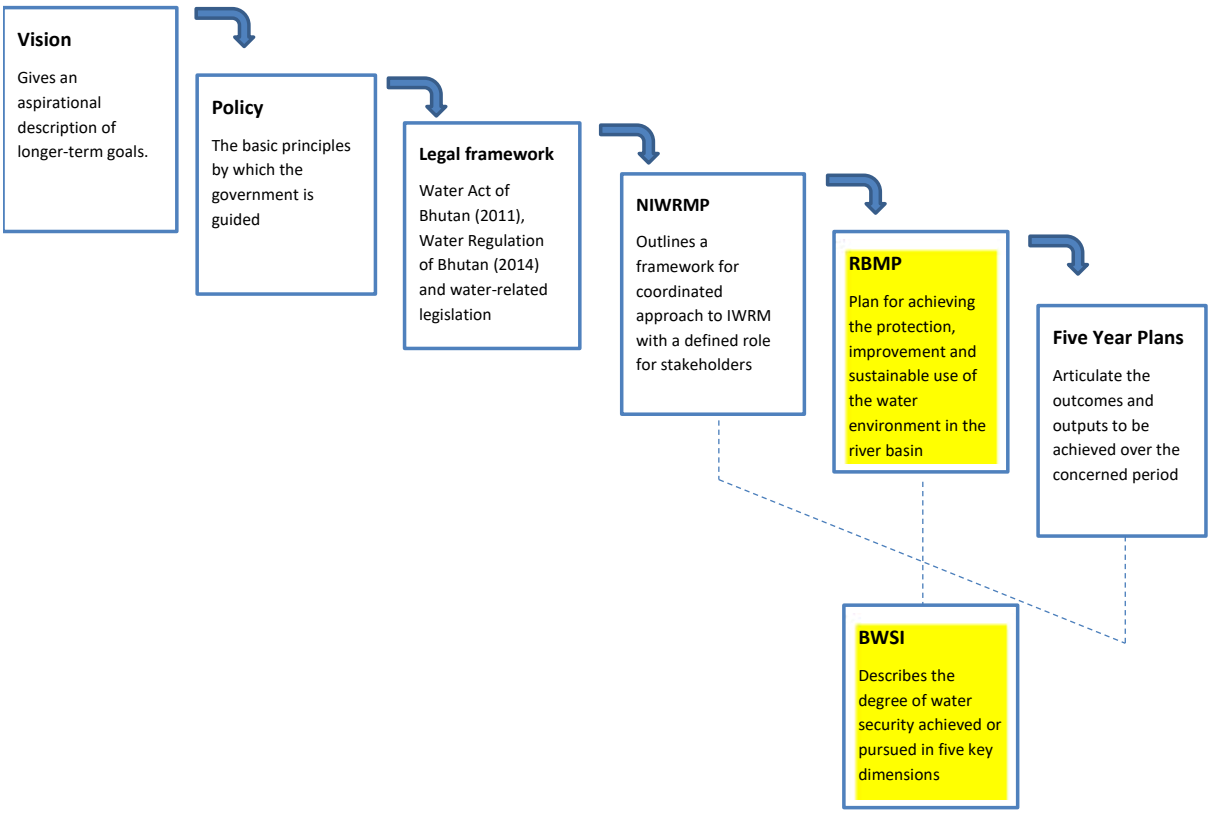


Figure 10: Diagram showing the relation between different documents

2 Wangchhu Basin

This chapter introduces the Wangchhu basin with respect to its geography and climate, administrative boundaries and socio-economic conditions. The state of the basin in terms of its water resources and current level of water security based on Bhutan Water Security Index are also described. Hydrological assessment, water resources of the basin are described at the level of districts and Gewogs. After briefly presenting previous plans and studies undertaken in the basin, this chapter gives a general description of Wangchhu basin It also describes the, the status of the Bhutan Water Security Index for Wangchhu, and the composition and role of the River Basin Committee.

2.1 General description

Geography

The Wangchhu basin is located in the western part of Bhutan between Amochhu basin in the extreme west of the country and Punatsangchhu basin to the east. It borders China to the north and India to the south (Figure 11).

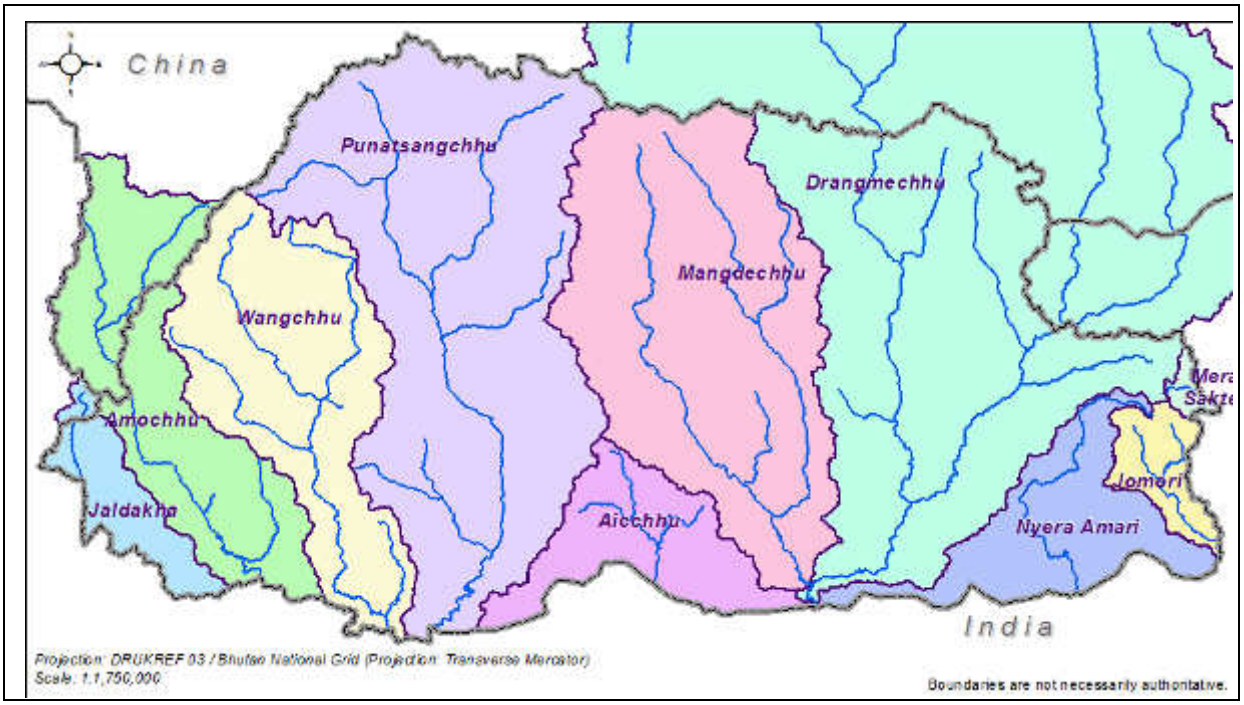


Figure 11: Location of Wangchhu basin in Bhutan

The total area is 4,596 km^2, almost 12% of the country. The elevation of the terrain varies from below 750 meters above sea level (m.a.s.l.) to over 5,000 m.a.s.l. (Figure 12).

The land cover map is presented in Figure 13 and shows the distribution of snow and glaciers, water bodies, shrub and grasslands, forest by type, agricultural and urban areas.

Figure 14 shows the protected areas and corridors for nature conservation in Wangchhu basin.

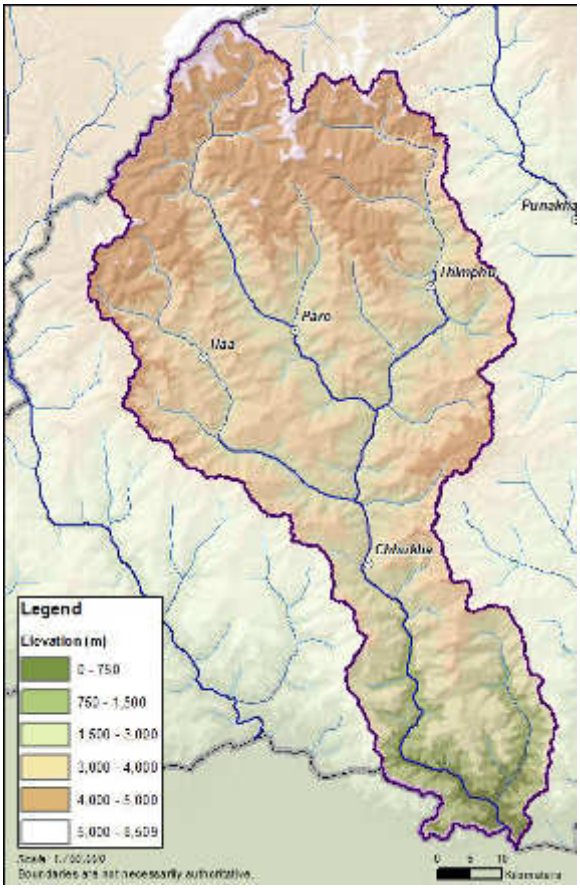


Figure 12: Topography of Wangchhu basin

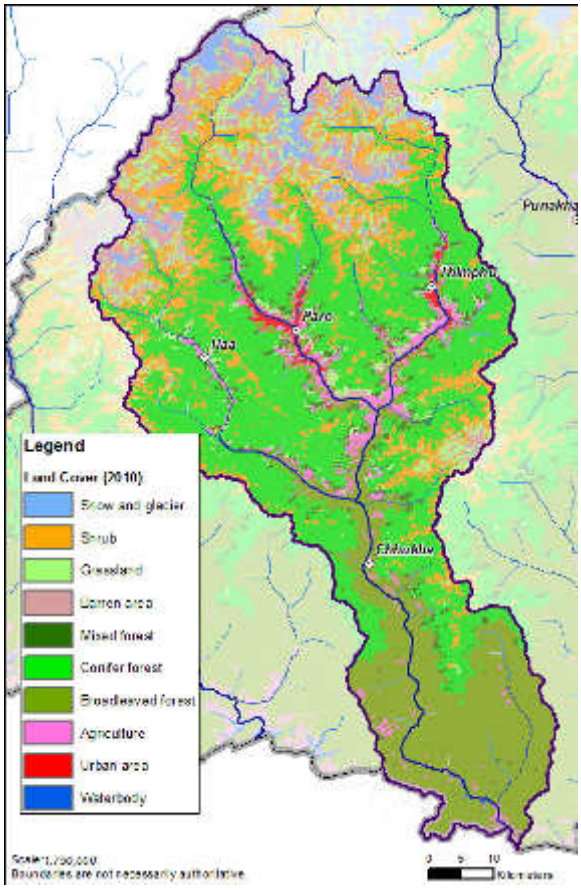


Figure 13: Land cover map of Wangchhu basin

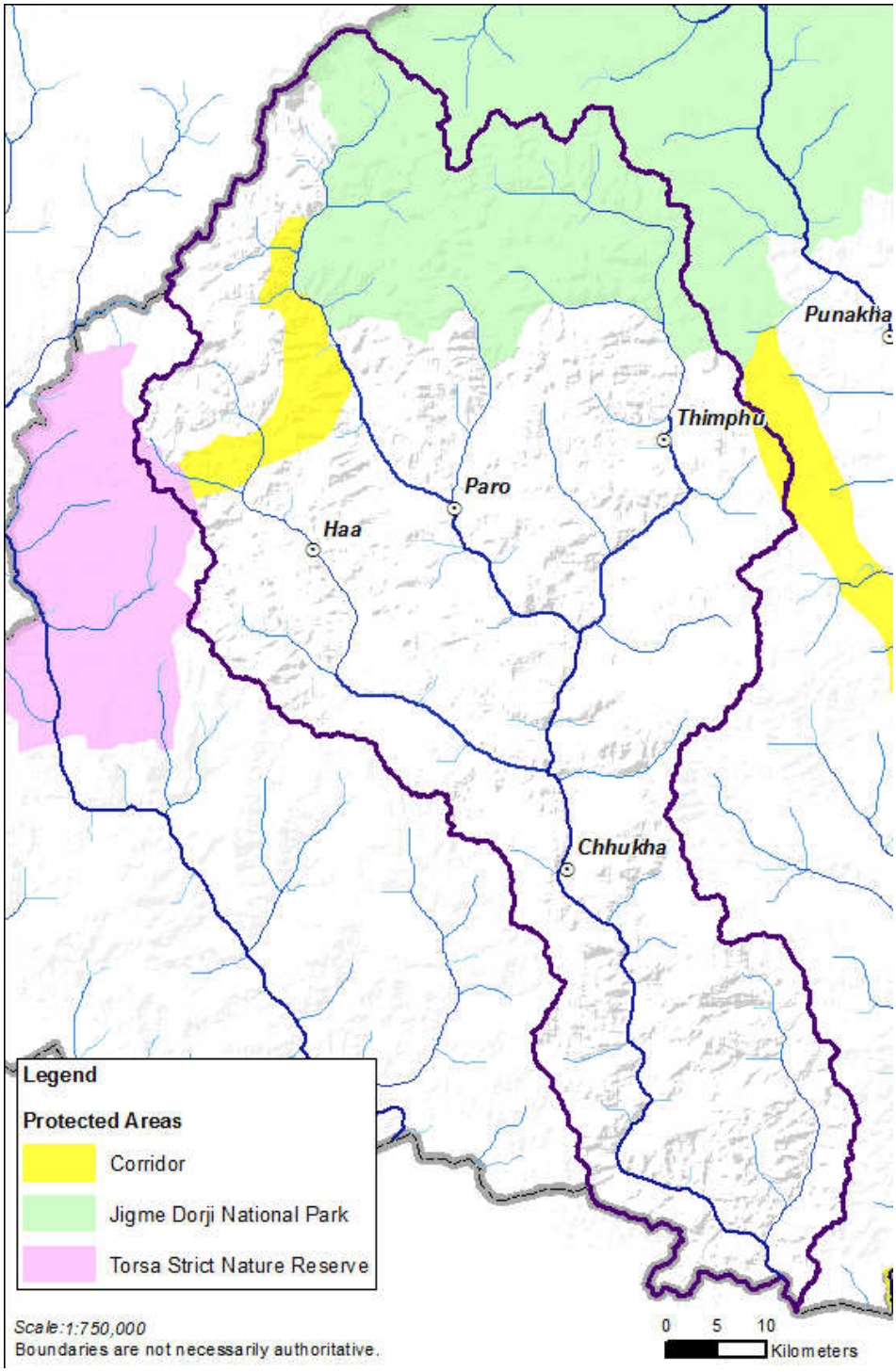


Figure 14: Protected areas and corridors in Wangchhu basin

Administrative boundaries

The Wangchhu basin comprises primarily of the districts of Chukha, Haa, Paro, Thimphu and a small part of Dagana with a total of 32 Gewogs as shown in Figure 15 and Table 1.

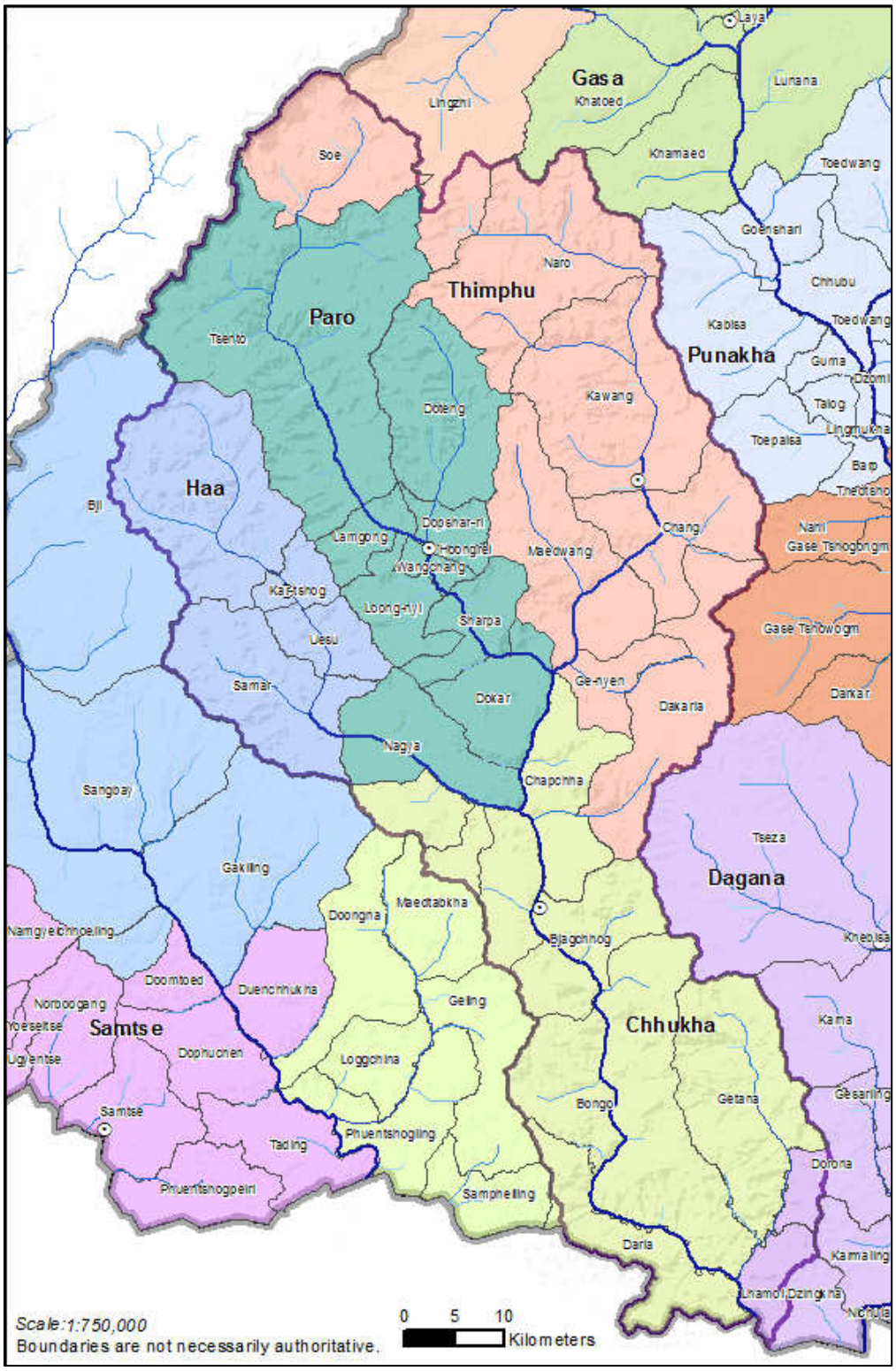


Figure 15: Wangchhu basin, local government units

Table 1: Gewogs in the Wangchhu basin

District	Gewog Name	Total Area km²	Area inside Wangchhu basin km²	Area inside Wangchhu basin %
Haa	Bji	747.3	283.3	37.9
Haa	Gakiling	338.7	-	-
Haa	Kar-tshog	40.6	40.6	100.0
Haa	Samar	200.6	200.6	100.0
Haa	Sangbay	507.4	-	-
Haa	Uesu	66.3	66.3	100.0
Haa	**Total**	**1,900.9**	**590.8**	**31.1**

District	Gewog Name	Total Area km²	Area inside Wangchhu basin km²	Area inside Wangchhu basin %
Chukha	Bjagchhog	140.2	140.2	100.0
Chhukha	Bongo	398.5	398.5	100.0
Chhukha	Chapchha	128.9	128.9	100.0
Chhukha	Darla	135.2	111.4	82.4
Chhukha	Doongna	202.0	58.5	29.0
Chhukha	Geling	221.4	81.3	36.7
Chhukha	Getana	241.1	241.1	100.0
Chhukha	Loggchina	71.8	-	-
Chhukha	Maedtabkha	129.4	30.0	23.2
Chhukha	Phuentshogling	133.2	-	-
Chhukha	Samphelling	73.8	-	-
Chukha	**Total**	**1,875.6**	**1,189.9**	**63.4**

District	Gewog Name	Total Area km²	Area inside Wangchhu basin km²	Area inside Wangchhu basin %
Paro	Dokar	105.8	105.8	100.0
Paro	Dopshar-ri	33.8	33.8	100.0
Paro	Doteng	194.4	194.4	100.0
Paro	Hoongrel	10.4	10.4	100.0
Paro	Lamgong	48.9	48.9	100.0
Paro	Loong-nyi	75.6	75.6	100.0
Paro	Nagya	136.4	136.4	100.0
Paro	Sharpa	80.0	80.0	100.0
Paro	Tsento	578.7	578.7	100.0
Paro	Wangchang	20.6	20.6	100.0
Paro	**Total**	**1,284.7**	**1,284.7**	**100.0**

District	Gewog Name	Total Area km²	Area inside Wangchhu basin km²	Area inside Wangchhu basin %
Thimphu	Chang	156.6	156.6	100.0
Thimphu	Dakarla	203.8	203.8	100.0
Thimphu	Ge-nyen	60.8	60.8	100.0
Thimphu	Kawang	297.2	297.2	100.0
Thimphu	Lingzhi	386.2	49.3	12.8
Thimphu	Maedwang	229.7	229.7	100.0
Thimphu	Naro	280.9	280.9	100.0
Thimphu	Soe	177.6	177.6	100.0
Thimphu	**Total**	**1,792.8**	**1,455.9**	**81.2**

District	Gewog Name	Total Area km²	Area inside Wangchhu basin km²	Area inside Wangchhu basin %
Dagana	Dorona	107.47	36.93	28.5
Dagana	Dzingkha	105.09	37.79	35.96
Grand total		**8,567.0**	**4,589.7**	

Socio-economic and other conditions

A profile of Wangchhu basin is presented in Table 2. As can be seen, Wangchhu basin occupies almost 12% of Bhutan's area. Its share in forest land (10.0%), agricultural area (12.1%), wetland (9.2%) and livestock (12.3%), as well as budgetary capital outlay under the 11th FYP (13.1%) is in the same order of percentage. However, the percentage of population relative to the whole country is much higher at 24%, and so are the number of contract firms and revenue generated from hydropower, which make up 19% and 47%, respectively, of the national total. These data show the socio-economic importance of Wangchhu basin.

Table 2: Profile of Wangchhu basin

Area	Weight	Total area	Forest		Agric. area		Wetland		Livestock	Rainfall	GLOF potential	Population	Contract firms	HP revenue	Capital outlay 11th FYP
	ratio	[ha]	[ha]	%	[ha]	%	[ha]	%	[number]	[mm]	[number]	[number]	[number]	[million units]	[million Nu]
Chukha	0.422	188,131	161,255	86	9,241	4.9	1,799	0.96	30,870	872-3041	0	88,320	1,016	1,907	560
Haa	0.554	186,595	121,709	65	2,780	1.5	88	0.05	17,851	814	0	13,417	325	4,914	349
Paro	1	125,164	76,020	61	6,340	5.1	1,753	1.40	17,624	490-2522	0	42,823	687		477
Thimphu	0.785	174,693	74,868	43	2,274	1.3	458	0.26	16,662	505-609	0	123,225	4,821		350
Dagana	0.05	171,300													
Wangchu basin		453,628	270,268	60	13565	3.0	2920	0.64	53620	505-3041	0	184259	5080	3527	1181
Bhutan		3,839,400	2,705,241	70	112,549	2.9	31,910	0.83	437,575	500-5000	24	763,977	13,144	7,550	9,000
% for Wangchu/ Bhutan		11.8	10.0	-	12.1	-	9.2	-	12.3	-	0.0	24.1	38.7	46.7	13.1

Source: Statistical yearbook Bhutan (2014)

Wangchhu basin has a population of 184,259, which is 24% of the national population. The distribution is shown in Figure 16. The population of Wangchhu basin is expected to grow by almost 30% to 240,000 by 2033.

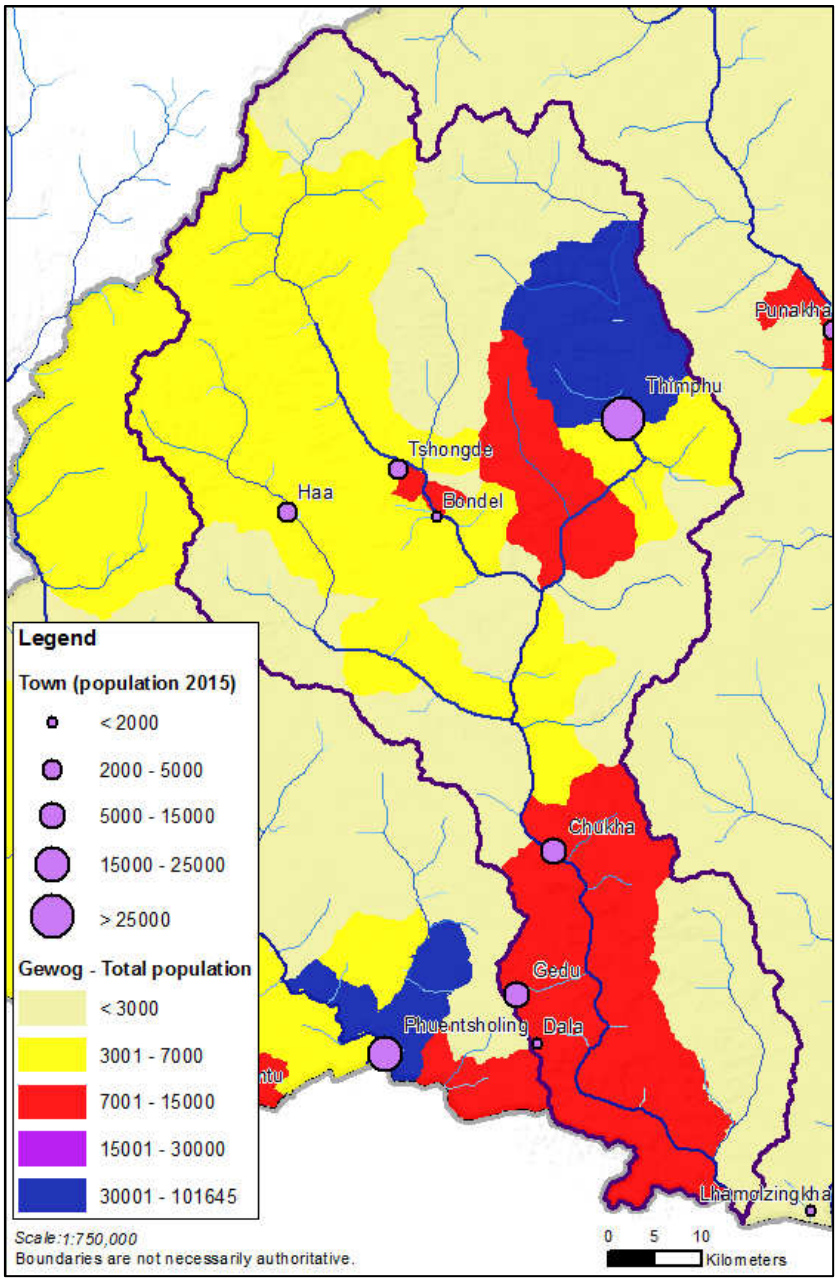


Figure 16: Population in Wangchhu (2015)

Table 3 shows the gender-segregated participation of men and women in the labour force and their respective share in unemployment. As can be seen, the total labour force participation is highest in Chukha (61.5%) and Paro (59.6%), both slightly above national average. The labour force participation for men is some 20% higher than for women in Wangchhu basin and at national level. The highest difference is in Thimphu (35%) and the lowest is in Haa (8%).

Table 3: District-wise labour force participation by gender

Dzongkhag	Labour Force Participation Rate			Unemployment Rate		
	Male	Female	Total	Male	Female	Total
Chhukha	74.7	48.3	61.5	1.9	2.9	2.3
Haa	61.3	53.5	57.4	1.4	2.0	1.7
Paro	65.3	54.5	59.6	3.3	2.3	2.8
Thimphu	71.7	35.9	53.0	4.3	11.5	6.9
Wangchhu	**68.3**	**48.1**	**57.9**	**2.7**	**4.7**	**3.4**
Bhutan	**69.5**	**49.9**	**59.4**	**2.4**	**3.2**	**2.7**

Source: Bhutan Living Standard Survey (BLSS), 2012

In Wangchhu basin, Thimphu (61.8%) has the highest proportion of income derived from wages and salaries followed by Chukha at 58%. Haa at 39.7% and Paro at 38.4% have much lower proportion of income derived from wages amongst the four Dzhonkhags and also when compared to Bhutan's average of 57.2%. Agricultural income is highest in Haa at 39.7% much above the Bhutan average of 10.2% with Thimphu having the lowest proportion – at 1.1%.[22] See Table 4.

Table 4: District-wise annual household income in Ngultrum by source

Dzongkhag	Income Source				% of Household income		
	Wages	Agric.	Non-Agric.	Total	Wages	Agric.	Non-Agric.
Chhukha	150,731	12,051	97,205	259,988	58.0	4.6	37.4
Haa	45,604	50,493	31,181	127,278	35.8	39.7	24.5
Paro	77,483	34,542	89,798	201,823	38.4	17.1	44.5
Thimphu	189,022	3,420	113,333	305,775	61.8	1.1	37.1
Bhutan	94,275	16,894	53,660	164,829	57.2	10.2	32.6

Source: Bhutan Living Standard Survey (BLSS), 2012

The status of poverty in the Gewogs of Wangchhu is presented in Table 5.[23] It appears that Paro has the least poverty (all Gewogs less than 15%), followed by Thimphu (two Gewogs 16-26%). Chukha has the most poverty with (two Gewogs above 52%, and another two Gewogs with 37-51%.

[22] Refer to standalone supporting document titled: *Social aspects of water resource management in Bhutan*

[23] Bhutan poverty assessment, National Statistics Bureau, RGOB, 2014: Poverty is defined as a consumption level of less than US$ 1.25 per capita per day.

Table 5: Status of poverty in Gewogs of Wangchhu basin

Dzongkhag	Gewogs inside Wangchhu basin	Class of Poverty in Gewog	Poverty Head Count[24]
1. Chhukha	Bjachhog	1	0% -15%
	Bongo	2	16%-26%
	Chapchha	1	0% -15%
	Darla	3	27%-36%
	Geling	3	27%-36%
	Getana	5	52%-69%
	Metakha (Metap)	4	37%-51%
2. Haa	Bji	1	0% -15%
	Kar-Tshog	1	0% -15%
	Samar	2	16%-26%
	Uesu	1	0% -15%
3. Paro	Dokar	1	0% -15%
	Dopsharri	1	0% -15%
	Doteng	1	0% -15%
	Hoongrel	1	0% -15%
	Lamgong	1	0% -15%
	Loong-nyi	1	0% -15%
	Nagya	1	0% -15%
	Sharpa	1	0% -15%
	Tsento	1	0% -15%
	Wangchang	1	0% -15%
4. Thimphu	Chang	1	0% -15%
	Darkarla (Dagala)	1	0% -15%
	Ge- Nyen	2	16%-26%
	Kawang	1	0% -15%
	Lingzhi	1	0% -15%
	Maedwang	1	0% -15%
	Naro	2	16%-26%
	Soe	1	0% -15%

Poverty head count classes: 1=0% -15%; 2=16%-26%; 3=27%-36%; 4=37%-51%; 5=52%-69%

Hydropower

Hydropower generation is the biggest earner of revenue in Wangchhu basin. The location of existing and planned hydropower stations is shown in Figure 17.

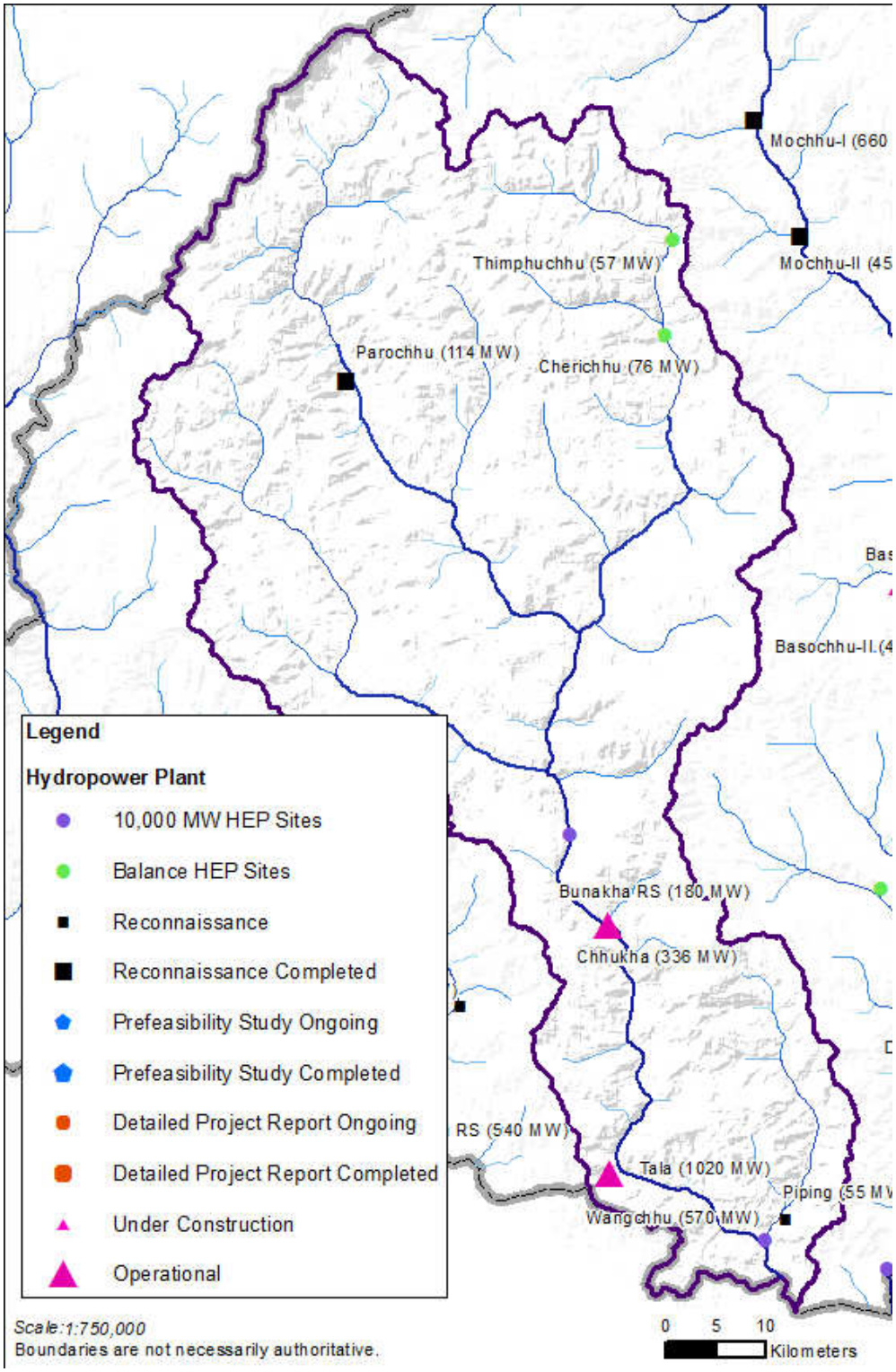


Figure 17: Existing and planned hydropower stations in Wangchhu basin

Large hydropower stations

Existing hydropower stations

There are two large existing run-of-the river hydropower stations in Wangchhu basin at Tala (1,020 MW) and at Chukha (336 MW). Run-off-the-river power stations divert river flow through their turbines and do not have a large reservoir.

New hydropower stations

Two new hydropower plants are planned in Wangchhu basin. They are Wangchhu Hydro Electric Project with proposed installed capacity of 570 MW. It will have a head race tunnel of 12.4 km length and storage dam of 134 meter height above foundation, with a crest level of 498 m.a.s.l. The Full Reservoir Level is set at 494 m.a.s.l. The live storage of the reservoir would be 14.5 million cubic meters (MCM).

Another planned project is at Bunakha, also in Chukha district located in Geling and Chapcha Gewogs. Its planned installed capacity will be 180MW. It is proposed to be a reservoir scheme project with some seasonal storage. The generators will be located at the toe of the storage dam, hence there will be no head race tunnel. The dam height will be 197 m above foundation, with a crest level of 2,010 m.a.s.l. The live storage of the reservoir would be 250.6 MCM.

Small hydropower stations

The status of existing small hydropower stations is given in Table 6.[25]

Table 6: Status of existing small hydropower stations

District	Location	Output in KW	Built/ Renovated
Thimphu	Gidakom	250x5	1973/ 2001
Thimphu	Mini	100x4	1967/ 1998
Thimphu	Lingzhi	8x1	1999
Thimphu	Thinleygang	30x1	1987/ Shut down

Three additional small run-of-the-river hydropower stations are under consideration in the Wangchhu basin.[26] Investigations have been done to check whether these plants could be equipped with a multi-purpose reservoir in order to level-out the seasonal variation of power generation, and to supply drinking and irrigation water. The findings are summarized in Table 7.

[25] Data collection renewable energy, JICA, 2013

Table 7: Proposed small hydropower stations and their potential for multi-purpose reservoir.

District	Location	Annual output in MWh	Potential for multi-purpose reservoir
Haa	Nagu	3	Yes
Chukha	Chapcha	23	No
Chukha	Tamachu	10	No

There may be a potential for a multi-purpose reservoir in connection with the proposed small hydropower stations only in Haa district.

Agriculture

Existing agricultural areas and irrigation infrastructure are shown in Figures 18 and 19. As elsewhere in the country, farming system in the Wangchhu basin includes crop production, horticulture, livestock and forestry. The basin has a total of 13,565 ha of arable land. There are 4,291 ha of dryland (Khamzhing), 3,428 ha of slash and burn practiced agriculture (tseri/pangzhing), 2,114 ha of wetlands, 1,169 ha of orchards and 166 ha of kitchen gardens.[27] In the Wangchhu basin, Chukha has around 9.3% of land under cultivation followed by Paro (6.3%), Haa (2.8%) and Thimphu (2.3%). Together they have 3% of the area under cultivation which is the same as the average of Bhutan (2.9%) as shown in Table 2.

[27] Tshering *et al*., 2009

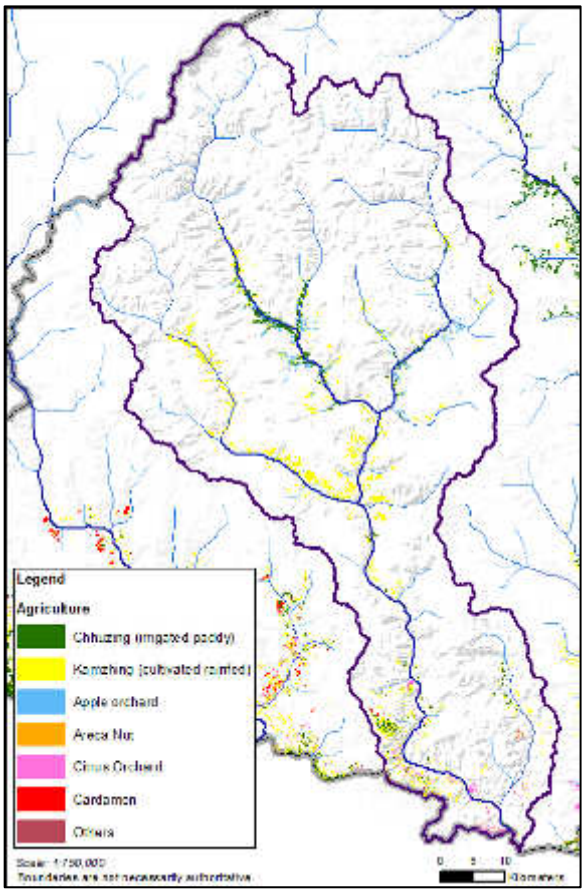


Figure 18: Agricultural areas in Wangchhu basin

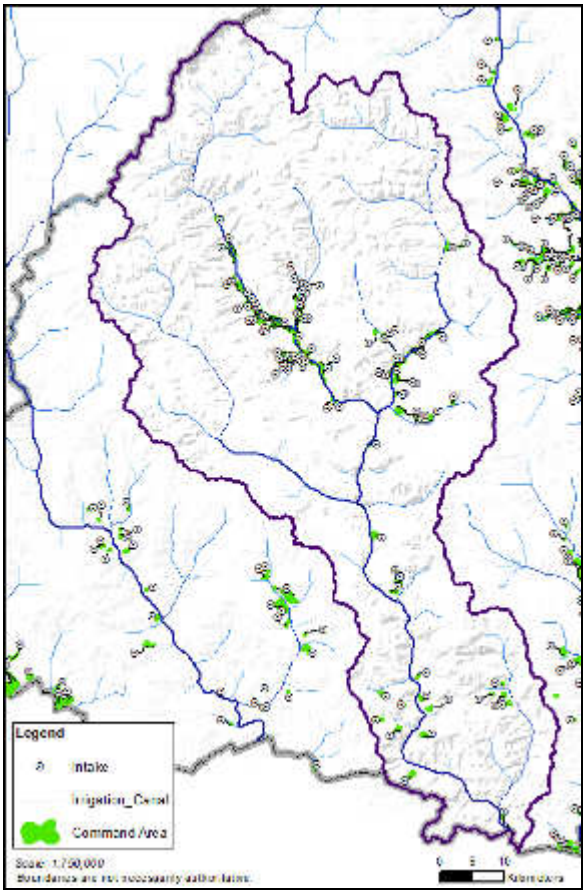


Figure 19: Irrigation infrastructure in Wangchhu basin

Common crops grown in Wangchhu basin are paddy, maize, wheat, barley, millet. Fruits like apples, oranges, plums, pears and vegetables like cauliflower, potato, carrot, tomato, and chillies are also grown.

Membership of groups for agriculture, irrigation and other purposes is presented in Table 8. As shown, agricultural groups are much stronger developed in Chukha (8.7%) than in other districts of Wangchhu basin (less than 2%), but WUAs are most developed in Paro district (15.75%) but not in other districts (0%).

As per Water Act and Regulations, WUAs shall be registered with the Gewog administration. In the past however, water users groups were formed as a cooperative group under the Marketing Act and they were expected to have an income-generating activity. They have been trained and operated a bank account, but most of them are in fact not functioning because the leaders became disconnected from the community.[28]

The existing water management groups are not registered with the government or under any official system; therefore, they do not have formal government recognition. Members often pay a contribution to employ a water tender for maintenance of the water supply system. Table 9 presents the number of informal water groups found in the primary survey conducted.[29]

[28] Feed-back from the national stakeholder consultation workshop held in Thimphu on 4 February 2016.

[29] See stand-alone supporting document: *Social aspects of Water Resources Management in Bhutan*

Table 8: Percentage of household membership in groups as per primary survey

Groups	Percentage of household members			
	Chukha	Haa	Paro	Thimphu
1. Agriculture Group or Association	8.70	0.00	0.00	1.56
2. Community Forest Group	2.47	18.90	0.72	2.08
3. Credit or Saving Group	0.00	0.00	0.00	7.54
4. Dairy Production Group	3.26	0.00	6.66	0.00
5. Education Service Group	15.78	0.00	0.00	0.00
6. Farmer Group–Other	32.30	0.00	0.00	0.00
7. Farmer Group–Production	0.00	2.84	0.00	5.84
8. Games, Sports, and Entertainment	38.47	0.00	0.00	47.36
9. Health Care and Cleaning Club/Group	36.84	0.00	0.00	8.71
10. Livestock Association or Group	9.55	0.00	0.00	0.00
11. Local Development Group	19.26	0.00	0.00	0.00
12. Occupation Group	5.86	0.00	11.94	43.45
13. Other Group	27.74	0.00	0.00	22.50
14. Spiritual Group or Association	6.06	0.84	4.53	4.23
15. Village or Community Group	0.00	0.00	0.00	24.74
16. Water User Association	0.00	0.00	15.75	0.00
17. Welfare and Charity Group	11.16	4.05	5.81	17.41
18. Women's Association	13.48	5.69	6.26	2.86
All	8.68	5.52	2.85	6.38

Table 9: Informal water groups found in primary survey

Dzongkhag	Villages	Existence of WUAs	Other Associations and groups
Chukha	*Gewog: Bjachhog*		
	Mebesa	No	Vegetable group, farmers group (male)
	Tashigatshel	No	No
	Gewog: Bongo		
	Meritsemo	One water caretaker - paid	Vegetable association. Male, women's group
	Pakshingkha	One water care taker - paid	No
	Gewog: Darla		
	Nimgang	Yes – 5 members	Vegetable association - Male; farmers association - women
	Taptangbu	No	Farmers group (men & women)
Paro	*Gewog:Tshento*		
	Namji	No	Farmers group (men & women), milk association (men & women)
	Phangdo	No	Farmers group (men & women)
	Gewog:Sharpa		
	Zhen-kha-na	Yes, 3 members	Farmers group (men & women)
	Bara	One caretaker - paid	Farmers group (men & women)
	Gewog:Nagya		
	Wanakha	Yes, 2 members	Farmers group (men & women)
	Tokha	Yes, 2 members	Gyalpo Zimpon for poor families only, framers group (men & women)
Haa	*Gewog: Samar*		
	Balamna	Yes, 3 members	No
	Puduna	No	No
	Gewog:Kar-Tshog		
	Ingo	Yes, 3 members	No
	Naktsho	Yes, 2 members & one paid plumber	No
	Gewog:Bji		
	Tokey	Yes, 3 members	
	Yangthang	Yes, 3 members	No
Thimphu	*Gewog: Maedwang*		
	Jamdo	Yes – 2 persons	Farmers group (male & female)
	Tshenden Dhapsa	No	Farmers group (male)
	Gewog:Kawang		

Dzongkhag	Villages	Existence of WUAs	Other Associations and groups
	Chokhor	No	Farmers group (male & female), milk association
	Zhoshie	Water caretaker - paid	No
	Gewog:Ge-Nyan		
	Chesing	Water caretaker – paid	No
	Wangbama	Water care taker - paid	No

Literacy and education

The gender-segregated literacy rate and educational attainment are given by district in Tables 10 and 11, respectively. This shows that the Wangchhu basin population has a higher literacy rate compared to the national average.

Table 10: District-wise gender segregated literacy status

Dzongkhag	General Literacy		
	Male	Female	Total
Chukha	79.5	61.4	70.5
Haa	79.5	56.8	68.6
Paro	77.7	57.5	67.3
Thimphu	87.4	73.3	80.0
Average	**81.0**	**62.3**	**71.6**
Bhutan	**71.6**	**54.7**	**63.0**

Source: Bhutan Living Standard Survey (BLSS), 2012

Table 11: District-wise educational attainment rate

Dzongkhag	Primary School Completion			Secondary School Completion		
	Male	Female	Total	Male	Female	Total
Chhukha	101.5	77.5	90.5	63.4	87.8	74.5
Haa	128.2	204.3	156.2	61.0	85.2	71.5
Paro	63.0	95.3	78.4	107.5	82.0	90.4
Thimphu	82.5	87.6	85.2	104.3	80.4	91.4
Bhutan	85.8	92.6	89.0	68.8	74.2	71.4

Source: Bhutan Living Standard Survey (BLSS), 2012

2.2 Water resources of Wangchhu basin

Climate pattern in Wangchhu basin

A summary of climatic data is given in Table 12.

Table 12: Summary of climatic data

District (Station)	Altitude (m)	Temperature (^{0}/C)		Rainfall (mm)	Relative humidity (%)	Wind speed (m/s)	Sunshine duration (hr)
		Max	Min				
Haa (Namjeyling)	2,751	16.31	4.89	866	72.84	0.85	5.45
Chukha (Phuentsholing)	270	29.77	19.84	3,888	79.08	0.87	4.83
Paro (DSC)	2,406	19.88	8.22	661	70.18	0.59	4.83
Thimphu (Simtokha)	2,310	22.04	8.24	597	67.78	0.97	5.68

Source: Department of Hydropower & Power Systems (DHMS)

The pattern of precipitation and evaporation over Wangchhu basin is shown in figure 20 and 21. The monthly distribution is shown in Table 13 and Figure 22.

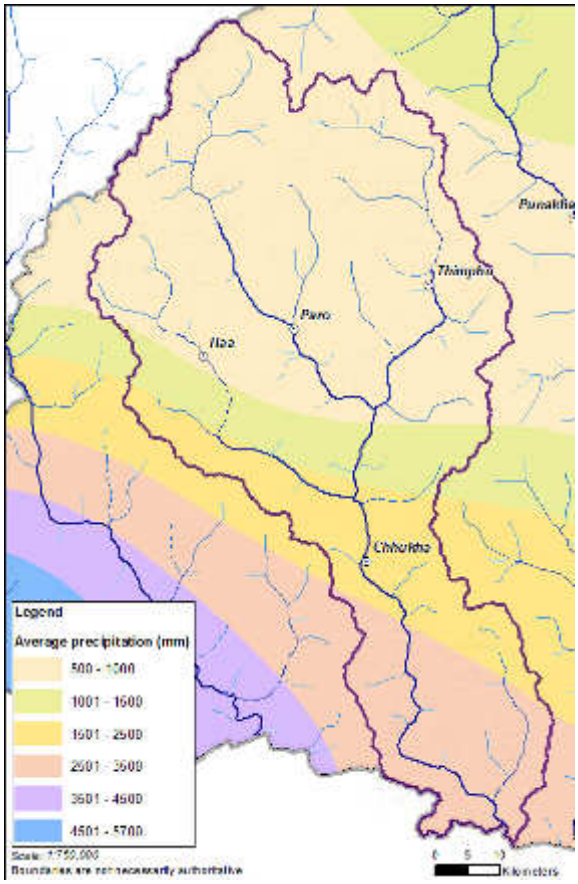


Figure 20: Annual precipitation over Wangchhu basin

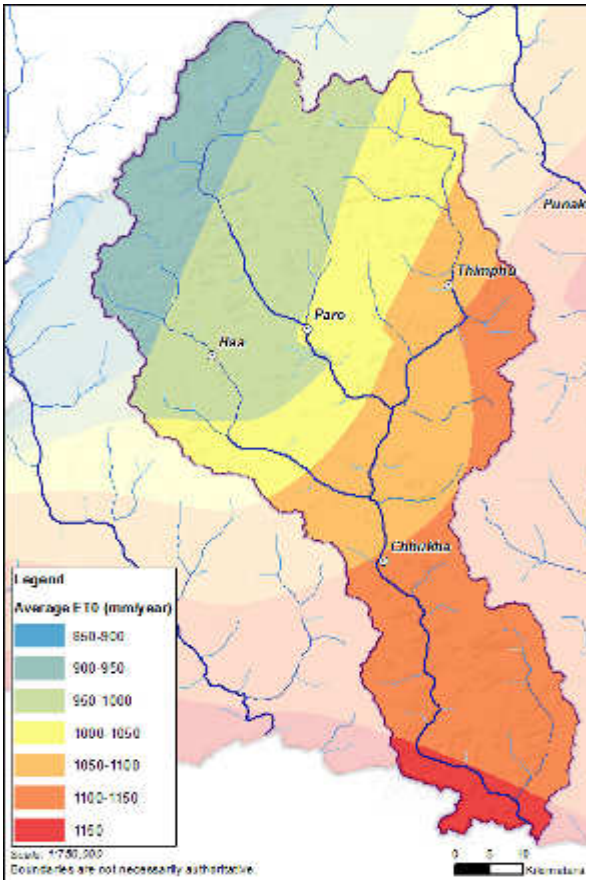


Figure 21: Annual evapotranspiration over Wangchhu basin

Table 13: Monthly 80%-dependable rainfall and evaporation per district

Month Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Haa rain	10.4	14.2	25.5	46.7	62.9	108.8	155.3	148.5	106.3	58.6	2.2	3.5	742.9
Haa Eo	47.1	52.6	75	87	98.6	91.8	97.7	96.1	83.4	75.3	57	47.4	909
Paro rain	5.9	8.8	14.4	22.3	40.4	58.5	120.5	79.3	62.2	35.5	6.4	2.8	457
Paro E0	45.3	54.9	78.4	90.6	103.5	96	97.3	97.3	84.9	78.7	55.2	42.5	924.6
Chukha rain	13	23.3	55.8	159.9	285.2	628.4	669	553.9	317.8	117.6	9.3	8.5	2841.7
Chukha Eo	59.2	72	103.5	112.8	119	101.4	99.5	102.9	92.4	100.1	80.7	66	1109.5
Thimphu rain	5.5	8.5	13.8	22.3	40.1	82.1	120.8	105.6	56.2	37.6	1.4	3.2	497.1
Thimphu Eo	53	62.2	89.6	102.9	115	108	113.8	110.4	96.9	88	65.4	53.9	1059.1

Source: National Irrigation Master Plan, 2016

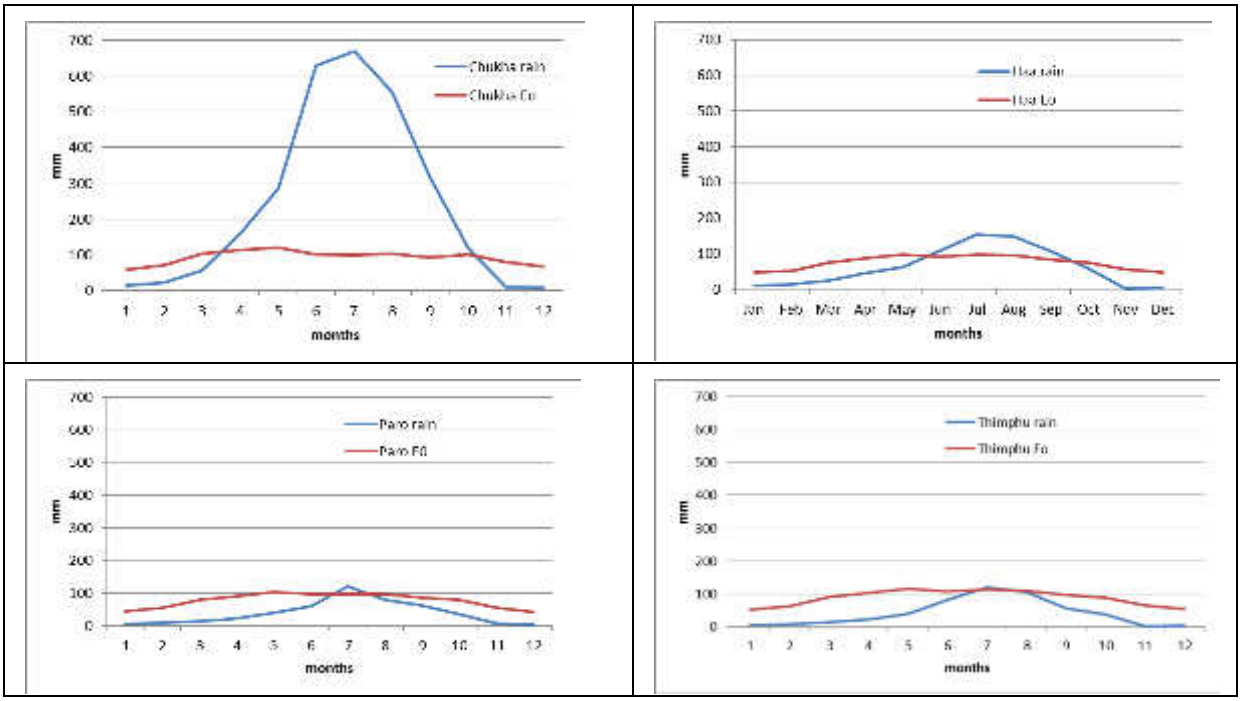


Figure 22: Graphical presentation of monthly 80%-dependable rainfall versus evaporation in mm

The present irrigation water demand per hectare for each agro-climatic zone is derived from the National Irrigation Master Plan, and is given per district in Table 14. These figures are used for calculating the present irrigation water demands of existing irrigated areas as well as proposed expansion areas.

Table 14: Irrigation water demand in l/s/ha

Station\Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Haa - Namjeyling	0.00	0.00	0.11	0.29	0.38	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Paro DSC	0.23	0.34	0.45	0.30	1.88	2.92	1.76	1.59	1.51	0.97	0.07	0.31
Chukha - Phuentsholing	0.56	0.90	0.74	0.37	1.36	1.17	0.37	0.29	1.42	1.42	0.52	0.19
Thimphu - Simtokha	0.27	0.38	0.51	0.34	1.93	2.92	1.88	1.57	1.61	1.01	0.08	0.34

Source: National Irrigation Master Plan 2016

As shown in Table 13, the 80%-dependable rainfall in Wangchhu basin ranges from 457 mm in Paro to 2842 mm in Chukha. Analysis of rainfall data over Wangchhu basin over the last two decades shows a negligible decreasing trend for Haa, Paro and Thimphu, but a clearly decreasing trend for Chukha as shown in Figure 23.

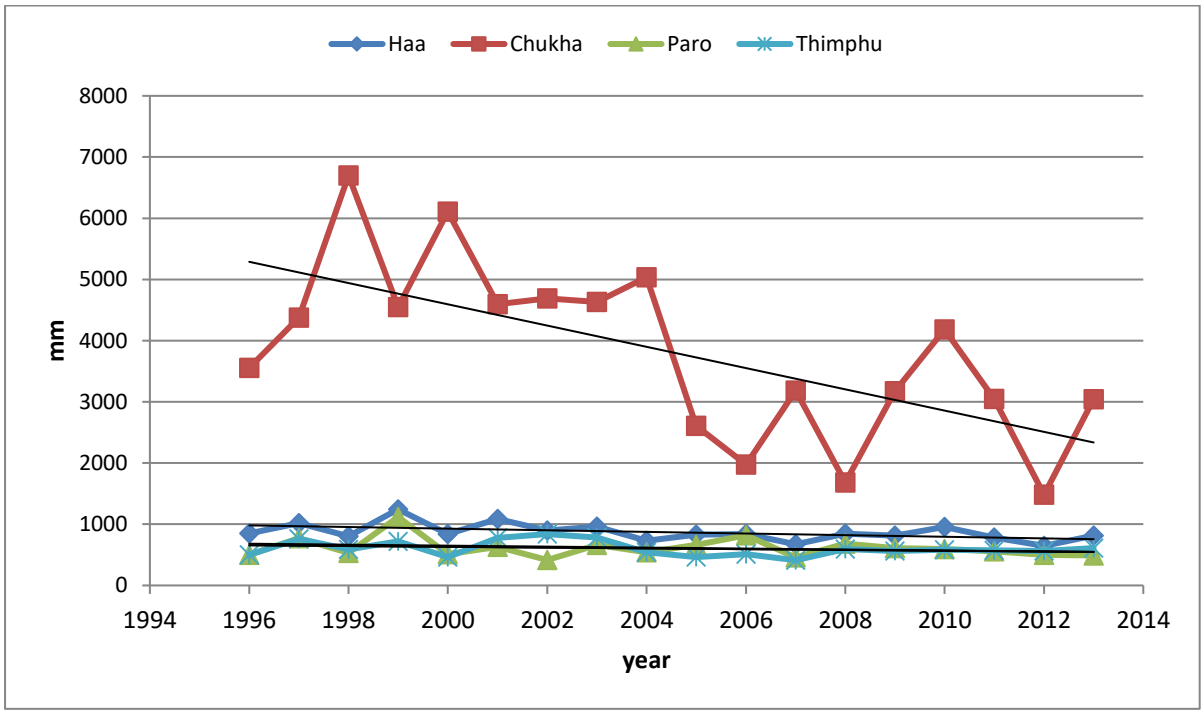


Figure 23: Rainfall trends in Wangchhu basin over the last two decades

The number of consecutive dry days (less than 1 mm precipitation per day) was investigated for different elevation zones in Bhutan over the last three decades. They fell slightly around values of 35 days for the southern foothills, 40 days for the inner Himalayas, and 60 days for the higher Himalayas, and these findings are also representative for the Wangchhu basin.

Fresh water resources

The entire drainage basin of Wangchhu is discharging an annual 5,200 MCM, or 7.4% of Bhutan's total river flow into India (Table 15). [30] The Wangchhu is the main drainage channel of the basin (Figure 24). The main tributaries are Tangochhu, Bjemirongchhu in Thimphu District, Deochhu and Parochhu in Paro District, Haachhu in Haa District, and Pipingchhu in Chukha District. The overall length of rivers in the basin is about 553 km comprising the Wangchhu, Parochhu and 19 tributaries. The longest river is Parochhu at 173 km. For hydrological assessments the river basin has been sub-divided into 19 sub-basins.

[30] A *drainage basin* or catchment basin is an extent or an area of land where all surface water from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join another body of water, such as a river, lake, reservoir, estuary, wetland, sea, or ocean.

Table 15: Average net monthly outflow (MCM and %) per basin

Basin	Wangchhu	Bhutan
Jan	82	1,028
Feb	102	1,336
Mar	144	1,512
Apr	265	3,115
May	397	4,713
Jun	713	10,002
Jul	1,132	16,382
Aug	965	13,410
Sep	723	10,392
Oct	441	5,769
Nov	143	1,792
Dec	103	1,126
Total MCM	5,209	70,576
Total in %	7.4%	100.0%

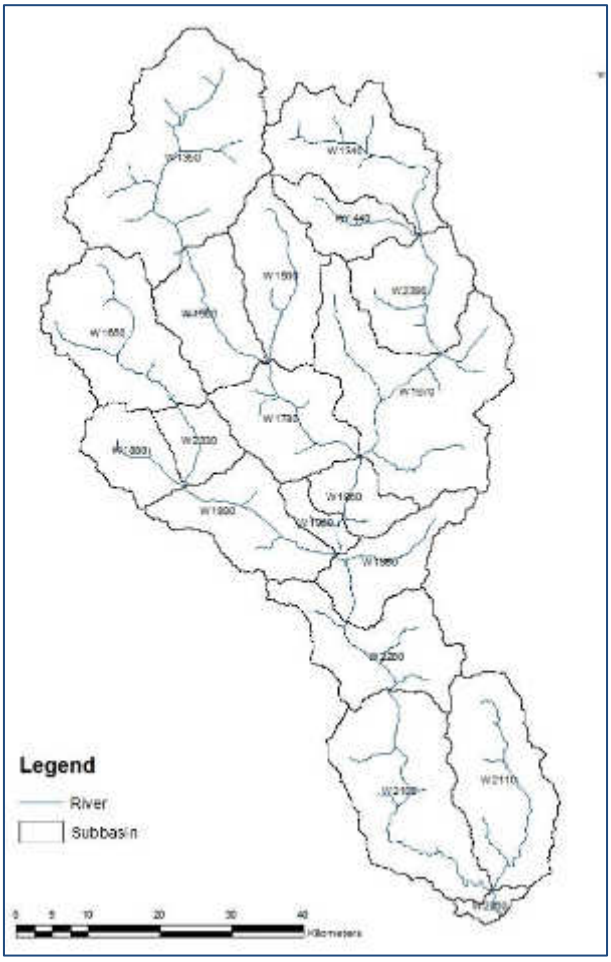


Figure 24: Sub-basins (19) delineated in hydrological modelling of Wangchhu basin

The average water availability per Gewog was assessed on the basis of hydrological modelling and the results are shown in Table 16.

Table 16: Average water availability per Gewog over the year

	Geog	Area	Monthly flows (MCM)											
		(km^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Soe	174.16	2.12	1.79	3.56	10.45	11.49	16.10	27.61	28.18	17.70	12.35	4.20	3.48
2	Tsento	573.13	7.45	7.89	11.65	29.91	34.95	50.67	86.81	87.91	56.95	42.51	14.64	11.30
3	Lamgong	48.99	0.78	1.16	0.99	1.50	2.33	3.81	6.48	6.43	4.59	4.10	1.45	0.91
4	Loong-nyi	75.71	1.45	1.94	2.14	3.21	4.12	6.32	10.85	11.44	8.53	6.35	2.15	1.69
5	Wangchang	20.65	0.37	0.48	0.56	0.86	1.07	1.61	2.79	2.95	2.20	1.61	0.54	0.43
6	Doteng	194.77	2.84	3.07	3.70	5.47	8.30	12.36	21.13	20.52	14.05	13.23	5.42	4.10
7	Dopshar-ri	33.89	0.46	0.51	0.62	0.91	1.37	2.05	3.51	3.40	2.33	2.20	0.88	0.67
8	Hoongrel	10.46	0.21	0.24	0.29	0.44	0.56	0.86	1.45	1.53	1.14	0.86	0.29	0.24
9	Sharpa	80.21	1.55	2.06	2.36	3.53	4.45	6.74	11.57	12.32	9.23	6.70	2.28	1.85
10	Dokar	106.04	2.25	2.88	3.00	4.33	6.00	8.76	15.83	15.80	11.38	8.49	3.86	3.56
11	Lingzhi	49.34	0.75	1.35	2.44	3.29	4.87	8.94	13.42	12.83	9.31	6.32	2.20	1.12
12	Naro	279.46	4.15	6.80	12.32	16.67	24.67	44.06	68.00	65.57	48.76	33.40	12.00	6.21
13	Kawang	297.17	4.63	6.65	8.22	11.66	18.13	30.46	49.34	52.12	37.69	29.27	12.10	6.21
14	Chang	156.38	2.52	3.05	2.89	4.46	6.99	11.69	21.78	23.36	15.06	11.22	4.35	3.32
15	Meedwang	230.09	3.70	4.14	3.99	6.19	9.62	16.07	31.71	33.40	21.12	14.89	5.42	4.90
16	Dakarla	202.56	3.78	4.28	4.82	7.70	12.27	21.46	35.97	32.06	22.89	15.16	7.34	5.60
17	Ge-nyen	60.93	0.96	1.09	1.07	1.63	2.54	4.25	8.38	8.84	5.60	3.94	1.43	1.31
18	Chapchcha	129.18	2.79	3.39	3.80	5.83	9.27	15.24	24.96	20.86	15.50	10.69	6.58	5.46
19	Bij	283.31	5.54	5.30	6.43	9.75	8.54	18.66	34.02	43.10	28.49	23.28	9.98	4.87
20	Kar-tshog	40.65	0.78	0.72	0.88	1.34	1.18	2.59	4.71	5.97	3.96	3.24	1.40	0.70
21	Uesu	66.46	0.86	1.94	2.01	3.29	4.66	7.23	11.49	11.68	8.01	5.79	1.17	0.88
22	Samar	199.74	3.00	5.03	7.69	11.02	13.37	22.42	35.84	37.50	26.67	21.51	6.22	4.04
23	Nagya	136.66	3.40	4.38	4.50	6.48	7.98	11.82	20.46	20.86	15.42	16.63	8.71	5.70
24	Doongna	58.53	1.42	1.84	1.96	2.85	3.43	5.18	8.84	9.16	6.69	7.66	4.17	2.62
25	Meedtabkha	29.98	0.83	1.09	1.50	2.80	4.79	8.86	13.39	10.02	7.98	4.39	1.24	0.96
26	Geling	81.29	1.58	1.98	2.71	4.98	8.57	15.91	23.78	17.46	14.10	7.47	2.64	1.98
27	Bjagchhog	139.56	4.07	5.35	8.04	16.10	29.22	55.60	82.76	58.63	47.67	21.24	3.73	3.54
28	Bongo	398.93	8.57	11.30	21.80	52.00	87.93	174.00	262.83	178.89	150.13	60.96	7.96	7.50
29	Darla	111.42	3.11	4.23	8.01	18.87	32.19	63.84	95.06	65.14	53.84	21.96	2.88	2.79
30	Getana	240.89	5.68	6.22	9.64	17.83	31.79	65.11	97.12	66.93	56.14	23.86	5.42	5.30
31	Dorona	30.63	0.72	0.80	1.23	2.26	4.04	8.27	12.32	8.49	7.13	3.03	0.70	0.67
32	Lhamoi Dzingkha	37.79	0.94	1.16	1.90	3.78	6.78	13.71	19.58	13.74	10.91	4.63	0.88	0.88

As shown in Table 17 and Figure 25, there are 56 glaciers in the northern part of the basin. Due to global warming, glaciers are decreasing in thickness and area thus contributing to the river flow.[31] However, glacial retreat due to climate change is likely to threaten the long-term sustainability of water flows.[32]

Table 17: Glaciers in Wangchhu basin

Basin	Sub-basin	Number of Glaciers		Glacier Area (km^2)			Largest Glacier
		CI	DC	CI	DC	Total	km^2
Wangchhu	Thimphuchhu	19	0	5.2±0.1	0.0±0.0	5.2±0.1	1.5
	Parochhu	37	2	22.2±0.4	5.4±0.0	27.6±0.5	7.2
	Subtotal	56	2	27.4±0.6	5.4±0.0	32.8±0.7	7.2

CI= Clean Ice, DC= Debris Covered

[31] NSDIC 2015: www.nsidc.org

[32] Bajracharyaet al., 2014. See also the stand-alone supporting document: Hydrological modelling and assessment for Bhutan.

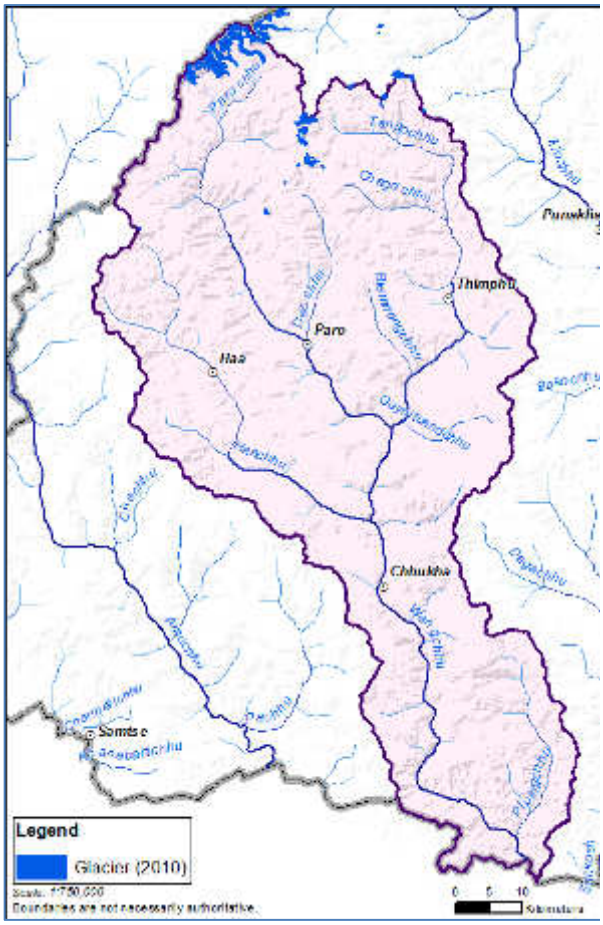


Figure 25: River network and glaciers in Wangchhu basin

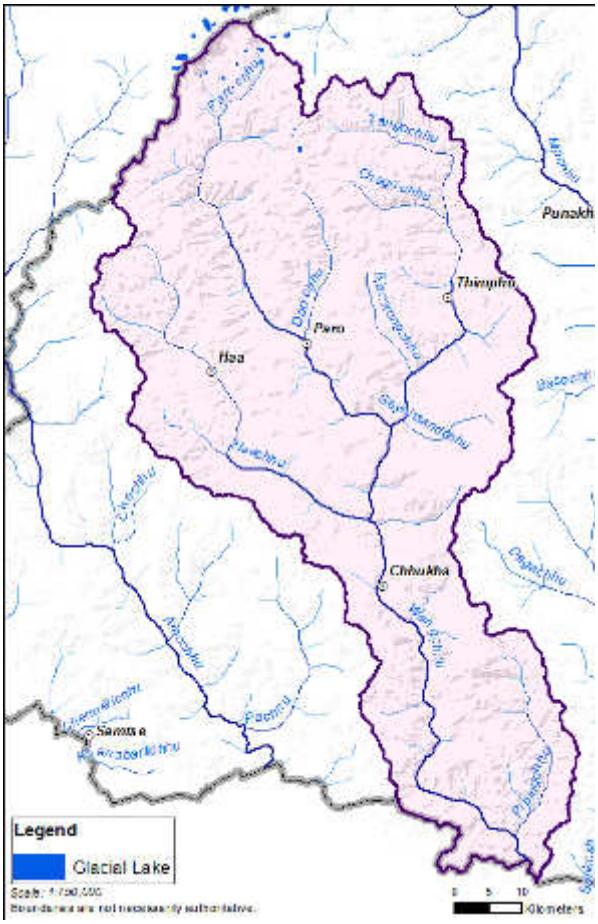


Figure 26: Glacial lakes in Wangchhu basin

There are also a few glacial lakes (Figure 26) in the northern part of Wangchhu basin, but none of them were classified as at risk of outburst.[33]

Hydrological basin as management unit

The Wangchhu drainage basin also serves as the *management* unit. It is the area of jurisdiction of the Wangchhu Basin Committee (RBC) that has a broad mandate to *coordinate* policies and actions concerning basin planning and management of water resources, including preparation and periodic updating of the basin plan. The RBC is specifically tasked with resolving inter-district issues related to water management such as upstream-downstream effects of interventions related to water abstraction, effluent discharge and pollution. The RBC also coordinates the water-related planning and management involving national agencies and the four districts within the basin to arrive at a balanced water resource allocation.[34]

[33] Mool et al., 2001. See also the stand-alone supporting document: Hydrological modelling and assessment for Bhutan

[34] Water security is defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."[34] Water security may be viewed in physical or economic terms. Physical water security is a situation wherein water is abundant enough to meet all demands, whereas economic water security depends on providing adequate investments in water infrastructure and services delivery.

Monitoring stations

The location of river gauging and meteorological stations in Wangchhu basin is given in Figure 27. The historical records from these stations have been used in the basin hydrological assessments.[35]

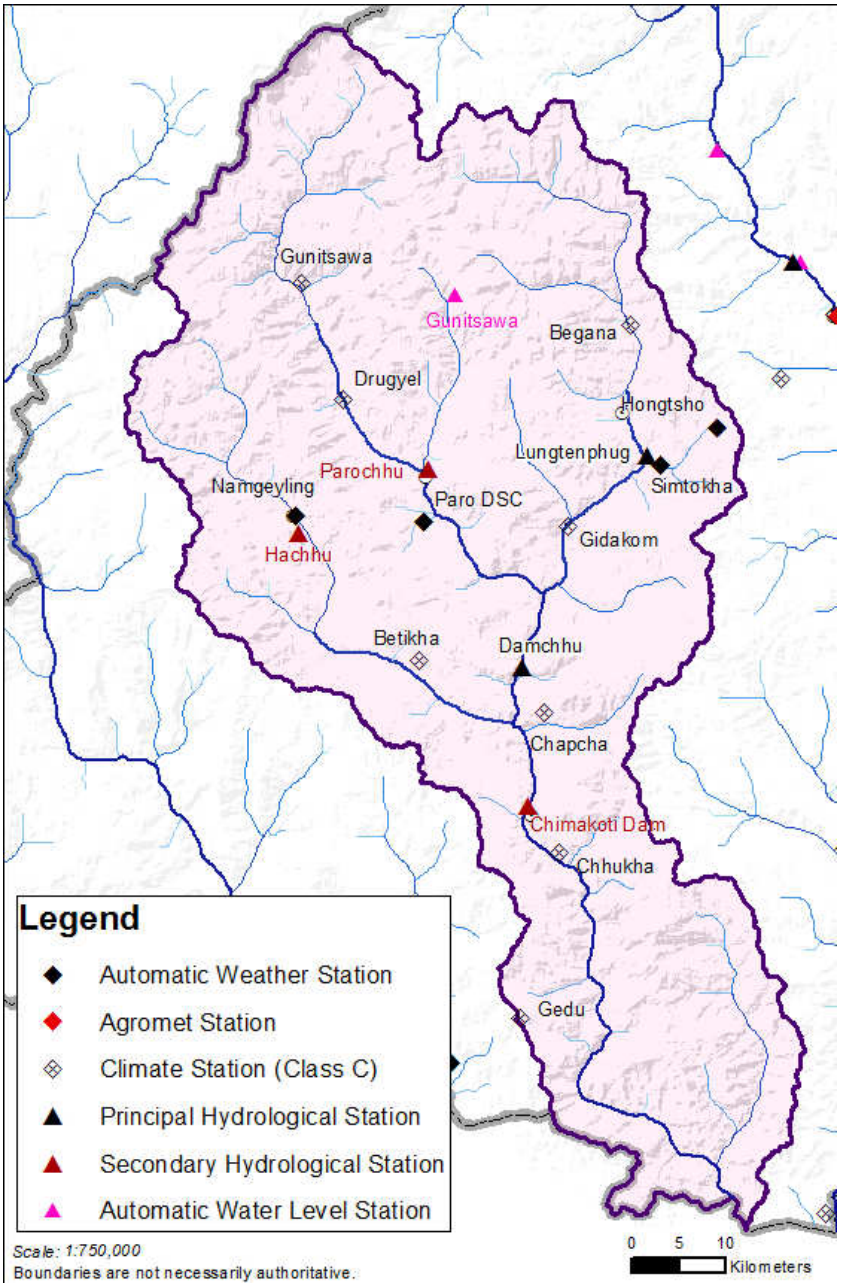


Figure 27: Rainfall and discharge monitoring stations in Wangchhu basin

At present, the ambient water quality is being monitored by the Water Quality Monitoring Section (WQMS) of the Water Resources Coordination Division (WRCD) of NECS. The locations of ambient water quality stations and effluent sampling points along Thimphuchhu and its tributaries are shown in Figures 28 and 29. Measurements on other locations in the basin are done ad-hoc.

[35] For details see the stand-alone supporting document: Hydrological modelling and assessment for Bhutan

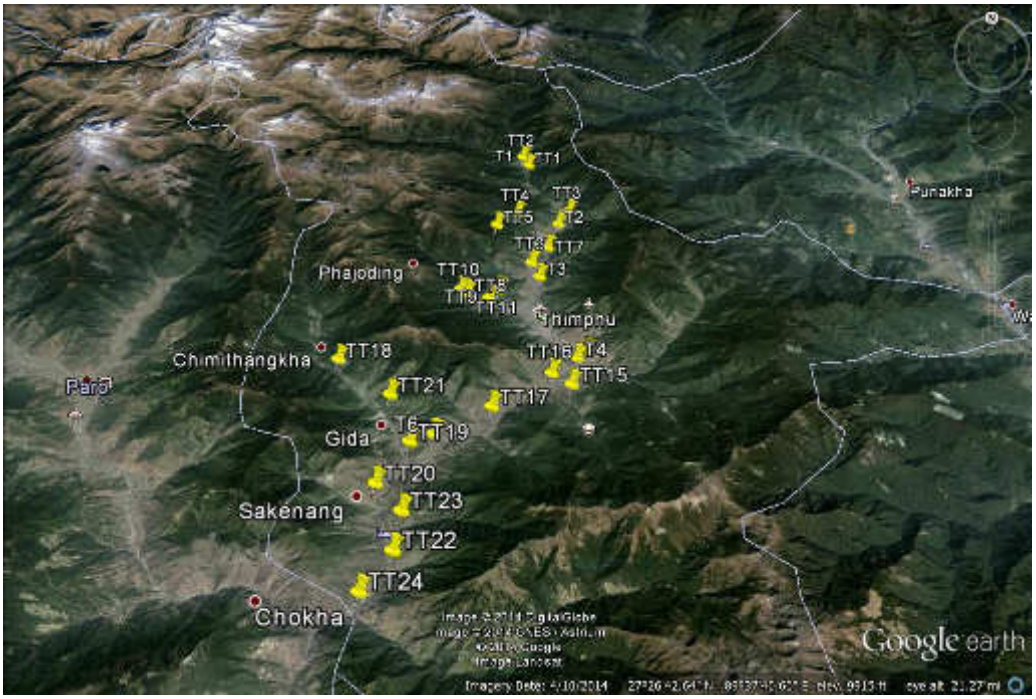


Figure 28: Ambient water quality sampling points along Thimphuchhu

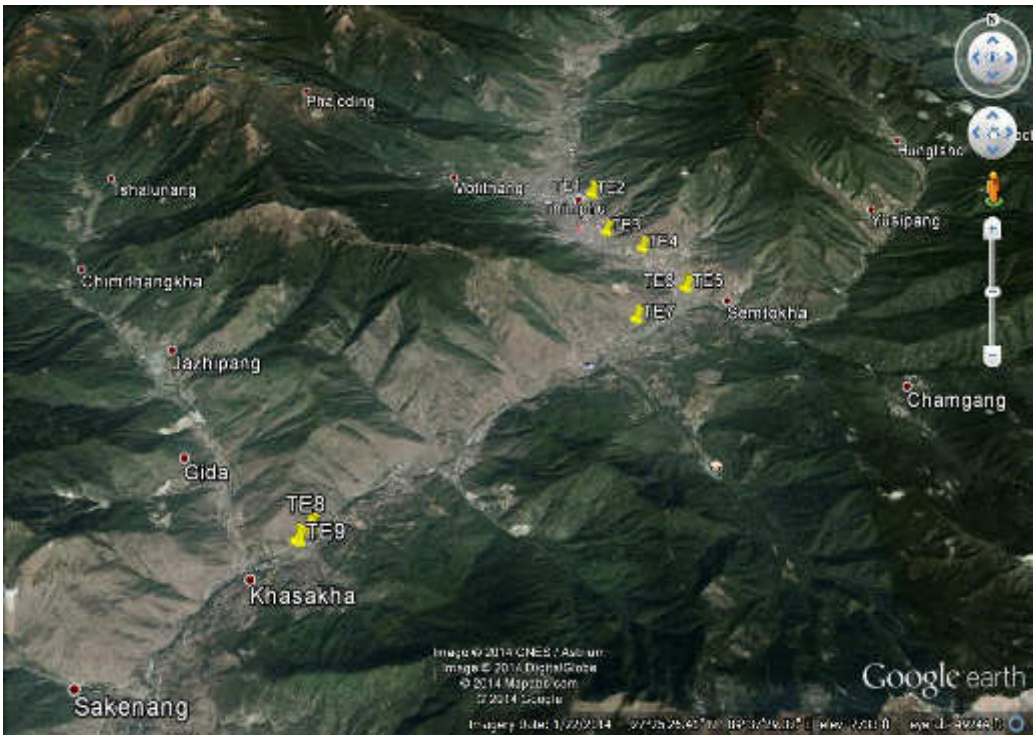


Figure 29: Effluent sampling points along Thimphuchhu

The thematic maps for Wangchhu basin are available in the Bhutan Water Security Information Management System, which is posted in the following website: www.nec.gov.bt.

2.3 Basin Management Scheme

Coordination through the Water Security Index

The coordination framework is provided by the Bhutan Water Security Index (BWSI) system. It measures on a scale of 1 (poor) to 5 (very good) the degree to which water resources and related services are developed, as measured across five key dimensions:[36]

1. Rural drinking water supply, sanitation and hygiene
2. Economic water utilization for agriculture, industries and hydropower
3. Urban water supply, sanitation and drainage
4. Environmental water security
5. Disaster preparedness and climate change resilience

The present score of the Bhutan Water Security Index under the five key dimensions is given for Wangchhu basin and at national level in Table 18 and Figure 30. As can be seen, the average score for Bhutan across the five water security dimensions is 3.08, and for Wangchhu basin the average score is 3.34.

Table 18: Score of the Water Security Index 2016

Key Dimension	Wangchhu basin	National level
1. Rural household water supply, sanitation and hygiene	4.5	3.5
2. Economic water security	2.1	2.0
3. Urban water supply and drainage	2.8	2.8
4. Environmental water security	3.4	4.0
5. Resilience to climate change and water-related disasters	3.9	3.1
Average Score	**3.34**	**3.08**

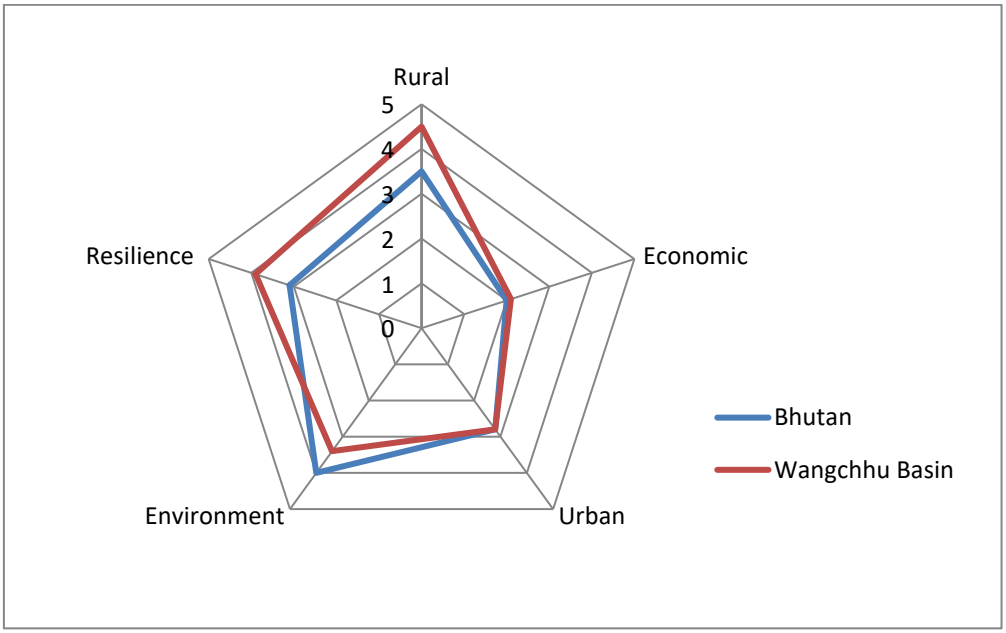


Figure 30: Water Security Index 2016

[36] See the National IWRM Plan, and the stand-alone supporting documents titled: *Bhutan Water Security Index*, and *Bhutan Water Security Index System: User's Manual.*

2.4 Basin governance and management structure

Governance mechanisms to promote management and accounting of water resources at the basin level has been an aspiration of the Royal Government and efforts are being made to institutionalize it with the preparation of the NIWRMP and WBMP. Although the need for coordinated and integrated approach to water resources has been acknowledged since early 2000 and integrated into policy and legislation, the concept of managing water resources at the level of basin is relatively new. The concept of river basin has been applied more at technical levels in assessing hydrology and water availability for hydropower development and less by district, Gewog and central level agencies in planning, implementation and monitoring of water resources. Like in the case of other development interventions, planning and management of water resources are carried out from the perspective of districts and not the basin as a whole. Other than planning and execution of hydropower projects by Ministry of Economic Affairs at the central level, interventions in other areas of water resource management such as drinking and irrigation are carried out independently for each district and the Gewogs within them. As a result, efforts to foster coordinated management of water resources at the basin level are new. The institution of River Basin Committee (RBC) is in its initial stage of being established.

The Wangchhu River Basin Committee established in April 2016 is Bhutan's first RBC to be put in place. The initial framework, composition and terms of reference of the committee will provide the basis for a coordination of water resource management in the basin. It is expected that the institution will require constant review and orientation on the basis of experiences and lessons learnt to evolve into an effective (See governance and implementation arrangements chapter).

2.5 Water resource management efforts in the basin

There have been several independent efforts to investigate and implement water resource management programmes in the Wangchhu basin. Some of the prominent ones include:

Water Resources Management Plan 2003[37]: The study was the first to provide nation-wide overview of Bhutan's water resources. The study was carried out by Norconsult for the Department of Energy, Ministry of Trade & Industry and completed in 2003. Focusing on the three main north-south rivers basins, the study provides a wealth of information water for drinking an irrigation and hydropower. Aspects of the study that are specific to Wangchhu include:

- Base maps in ARC GIs format established in the Land Use Planning Section (LUPS) of the Planning & Policy Division of the Ministry of Agriculture, Thimphu
- possible sources of water pollution from local sanitary effluents and use of herbicides, pesticides, fertilisers n the agricultural sector.
- there may be competition between irrigation and hydropower, and some sub-basins could reach water stress situation in the future.
- Multi-purpose storage schemes are generally not feasible for economic and flood control purposes.
- need for improved coordination between municipalities and agencies involved in rural water supply, urban water supply, irrigated agriculture, pollution abatement, and flood protection
- need for improved irrigation efficiencies (only) in Paro & Thimphu valleys
  Future river basin management must take care not to override Dzongkhag and Gewog level decision-making frameworks

Wang Watershed Management Project (WWMP): The European Union supported Wang Watershed Management Project (WWMP) was implemented in the four districts of Wangchhu basin from September 2000 to July 2007. The purpose of the project was to develop, test and institutionalize practical watershed,

[37] Water Resources Management plan, Department of Energy, Ministry of Trade and Industry, 2003.

land, and farm management techniques and procedures. The project was envisaged to benefit 10,000 rural households in the districts of Chukha, Haa, Paro and Thimphu. The project was implemented by Ministry of Agriculture. The Royal Society for Protection of Nature (RSPN) was the implementing partner for the Environmental Education and Advocacy component of the project. The project cost was Euros 9.2 million.

Environmental Impact Assessment for Bunakha Hydropower station[38]: The report describes the hydropower project, water and environment, physical environment, bio-diversity, and socio-economic environment. It gives an identification, prediction and evaluation of impacts of the project. The report has been endorsed by NECS.

Environmental Impact Assessment for Wangchhu Hydropower station[39]: The report gives project details, an environmental baseline status with physic-chemical aspects, ecological aspects, and socio-economic aspects. It also predicts the impacts of the project on water quality; air, noise and land environment; ecology; and socio-economic environment. It proposes an environmental management plan, and a resettlement and rehabilitation, as well as a monitoring plan. It also contains a disaster management plan and cost estimates. The report was endorsed by NECS.

Assessment of vulnerability to climate change[40]: Vulnerability to climate change and possible adaptation options in Bhutan were assessed under the National Adaptation Program of Action (NAPA), supported by ADB. It did not specifically target Wangchhu basin, but Wangchhu was included in the study. The study identified three high risks areas and screened adaptation options based on set criteria. A Multi-Sectoral Technical Committee on Climate Change CCC) was established as a national technical forum for coordinating all climate change issues in Bhutan. It became the task force for revising the NAPA documents. The Multi-Criteria Analysis (MCA) was used in the NAPA 2006 document to screen, select and rank the projects. Out of the nine prioritized adaptation measures, three projects are being implemented with financing from the LDC Fund and other donors. They are i) Artificial Lowering of Thorthomi lake, implemented by DGM, ii) GLOF hazard zoning-Disaster, implemented by Department of Disaster Management, and iii) Installation of early warning system for Phochhu, implemented by DHMS. The other six projects that were reviewed and integrated in the NAPA-2 program for implementation include i) flood and landslides risk reduction in Phuentsholing ii) ii) enhancing community resilience to climate risks through building or rehabilitating water harvesting structures, water storage and distribution facilities in water-scarce villages, and improving the information base for water management iii) Improving the quality, analysis and dissemination of climate information. A project on gathering detailed information for local water management is being piloted in the districts of Mongar, Pemagatshel, Samtse and Tsirang. Though these projects are not specifically located in Wangchhu basin, the experiences and outcomes are relevant for local water management in Wangchhu basin too.

Wang Integrated River Basin Management Plan[41]: The Social Forestry Division of the Department of Forest in the Ministry of Agriculture and Forest prepared the Wang Integrated River Basin Management Master Plan in 2008, with the stated objective to give strategic guidance to policies, decision-making and lobbying. It identified all stakeholder agencies and provided directions on the role of each agency, as well as coordination arrangements needed for successful achievement of objectives. The Plan provided broad strategic actions, whereas the individual agencies were expected to identify suitable implementation activities.

[38] Comprehensive Environmental Impact Assessment for the proposed Bunakha Hydro-Electric Project (180 MW), THDC, India, 2013

[39] Comprehensive Environmental Impact Assessment Studies for Wangchhu HEP (570 MW), Bhutan, WAPCOS India, October 2014

[40] National Adaptation Program of Action (NAPA), http://www.adaptation-undp.org/search/node/bhutan

[41] Wang Integrated River Basin Management Plan, Social Forestry Division, Department of Forest, MOA, 2008

However, the Master Plan was not implemented and has in fact been superseded by a system of rapid watershed classification done for Wangchhu in 2011 by the Watershed Management Division under the Department of Forests and Park Services of the Ministry of Agriculture and Forests (see Chapter 3.1.4.).

Sensitization workshops[42]: A great number of sensitization workshops were held for local leaders throughout the country including Wangchhu basin in the period 2013-2015, and an inventory was prepared of water-related issues. The findings for Wangchhu basin showed that nearly all Gewogs in the basin do experience one or another issue related to water, mostly related to lack of water (access). The causes and extent of the problems have not been stated.

Paro Valley Geo-technical Investigation[43]: A geo-technical investigation was completed in 2015. It studied the nature of slopes, the types of exposed rocks, ground conditions such as presence of sinking and marshy areas, and risks that the site is exposed to due to flooding and landslides. It concluded that Paro valley is topographically stable and is not likely to experience landslides in the near future with possible exception at the periphery near Satsam and Chorten. No groundwater was encountered in the soil pits, but there was no indication of their depth. It was mentioned however that in the lower parts of Paro valley water seeped into construction pits at a depth of 4 meter with coarse-grained (not clayey soils).

It was concluded that the soils are suitable for development activities, and no major settlement problems are expected in Paro valley. The main risks identified to development related to inundation from the river and earthquakes. The criteria recommended for hazard mapping were flood map, geological map, river buffer and slope variables.

The study established a need to complement the existing river training works such as repair of the Reno mattress gabion along high impact zones along Pachhu and Dochhu. The cost was estimated at Nu. 133.6 million.

[42] RSPN, 2015

[43] Paro Valley geotechnical investigation, Budes, MOWHS, 2015

3 Situation analysis

This chapter first analyses a number of stress factors related to water management in Wangchhu basin, ranging from basin-specific impact of climate change, water scarcity at Gewog level, flood-prone areas, critical watersheds, limitations and impacts of hydropower development, to water governance issues. The chapter also presents a problem analysis and strategy development based on a participatory logical framework analysis with the incumbent RBC members and other stakeholders.

3.1 Stress factors in water management

3.1.1 Climate change and its impacts on hydrology

Climate change

The longer-term climate change projections derived from climate modelling, show an increasing trend in annual rainfall toward the 2060s, especially in the south as shown in Figure 31.[44]

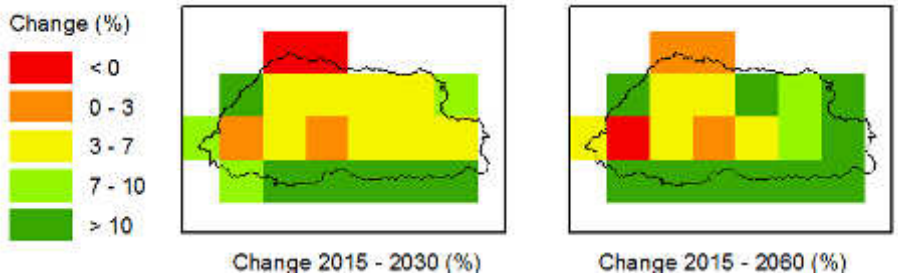


Figure 31: Projected long-term change in precipitation for RCP 4.5

According to the climate change projections, the average temperature is also expected to rise, as shown in Figure 32.

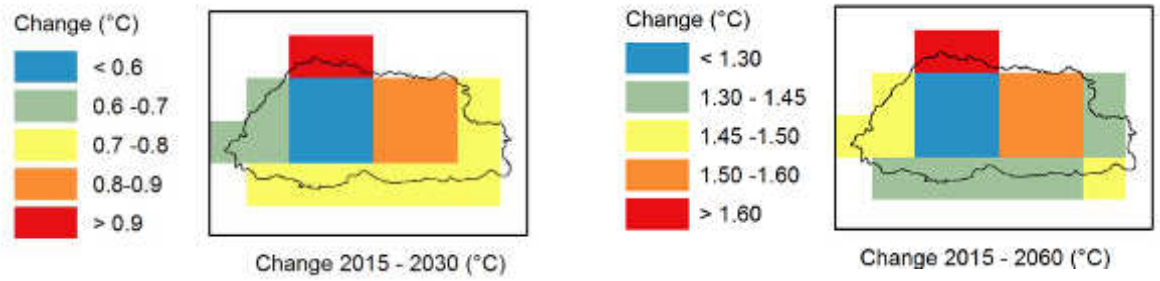


Figure 32: Projected rise in average temperature for RCP 4.5

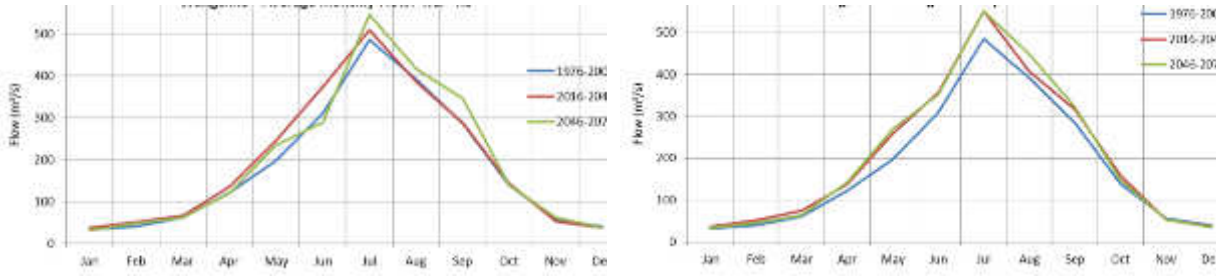
The number of consecutive dry days (precipitation less than 1 mm/ day) is expected to increase very little until 2040 with values around 35 days for the southern foothills, 40 days for the inner Himalayas and 60 days for the higher Himalayas.

There was no clear trend found in future evapotranspiration.

[44] RCP4.5 stands for a climate scenario with curbed greenhouse gas emissions

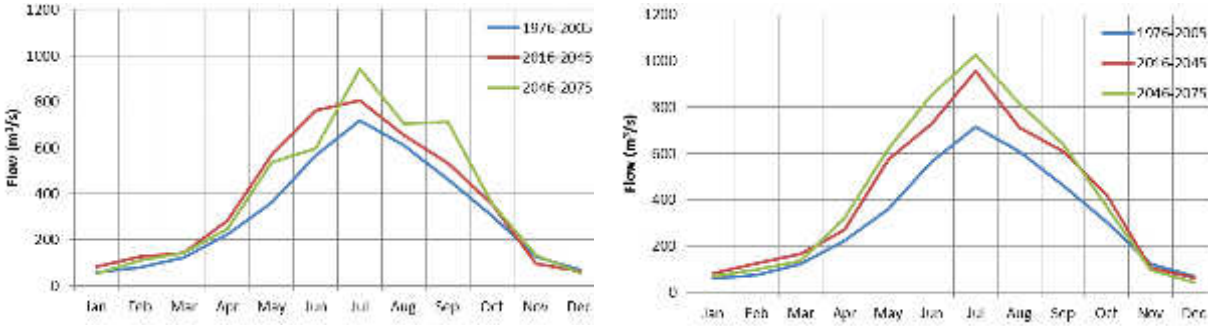
Impacts on hydrology

The average monthly and maximum outflows of the Wangchhu basin are expected to increase (Figure 33 and 34), based on hydrological assessments with increased rainfall and temperature following from climate change projections. The figures represent two climate change scenarios, RCP 4.5 and RCP 8.5.[45], [46]



(a) RCP 4.5 (b) RCP 8.5

Figure 33: Average monthly outflows of Wangchhu basin over time



(a) RCP 4.5 (b) RCP 8.5

Figure 34: Monthly maximum outflows of Wangchhu basin over time

The impact of climate change on high flows can also be expressed in terms of frequency of occurrence, as shown in Table 19 and Figure 35. For example: A present flood of 100 year return-period (1% chance with 1,275 m3/s) would occur once per five years (20% chance with 1,280 m3/s) by 2060s.

Or: a once-in-fifty-year flood (2% chance) is projected to increase from 1,189 m^3/s at present to a projected 1,498 m^3/s in 2030s and further to 1,818 m^3/s by 2060s.

The implication is that flood zonation and flood protection measures that are traditionally designed as per present return periods would under-estimate future flows by about 50% during the 2060s (i.e., 2046-2075)!

[45] RCP stands for Representative Concentration Pathway, a climate change scenario which depends on the quantity of greenhouse gases emitted into the atmosphere. RCP 4.5, one of the scenarios, represents stabilization of greenhouse gas emissions, whereas RCP8.5 stands for a significantly larger increase in such emissions.

[46] For details, see stand-alone supporting document: Hydrological modelling and assessments for Bhutan.

Table 19: Outflows of Wangchhu and corresponding return periods

Return Period (yr)	Flow (m^3/s)		
	1976-2005	2016-2045	2046-2075
5	895	1112	1280
10	987	1233	1448
25	1103	1385	1661
50	1189	1498	1818
100	1275	1611	1975

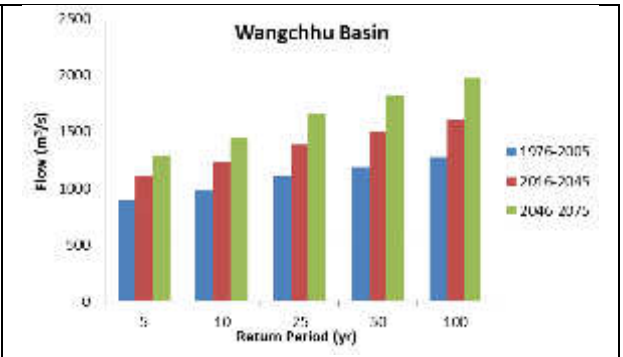
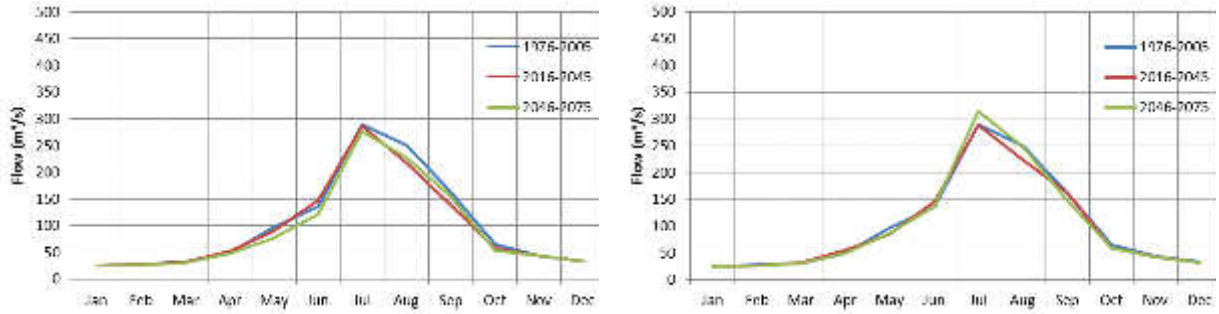


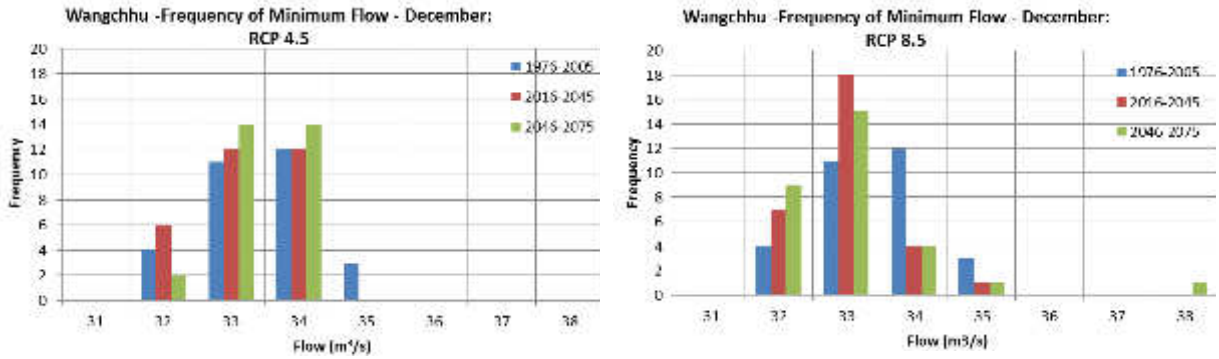
Figure 35: Present and projected monsoon outflows of Wangchhu for various return periods

Conversely, for the lean season there is no clear change in monthly minimum outflow (Figure 36). But Figure 37 shows that smaller flows will occur more frequently in future, although the minimum flow itself (32 m^3/s) would not decrease.



(a) RCP 4.5 **(b) RCP 8.5**

Figure 36: Monthly minimum outflows of Wangchhu basin over time



(a) RCP 4.5 **(b) RCP 8.5**

Figure 37: Frequencies of minimum outflows of the Wangchhu basin during the lean season

Figure 37 shows for example for RCP 8.5 that the minimum flow will remain at 32 m3/s, but its frequency of occurring increases from 4 to 9, whereas the frequency of flows of 35m3/s would decrease from 3 to 1. However, this shift towards lesser flows is accompanied by a low frequency of high outflow (39 m3/s) that so far did not occur.

Given the limited number of climatic stations, the impact of climate change on hydrology could realistically only be assessed at basin level, and not at sub-basin level.[47]

3.1.2 Anecdotal Water-scarcity

Water scarcity in the basin has been widely reported in the media. This issue has been investigated in four ways:

1. A questionnaire survey in all Gewogs in Wangchhu.
2. Calculation of the total amount of water available per person per year (Falkenmark Index).
3. Calculation of the total volume of water available per Gewog.
4. Calculation of the fraction of water consumed in future as compared with water available per Gewog.

This issue is elaborated in the following paragraphs.[48]

Gewog questionnaire

An IWRM questionnaire was completed by all Gewogs in Wangchhu basin in 2015. The Gewogs reported that 65 villages in the basin were experiencing seasonal water shortage. Paro district suffers most with 40 villages reporting seasonal water scarcity (see Figure 38). In particular, the Gewogs of Wangchang, Dogar, and Shaba in Paro stand-out as the most water scarce, followed by Mewang Gewog in Thimphu.

It should be noted that this is only a qualitative inventory; it does not assess the magnitude or frequency of the scarcity.

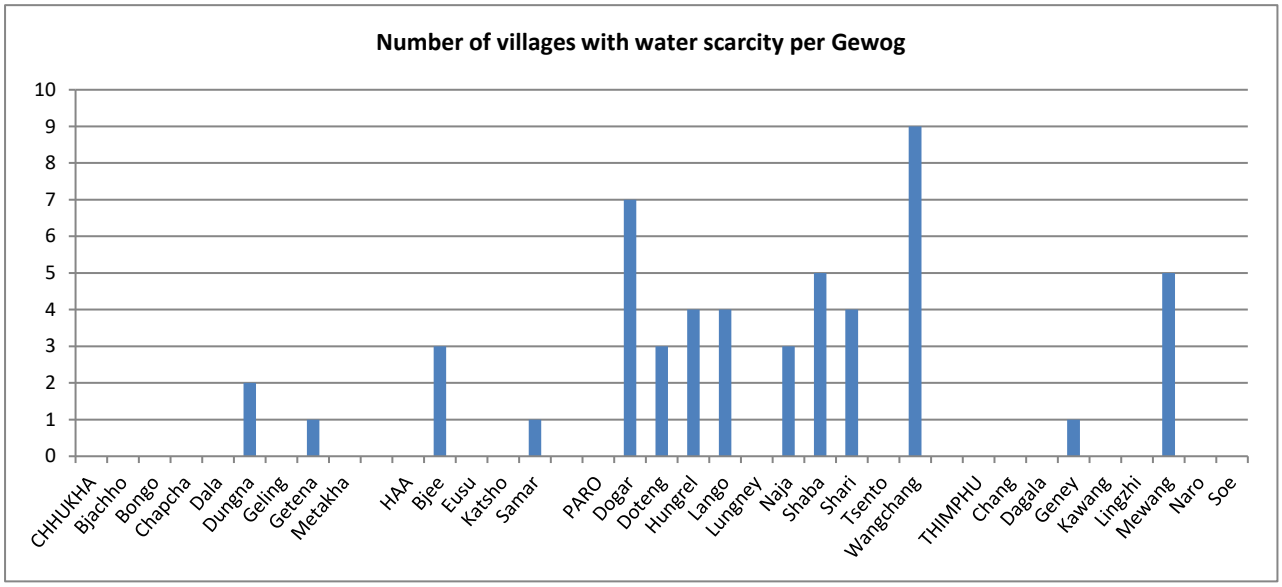


Figure 38: Number of villages having seasonal water shortage per Gewog

Information about groundwater is sparse and inconclusive not just for Wangchhu but also at the national level. Consequently, the government does not encourage groundwater exploitation[49]. Nevertheless, there are

[47] Bhutan is represented by only 21 Aphrodite stations.

[48] The details of calculations are given in the stand-alone supporting document: *Hydrological modelling and assessments for Bhutan.*

[49] Geo-electrical survey in Paro area, Bhutan, CEGR-Kathmandu, 2015?

various reports of groundwater potential, concentrated in Paro district in the Gewogs of Shari (5), Lango (4), Shaba (3), Wangchang (1 in Bondey town). In Thimphu district the use of groundwater has been reported in Mewang Gewog (1 for a school), see Figure 39. It appears that groundwater is being tapped in areas that have been assessed in this report as potentially water-scarce.

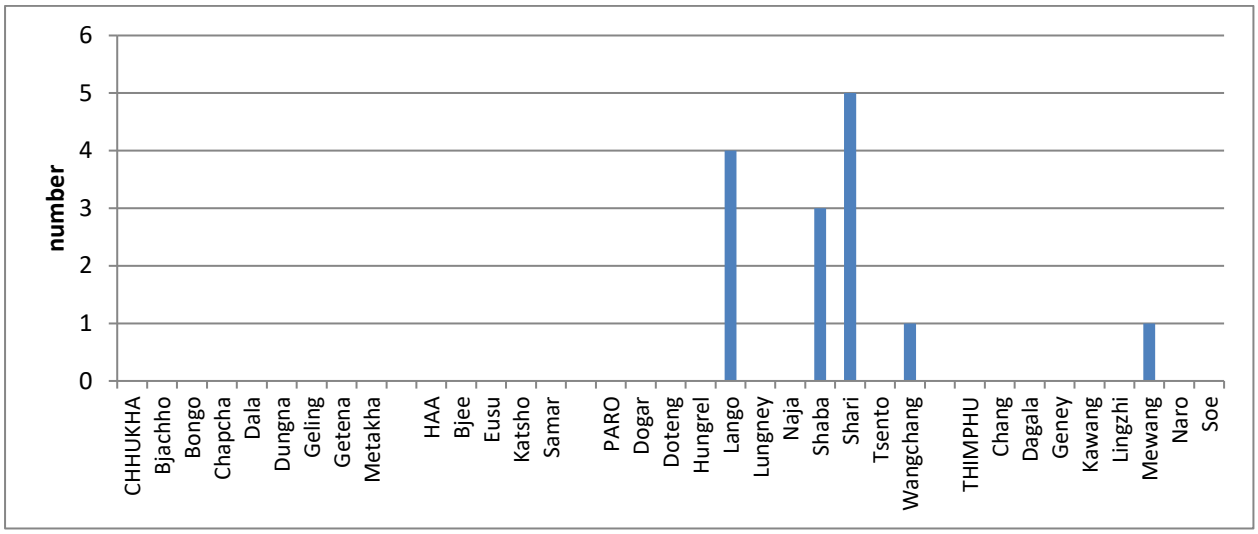


Figure 39: The number of villages per Gewog reportedly exploiting groundwater

UN-Falkenmark index

The United Nations (UN) has adopted the Falkenmark (1989) criterion which assumes that a region is experiencing overall water abundance when the average amount of water per capita per year is over 1,700 m^3. There is stress when annual water supplies drop below 1,700 m^3 per person. When annual water supplies drop below 1,000 m^3 per person, the population faces water scarcity, and below 500 m^3 per year there is "absolute scarcity".[50] This is given in Table 20.

Table 20: UN-Falkenmark criteria for water availability

Classification	Water available	Water available
Abundance	Above 1,700 m3/ capita/ year	Above 4,657 l/c/d
Stressed	Below 1,700 m3/ capita/ year	Below 4,657 l/c/d
Scarcity	Below 1,000 m3/ capita/ year	Below 2,740 l/c/d
Absolute scarcity	Below 500 m3/ capita/ year	Below 1,370 l/c/d

This index is typically used in assessments on a regional scale where the data is readily available and provides results that are easy to understand.[51] However, the use of regional averages tends to obscure important scarcity information at smaller time intervals and local spatial variations.[52]

[50] http://www.un.org/waterforlifedecade/scarcity.shtml

[51] Amber Brown and Marty D. Matlock. A Review of Water Scarcity Indices and Methodologies, , University of Arkansas, The Sustainability Consortium, White Paper #106, April 2011.

[52] Rijsberman 2006

Hence in deviation of the standard practice, the index was applied under the following conditions:

- The driest month of the year (January) instead of the whole year.
- At Gewog level instead of at national level.
- For the 80%-dependable water availability (minimum flow expected on average to occur four out of five years) instead of the average water availability (occurring on average once every two years).
- The index was calculated for the year 2015 and 2030, taking into account the growth of population and rate of economic development.
- The water availability at Gewog level in 2030 was assumed to be the same as in 2015, because future hydrological assessments proved inaccurate at smaller scale than basin level. Given the expected impact of climate change on hydrology this assumption was considered to be sound.
- Inflow from upstream of the areas was not considered.

The results of the dependable water availability per Gewog in the basin per capita per day during the driest month (January) for 2015 and projected for 2030 are given in Table 21.

Table 21: Falkenmark index for 80%-dependable water availability per capita during the lean month of January in 2015 and 2030

UN-Falkenmark index for internal *dependable* runoff water			
2015	**2030**	Legend	
CHUKA	**CHUKHA**		stress < 1,700 m3/ c/ yr or < 4657 l/c/d
			scarce < 1,000 m3/ c/ yr or < 2740 l/c/d
			absolute scarce < 500 m3/ c/ yr or < 1400 l/c/d
Haa	**Haa**	**NB**	Inflow from upstream is not considered
	Katsho		
Paro	**Paro**		
Hungrel	Hungrel		
Lango	Lango		
Shari	Shari		
Wangchang	Wangchang		
THIMPHU	**THIMPU**		
Chang	Chang		
Kawang	Kawang		
Basin	**Basin**		

Table 16 allows for the following observations:

- There would be absolute scarcity in Wangchang in 2015 and 2030.
- Chang would have scarcity in 2015 that worsens to absolute scarcity in 2030.
- Kawang has scarcity in 2015 and 2030.
- Hungrel, Lango and Shari have stress in 2015 and 2030.
- Katsho would have water stress in 2030.

However, all Gewogs have ample water supply if inflow from upstream is also considered. But accessibility may be a problem.

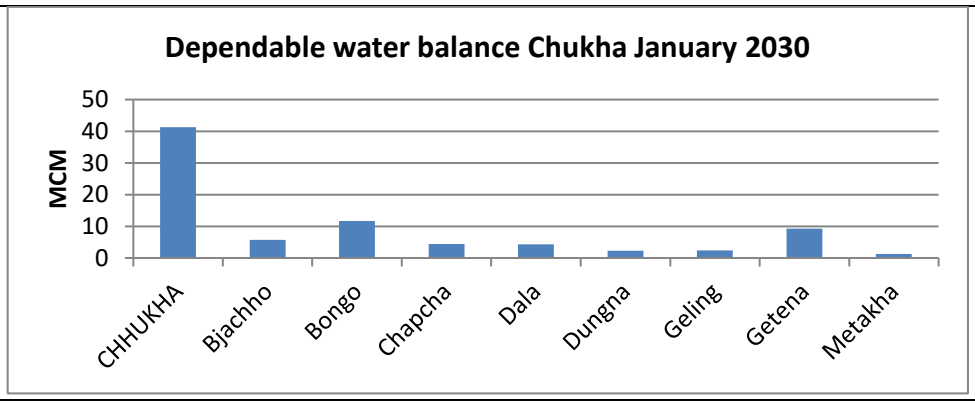
Net water balance by 2030

The 2030 net water balance simply deducts the additional future water demand from the 80%-dependable available water.[53] The bigger the balance amount expressed in million m3 (MCM), the larger volume of water is left un-used. Since there is no objective norm for the net water balance it has been assumed generously that 1 MCM per month is the threshold for potential water stress.[54] Only the months of January, May and June were considered; January because it is the driest month of the year, May and June because high irrigation water demand for transplanting paddy may exceed the natural increase of water availability.

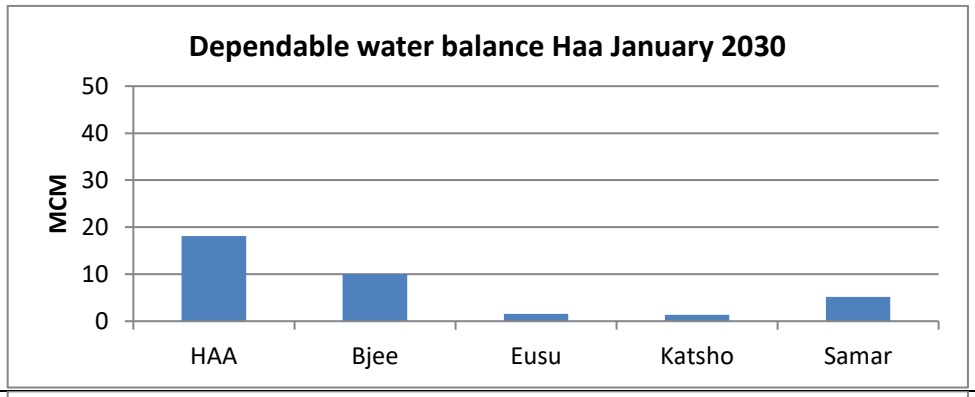
The figures have been plotted for the months of January, May and June in Figures 40 to 42.

[53] For details see supporting document: Hydrological modelling and assessment for Bhutan.

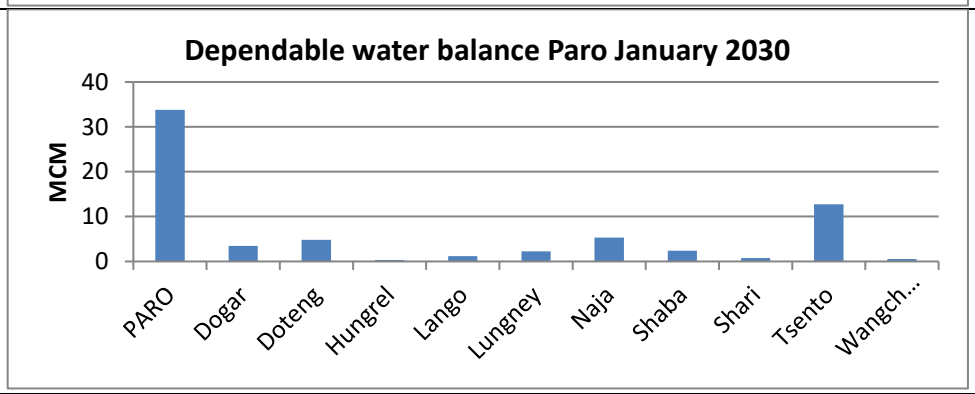
[54] One MCM is enough water to supply 740,000 people with drinking water for the period of one month at the present rural norm @ 45 litres per capita per day.



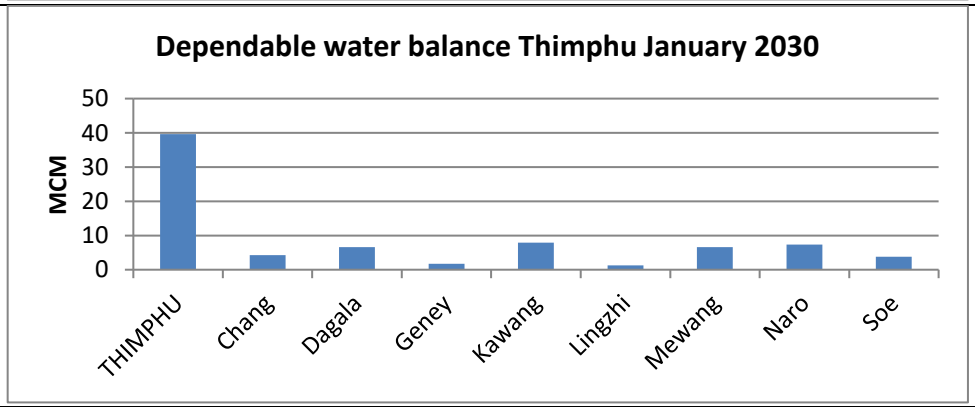
The Gewogs of Bongo and Getena appear to have ample water, but Metakha, Dungna and Geling are low on water.



The Gewogs of Bjee and perhaps Samar have ample water, but Katsho and Eusu have little water.

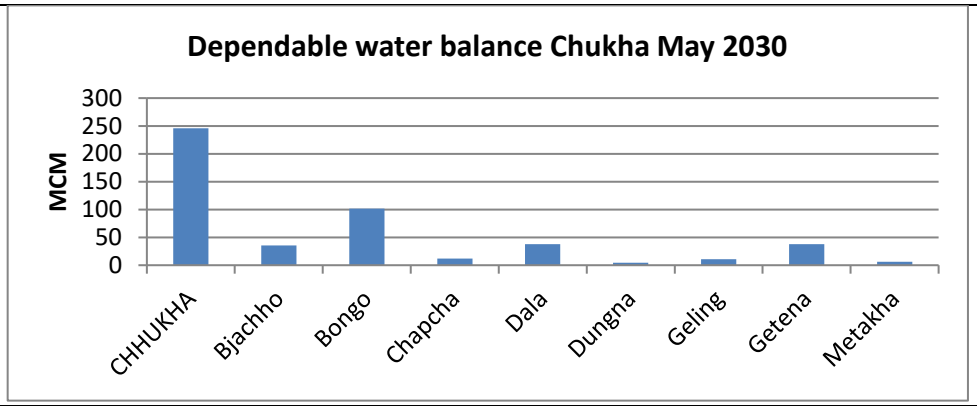


Only Tsento Gewog appears to have ample water. Hungrel, Wangchang, and Shari are low on water.

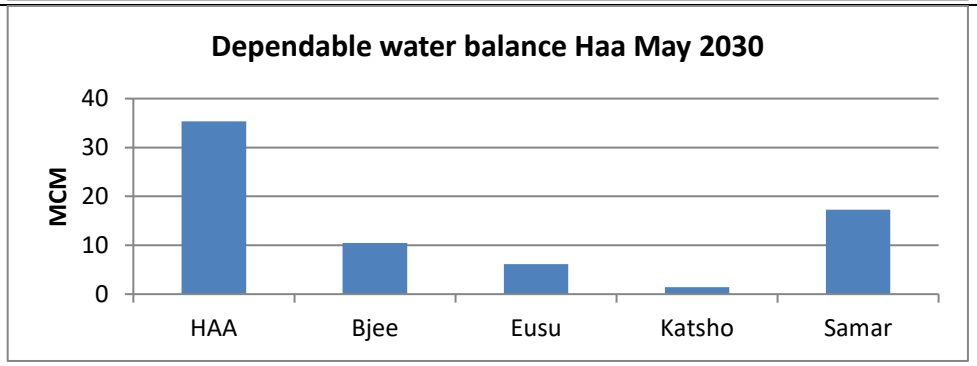


The balance is most favorable in Naro Gewog. Lingzhi and Geney have little water.

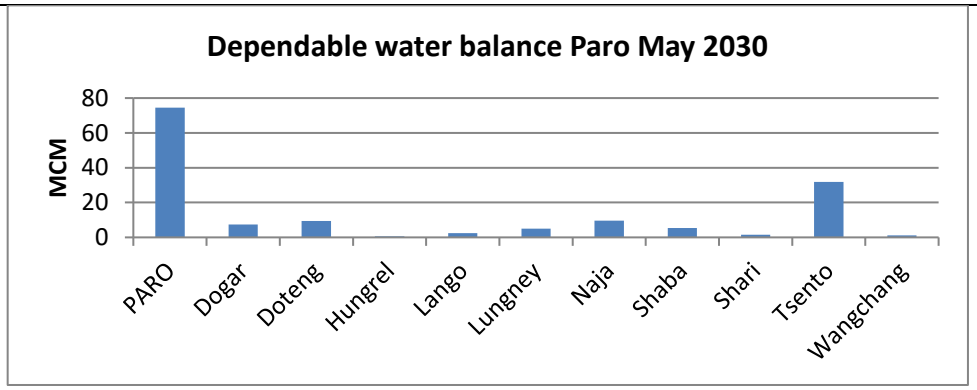
Figure 40: Water balance per Gewog in January (critical for drinking water supply).



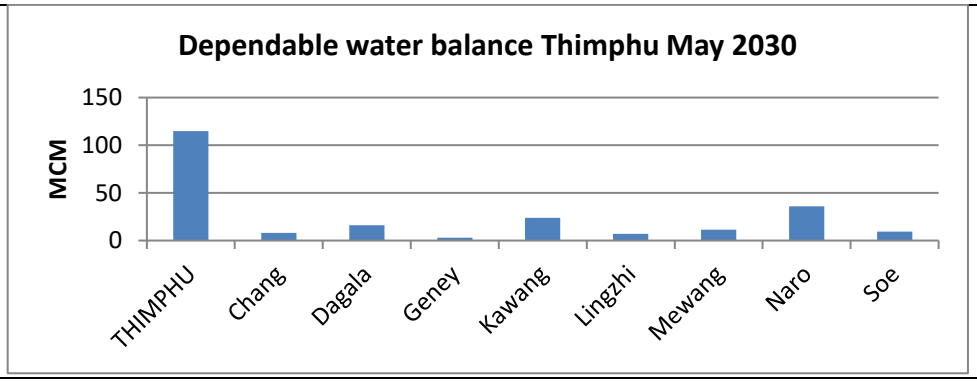
The Gewogs of Bongo, Dala and Getena have some surplus, whereas Dungna and Metakha have less.



Katsho Gewog seems stressed, but Samar has surplus.

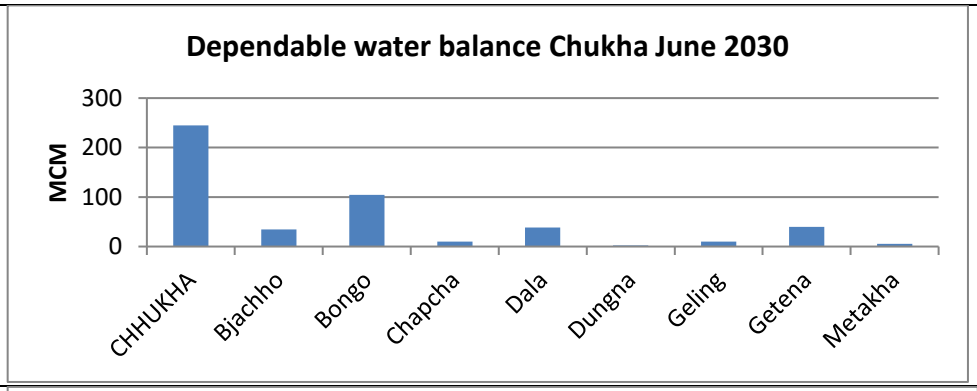


Only Tsento Gewog has ample water in May. Hungrel, Lango, Shari and Wangchang have less water.

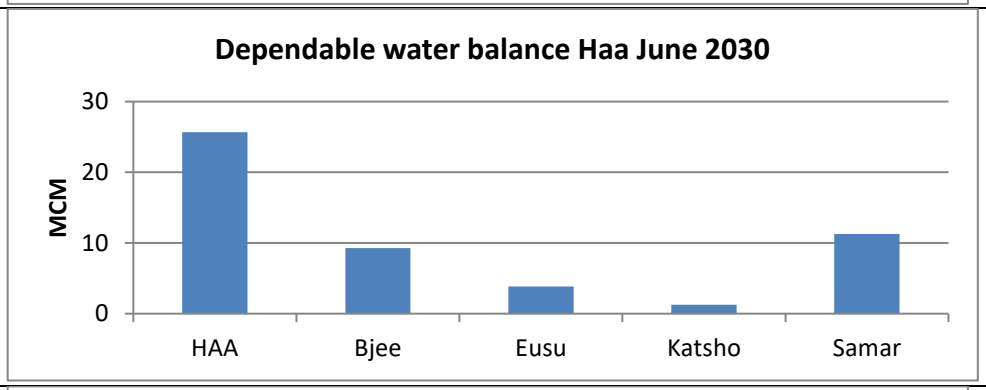


Geney, Chang and Lingzhi are tight. Only Naro has some surplus.

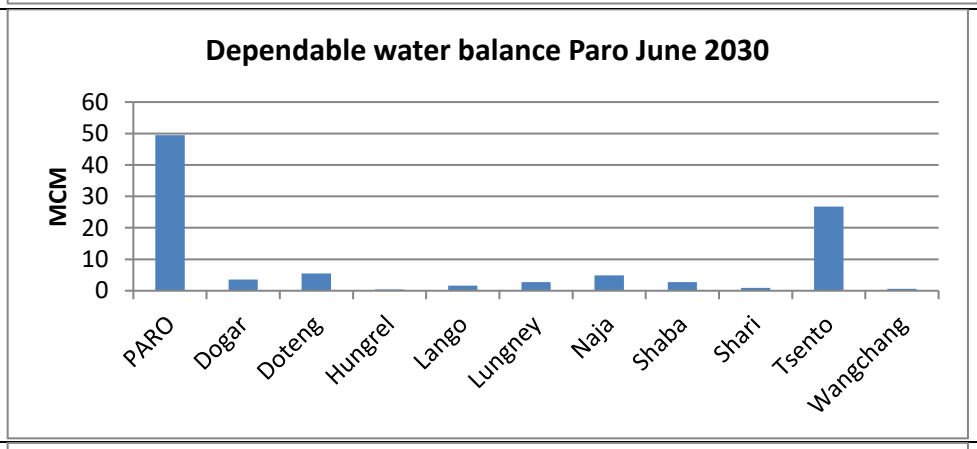
Figure 41: Water balance per Gewog for May (critical for irrigation)



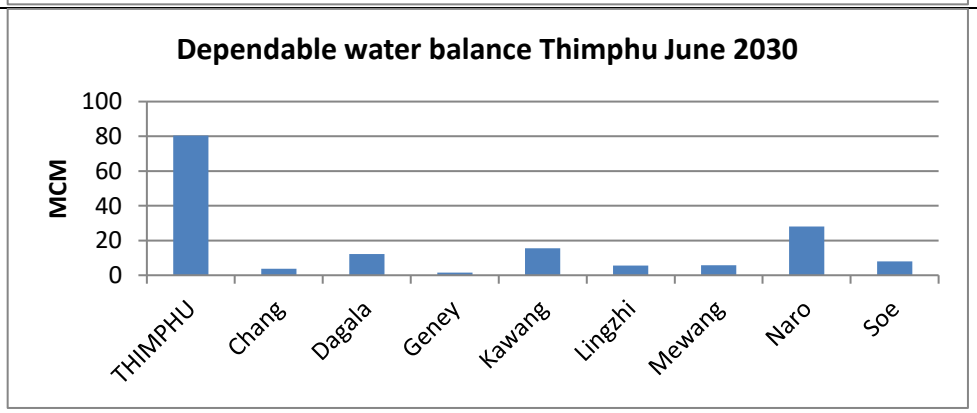
The balance in Dungna and Metakha Gewog is very low, whereas Bongo has surplus.



The water is tight in Katsho Gewog



Only Tsento Gewog has surplus, whereas Hungrel, Wangchang, Shari are low.



Naro Gewog is best off, Geney worst.

Figure 42: Water balance per Gewog for June (critical for irrigation)

Figures 40 to 42 serve to locate areas suffering from water shortages and where opportunities may exist for water development for drinking supply or irrigation. This water balance tool is not to identify irrigation expansion areas as such.

Percentage of dependable water used for consumption by 2030

This approach assesses water scarcity by expressing the additional demand for water by 2030 as a percentage of the 80% dependable net water presently available (water generated within each Gewog per month minus present demand). Delivery efficiency has been assumed for irrigation water (40%) as well as domestic water (40%). In the absence of a generally accepted norm it has been assumed that 10% is the threshold value for potential water stress. The results are given for January (critical month for drinking water supply) and May and June (critical months for irrigation) in Table 22.

Table 22: Percentage of 80%-dependable water used for consumption by 2030

Area	JAN	MAY	JUN
Chukha	**3.7**	**1.0**	**0.5**
peak gewog demand	5.2 Dala	1.9 Dungna	1.4 Dungna
Haa	**0.4**	**0.3**	**0.15**
peak gewog demand	6.2 Samar	6.1 Katsho	3.3 Katsho
Paro	**3.4**	**5.5**	**5.4**
peak gewog demand	30.2 Wangchang	16.6 Wangchang	15.7 Wangchang
with inflow	*0.7 Wangchang*	*0.4 Wangchang*	*0.8 Wangchang*
Thimphu	**4.6**	**3.0**	**2.6**
peak gewog demand	19.6 Chang	11.6 Chang	10.8 Chang
with inflow	*4.4 Chang*	*1.5 Chang*	*1.1 Chang*
Basin	**3.4**	**2.2**	**1.6**

The table shows that:

- At basin-level the additional water consumption by 2030 would take only a few percent of the dependable water.
- At district-level the additional consumption by 2030 would be about 5.5% of the dependable water in Paro during the months of May and June.
- At Gewog-level the additional consumption would consume up to 30% of runoff in Wangchang and 20% in Chang in January.
- None of the Gewogs has any water stress if inflow from upstream areas into the Gewog is also considered.

Interpretation of results

The different approaches yield the ranked (potential) water-scarce areas as given in Tables 23 and 24. As can be seen, Wangchang, Chang, Hungrel and Shari rank high in potential water scarcity, but other Gewogs like Kawang and Katsho should not be discarded. The ranking should not be over-rated because different assumptions (most notably regarding irrigated areas) can significantly change the ranking.

Table 23: Ranked potentially water-stressed Gewogs identified under different methodologies

Ranking	Scarcity survey	Groundwater survey	Water disputes survey	Falkenmark Index	Demand ratio >10%	Water balance < 1 MCM
1	Wangchang	Shari	Shari	Wangchang	Wangchang	Hungrel
2	Dogar	Lango	Lango	Chang	Chang	Wangchang
3	Mewang	Shaba	Wangchang	Kawang		Shari
4	Shaba	Wagchang	Mewang	Lango		Lango
5	Shari	Mewang		Hungrel		Metakha
6	Lango			Katsho		Lingzhi
7				Shari		Katsho
8						Eusu
9						Geney

Table 24: Gewogs in Wangchhu basin with the highest potential for water stress

Rank Method	1	2	3	4
Questionnaires	Wangchang	Dogar	Mewang	Shaba
Falkenmark	Wangchang	Chang	Kawang	Shari Hungrel
Demand ratio	Wangchang	Chang	Shari	Kawang
Water balance	Hungrel	Wangchang	Shari	Katsho
Overall	**Wangchang**	**Chang**	**Hungrel**	**Shari**

The Gewogs with highest potential for water stress are given in Table 24, and depicted in Figure 43.

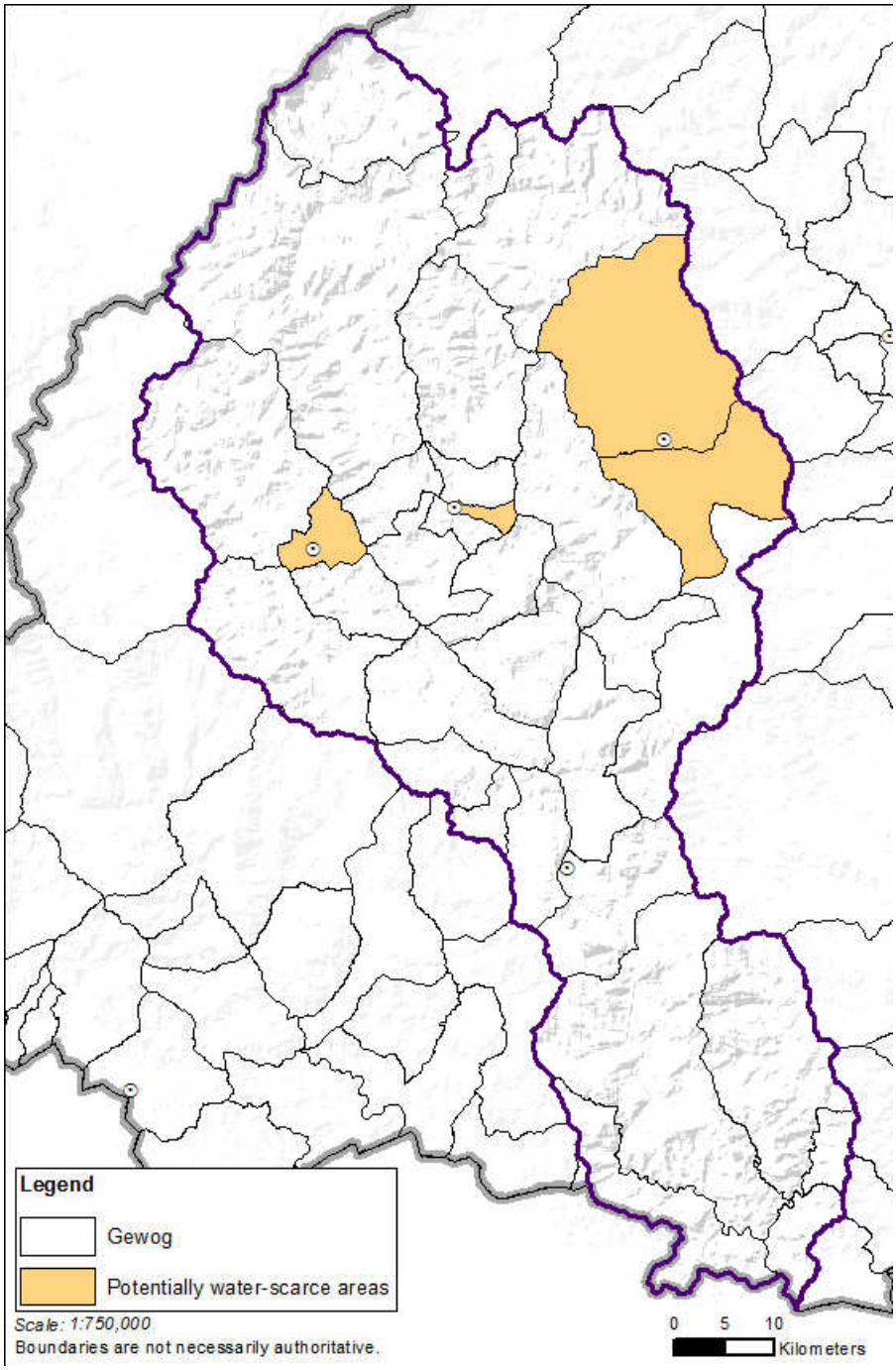


Figure 43: Gewogs with potential for water stress

The results shown in Table 23 and Table 24 show that water scarcity is not obvious when looking at larger areas, notably basins and districts. Overall there may be sufficient water at the basin and district scale, however it may not be accessible at all locations within the district, as shown in the large differences in available water at Gewog level (Table 16). The fact that water stress within a Gewog can easily be compensated by inflow from upstream areas proves that this water is only available in the main streambed of the river – which may be tens of kilometres away and/ or hundreds of meters below the hill sites where people need it.

Possible mitigating measures: (i) pump water over the required distance/ elevation; (ii) store water at upstream locations for local use by means of small dams or ponds; (iii) tap groundwater if the geology and

terrain permit; (iv) improve the efficiency of water use in order to reduce the demand; and (v) reduce the demand itself.

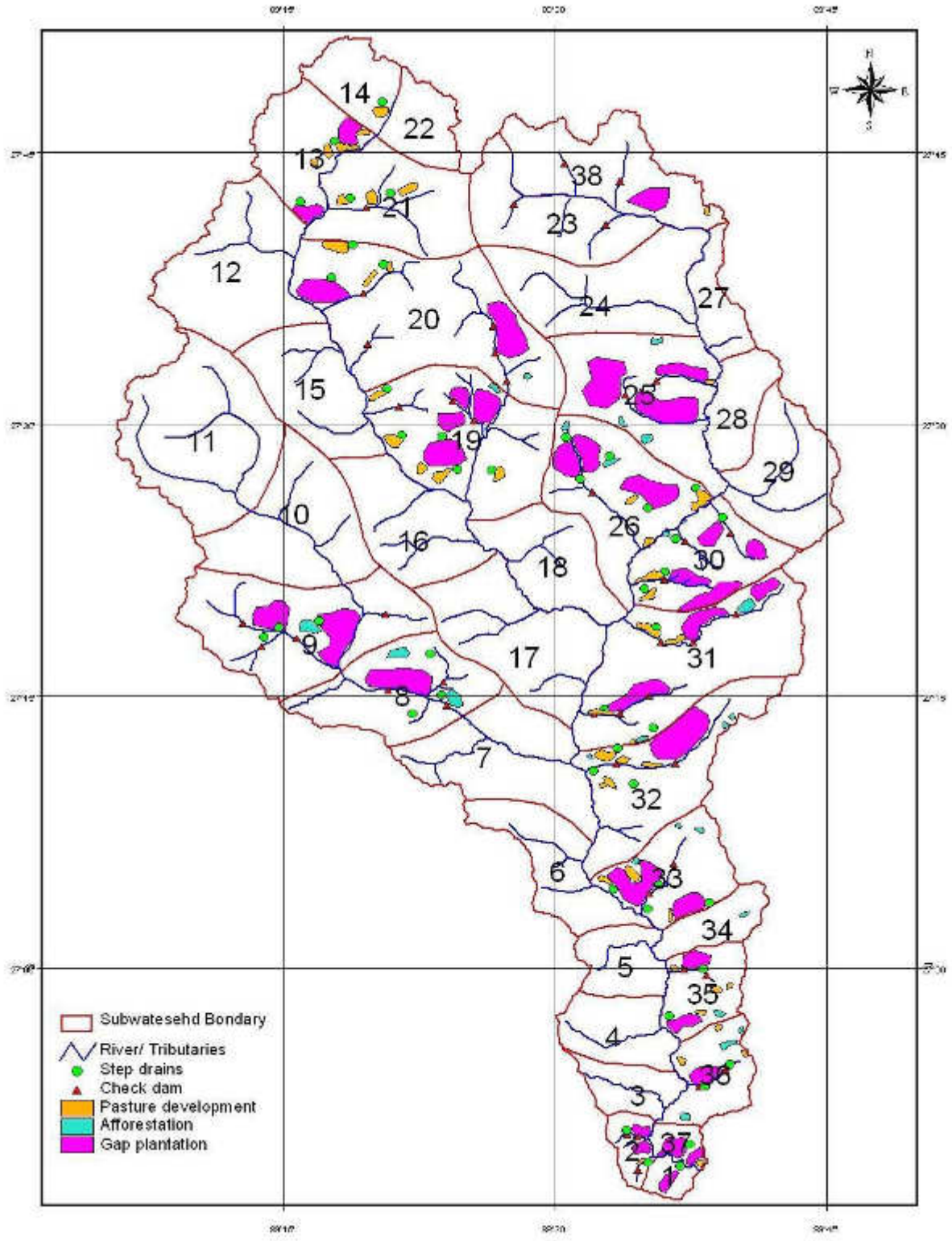
Potential sites for check-dams

The Water Resources Management Plan of 2003 stated that multi-purpose reservoirs are generally not feasible.[55] This conclusion was adopted by the Water Risk Assessment study recently being undertaken under the 'Living Himalayas Initiative' sponsored by WWF.

On the other hand, the Environmental Impact Assessment study for the proposed Wangchhu hydropower plant has suggested a considerable number of potential sites for small dams throughout the basin as part of the catchment treatment measures, see Figure 44.[56]

[55] Water Resources Management Plan and Update of the Power System Master Plan of Bhutan, Department of Energy, Ministry of Trade and Industries, RGOB, 2003.

[56] Comprehensive Environmental Impact Assessment Studies for Wangchhu HEP (570 MW) Bhutan, Wapcos, 2014, Volume 2 – Final EMP.



Source: Comprehensive Environmental Impact Assessment Studies for Wangchhu HEP (570 MW) Bhutan, Wapcos, 2014, Volume 2 – Final EMP

Figure 44: Proposed catchment area treatment measures, including check-dams.

3.1.3 Flood-prone areas

Areas that are prone to monsoon flooding have been determined in three ways:

i) by Gewog questionnaire

ii) by hydrological modelling in HEC-RAS

iii) by using Geographical Information System (GIS)

The findings are presented in the following paragraphs.

Gewog questionnaire

The Gewogs in Wangchhu basin reported in an IWRM questionnaire in 2015 that, in total, 45 locations in Wangchhu basin are susceptible to flooding. The number of villages affected by flooding is shown in Figure 45.

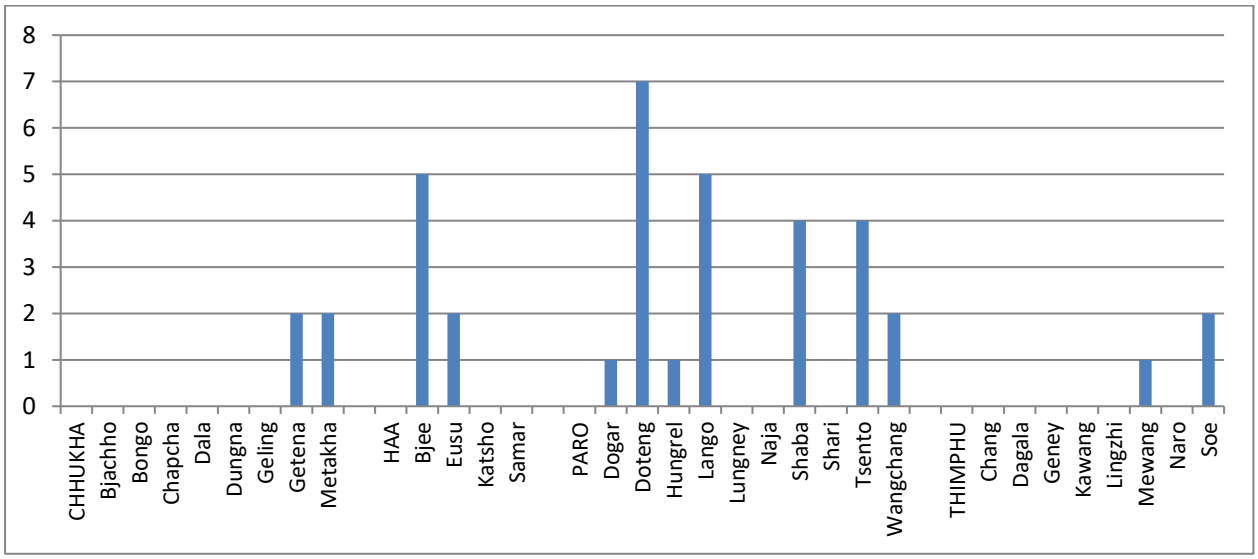


Figure 45: Diagram showing number of flood-prone areas reported per Gewog.

As can be seen, the Gewogs of Doteng, Lango, Shaba and Tsento in Paro district; and Gewog Bjee in Haa district reported the highest number of flood incidences. This, however, provides no information on the extent or severity of flooding (depth and duration).

Flood modelling

Hydrological models such as HEC-HMS (for stream flow analysis) and HEC-RAS (for water levels) were used in the study to assess flood prone areas.[57] The simulated flood flows corresponding to return periods of 25, 50 and 100 years for Haachhu at Haa, Parochhu at Nyemezampa, and Thimphuchhu at Lungtenphug were used to estimate water levels. The vicinity of the towns of Haa, Paro and Thimphu were chosen to assess flood hazard, given their proximity to rivers. Chukha was ignored as it does not have any flood risk from the main river. Details of each of these locations and the results are discussed below. Areas at risk of flooding in a 100-year return period in the three districts mentioned have been identified as worst-case scenario. A summary of flood-prone areas per district is given in Table 25. The 100 year return period was taken as the worst case scenario. The impacts of climate change on the flood magnitude had not been considered as it would then lead to very high flood estimates. The 100 year return period flow itself is a flood magnitude with only a possibility of 1% of occurrence in any given year. It is thus, considered that any impacts due to climate change is also considered within this flood magnitude with a 1% probability.

Table 25: Summary of flood-prone areas in Wangchhu

District	Gewog	Flood-prone area
Haa	Uesu	• Some schools, residential homes, agricultural fields • Haa proper town is also shown to have some risk
Paro	Tshento	• The villages behind Drukgyel Dzong
	Hungrel	• Downstream the confluence towards the base of the Rimpung Dzong
	Shaba	• Near the riverside
Thimphu	Chang/ Kawang	• Lower parts of Pamtsho by the river • Hejo near the Crematorium • Langjophakha near Ludrong Garden opposite to the Dzong • part of the urban road after the Lingkarna bridge/ royal garage • Part of Centenary Farmers' Market and • Changlimithang Stadium • Coronation Park • Chanjiji Football stadium • Pelkhil School ground • lower part of Olakha workshop complex • Hotel Terma Linca • Lower parts of Ramtokto and • Lower agricultural land in Kharsadrapchu area.

Flood Hazard of Haa district

For Haa, the stretch of river starting from Damthang to the end of Haa valley at Tshaphel village of Uesu Gewog was modelled in HEC RAS with a river length of about 20 km. The image for Haa was from Google Earth as no other satellite image was available. The Digital Elevation Model (DEM) used was based on the 90m resolution Shuttle Radar Topography Mission (STRM) satellite imagery.

Based on the projected 100 year flood of 62.5 m^3/s, the HEC RAS model was set up and the flooding hazard was assessed. According to the analysis shown in Figure 46, some schools, residential homes, agricultural fields fall under the yellow zone with flood depths of up to 2 meters. Haa town is also shown to have some risk. It should be noted that most parts of the town now have a river

[57] Refer to standalone supporting document titled: *Hydrological Modelling and water resource assessment in Bhutan*

embankment, which was not there when the digital elevation map was produced. In any case the hazard map does give an indication that there are a number of potentially dangerous places along the Haa River that require protection. It is recommended that a more in-depth hazard assessment be carried out as part of the basin plan implementation, with field measurements of river banks, courses and confirmation of the digital terrain. The findings presented here were based on desk study and they need field confirmation before flood protection works are considered to be implemented. Indeed, the Department of Engineering Services[58]under the Ministry of Works and Human Settlement has recently started working on some field measurements and in-depth flood modelling in the area.

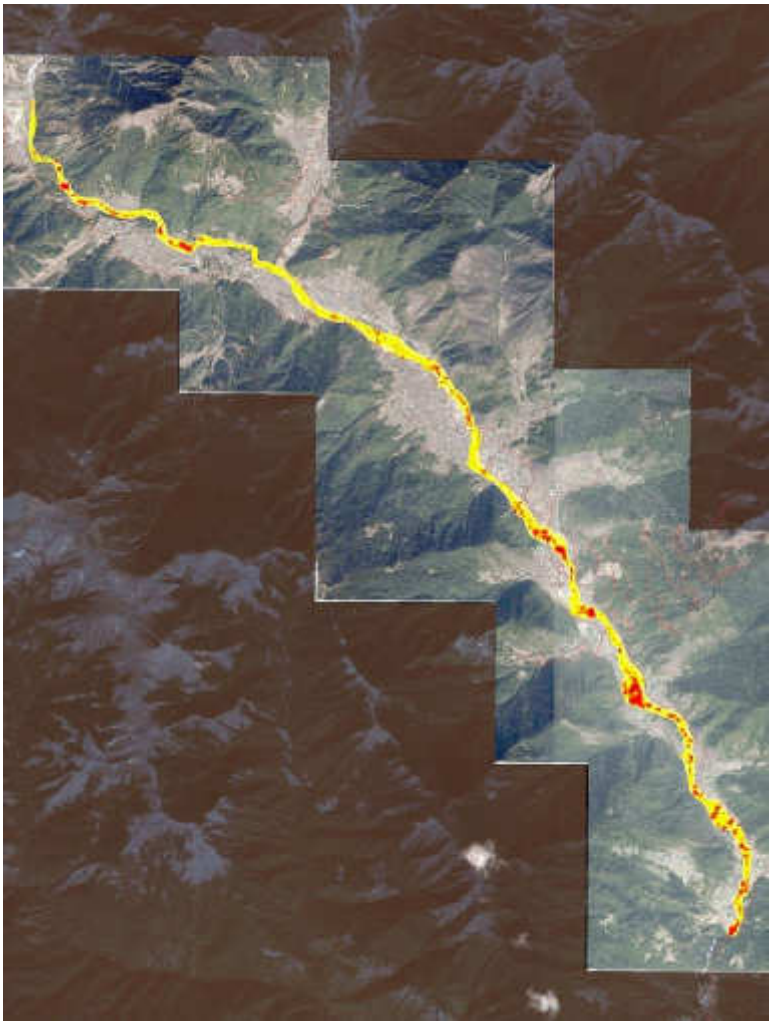


Figure 46: Map of flood-prone areas in Haa district

Flood Hazard in Paro district

The peak flows at Nyemezampa in Paro, which is on the main river, after the confluence of Dotaychhu and main Parochhu, was analyzed. The 100 year flood of magnitude 378 m^3/s was used to determine the extent of flooding. The stretch of Parochhu from Gunitsawa to Tshongdue, Dotey (near Kuenga HSS) to Tshongdue and Tshongdue to Isuna with a total length of about 45 km was analyzed. Based on the analysis it is found that a lot of the Paro valley is under flood threat, although parts of the river banks are fairly well protected. However,

[58] Personal Communication with Ms. Kunzang Choden, TAC Member, Flood Engineering and Management Division, DES, FEMD, June 2015.

there are definitely parts of the valley that need more attention and study, such as the villages in Tsento gewog behind Drukgyel Dzong, Parts of Hungrel gewog after the confluence towards the base of the Rimpung Dzong, parts of Woochu, and Shaba near the riverside. A flood hazard assessment of the valley has been done by Department of Human Settlement. It showed almost the same areas at risk. The flood hazard map for Paro is shown in Figures 47 and 48.

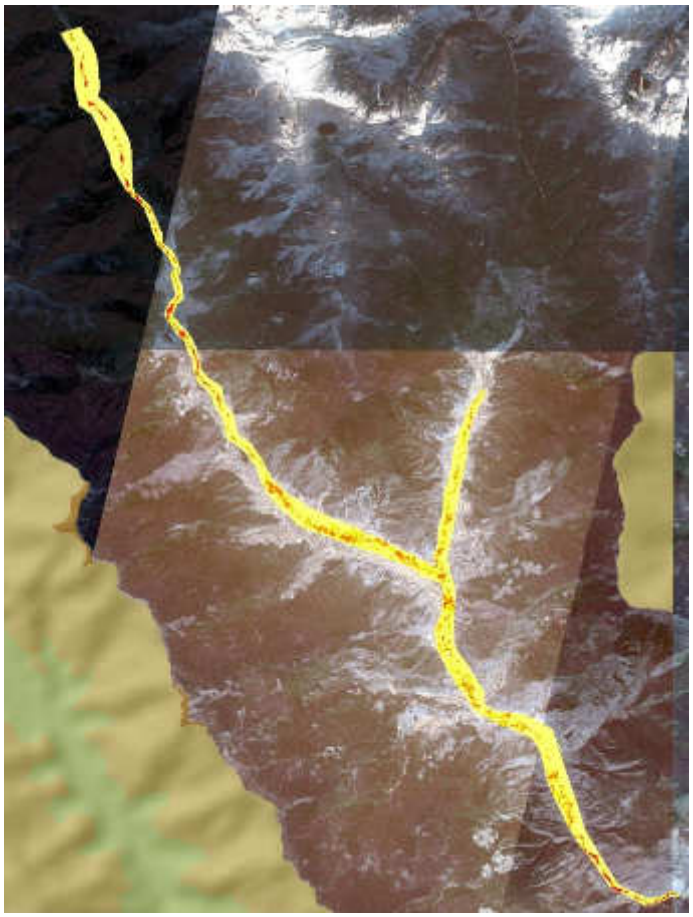


Figure 47: Map of flood-prone areas in Paro district

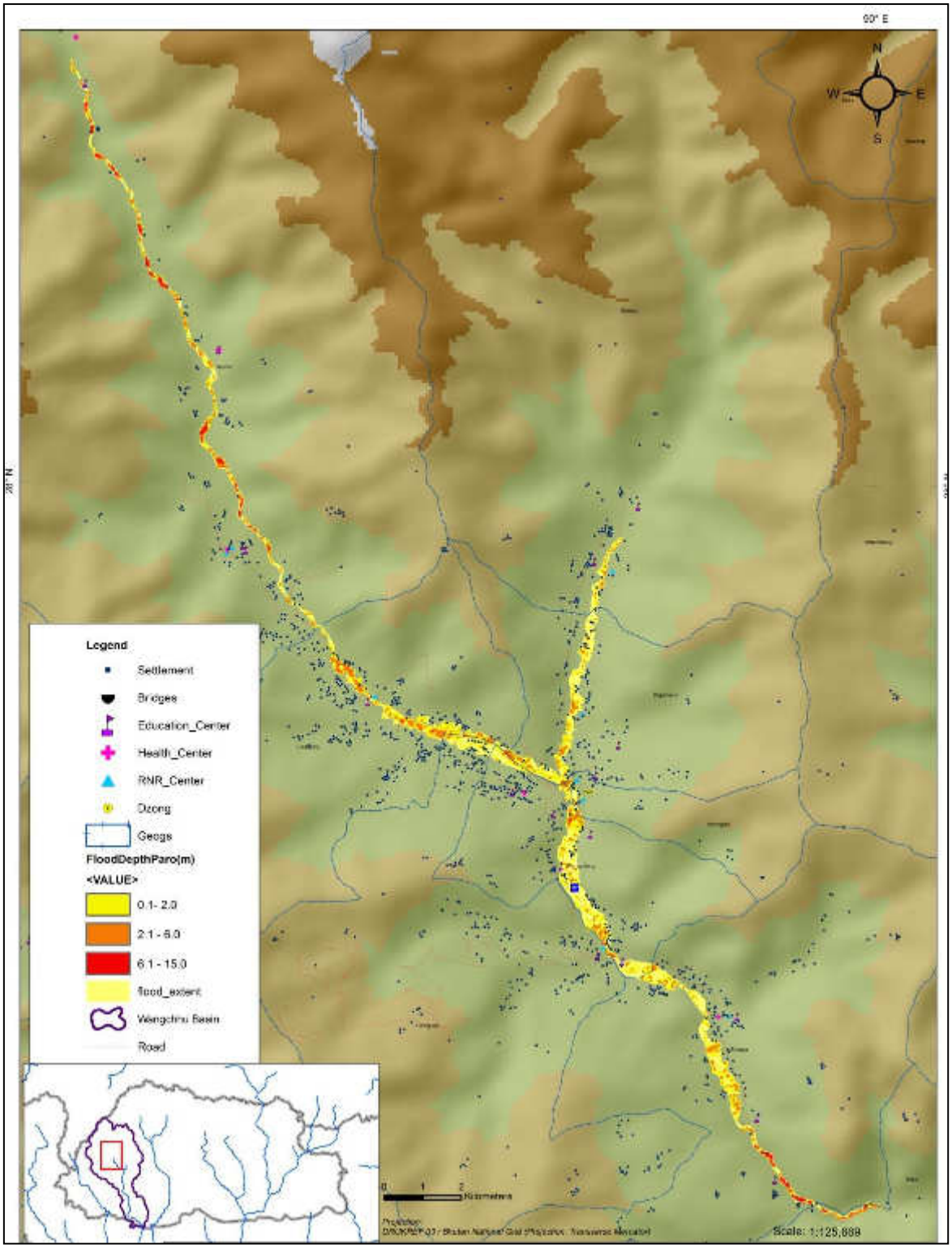


Figure 48: Flood-prone areas in Paro

Flood Hazards in Thimphu district

The projected 100 year flood of magnitude 512 m^3/s at Lungtenphug was used to determine the flood extent and depth in Thimphu valley. A DEM of 5m resolution with ortho-corrected satellite image for Thimphu was used for working on the stretch of Thimphuchhu from Dechencholing to Kharsadrapchu.[59] [60] The stretch Olarungchhu from Semtokha to Olakha was also analysed which makes the total length of the river analysed to about 26 km.

According to the flood extent mapping it is clear that quite a few places in Thimphu are prone to a 100 year flood (a flood with return period of 100-year has 1% chance of occurrence in any given year). Some of the notable places include parts of Pamtsho by the river, Hejo near the Crematorium, Langjophakha near Ludrong Garden opposite to the Dzong, part of the urban road after the Lingkarna bridge/ royal garage, Part of Centenary Farmers' Market and Changlimithang Stadium along with Coronation Park, Chanjiji Football stadium, Pelkhil School ground, lower part of Olakha workshop complex, Hotel Terma Linca and parts of Ramtokto and some agricultural land in Kharsadrapchu area. The flood hazard map for Thimphu is shown in Figures 49 to 52.

The analysis above was based on historical records. The impact of climate change will worsen the flood risks as explained in section 3.1.1 and should be taken into account when mitigating measures are considered.

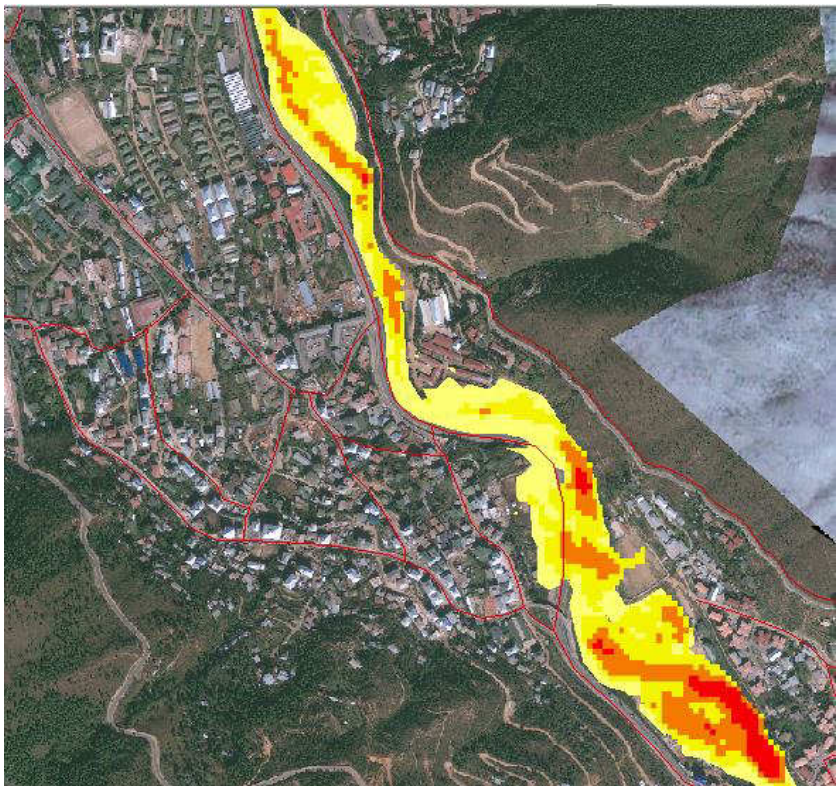


Figure 49: Map of flood-prone areas in Thimphu town

[59] Courtesy Thimphu Thromde, GIS Section.

[60] Courtesy Department of Human Settlement, MOWHS, Thimphu.

Figure 50: Field view of flood-prone area near Jang-Ji sports ground in Thimphu

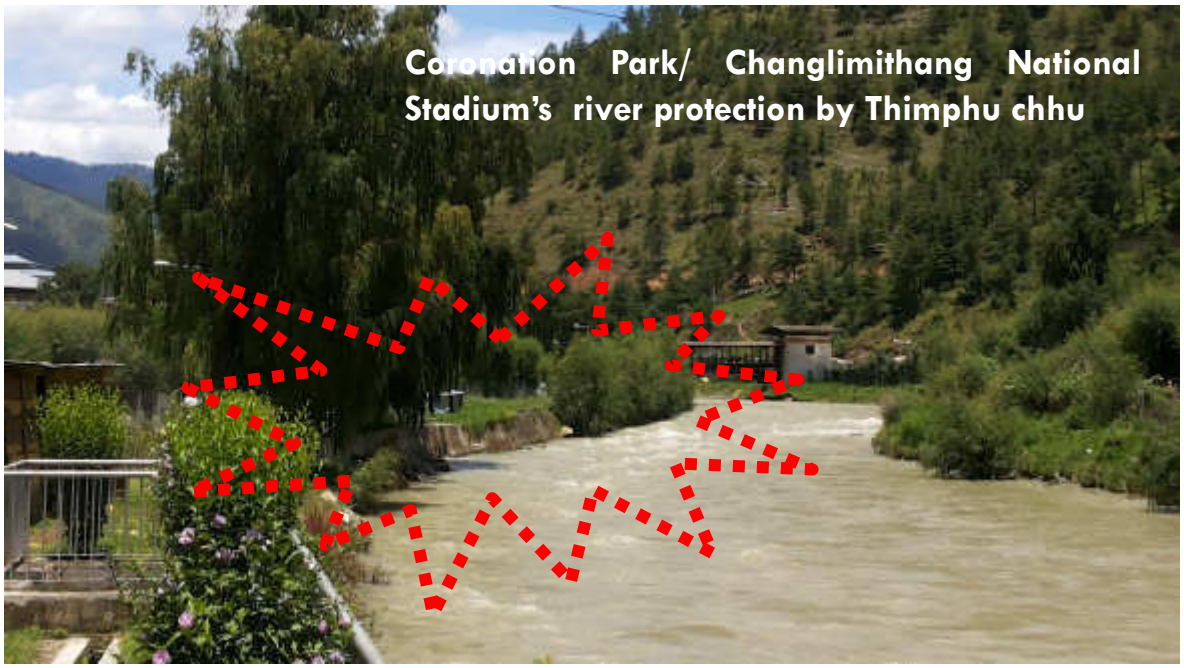


Figure 51: Existing River bank protection near Coronation Park, Thimphu

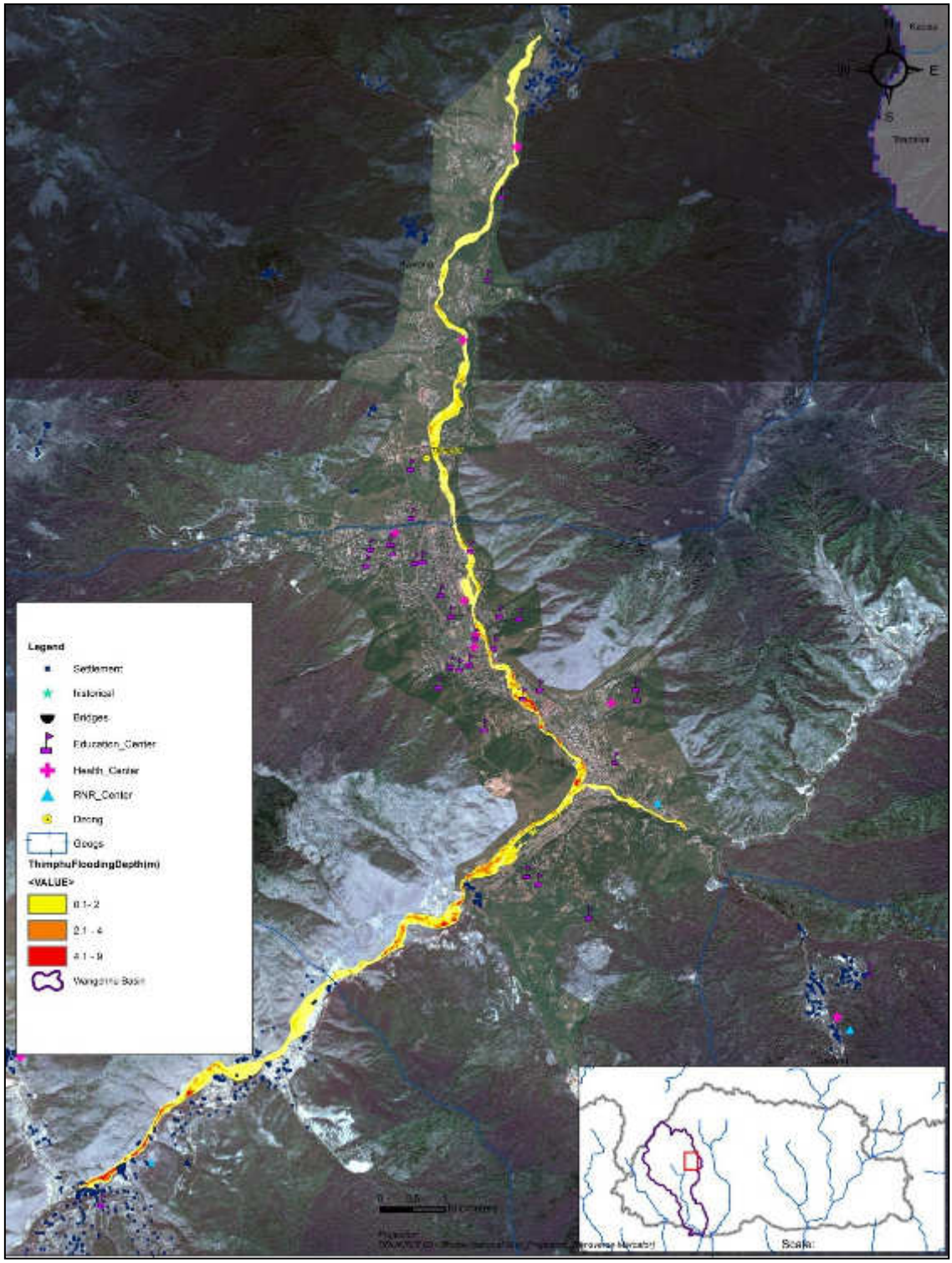


Figure 52: Flood-prone areas in Thimphu district

GIS-based method

The flood modelling methodology described above was supplemented by simpler analysis using GIS in order to cover a larger study area.[61] The GIS results appear to match well with the findings of hydrological flood modelling. The results of the GIS-based method for identifying flood-prone areas are given in Figure 53.

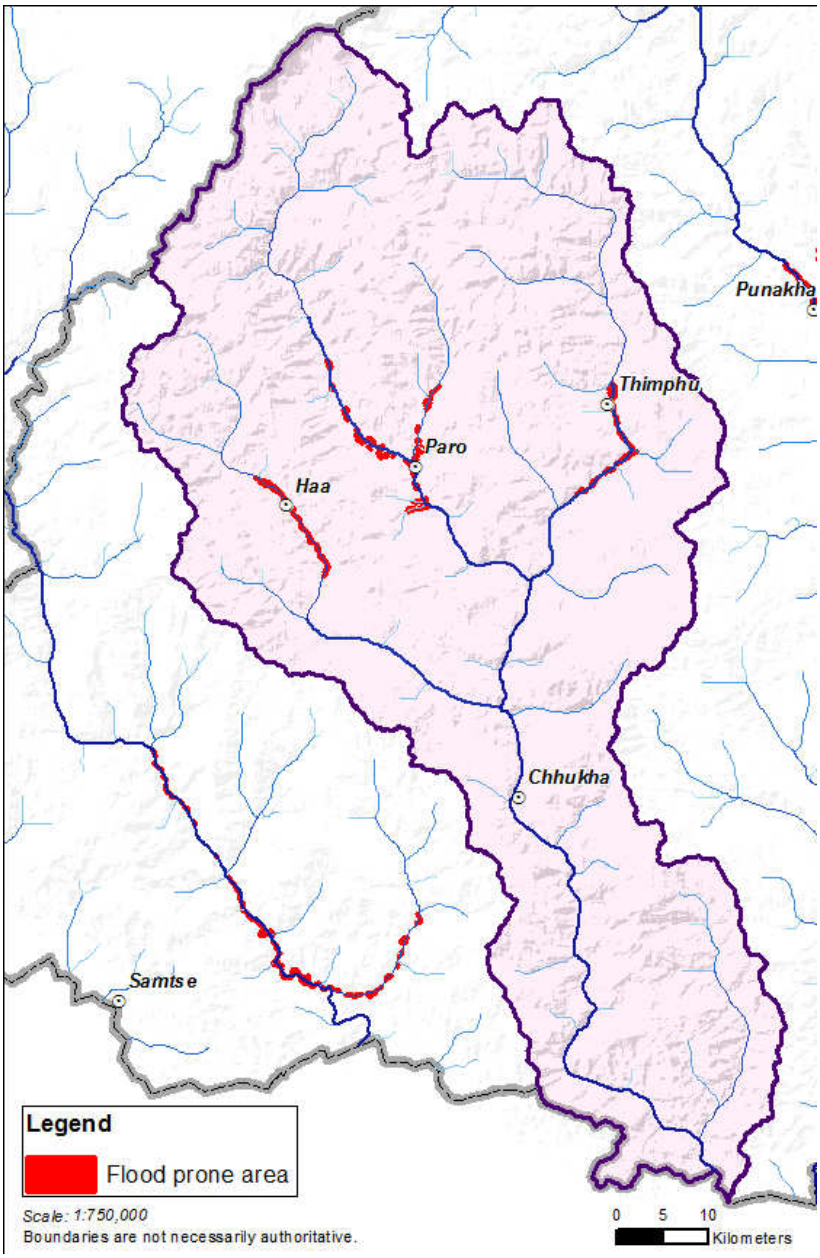


Figure 53: Map showing flood-prone areas in Wangchhu basin, based on GIS method

[61] For details see supporting document: Hydrological modelling and assessment for Bhutan.

3.1.4 Critical watersheds

As replacement for the Watershed Master Plan mentioned in Chapter 2, the Watershed Management Division under the Department of Forests and Park Services of the Ministry of Agriculture and Forests prepared system of rapid watershed classification for Wangchhu in 2011 by. The main objectives were:

- to identify critical watersheds within the Wangchhu basin,
- to set up a baseline for water discharge from various streams, and
- to prepare a *Critical Watershed Management Plan* for each of the critical watersheds identified.

The report states that most of the watersheds in Bhutan are in pristine condition, hence there is no need to develop a master plan for each basin. A more cost-effective strategy would be to focus on 'critical' watersheds where attention is most needed, and to periodically monitor the watersheds that are still in "normal" condition. Together, the watersheds management plan for the critical watersheds would constitute a master plan. The report concludes the following for Wangchhu basin:[62]

- The upstream watershed conditions (Haa, Paro, Thimphu) are much better than the downstream (Chukha).
- The sub-watersheds under Haa Dzongkhag are mostly in pristine conditions and only need a precautionary approach.
- The sub-watersheds under Paro Dzongkhag need periodical monitoring as they are mostly in the "normal" class.
- The sub-watersheds under Thimphu Dzongkhag need strong periodical monitoring; a precautionary management approach is recommended, including need to develop critical watershed management plan.
- The sub-watersheds under Chukha Dzongkhag need more attention especially watershed number 158 which requires critical watershed management plan to be prepared.
- Only two watersheds are classified as critical: number 158 and 67.

The watersheds in Wangchhu basin identified by WMD are shown in Figure 54.[63]

[62] Rapid classification of watersheds in Wangchhu basin, Watershed Management Division, Department of Forests and Parks Services, MOAF, 2011

[63] The watersheds identified by WMD correspond reasonably well with the sub-catchment areas delineated for hydrological assessments mentioned in chapter 2.

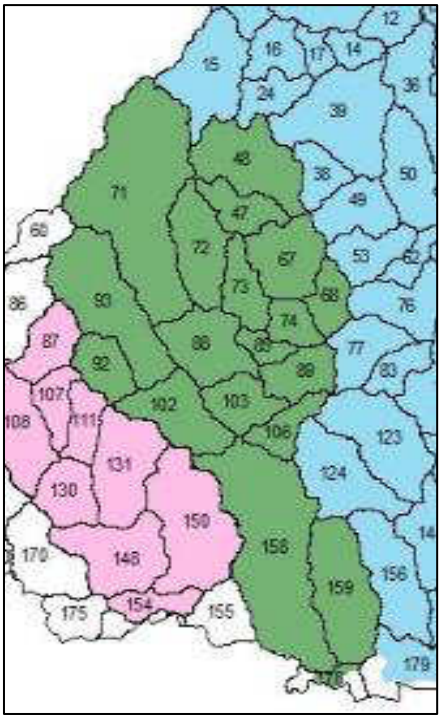


Figure 54: Watersheds in Wangchhu basin as delineated by WMD

Watershed 158

This watershed covers most of downstream of Wangchhu. It has an area of 712 km^2 (71,196 ha). It covers the township of Tshimasham, Chukha Hydropower Project, Gedu town, Tala Hydropower Project, and Bhutan Board Products in Darla in addition to numerous communities. It covers 8 Gewogs of Bongo, Bjachho, Darla, Geling, Chapcha, and portions of Metap, Getana and Dungna under Chukha Dzongkhag.

Watershed 67

This watershed is classified as "critical by function", because it is used as a drinking water source for Thimphu; it is not critical by conditions of the watershed. It falls under Thimphu Dzongkhag and has an area of 225 km^2 (22,487 ha). It covers the capital city of Thimphu and its surrounding areas. The two Gewogs that are located in the watershed are Kawang (18,480 ha) and Chang (3952 ha); parts of Mewang, Kabjisa and Toepisa are also located in this watershed.

3.1.5 Limitations and Impacts of hydropower development

There are two large existing run-off-the river power plants in the Wangchhu basin at Tala (1,020 MW) and Chukha (336 MW). The hydrographs on those locations have been plotted in Figure 55, along with the flow requirements of the respective turbines.

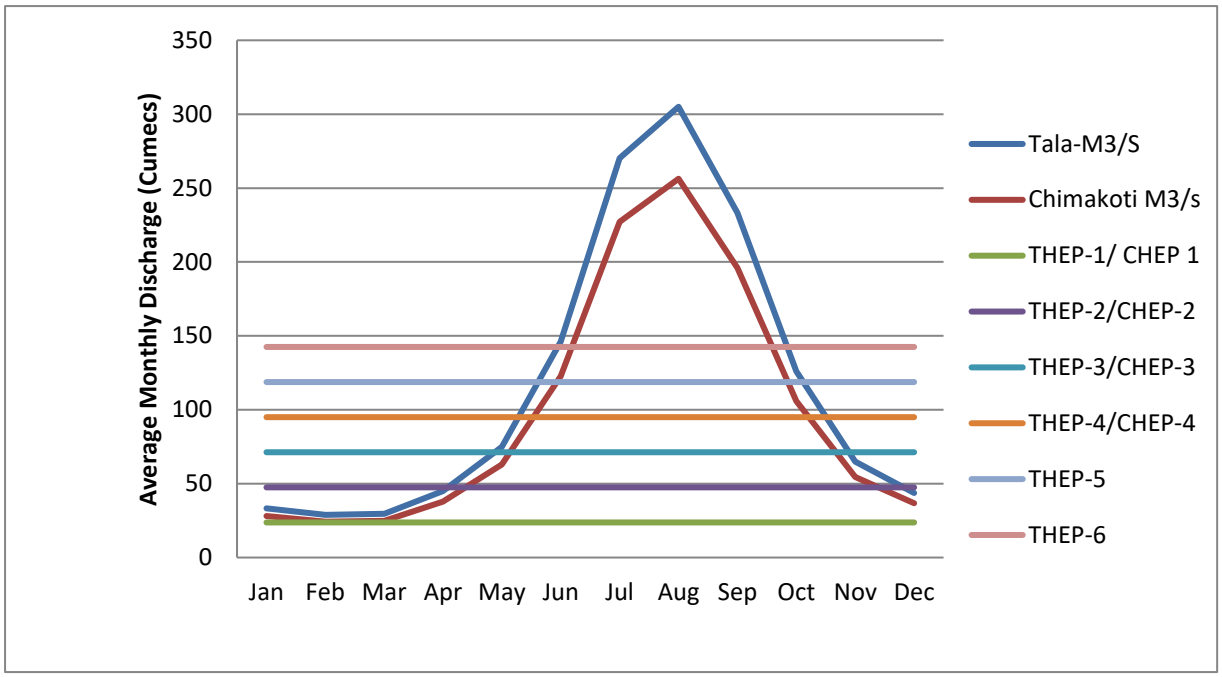


Figure 55: The hydrographs at Tala and Chukha (Chimakoti) power stations compared with the requirements of their generators

Figure 55 shows that the stream flow varies strongly over the year. During the wet season there is enough flow to drive all six generators from June up to October. From November to April not all generators can be operated and around February there may not be enough flow to drive even one generator. This shows that the large seasonal variation of stream flow limits the efficiency of power generation. This could be improved by building large water storage dams, but these would have negative side effects on the natural environment, such as inundation of land with decomposition of vegetation, interrupting the movement of migratory fish, changing the temperature and silt content of the water. Large dams could also pose a risk of failure considering that Bhutan is prone to earthquakes.

For the hydropower station under construction at Bongo, 439 ha will be acquired of which 388 ha is forest land and 50 ha is private. Thirty four hectares of agricultural land will be lost, including 0.8 ha wetland.[64]

For the proposed hydropower station at Bhunakha, 820 ha of land would have to be acquired, of which 796 ha is forest area, 2 ha is government land and 23 ha is agricultural land.

3.1.6 Water quality

Water quality is generally good, but is deteriorating within and downstream of Thimphu and Paro urban centres. The causes of water pollution are car workshops spilling oil and waste water, insufficient sewage water treatment, and solid waste disposal.

At present there is no regular and systematic monitoring of ambient water quality in Bhutan. The Water Quality Monitoring Section (WQMS) of WRCD, NECs is a two-person section that started basic operations in 2011-2012. The section has a water quality laboratory capable of doing all necessary basic water quality tests. It does conduct random and isolated water quality measurements around the country, and more regular and focused in Thimphu but this is not adequate. There is also lack of manpower, equipment and systems in place to meet the requirements. Therefore, it is proposed that NECS work with competent authorities in order to

[64] Environmental impact assessment for Bongo hydropower station

establish a network of water quality monitoring stations across the country and collect water quality data on a regular basis.[65]

3.1.7 Governance

An analysis of stakeholders in integrated water resources management was provided in the National IWRM Plan. The most relevant governance issues that also pertain to Wangchhu basin are:

- Lack of coordination between agencies involved in, or affecting water management.
- Lack of capacity of agencies involved in water management.
- Lack of capacity in local government to deal with their work load.
- Subordinate role of Water Users Associations.
- Lack of data/ information and exchange.

Wangchhu is the first basin where a River Basin Committee (RBC) has been formed for improved planning, coordination and management related to water resources. Strengthening the position of the RBC is of utmost importance for the success of IWRM.

In IWRM, the river basin is the most logical unit for coordinated management of water resources (e.g., for proper water resources accounting and allocation). As such, a basin organization is the most appropriate institutional mechanism for ensuring such coordination at the basin level. The aim of coordination is to ensure that policies and programs in the basin—involving multiple actors and stakeholders--are characterized by minimal redundancy, incoherence, conflict and gaps. For instance, the RBC shall ensure that district-level plans do not compete for water and that they remain within the total water available within the basin. If development plans are set to draw more water than is available, RBC can flag the issue at NEC and GNHC – who in turn could block certain plans so as to remain within the water available.

Chapter 6 of the Water Act mandates that RBCs shall be set up for the "purpose of proper management of water resources." C*oordinated* planning and development is the underlying IWRM principle, and through a multi-stakeholder approach this coordination task is assigned to an organization *at the basin* level.

Chapter 2, Section 6 of the Water Act states that a national integrated water resources management plan shall be formulated for the "*coordinated* development, management, conservation and efficient use of water resources" and this shall serve as "a binding guideline for the preparation of river basin management plans" (Chapter 5, Section 24).

Accordingly, the framework, composition, and terms of reference of River Basin Committees was endorsed by the NEC during its forty first meeting held on 25 June 2015. The River Basin Committees shall be composed of Chairpersons of the district development councils (Dzongkhag Tshogdus*)*, district governors (Dzongdags), Mayors (Thrompons) of class 'A' municipalities (Thromde) and Dzongkhag environment officers (DzEOs) in the basin. The NEC will appoint the district governors on a annual rotation basis to take up the position of RBC chairperson. NECS shall serve as the Secretariat to the RBC with the understanding that i) the RBC may have their respective Secretariat in the long term; ii) The River Basin Committee shall report to NEC.

A diagram showing the structure of the RBC is shown in Figure 56.

[65] Refer to the stand-alone supporting document: *Hydrological modelling and assessments in Bhutan.*

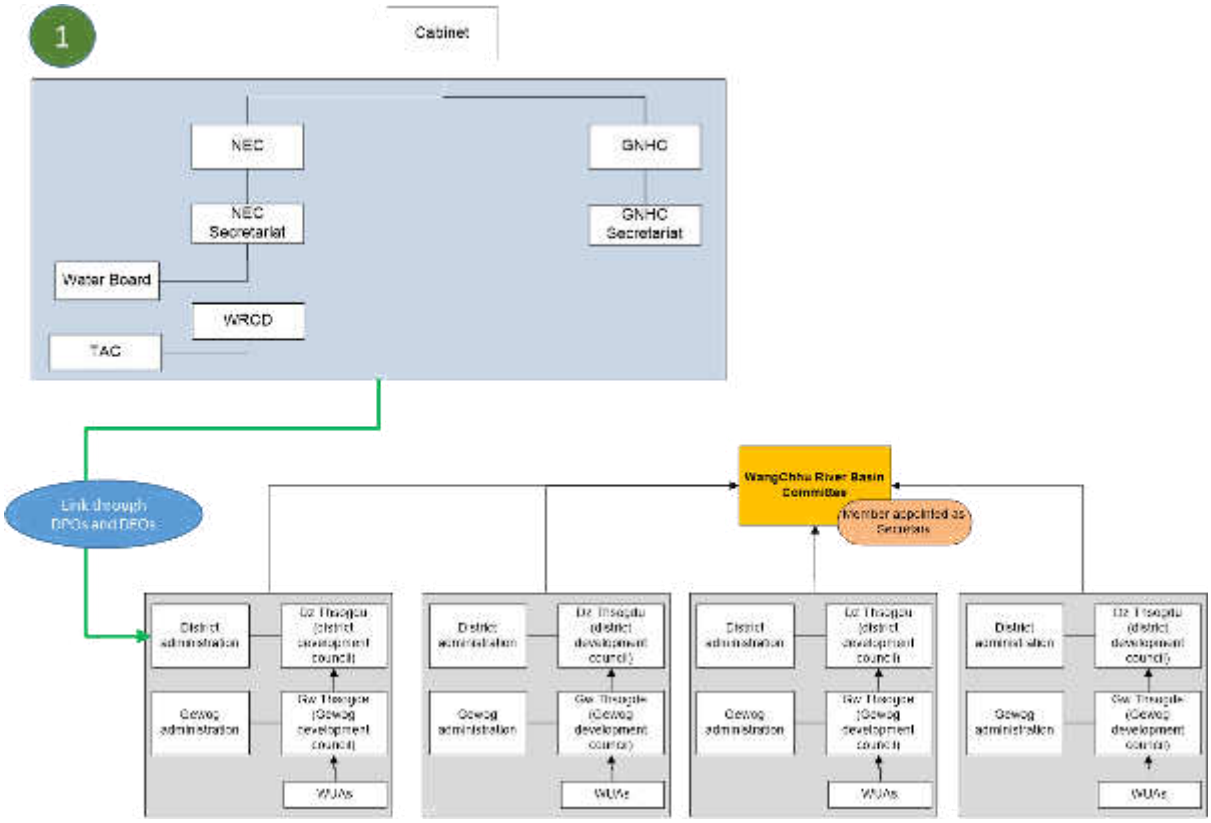


Figure 56: Diagram of the River Basin Committee

3.1.8 Lack of understanding of dimensions of water management

IWRM sensitization workshops for local leaders

Sensitization workshops were held for local leaders throughout the country in the period 2013-2015, and an inventory has been prepared of water-related issues. The list shows that nearly all Gewogs in Wangchhu basin do experience one or another issue related to water, but it does not provide any analysis or solution.

Role of local government and WUAs

Gewog administration and Water Users Associations (WUAs) take care of local water management in daily practice, but at this level all dimensions of water-related issues are not always fully understood. Climate change as a concept is unknown to many rural people. However, people stated that there are adverse changes in the availability of water. Sustainable use, ensuring quality of water, relationship with climate change, etc. are not issues of concern to the community as long as there is water in the pipes.

There is a need to make people more aware of water being a resource in wider socio- economic and environmental perspective through information, education, and communication (IEC).[66]

3.1.9 Other water-related findings

River bank protection works

[66] The details are given in the supporting stand-alone document: *Social aspects of water management*.

The Gewogs responded in a questionnaire in 2015 about the number of river bank protection works and their nearest village in the Gewog. The result is presented in the column chart in Figure 57.

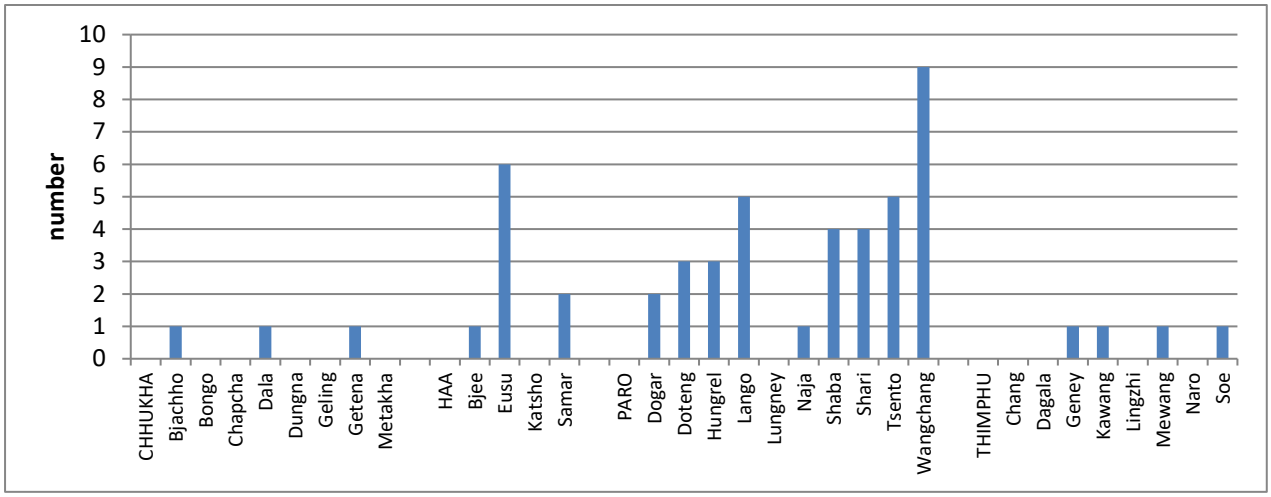


Figure 57: The number of river bank protection works reported per Gewog

As can be seen, most works are concentrated in Paro district, particularly in the Gewogs of Wangchang (9), Tsento (5), and Lango (5). There are 6 works in Haa district. On-site investigations are required to assess the need for future river training work.

Major water abstractions

According to the Gewog questionnaire survey, there are numerous major river water abstractions for drinking water and/or irrigation, most notably in Haa district with Bjee Gewog (8) , in Paro district in Doteng (6) and Lango (6) Gewog, see Figure 58. These abstraction need to be quantified and entered into the water accounting system (WEAP) that has been established for NECS.

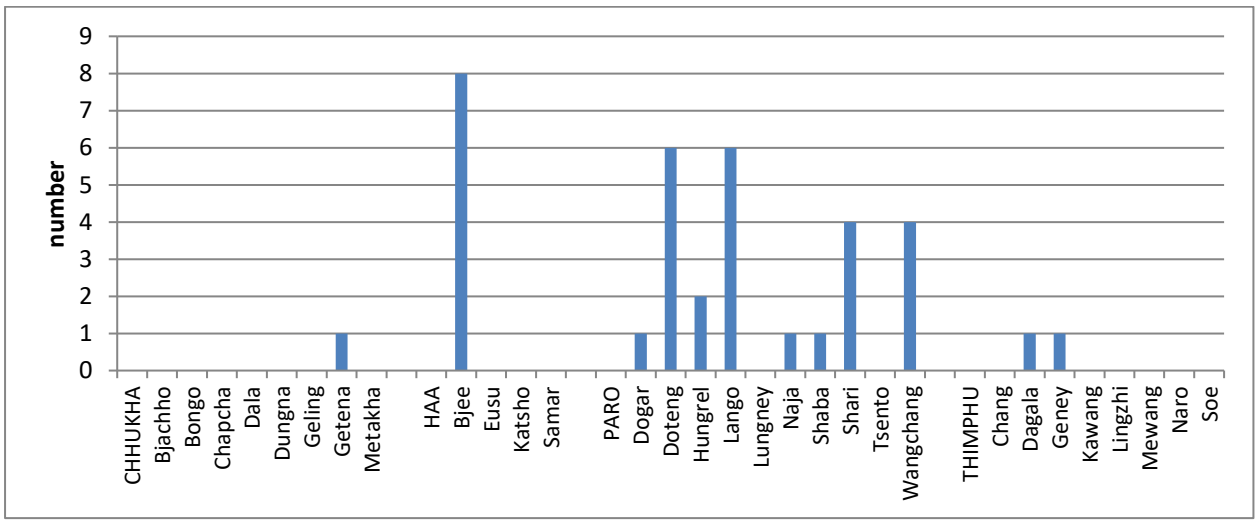


Figure 58: The number of major river water abstraction points reported per Gewog

Major water diversions

The Gewogs that reported existing water diversions are as follows: in Chukha district in Bjacho Gewog (3) for hydropower stations; in Paro district in Hungrel Gewog (2) for drinking water and Thimphu Gewog in Dagala (1 for drinking water) and Mewang (1 for mini hydropower station) Gewog, see Figure 59. The water diverted for

consumptive use needs to be quantified and entered into the water accounting system (WEAP) that has been established in NECS.

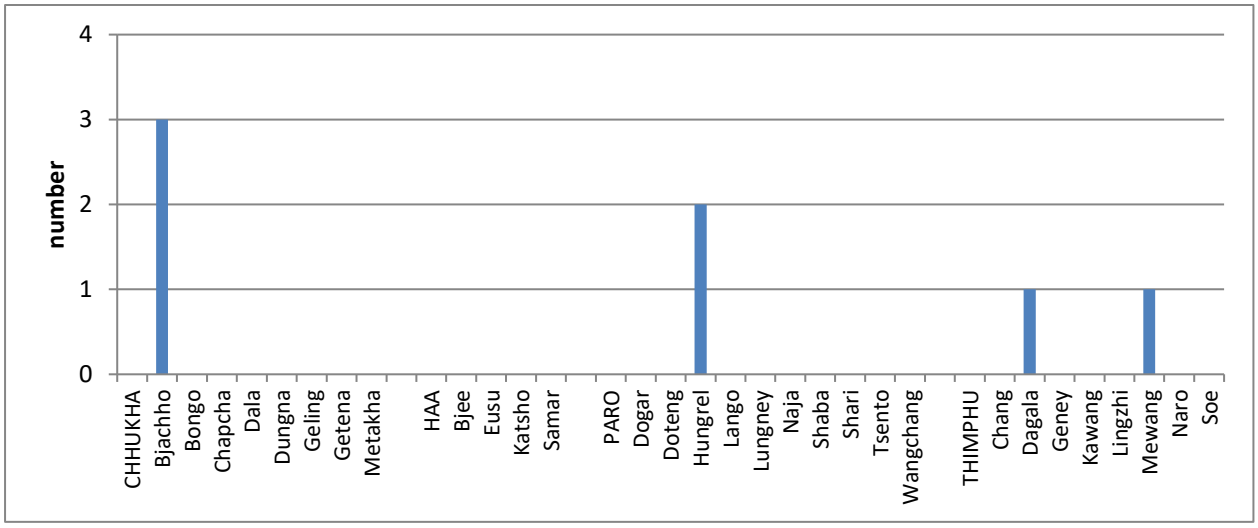


Figure 59: The number of major river water diversions reported per Gewog

Effluent discharge

Untreated effluent discharge has been reported in Chakha district in Dala Gewog (5), Paro district in Lango (7), and Hungrel, Shaba, Tsento Gewog (1 each), and Haa district in Katsho Gewog (2), see figure 60.

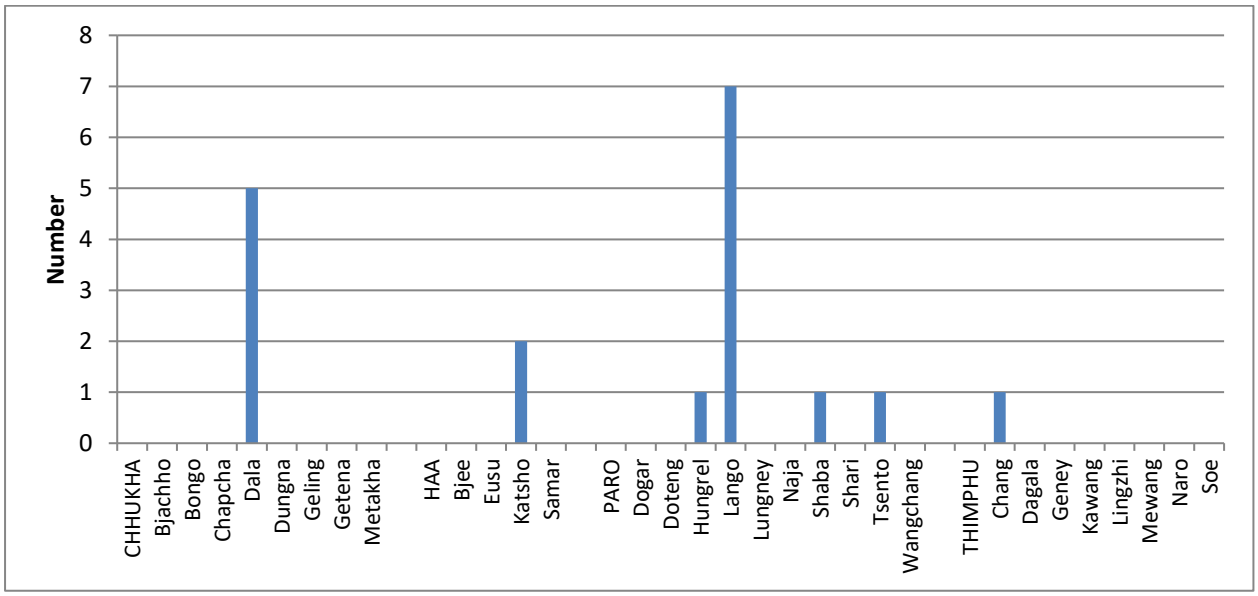


Figure 60: The number of effluent discharge points reported per Gewog

GLOFs

A number of Gewogs reported risk of Glacial Lake Outburst Flood. In Paro district in Doteng Gewog there are reportedly 7 villages at risk and in Tsento Gewog 4 villages, see figure 61.

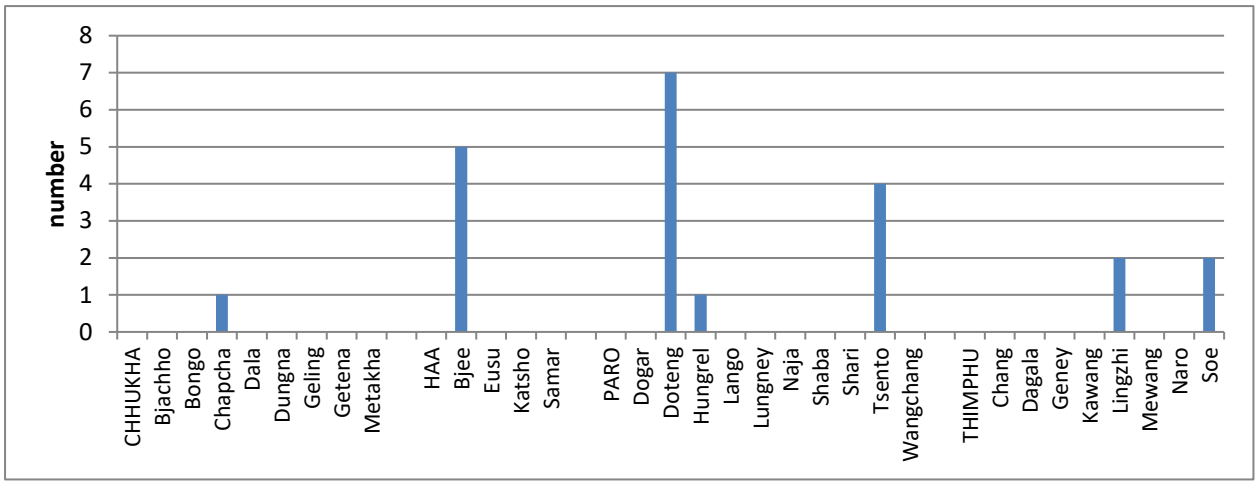


Figure 61: The number of villages with GLOF-risk reported per Gewog

Water-related disputes

As shown in Figure 62, a number of disputes have been reported in the Gewog questionnaire, concentrated in Paro district with Wangchang (5), Shaba (3) and Hungrel (3), Doteng, Lango, Shari Geney, and Mewang (2 each). The disputes are concentrated in areas that have been assessed as potentially water-scarce.

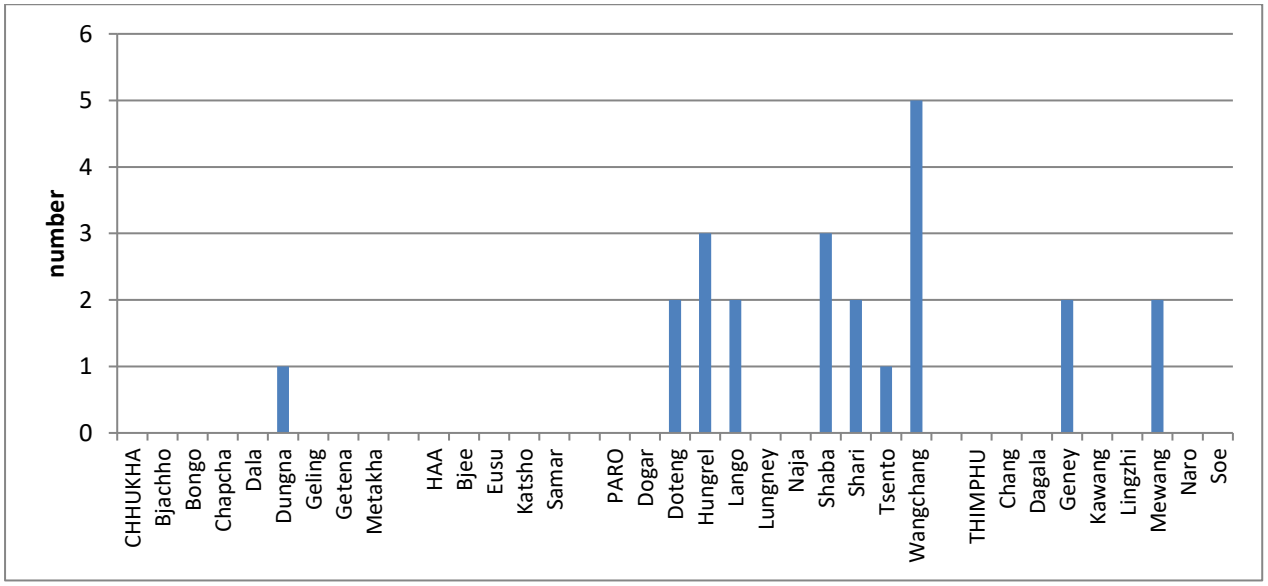


Figure 62: Number of water-related disputes reported per Gewog

Suitability of geological formations for groundwater aquifers

The Geological map of Wangchhu basin and Bhutan is given in Figure 63.[67] Experience in cross-border areas in India and in similar geological formations occurring in other regions of the Himalayas has shown that several geological formations have varying potential of ground water availability depending upon their porosity, permeability and hydro-geomorphological characteristics. Based on

[67] http://www.pitt.edu/~nmcq/Long_etal_2011_JOM_Bhutan_Map_1-500k.pdf

that experience, a very preliminary assessment of the potential for groundwater development, based on the type of geological formation, from higher to lower potential was reported as follows:[68]

1. Quaternary sediment.
2. Lesser Himalayan Zone-Gondwana succession (Permian) & Baxa Group (for spring lines).
3. Siwalik Group (Miocene-Pliocene)- Upper member & Middle member.
4. Greater Himalayan Zone- Structurally-lower Greater Himalayan section (for spring lines).
5. Tethyan Himalayan Zone -Undifferentiated (Paleozoic-Eocene).

The locations of the two most-promising formations have been investigated, and the results are presented in Table 26. The geological subsoil and supposed potential for groundwater in district capitals in Wangchhu basin is given in Table 27.

Table 26: Occurrence of geological formations with supposedly promising groundwater potential

Nr.	Main Formation	Symbol	Wangchhu	Bhutan
1	Quaternary sediment	Qt	No	Sipsu area
2a	Lesser Himalayan			
	Gondwana	Pzg	No	Narrow strip in extreme south -central east, including Deothang
	Jaishidanda	Pzj	Narrow strip passing Gedu	Narrow belt in the south
2b	Baxa group			
	Phuentsholing	Pzph	No	Narrow strip in extreme south west, incl uding Phuentsholing
	Manas	Pzm	Belt in the south	Southern belt, including Sarpang, Gonphu, Panbang, Pemagatshel

Table 27: District capitals in Wangchhu basin with their geological subsoil and supposed groundwater potential

Nr.	City	Symbol on geological map	Rank for groundwater development
1	Haa	Pzpu	-
2	Chukha	GHlml	4
3	Paro	Pzpu	-
4	Thimphu	GHlml	4

[68] M. Mehta, former Commissioner of the Ministry of Water Resources, GoI, e-mail communication 2 March 2016

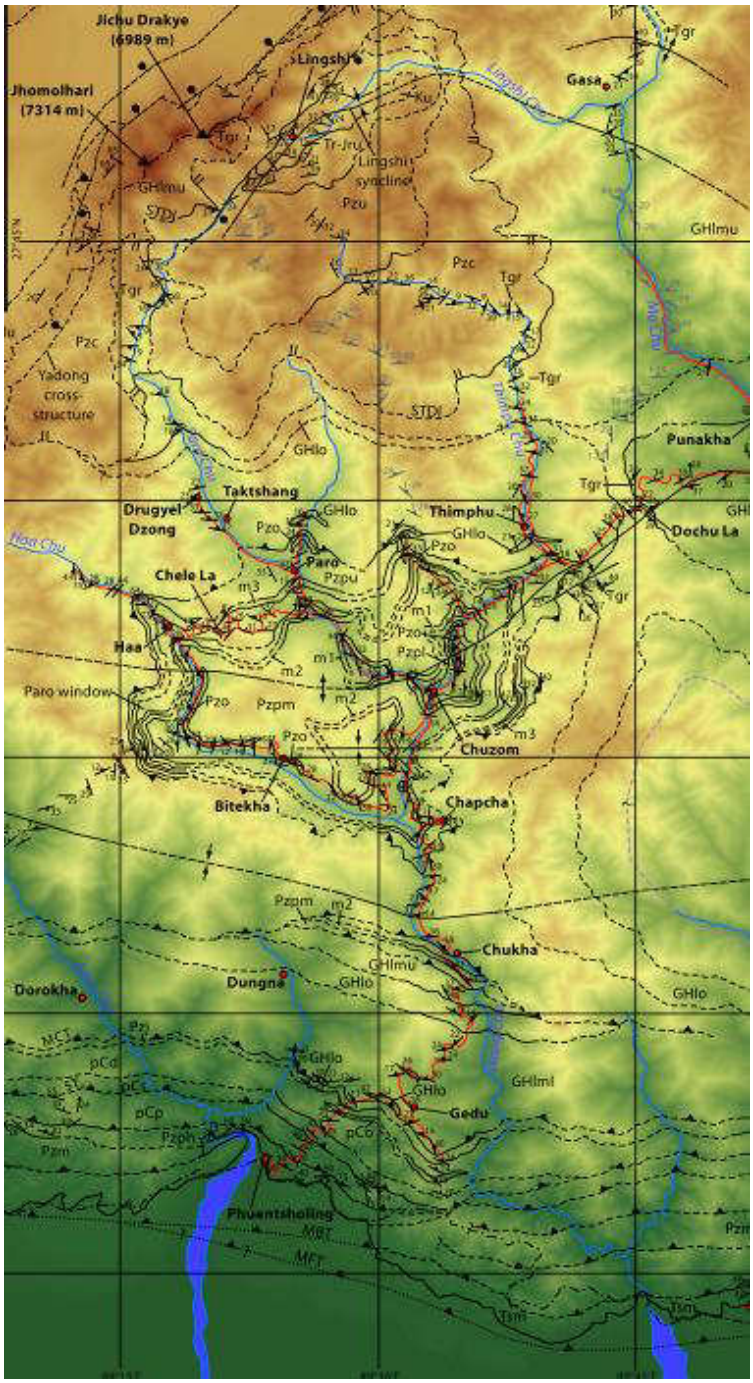
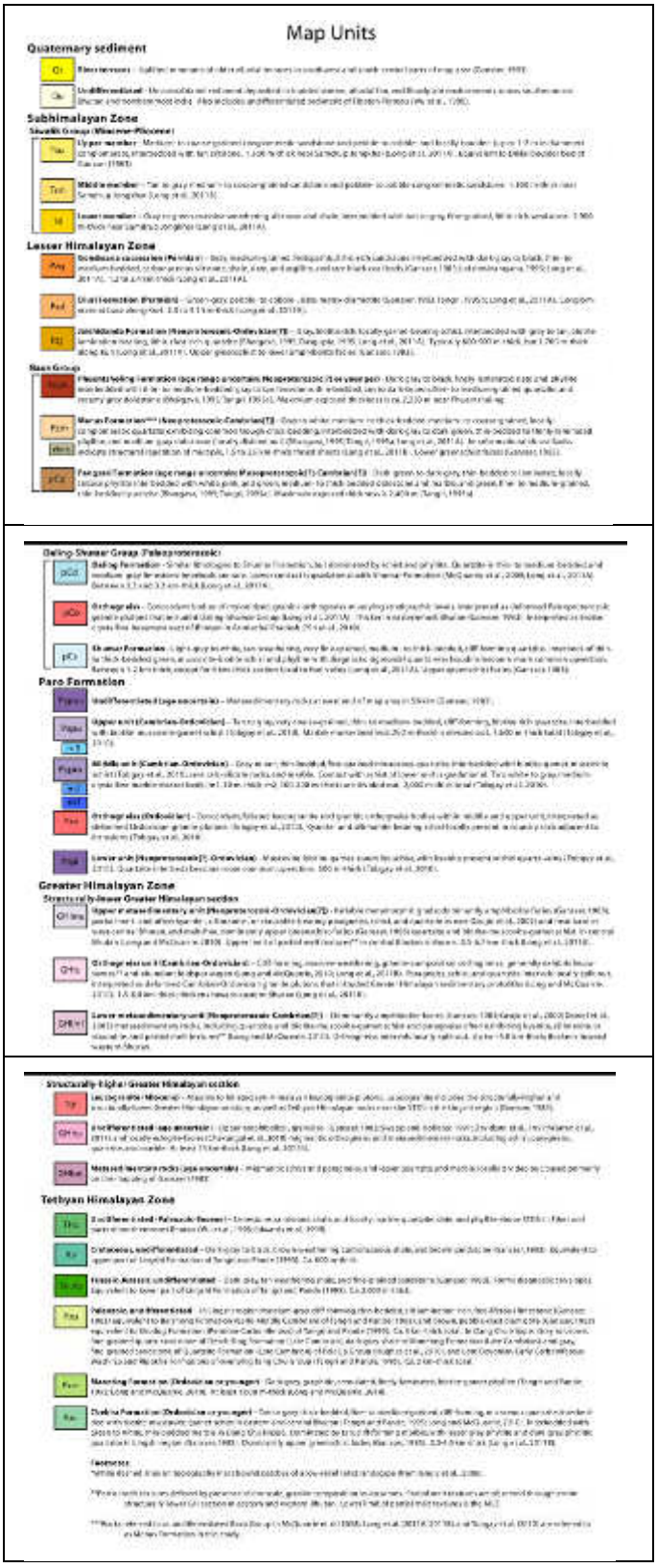


Figure 63: Snapshot of the geological map for Bhutan showing Wangchhu basin (see legend in Table 28)

Table 28: Legend of the geological map of Bhutan



3.2 Problem analysis and strategy development

Two workshops were held with prospective members of the River Basin Committee to be formed and basin representatives, amongst whom the possible members of the RBC to be formed. The first workshop was held on 13-15 July on preparing problem trees and solution trees related to the five water security dimensions. The second workshop was held on 14-16 October 2015 on formulating goals and objectives. The problem and strategy trees against the five Key Dimensions of water security and for Thromdes as a separate group are given in Appendix 3.

The diagrams are read as follows. In the problem tree, the central box contains the core statement related to the concerned Key Dimension. The boxes below analyse the causes of the central problem down to three levels. The boxes above the central statement mention the impact of the central statement. Hence, the total diagram provides a logical cause-effect relationship.

The strategy tree is organised in a similar fashion. Interventions on the ground lead to Key Result Areas and then to the goal formulated in the central box, with their specific objectives/ impacts on top of the diagram.

The success of interventions is measures along Key Performance Indictors. This logic is further elaborated into plans and targets for each Key Dimension in the next chapter.

4 Wangchhu Basin Plan

This chapter presents the plan expressed in Key Result Areas and Key Performance Indicators. Baseline values and targets are provided with an explanation of the next steps to be taken.

4.1 Introduction

The plan formulation is based on the results of the participatory logical framework analysis, structured along the five key dimensions of the Bhutan Water Security Index system. The qualitative results are described in the following tables, specifying for each Key Dimension of water security the Goal, Specific Objectives, Key Result Areas, Performance Indicators (KPIs) and Main interventions at basin level. The KPIs following from the Bhutan Water Security System are in ***italic*** font, to distinguish them from other performance indicators that have been identified by stakeholders during the Logical Framework Analysis exercise. The priority interventions are also in ***italic*** font.

A number of the indicators of the BWSI are not *actionable.* An obvious example is the Coefficient of Variation of rainfall. These are used only for monitoring purposes and have not been elaborated in the action plans and cost estimates.

The plans for the actionable indicators are elaborated for each district in Appendix 4, specifying their baseline values, target values, estimated workload involved, and cost estimate against current prices for respectively the 12^{th}, 13^{th}, and 14^{th} FYP. The main quantitative findings are summarized under the tables describing the qualitative plans.

The role of the RBC is prominent in formulating the assumptions for planning across the basin. An equitable development is pursued among the district in most water security domains, but differentiation is accepted for example with respect to hydropower development, expansion of irrigated areas in the respective districts.

The responsibilities of the District Administration and central agencies are in *preparing* and *implementing* the FYPs.

4.2 Wangchhu Basin Plans and targets

Table 29: Plan for KD1-Rural water security

1. *Rural household water security*	**Key Result Areas**	**Key Performance Indicators**	**Main Interventions/Projects**
Goal: To improve and protect rural drinking water and sanitation in Wangchhu basin Specific objectives: • Reduce morbidity and mortality rates • Improve the quantity and quality of household water supply • Reduce the incidence of water related disputes • Reduce drudgery in water fetching among women and children	• Improved condition of water sources and catchments • Improved access to alternative drinking water sources • Improved management of rural water supply • Increased access to improved sanitation	• *Percent of population with access to piped water supply* • *Percent of people with water-sealed sanitation* • *Incidence of diarrhoea* • Number of water sources revived • Access to drinking water in hrs/day (%) • Number of water user association formed • Number of small reservoirs and rain water harvesting units established	• *Expand piped water connections* • *Expand improved sanitation facilities* • *Develop and apply water harvesting technologies* • *Construct water reservoirs and wells* • Carry out mass afforestation and reforestation program • Carry out public education and awareness on catchment management laws and regulations • Improve livestock management to reduce the impact of over-grazing • Improve knowhow and technology to access water sources • Improve design of water supply systems to reduce losses • Organize and train water user associations

Table 30: Targets and cost estimates for KD1- Rural water security

KD1	Rural household water security												
INDICATORS						TOTAL TARGET	TOTAL COST ESTIMATES	PHYSICAL TARGETS			COST		
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**		**Total Cost in Mln Ngu**	**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
1	% households with piped water supply by investments	% invest	% invest	% invest	% invest	Nr of HH to connect by 2033	Total Cost in Mln Ngu	Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	92.0	100	100	100	2,540	160.8	847	847	847	53.6	53.6	53.6
31%	Haa	96.4	100	100	100	802	24.9	267	267	267	8.3	8.3	8.3
100%	Paro	96.5	100	100	100	1,477	147.7	492	492	492	49.2	49.2	49.2
81%	Thimphu	96.3	100	100	100	612	49.7	204	204	204	16.6	16.6	16.6
						5,431	383.0	1810	1810	1810	127.7	127.7	127.7
2	% households with *functional* piped water supply	% function	% function	% function	% function	Nr of connections to improve by 2033	Total Cost in Mln Ngu	Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	63.0	75	88	100	4,902	77.6	1634	1634	1634	25.9	25.9	25.9
31%	Haa	43.0	62	81	100	1,902	14.7	634	634	634	4.9	4.9	4.9
100%	Paro	27.0	51	76	100	7,303	182.6	2434	2434	2434	60.9	60.9	60.9
81%	Thimphu	99.0	99	100	100	545	11.1	182	182	182	3.7	3.7	3.7
						14,652	286.0	4884	4884	4884	95.3	95.3	95.3
3	% households with water-sealed sanitation	%	%	%	%	Nr of sealed toilets to put in by 2033	Total Cost in Mln Ngu	Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	58.2	69	79	90	4,479	510.3	1493	1493	1493	170.1	170.1	170.1
31%	Haa	32.5	52	71	90	1,912	106.7	637	637	637	35.6	35.6	35.6
100%	Paro	61.2	71	80	90	3,598	647.6	1199	1199	1199	215.9	215.9	215.9
81%	Thimphu	79.7	83	87	90	777	113.6	259	259	259	37.9	37.9	37.9
						10,766	1378.2	3589	3589	3589	459.4	459.4	459.4
							689.1						
SUB TOTAL KD1							**1358.1**	**6,694**	**6,694**	**6,694**	**223**	**223**	**223**

Providing rural households with piped water supply is a routine activity of DPH-MOH and the Engineering Sector of the District as laid down in the FYPs. The same holds for rural sanitation, but the beneficiaries shall bear half the cost. In rural areas the focus is so far on improved latrines. A start will be made with introduction of water-sealed toilets.

Table 31: Plan for KD2-Economic water security

2. Economic Water Security	Key Result Areas	Key Performance Indicators	Main Interventions/Projects
Goal: To maximize economic benefits derived from use of water resources in Wangchhu basin, and ensure adequate and sustainable availability Specific objectives: • Maximize agricultural productivity, contributing to enhanced food security • Sustain growth in revenue from hydropower generation, along with enhancement of energy security • Enhance industrial development, particularly for small and medium enterprises • Maximize and sustain potential revenues from water-based tourism	• Increased dependable availability and access to water for agricultural use • Enhanced ability to generate hydropower at full capacity and minimize power imports during the lean season • Increased utilization of water resources for industrial development purposes • Enhance use of water resources for tourism attraction	• *Percent of arable land irrigated* • *Percent of water stored in small reservoirs for agricultural use* • *Percentage increase in agricultural revenue* • *Percent increase in hydropower generation during lean season* • *Percent increase in industry contribution to GDP* • Percentage increase in tourism revenue	• *Construct reservoirs and increase water recharge in catchments* • *Develop infrastructure to tap available water resources in deep valleys using appropriate technologies (and tapping international climate funds for financing)* • Construct hydropower reservoirs to sustain power generation by storing water for lean periods, and to adapt to climate change • Provide suitable technologies and support infrastructure to increase the beneficial use of water for agricultural and industrial development • Improve water resource information systems

Table 32: Targets and cost estimates for KD2-Economic water security

KD2	Economic water security												
INDICATORS						TOTAL TARGET	TOTAL COST ESTIMATES	PHYSICAL TARGETS			COST		
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**		**Total Cost in Mln Ngu**	**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
1	% arable land irrigated	%	%	%	%	Increase in acres	Total Cost Mln BTN	Acres	Acres	Acres	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	16.2	19	22	24.3	2,222	133.61	741	741	741	44.5	44.5	44.5
31%	Haa	14.2	17	19	21.3	110	3.24	37	37	37	1.1	1.1	1.1
100%	Paro	28	33	37	42	2,165	205.67	722	722	722	68.6	68.6	68.6
81%	Thimphu	20.9	24	28	31.35	566	43.63	189	189	189	14.5	14.5	14.5
						5,062	386.15	1687	1687	1687	128.7	128.7	128.7
2	% of potential hydropower developed	%	%	%	%	Unit cost in Mln Ngu	Total Cost in Mln Ngu				Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	60	73	87	100	40,608 + 29,527	70,135				23378.3	23378.3	23378.3
100%	Haa	0	0	0	0						0.0	0.0	0.0
100%	Paro	0	33	67	100	18,000	18,000				6000.0	6000.0	6000.0
100%	Thimphu	0	33	67	100	9,000 + 12,000	21,000				7000.0	7000.0	7000.0
							109,135				36378.3	36378.3	36378.3
3 TOTAL KD2							**109,521**				**36,507**	**36,507**	**36,507**

Expansion of irrigated agriculture follows the National Irrigation Master Plan (2016), increasing the irrigated area by 50% by 2033 and facilitated by the DOA.

Hydropower development plans of the DHPS have been incorporated in the WBMP.

Table 33: Plan for KD3-Urban water security and drainage

3. Urban water security	Key Result Areas	Key Performance Indicators	Main Interventions/Projects
Goal: To improve the efficiency of urban water supply system, and protect water quality and drainage capacity of waterways in urban areas of WangChhu basin Specific objectives: • Avoid water losses • Reduce health care costs from morbidity and mortality related to water safety • Minimize disputes over water sources, and enhance social cohesion • Secure vital water sources	• Increased water supply capacity and improved condition of existing piped water supply network • Water quality degradation in urban waterways prevented • Reduced water losses from the water supply system • Increased control over illegal tapping of water, and more equitable water distribution • Reduced incidence of urban flooding • Improved sewerage and sanitation systems	• *Percentage of households with piped water supply* • *Percentage of household sewer connections* • *Percentage reduction in piped water losses* • *Percentage of households with solid waste disposal* • *Reduction in flood damage* • Number of Thromde water supply master plans prepared • Number or urban drainage plans developed • Length of drains constructed (target 100% coverage of storm water drains) • Urban sewerage master plans developed • Length of sewer lines constructed • Number of additional urban water sources identified, and new intakes constructed	• *Expand piped water system* • *Expand sewerage coverage* • *Improve drainage network, following a master plan* • *Replace leaky water supply pipes* • *Initiate water metering, combined with public awareness raising on the aims of proper water pricing* • *Establish monitoring system to minimize illegal water tapping* • Tap alternative water sources to expand urban water supply (Groundwater survey) • Construct water storage facilities, including for rain water harvesting • Improve the management of solid wastes • Improve urban planning, including strengthening of coordination and human resources • Improve construction and maintenance standards

Expansion and maintenance of the urban piped water and sewerage system is a routine program of the WSD-DES-MOWHS as laid down in the FYPs.

Solid waste collection and disposal is a routine program under the District Administration.

Table 34: Targets and cost estimates for KD3-Urban water security and drainage

KD3	Urban water security and drainage												
INDICATORS						TOTAL TARGET	TOTAL COST ESTIMATES	PHYSICAL TARGETS			COST		
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**		**Total Cost in Mln Ngu**	**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
1	% of urban households with piped water supply	%	%	%	%	Nr HH to be connected	Total Cost in Mln Ngu	Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	92	95	97	100	490	9.80	163	163	163	3.3	3.3	3.3
100%	Haa	96	97	99	100	245	4.91	82	82	82	1.6	1.6	1.6
100%	Paro	96	97	99	100	273	5.46	91	91	91	1.8	1.8	1.8
100%	Thimphu	96	97	99	100	4,127	82.54	1376	1376	1376	27.5	27.5	27.5
						5,135	102.70	1712	1712	1712	34.2	34.2	34.2
2	% of households with *treated* piped water supply	%	%	%	%	Nr HH to have treated water	Total Cost in Mln Ngu	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	56	67	79	90	1,157	5	386	386	386	1.67	1.67	1.67
100%	Haa	27	48	69	90	691	5	230	230	230	1.67	1.67	1.67
100%	Paro	7	35	62	90	924	5	308	308	308	1.67	1.67	1.67
100%	Thimphu	90	90	90	90	5,561	5	1854	1854	1854	1.67	1.67	1.67
						8,334	20	2778	2778	2778	6.7	6.7	6.7
						2,083	**5**						
3	Urban water lost (not accounted for)	%	%	%	%	Target	Total cost in Mln Ngu	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	?				2,195	10.125	732	732	732	3.4	3.4	3.4
100%	Haa	?				866	4.0	289	289	289	1.3	1.3	1.3
100%	Paro	?				976	4.5	325	325	325	1.5	1.5	1.5
100%	Thimphu	?				27,073	124.9	9024	9024	9024	41.6	41.6	41.6
						31,110	143.5	10370	10370	10370	47.8	47.8	47.8
4	% households without sewage treatment	%	%	%	%	Nr HHs to be connected	Total Cost in Mln Ngu	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	22	18	14	10	564	1.66	188	188	188	0.6	0.6	0.6
100%	Haa	18	15	13	10	271	0.80	90	90	90	0.3	0.3	0.3
100%	Paro	2			2	244	0.72	81	81	81	0.2	0.2	0.2
100%	Thimphu	7			7	3,171	9.35	1057	1057	1057	3.1	3.1	3.1
						4,250	12.53	1417	1417	1417	4.2	4.2	4.2
5	% households with solid waste disposal	%	%	%	%	Nr HHs to be served	Total Cost in Mln Ngu	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	34	37	41	44	527	0.78	176	176	176	0.3	0.3	0.3
100%	Haa	25	28	32	35	284	0.42	95	95	95	0.1	0.1	0.1
100%	Paro	16	19	23	26	317	0.47	106	106	106	0.2	0.2	0.2
100%	Thimphu	7	10	14	17	5,561	8.20	1854	1854	1854	2.7	2.7	2.7
								2230	2230	2230	3.3	3.3	3.3
						6,689	9.86						
B TOTAL KD3							**289**	**18506**	**18506**	**18506**	**96**	**96**	**96**

Table 35: Plan for KD4-Environmental water security

4. Environmental water security	Key Result Areas	Key Performance Indicators	Main Interventions/Projects
Goal: To prevent degradation of catchment areas in the basin, and remediate existing damage Specific objectives: • Reduce the incidence of water-related conflicts by preventing the drying up of water sources • Prevent abandonment or excessive fallowing of productive lands • Reduce occurrences of landslides and forest fires • Improve the quality of water for various purposes	• Negative impacts of development activities in the watershed are prevented • Degradation of watersheds reduced • Adaptation to climate change effects enhanced (particularly due to temperature rise and more erratic rainfall pattern)	• *Percentage cropped land* • *Percentage of built area* • *Percentage wetland area* • *Suspended solids in water* • *BOD of surface waters* • *Percentage water consumed in January* • *Percentage water consumed in May* • *Number non-native fish species* • *Percentage non-native fish species* • Number of awareness-raising programs conducted for watershed protection • Number of training programs conducted on watershed-friendly agricultural practices • Number of regulations developed to regulate use of farming chemicals	• *Remediate forest loss and degradation* - ***Enforce rules and regulations to prevent land conversion in critical areas*** - ***Promote/pilot sustainable pasture development to prevent over-grazing*** - ***Stop illegal logging, and regulate extraction of forest products*** • Carry out proper planning and implementation of infrastructure and agricultural development - Enforce EFRC methods for road construction - Enforce compliance to plans - Identify and demarcate critical areas for management - Raise awareness on use of fertilizers and pesticides - Enforce environmental regulations on mining activities • Set up adequate network of weather stations to monitor changes in climate

		• Number of regulations developed to monitor mining and industrial activities in watersheds • Number of areas where PES (payment for environmental services) is practiced • Amount of fines and penalties collected • Length of forest fire lines constructed • Number of weather monitoring stations established, including data processing and dissemination • Number of forest patrols set up	

None of the BWSI indicators for KD4-Environmental water security are presently actionable and therefore they are not elaborated in the WRBM. However, the following activities shall be implemented:

1. NECS shall establish ambient and effluent water quality standards along with a monitoring system within the 12th FYP.
2. WMD shall implement watershed conservation programs particularly in watershed Nr. 158 and 67 within the 12th FYP (cost estimates are in preparation).
3. DHMS shall expand its climate and river discharge monitoring network as per existing plans (supported by WB).
4. MoAF will implement a national conservation program for the wildlife protection areas and corridors over the next 15 years with a total value of Nu. 103 million (including international co-funding under Bhutan for Life), of which a proportional amount pertains to Wangchhu basin.

Table 36: Plan for KD5-Resilience to disaster and climate change

5. Disaster resilience and climate change security	Key Result Areas	Key Performance Indicators	Main Interventions/Projects
Goal: To reduce and prevent socio-economic loss due to water-related natural disasters, particularly flooding and landslides in WangChhu basin Specific objectives: • Avoid loss or damage to infrastructure • Avoid reduction of hydropower generation capacity • Avoid community displacement • Avoid adverse impact on bio-diversity • Avoid damage to agricultural lands, including livestock losses	• Implemented flood and disaster mitigation measures • Disaster resilience mainstreamed into development planning • Improved planning and development of infrastructure and mining activities • Sustainable land management • Reliable weather forecasting and warning system established	• *Percentage change in forest cover* • *Percentage-point deviation from mandatory forest cover* • *No. of Emergency Response Units* • *Water storage capacity* • *Flood hazard zonation* • *Flood/ GLOF Early Warning* • No. of disaster mitigation measures put in place • No. of agencies mainstreaming disaster mitigation and resilient in their plans • Acreage of degraded land under sustainable land management • Number of disaster-prone sites and areas identified • Number of trainings and awareness programs conducted • Number of forest fire incidences reduced (baseline: 15 fire incidences as of 2014) • Functional and reliable communication systems put in place	• *Apply remedial measures in hazard prone areas (e.g., reforestation, bio-engineering works, land treatments, controlled grazing)* • *Implement activities to reduce forest fire incidence (forest lines, community organization and training)* • Conduct flood modelling, hazard mapping and assessment • Develop capacity for disaster-resilient urban planning • Promote and use EFRC methods in road construction • Strengthen mining regulations and their enforcement • Expand network of weather monitoring stations, and improve information management and sharing

Table 37: Targets and cost estimates for KD5-Resilience to disaster and climate change

KD5	Resilience to water-related disaster												
INDICATORS						TOTAL TARGET	TOTAL COST ESTIMATES	PHYSICAL TARGETS			COST		
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**		**Total Cost in Mln Ngu**	**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
4	Emergency response Mechanism	Nr.	Nr.	Nr.	Nr.		Total Cost in Mln Ngu				Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	0					5				1.67	1.67	1.67
100%	Haa	0											
100%	Paro	7											
100%	Thimphu	0											
5	(Rural) water storage	MCM	MCM	MCM	MCM		Total Cost in Mln Ngu	Storage Volume m3			Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha		17,361	to be determined			174	17,361			174		
100%	Haa		6,763				68	6,763			68		
100%	Paro		35,249				352	35,249			352		
100%	Thimphu		144				1	144			1		
			59,517				595	59,517			595		
6	Flood hazard zonation	Nr.				X	X	ha	ha	ha	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	1				Basin figure							
100%	Haa	1											
100%	Paro	1											
100%	Thimphu	1											
7	Flood protection mesasures pending	Nr.					Total Cost in Mln Ngu	m length	m length	m length	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	0					tba	tba	tba	tba	tba	tba	tba
100%	Haa	1					tba						
100%	Paro	1					133.6	4500			133.6		
100%	Thimphu	1					tba						
							133.6	4500			133.6		
8	Flood/ GLOF Early Warning						Total Cost in Mln Ngu				Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	3	1	2	3	See DHMS activities	160				80	80	
100%	Haa	0											
100%	Paro	0											
100%	Thimphu	0											
							160				80	80	
3 TOTAL KD5							**894**				**810.4**	**81.7**	**1.7**
GRAND TOTAL OF PLANNED EXPENDITURES TILL 2033 IN FOUR DZONGKHAGS (INCLUDING INCREASE OI							**112,062**				**37,637**	**36,908**	**36,828**

The WBC, assisted by NECS shall establish a revolving fund of Nu. 5 million in order to be able to deal swiftly with any calamities.

As a pilot project, it is planned to provide water storage facilities to 10% of the neediest rural families (at least 65 villages) who have difficulties with domestic water supply during the lean season. The project would be implemented by WSD-DES-MoWHS in the 12th FYP.

Flood-prone areas have been identified in the WBMP. WSD-DES-MoWHS will follow-up demarcating the areas on the ground for public awareness. It will also follow-up with detailed field surveys for identification of flood-protection measures such as building embankments or raising the ground level with spoil from road construction on specific sites.

DHMS will complete its on-going work with respect to flash flood forecasting and early warning within the 12th and 13th FYP, with a preliminary cost estimate of Nu. 160 million based on similar work done in Punakha.

Expected increase in basin water security score (2016-2033)

Based on the interventions given above, the average score of water security in Wangchhu basin across the five key dimensions is expected to increase from 3.3 at present to 3.6 by 2033, see Table 38 and Figure 64.

Table 38: Expected increase in Wangchhu water security score 2016-33

Key Dimension/ Year	Wangchhu 2016	Wangchhu 2033
Rural	4.5	4.8
Economic	2.1	2.6
Urban	2.8	3.2
Environment	3.4	3.4
Resilience	3.9	4.0
Average	**3.3**	**3.6**

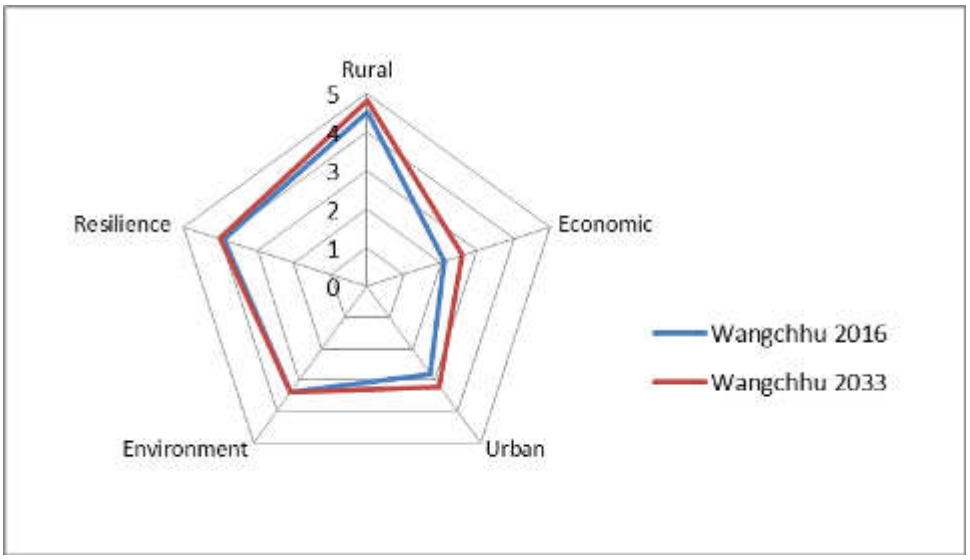


Figure 64: Expected increase in Wangchhu water security score 2016-2033

Next steps in the planning process

Review and refinement of the overall WBMP

Guided by the RBC, the Districts of Wangchhu Basin shall review and refine the WBMP particularly with respect to the value of the baseline data on the indicators, the assumptions used in the plans, and the targets that have been set against these assumptions.

Review and refinement of the cost estimates

The cost estimates in the WBMP are preliminary only. Review and refinement of the cost estimates shall therefore follow the review of the planning assumptions by the RBC.

Adjustment of the 11th FYP

The current 11th FYP is due for mid-term adjustment in 2016. The WBMP can provide planning guidelines to that effect, for example by putting the resources there where they are most needed and have the most impact in terms of increasing water security.

Preparation of the GNHC guidelines for preparation of the 12th FYP

The WBMP shall serve as a reference when the GNHC formulates its guidelines for preparation of the 12th FYP.

Preparation of the 12th and following FYPs

The WBMP shall also serve as a reference during the preparation of the 12th and following FYPs.

Iterative process

It is emphasized that the WBMP 2016 is just the starting point of the IWRM planning spiral discussed in this report. This first iteration has taken stock of the present state of the water resources in terms of water availability, water demand, and impacts of climate change, population growth, agricultural and economic development, environment and resilience. A concept has been elaborated for water security along 57 indicators for which the baseline values have been determined. Different agencies involved in, or affecting water management, play a coordinated role in achieving water security. Initial targets have been set for each of them. The plan shall now be implemented and monitored along the specified indicators in order to be able to take stock of progress, re-assess conditions or priorities at appropriate time intervals, such as mid-term adjustment of the FYP, and preparation of the next FYP. The IWRM spiral towards water security is again depicted in Figure 65.

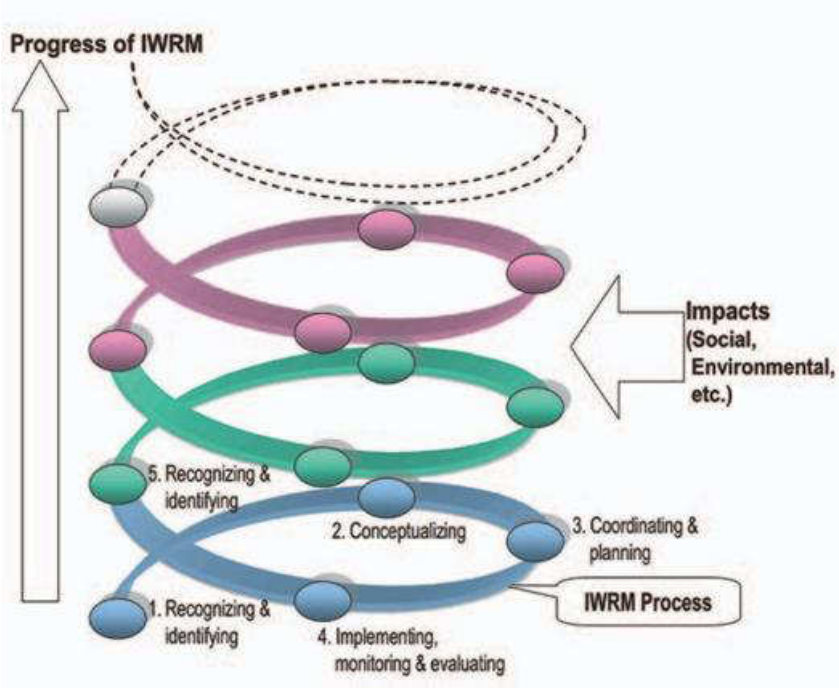


Figure 65: IWRM spiral (from ADB/ AWDO 2013)

4.3 Strengthen governance and institutional capacity for coordinated planning, implementation and monitoring of basin management plan

Effective implementation of the Wangchhu basin management plan not only requires strong coordination and cooperation between the four districts administrations and the sectors within them. Considering that the implementation of basin management plans will ultimately contribute to enhanced water security at the national level, it is also equally important for the basin committee to synergize and synchronize the priorities with sectoral priorities.

As presently stated in the Water Act and Regulation, the RBC is not a regulatory body. The Water Act does not authorize or mandate it to promulgate standards and regulations, or even to enforce existing regulations (the latter is the responsibility of the competent authorities). However, note again the prerogative for NEC to expand the RBC's functions.

The river basin committee is also not an implementer. The RBM plan is to be implemented by competent authorities and local administrations. However, at the 23 June 2015 consultation with stakeholders, district governors from Wangchu basin questioned the RBC's apparent lack of authority to implement programs. Further, during the WBC meeting in April 2016, the existing system of budget ceiling for districts has been seen as a constraint to integrating water priorities in district plans keeping in mind that many other non-water related development priorities have to be financed within the budget ceiling. Reflecting this concern, it was proposed that the RBC could develop program proposals for basin-wide implementation, identify funding sources (e.g., ODA), and manage funds secured that are intended for the whole basin (e.g., for capacity building) or that address inter-district issues. If the Commission finds this reasonable, approval may be accorded under Section 13 e) and p) of the Water Act pertaining to powers and functions of the NEC.

The goals, objectives and strategies are defined below:

Goal: To promote effective and efficient implementation of Wangchhu basin management plan.

4.3.1 Empowerment of Wangchhu basin committee for effectiveness

Other priority activities for the WBC include:

- Develop and update operational guidelines for the operation of the Wangchhu Basin Committee, including procedures and timetable for granting water permits and procedures for WUA registration based on the guidelines prepared by the NEC.
- Hold at least three basin committee meetings a year and finalize minutes.
- With assistance from the river basin committee secretariat, generate the water security statistics and score for the Wangchhu basin on an annual basis.
- adopt of mechanism of learning by doing and seeking to constantly apprise the NEC on the constraints and challenges that lie in the way of effective coordination and where necessary seek to enhance its mandate and authority within the provisions of the law for effective implementation of the basin plan.

4.3.2 Capacity of partners in IWRM concepts and river basin management enhanced

Strategies:

- Train the designated member secretary of the Wangchhu Basin Committee in agenda preparation, drafting of minutes, and record keeping.

- provide orientation and training to members of RBC, relevant staff of district and Gewog Administrations in IWRM and river basin management concepts through:
    - Orientation to the IWRM principles and pillars; Bhutan Water Security Index; hydrological and management basins of Bhutan, framework for planning, implementation and monitoring of water security; institutional linkages between basin level authorities and agencies (RBC, district administrations, sectors and Gewog administrations) and national level sectoral agencies, TAC, NECS and GNHC); flow of information between basin level players and national level agencies.
    - Provide technical training on water balance accounting and monitoring systems (such as WEAP).
    - conduct study visits for RBC members to functional river basin committees.
    - BWSI indicator monitoring at Gewog and district levels, timely reporting and consolidation of information at basin levels.

4.3.3 Capacity of district, Gewog and Thromde administrations in monitoring and reporting status of water security strengthened

Within the basin, the district and Gewog administrations are crucial coordinating and monitoring entities. The district administration in particular is the agency that coordinates planning as well as implements, monitors and reports progress. The district planning officer and district environmental officers play an important role in ensuring that plans for enhancing water security at the district and Gewog levels are integrated in the five year plans priorities. Further, basin wide programmes identified by the RBC must be integrated in respective district plans for adequate human and financial resources. and implementing particularly the DEO will play a crucial role in implementation of IWRM. For this, capacity of district, Thromde and Gewog level officials should be enhanced in the following areas:

- collection of information on water resources at the Gewog and Thromde levels. Concerned officials and community leaders should be trained in collecting and recording information on various sources of water, names, discharge and abstractions.
- Incorporating RBC determined basin wide programmes and activities into district, Thromde and Gewog level plans.
- Cooperating and collaborating with sectors within the district administration to gather and update information on BWSI indicators.
- Collating Gewog and Thromde level data to prepare district level water security information and submitting to Wangchhu Basin Committee Secretariat through the Dzongdags.

It is proposed to design and implement these trainings before the end of the 11th FYP.

4.3.4 Water User Associations formally registered and monitored

The Gewog Administration is the level most appropriate for official registration of Water User Associations. The Gewog Administration, in accordance with the requirements set by the River Basin Committee:

- Guidelines for registration of Water User Associations developed and approved by NEC.

- RBC and District/ Gewog Administrations oriented to the legal requirements and process for registration of WUAs.
- Conduct advocacy and education for communities at the Gewog level on the importance of Water User Associations, its nomenclature, legal requirements and obligations, and process of registering Water User Associations.
- Process the applications for registration of WUAs (including those that already exist in some form).
- Maintain and update an inventory of WUAs, their allocated abstraction amounts, and the purpose of abstraction.
- Monitor WUA compliance to the provisions of their 'Articles of Association' and water permits.

5 Basin management and Implementation arrangements

This chapter describes the management mechanisms and institutional arrangements for implementation of the WBMP. The governance mechanisms under the newly established WBC, institutional capacity building, financial aspects, and monitoring are described here.

The WBC is the mandated entity for coordinating implementation of Wangchhu Basin Management Plan. In doing so, the committee, through the support and cooperation of the district and Thromde representatives ensure that the targets identified in the basin plan are deliberated and translated into district or Thromde targets for integration in the Five Year Plans. Once the plans find their way into the FYPs, the WBC shall coordinate monitoring of the water related plans that are implemented by various districts and central agencies. Progress shall be monitored in terms of the Bhutan water security dimensions and indicators and results anlayzed and annually reported in the form of Water security score for the basin. Within this overall framework of prioritizing and integrating basin plans into existing planning system, the following implementation arrangements are proposed.

5.1 Basin Management Structure

The management of the basin rotates around the concept of coordination as contained in the terms of reference of the WBC. The fifteen member WBC comprised of the governors, Dzongkhag Tshogdu chairpersons, and Dzongkhag environmental officers of the four districts of Chukha, Haa, Paro and Thimphu, the Mayor and Chief Environment Officer of Thimphu Thromde, and the Chief Environment Officer of WRCD, NECS as the interim member Secretary will play an important role in coordinating the implementation of the river basin management plan. Until further revision by the NEC, the extent of implementation of the Wangchhu basin management plan will be governed by the mandate and authority wrested in the WBC as per the Executive order of the Honorable Prime Minister of Bhutan and Chairman of NEC issued on 14 April 2016. This is prescribed by the following functions of the WBC:

1. To promote community participation in the protection, use, development, conservation, management and control of water resources in its area of operation through education and other relevant activities, specifically through:
    - Formulating rules and procedures for the establishment and operation of community-level Water Users Associations;
    - Promoting and rewarding positive behavioral changes toward efficient water use and protection/maintenance of water sources;
    - Raising community awareness on water-related issues, such as wasteful water consumption, unhygienic sanitation, improper disposal of solid and liquid wastes, water borne diseases, and environmental damage;
    - Awareness-creation on the various technical options of efficient water distribution and avoidance of losses;
    - Encouraging users to pay for water-related services within the scope of existing regulations;
    - Promoting community adherence to directives from the RBC in resolving water-related disputes;
    - Provide regular (say annual or bi-annual) platform to inform and hear from stakeholders on matters related to water management in the basin.
2. To prepare a River Basin Management Plan
    - Assemble information required to prepare the basin plan;
    - Consolidate water resources management plans prepared at the Gewog level, and ensure that these

are reflected in the basin plan (i.e., checking that the plans do not draw more water than is available);

- Provide detailed specifications of programs and projects incorporated in the basin plan, including a proposed "responsibility framework" that identifies the appropriate level of plan implementation (i.e., by national agency or local administration);
- Ensure that the basin plan is consistent with the principles and objectives of the National Integrated Water Resources Management Plan (NIWRMP), and that the *water-related Key Result Areas (KRAs) and Key Performance Indicators (KPIs)* incorporated in the GNHC's medium term planning guidelines are reflected in the basin plan;

3. To monitor and report to the Commission on the effectiveness of policies and action in achieving sustainable management of water resources in its area of operation
    - Review the district-level integrated water use management and safety plans prepared by the respective Dzongkhag administrations based on the basin plan, and monitor their implementation for reporting to the NEC;
    - Review the management/safety plans prepared by the Class A Thromde Administrations in the basin to ensure efficient urban water supply and effluent disposal, including urban drainage systems, and monitor their implementation for reporting to the NEC and the Ministry of Works and Human Settlements;
4. To collect, manage and share such data as are necessary to properly manage the basin in coordination with the Commission
    - Establish baseline data on the water security indicators for the basin, following the framework set up by the NEC and GNHC for a national water security indicator system;
    - Based on the basin plan implementation reports of the Dzongkhag and Thromde administrations, consolidate data to periodically update the water security indicators for the river basin, and report these to the NEC and GNHC, as well as to the basin consultative council;
    - Facilitate the exchange of data and information among agencies operating in the river basin, and among the district and Gewog level administrations.
5. To help resolve cross-sectoral and Dzongkhag trans-boundary issues relating to water resources in its area of operation
    - Serve as forum through which issues/disputes related to water sharing and distribution among districts and Gewogs within the basin can be discussed and resolved in an informed and consultative manner;
    - Establish procedures/rules for hearing and resolving trans-boundary water allocation issues;
    - Monitor and report to the NEC on adherence of parties to agreed trans-boundary water resources sharing.
6. To perform any such additional functions as the NEC may direct.

    The WRCD has been designated as the interim Secretariat until further notice by the NEC.

The functions of the **RBC Secretariat** will be assigned in the interim period to the NECS-WRCD. The secretariat shall prepare the meeting agenda for the basin committee, gather information needed to brief the committee on issues to be tackled, document proceedings, and consolidate the water plan for the basin (derived from the district and Gewog plans). As mandated by the RBC chairperson, the secretariat may summon representatives from the sectoral competent authorities to serve as resource persons. The latter shall give advice on technical matters, and ensure coordination of the basin plan with sector-level plans and programs for water resources development and management. The Secretariat will draw support from sectoral Competent Authorities on technical matters.

The RBC secretariat shall also act as an administrative support unit to the basin committee. It will be responsible

for following through and monitoring implementation of measures authorized or directed by the basin committee; it will also work with the district and Gewog administrations to monitor water use/issues in the basin, including water infrastructure activities and related programs in the basin (in coordination with sectoral competent authorities). The DEOs of respective districts in the basin, coordinated by the member Secretary of the RBC, will assist in carrying out Secretariat functions.

The detailed terms of reference of the River Basin Committee and its Secretariat issued by the NEC is given in Appendix 2.

5.2 Overall framework for Basin planning and implementation

Based on the five-year basin plan, each year in accordance with the local planning procedure and timetable mandated by the GNHC, the RBC secretariat assisted by competent sectoral authorities and DEOs will assess the current water situation and emerging issues in the basin, and brief the basin committee on its findings. The current situation will be compared with targets set in the basin plan, which coincides with the national FYP, and referring to monitoring data assembled by the basin committee secretariat.

Gewog and Dzongkhag stakeholders will deliberate water concerns through their respective development councils, and raise basin-level issues and actions requiring inter-district coordination or conflict resolution to the RBC. The RBC, through the secretariat, will review proposed water development activities of the district administrations and ensure that there are no conflicts in water use with other districts. If the district plans are in harmony with the RBMP, as checked by the basin committee, then the district plans can be submitted to GNHC following existing planning procedures. The Wangchhu basin committee will liaise closely with GNHC to hold the district administrations responsible for achieving the KRAs and KPIs for water security in their respective jurisdictions.

The RBC will provide guidelines on how the prioritized water resources development activities in the basin are to be differentiated between Gewog, Dzongkhag and central responsibilities (i.e., how are the priority activities to be divided between district and sub-district levels, and which ones should be assigned to competent sector agencies/authorities).

Plans and proposed budgets/financing for these activities will then be prepared at the assigned level, after which they will be reviewed and consolidated at the basin level by the basin committee through its secretariat—then endorsed to the GNHC. Hence the basin plan is converted into corresponding district plans, for which the RBC will ensure that they are in harmony with the river basin management plan.

5.3 Explore possibility of reorienting the water related priorities of the 11th FYP to priorities of the Wangchhu Basin Management Plan

Considering that the WBMP is prepared midway through the 11 FYP, efforts must be made to orient or adjust the water related priorities for the remaining period of the plan to the priorities set out in the basin plan.

5.4 Ensure water security priorities are integrated into the Guidelines for preparation of FYPs.

This is a priority under the National IWRM Plan. However, it is equally important that guidelines for preparation of subsequent five year plans integrate water security priorities if basin plans are to be mainstreamed and supported by the government.

Within the framework of the guidelines, the river basin committee shall, through respective Dzongdags, Thrompons and members ensure that the basin committee determined basin plans and priorities (as specified in

the river basin management plan) are integrated into district, Thromde and Gewog level plans and priorities for integration in FYPs.

5.5 Implementation of basin plans

Once the plans are integrated in the national FYPs, the respective districts and Thromdes are expected to implement and monitor progress towards the targets under existing mechanisms. The budgets for the planned priorities would automatically be provided through the existing planning and budgeting processes.

On an annual basis, the targets identified in the basin plan, the WBC will agree on specific targets to be adopted by the respective districts and Thromdes in the basin. The respective districts and Thromde administrations in the basins are obliged to:

- pursue implementation of the planned water security interventions, and
- ensure that concerned officials at the Gewog and Thromde levels collect, maintain and provide information on sources of water, discharge, and abstractions and support water balance

5.6 Monitoring and reporting progress on water security index

Monitoring of the plans will automatically be part of the government's plan monitoring system. However, the river basin committee has a special responsibility of coordinating the implementation as well as monitoring the water related plans in the context of ensuring that the water resources in the basin are optimally utilized for basic human needs and health, socio-economic advancement, environmental sustainability and resilience to disasters. in view of this, the districts through their Dzongdags and representative have the obligations to:

- Cooperate and collaborate with sectors within the district administration to gather and update information on BWSI indicators.
- Collate Gewog and Thromde level data to prepare district level water security information and submitting to Wangchhu Basin Committee Secretariat through the Dzongdags.
- provide regular information on the progress to the basin committee secretariat i.e., the WRCD, NECS that will assist the basin committee in computing the annual water security score for the basin.
- the basin committee will formally submit the report on the status of water security in the basin to the National Environment Commission. This is to be facilitated by the WRCD of NECS.

5.7 Financing the operation of Wangchhu basin committee and its basin wide programmes and priorities

The operational budget for Wangchhu Basin Committee will be integrated into NECS's annual budget during an interim period. Specifically, the budget line should be reflected under the Water Resource Coordination Division as the Secretariat of the basin committee. The budget should include no less than three basin committee meetings, the associated travel and logistics cost; furniture and equipment for the Secretariat; stationery and consumables; travel and logistic support for Secretariat staff to the basin. The Chief, WRCD has the responsibility to ensure that the budgets are endorsed by the basin committee and incorporated in the five year plans budgets as well as in the annual budget request to the GNHC.

In the long term, the cost of operating the river basin committee and that of updating the basin plan will be financed directly from GNHC/MOF. Sources of funding could be drawn from either general taxation or from water-related tariffs collected within the basin (e.g., from water use permits), and even levies/royalties from hydropower operations.

It is expected that the WBC will identify basin wide programmes that may not be covered by the FYP. Provisions should be made for resource mobilization for such priorities as long as they are in line with fostering the water security of the basin. In this respect, the WRCD as the Secretariat for the basin committee shall facilitate preparation of project concepts and proposals, liaising with donors and partners, and securing GNHC approvals and support for resource mobilization. The WRCD may facilitate also facilitate receipt and expenditure of funds for the basin.

References

1. EGIS and RSPN/ BhWP, 2016. **Bhutan Water Security Index System: User's Manual**. A technical report prepared under ADB technical assistance to Bhutan: Adapting to Climate Change through Integrated Water Resource Management. Thimphu Bhutan.

2. EGIS and RSPN/ BhWP, 2016. **Hydrological Modelling and Assessment for Bhutan.** A technical report prepared under ADB technical assistance to Bhutan: Adapting to Climate Change through Integrated Water Resource Management. Thimphu Bhutan.

3. EGIS and RSPN/ BhWP, 2016. **Social Aspects of Water Resource Management in Bhutan.** A technical report prepared under ADB technical assistance to Bhutan: Adapting to Climate Change through Integrated Water Resource Management. Thimphu Bhutan.

4.EGIS and RSPN/ BhWP, 2016. **Thematic Atlas of Wangchhu Basin**. A technical report prepared under ADB technical assistance to Bhutan: Adapting to Climate Change through Integrated Water Resource Management. Thimphu Bhutan.

5. **A Review of Water Scarcity Indices and Methodologies**, Amber Brown Marty D. Matlock, University of Arkansas, The Sustainability Consortium, White Paper #106 | April 2011

6. **Comprehensive Environmental Impact Assessment Studies for Wangchhu HEP** (570 MW) Bhutan, Wapcos, 2014, Volume 2 – Final EMP.)

7. **Data collection renewable energy**, JICA, 2013

8. **Geo-electrical survey in Paro area, Bhutan**, CEGR-Kathmandu, 2015?

9. **National Integrated Water Resources Management Plan** (NIWRM), Gross National Happiness Commission, RGOB, 2016.

10. **Rapid classification of watersheds in Wangchhu basin**, Watershed Management Division, Department of Forests and Parks Services, MOAF, 2011

11. **Water Resources Management Plan and Update of the Power System Master Plan of Bhutan**, Department of Energy, Ministry of Trade and Industries, RGOB, 2003.

http://www.nec.gov.bt

http://www.pitt.edu/~nmcq/Long_etal_2011_JOM_Bhutan_Map_1-500k.pdf

http://www.un.org/waterforlifedecade/scarcity.shtml

Appendices

Executive order for establishing Wangchhu Basin Committee

Terms of reference for the Wangchhu Basin Committee

Problem and strategy trees for Wangchhu basin

Overview of plans, targets and cost estimates

APPENDIX 1

Executive Order For Establishing Wangchhu Basin Committee

PRIME MINISTER

རྒྱལ་ཡོངས་འབྲུག་གཞུང་།

Royal Government of Bhutan

C-2/273

14 April, 2016

[Translated Text]

Government Order

Sub: establishment of Wangchhu Basin Committee (WBC)

In accordance with Chapter 6 Section 27 a) and b) of the Water Act, 2011 and as per the framework and terms of reference for River Basin Committee approved during the 41st Commission Meeting held on 25 June 2015, the National Environment Commission (NEC) hereby announces the establishment of **Wangchhu Basin Committee** (WBC) for proper coordination and management of water resources within the basin.

In accordance with the decision of the Commission, the Wangchhu Basin Committee (WBC) shall comprise the following representatives of the four dzongkhags:

1. Dasho Dzongdag, Dzongkhag Administration, Haa, Chairman
2. Dasho Dzongdag, Dzongkhag Administration, Paro, member
3. Dasho Dzongdag, Dzongkhag Administration, Thimphu, member
4. Dasho Dzongdag, Dzongkhag Adminisration, Chhukha, member
5. Dasho Thrompon, Thimphu Thromde, member
6. Chairman, Dzongkhag Tshogdu, Haa, member
7. Chairman, Dzongkhag Tshogdu, Paro, member
8. Chairman, Dzongkhag Tshogdu, Thimphu, member
9. Chairman, Dzongkhag Tshogdu, Chhukha, member
10. Environment Officer, Dzongkhag Administration, Haa, member
11. Environment Officer, Dzongkhag Administration, Paro, member
12. Environment Officer, Dzongkhag Administration, Thimphu, member
13. Environment Officer, Dzongkhag Administration, Chhukha, member
14. Environment Officer, Thimphu Thromde, member
15. Chief Environment Officer, Water Resource Coordination Division, NECS, member secretary.

ཀཡལ་གྱན་འཛུག་གཞུང་།

Royal Government of Bhutan

PRIME MINISTER

The Chairperson of the Committee shall rotate among the Dzongdags of the four dzongkhags on an annual basis. Haa Dzongdag shall serve as the first Chairperson of the Wangchhu Basin Committee. The subsequent Chairpersons shall assume responsibilities in alphabetical order i.e., Chhukha, Paro, and Thimphu. The next Chairperson shall assume responsibility beginning 1st of July 2017.

Until further notice from the NEC, the Water Resources Coordination Division of NECS shall be the Secretariat to the Committee and the Chief Environment Officer of the Division shall be the member secretary.

The Chairman and members of the WBC are hereby directed to conduct the affairs of the Committee in accordance with the Terms of Reference (TOR) attached to this order.

This order shall be effective from 2nd April 2016.

Sd/-
(Dasho Tshering Tobgay)
Prime Minister &
Chairman, National Environment Commission

CC:

1. Hon'ble Members of National Environment Commission for kind information
2. Hon'ble Minister, Ministry of Agriculture and Forest, and Vice-chair, for kind information
3. Offtg. Secretary, National Environment Commission Secretariat, for necessary action.

APPENDIX 2

Terms Of Reference For The Wangchhu Basin Committee And Its Secretariat

1. THE RATIONALE

The boundaries of Water Resource Management (WRM) has greatly expanded over the decades (from water to water+ecology, then to water+ecology+institutions, and now towater+ecology+institutions+other concerns). There remains a strong sense that the most logical unit for management is the river basin, hence the need to set up basin-scale organizations for management and coordination. The coordination model being developed here does not necessary (actually, not politically realistic) aim for creating unitary basin organizations that take over the role of water resource management from existing administrative institutions, even as efforts continue to streamline the patchwork of such institutions. Standalone basin organizations would also be against the concept of cross-sectoral 'integration' and holistic views propagated by Integrated Water Resource Management (IWRM).

In IWRM, the river basin is the most logical unit for coordinated management of water resources (eg. for proper water resource accounting and allocation). A river basin organization is the most appropriate institutional mechanism for ensuring such coordination at the basin level. The aim of coordination is to ensure that policies and programs in the basin- involving multiple actors and stakeholders - are characterized by minimal redundancy, incoherence, conflict and gaps. Coordinated planning and development is, thus, the underlying IWRM principle adopted in Bhutan; and through a multi-stakeholder approach this coordination task is assigned to the River Basin Committee (RBC) at the basin level.

The Water Act of Bhutan 2011, mandates National Environment Commission (NEC) to establish RBC for each basin for the purpose of proper coordinated development, management,and conservation of water resources. The Water Act 2011 and Water Regulation of Bhutan 2014, provides broad guidelines on the composition of the RBC and their functions.

The terms of reference have been elaborated based on the guidelines in the Water Act and Regulation. The discussion from the stakeholders recommends that the members of the RBC shall be drawn from within the basin and shall comprise of incumbent chairperson of the DzongkhagTshogdu, Dzongdags, Thrompons of class A Thromde, Dzongkhag environment officers and a representative from the National Environment Commission Secretariat (NECS). Individual stakeholders shall be invited by the RBC during deliberation of matters relevant to the stakeholders' specific concern. A representative from NECS shall serve as member-secretary.

The composition of RBC, terms of reference and its secretariat's functions have been endorsed by the NEC during the 41st Commission meeting held on June 25, 2015. The Commission also approved to establish Wangchhu Basin Committee as first RBC for piloting proper coordination and management of water resources within the Basin.

2. COMPOSITION OF WANGCHHU BASIN COMMITTEE(WBC)

As approved by the NEC during its 41st Commission meeting held on 25 June 2015, the WBC shall comprise the following members:

1. DashoDzongda, Dzongkhag Administration, Haa, Chairman
2. DashoDzongda, Dzongkhag Administration, Paro, member
3. DashoDzongda, Dzongkhag Administration, Thimphu, member
4. DashoDzongda, Dzongkhag Administration, Chhukha, member
5. Chairman, DzongkhagTshogdu, Haa, member
6. Chairman, DzongkhagTshogdu, Paro, member

7. Chairman, DzongkhagTshogdu, Thimphu, member
8. Chairman, DzongkhagTshogdu, Chhukha, member
9. Dasho Thrompon, ThimphuThromde, member
10. Environment Officer, Dzongkhag Administration, Haa, member
11. Environment Officer, Dzongkhag Administration, Paro, member
12. Environment Officer, Dzongkhag Administration, Thimphu, member
13. Environment Officer, Dzongkhag Administration, Chhukha, member
14. Environment Officer, ThimphuThromde, member
15. Chief Environment Officer, Water Resource Coordination Division, NECS, member secretary.

The Commission appoints Dasho Dzongda, Haa as the first Chairperson of the WBC, however, the position of WBC chairperson shall be rotated annually among the Dzongdags of the districts covered by the basin, and Chief Environment Officer of Water Resource Coordination Division shall serve as member secretary. The WBC shall meet atleast once every four months and the quorum of the meeting shall be two third. The WBC is expected to take a consensus approach in adopting policy positions and making decisions.

3. FUNCTIONS OF THE WANGCHHU BASIN COMMITTEE

The functions of the WBC are as follows:

7. Promote community participation in the protection, use, development, conservation, management and control of water resources in its area of operation through education and other relevant activities, specifically through:

    - Formulating rules and procedures for the establishment and operation of community-level Water Users Associations;
    - Promoting and rewarding positive behavioral changes toward efficient water use and protection/maintenance of water sources;
    - Raising community awareness on water-related issues, such as wasteful water consumption, unhygienic sanitation, improper disposal of solid and liquid wastes, water borne diseases, and environmental damage;
    - Awareness-creation on the various technical options of efficient water distribution and avoidance of losses;
    - Encouraging users to pay for water-related services within the scope of existing regulations;
    - Promoting community adherence to directives from the WBC in resolving water-related disputes;
    - Provide regular (say annual or bi-annual) platform to inform and hear from stakeholders on matters related to water management in the basin.

8. Prepare a River Basin Management Plan
    - Assemble information required to prepare the basin plan;
    - Consolidate water resources management plans prepared at the Gewog level, and ensure that these are reflected in the basin plan (i.e., checking that the plans do not draw more water than is available);
    - Provide detailed specifications of programs and projects incorporated in the basin plan, including a proposed “responsibility framework” that identifies the appropriate level of plan implementation (i.e., by national agency or local administration);

- Ensure that the basin plan is consistent with the principles and objectives of the National Integrated Water Resources Management Plan (NIWRMP), and that the water-related Key Result Areas (KRAs) and Key Performance Indicators (KPIs) incorporated in the GNHC's medium term planning guidelines are reflected in the basin plan;

9. Monitor and report to the Commission on the effectiveness of policies and action in achieving sustainable management of water resources in its area of operation
    - Review the district-level integrated water use management and safety plans prepared by the respective Dzongkhag administrations based on the basin plan, and monitor their implementation for reporting to the NEC;
    - Review the management/safety plans prepared by the Class AThromde Administrations in the basin to ensure efficient urban water supply and effluent disposal, including urban drainage systems, and monitor their implementation for reporting to the NEC and the Ministry of Works and Human Settlements;
10. Collect, manage and share such data as are necessary to properly manage the basin in coordination with the Commission
    - Establish baseline data on the water security indicators for the basin, following the framework set up by the NEC and GNHC for a national water security indicator system;
    - Based on the basin plan implementation reports of the Dzongkhag and Thromde administrations, consolidate data to periodically update the water security indicators for the river basin, and report these to the NEC and GNHC, as well as to the basin consultative council;
    - Facilitate the exchange of data and information among agencies operating in the river basin, and among the district and Gewog level administrations.
11. Help resolve cross-sectoral and Dzongkhag trans-boundary issues relating to water resources in its area of operation
    - Serve as forum through which issues/disputes related to water sharing and distribution among districts and Gewogs within the basin can be discussed and resolved in an informed and consultative manner;
    - Establish procedures/rules for hearing and resolving trans-boundary water allocation issues;
    - Monitor and report to the NEC on adherence of parties to agreed trans-boundary water resources sharing.
12. Perform any such additional functions as the NEC may direct.

4. FUNCTIONS OF WBC SECRETARIAT

The functions of the WBC Secretariat is assigned in the interim period to the Water Resource Coordination Division in NECS. The secretariat shall prepare the meeting agenda for the basin committee, gather information needed to brief the committee on issues to be tackled, document proceedings, and consolidate the water plan for the basin (derived from the district and Gewog plans). As mandated by the WBC chairperson, the secretariat may summon representatives from the sectoral competent authorities to serve as resource persons. The latter shall give advice on technical matters, and ensure coordination of the basin plan with sector-level plans and programs for water resources development and management. The Secretariat shall draw support from sectoral Competent Authorities on technical matters.

The secretariat shall also act as an administrative support unit to the WBC. It is responsible for following through and monitoring implementation of measures authorized or directed by the basin committee; work with the district and Gewog administrations to monitor water use/issues in the basin, including water infrastructure activities and

related programs in the basin (in coordination with sectoral competent authorities). The Dzongkhag Environment Officers of respective Dzongkhags in the basin, coordinated by the member Secretary of the WBC, shall assist in carrying out secretariat functions.

Specifically, the functions of the WBC secretariat are as follows:

1. Assist the Chairperson of the WBC in preparation of annotated agenda of WBC meetings; draft minutes of the meetings and maintain records of meetings;
2. Prepare and propose annual operational budget for WBC, seek WBC approval and submit to WRCD, NECS for timely inclusion in the annual budget proposal;
3. Assist the WBC in applying the water security performance indicator system for the basin;
4. Coordinate with the concerned Dzongkhag administrations and national sectoral agencies to ensure that basin plan items are being implemented;
5. Advise the WBC in evaluating impacts of development plans or actions proposed by local administrations and national sectoral agencies operating in the basin;
6. Assist the WBC in preparing water security and water-related reports to the NEC and GNHC;
7. Facilitate conveyance of advisories or directives of the WBC to the district and Gewog administrations, as well as collate responses;
8. In coordination with the NECS, maintain a water database for the basin, and coordinate the updating of information collected by local administrations and sectoral agencies operating in the basin;
9. Establish a “knowledge hub” for matters pertaining to basin water resources management and coordination;
10. Document successful IWRM interventions in the basin for reporting to the WBC, as well as dissemination to national policy-makers, stakeholders and the media;
11. Facilitate networking and partnerships with NGOs, communities, state enterprises and private organizations operating in the basin;
12. Identify needs and facilitate training and capacity building (with assistance from the NECS) among local administration staff on integrated water resources planning and management;
13. Coordinate with the Dzongkhag and Gewog administrations to collect, compile, check, sort and analyze data about the status of water resources in the basin, and the ongoing implementation of basin plans;
14. Prepare necessary M&E forms and formats to collect data and information on the status of water resources and water security in the basin;
15. Monitor performance of local administrations in implementing their assigned roles under the river basin plan, and report to the WBC.

As noted above, the WBC shall convene a consultative assembly to deliberate on the basin plan and, on need basis consult stakeholders on specific water management issues that arise and that have basin-wide implications.

APPENDIX 3

Problem and strategy trees for Wangchhu basin

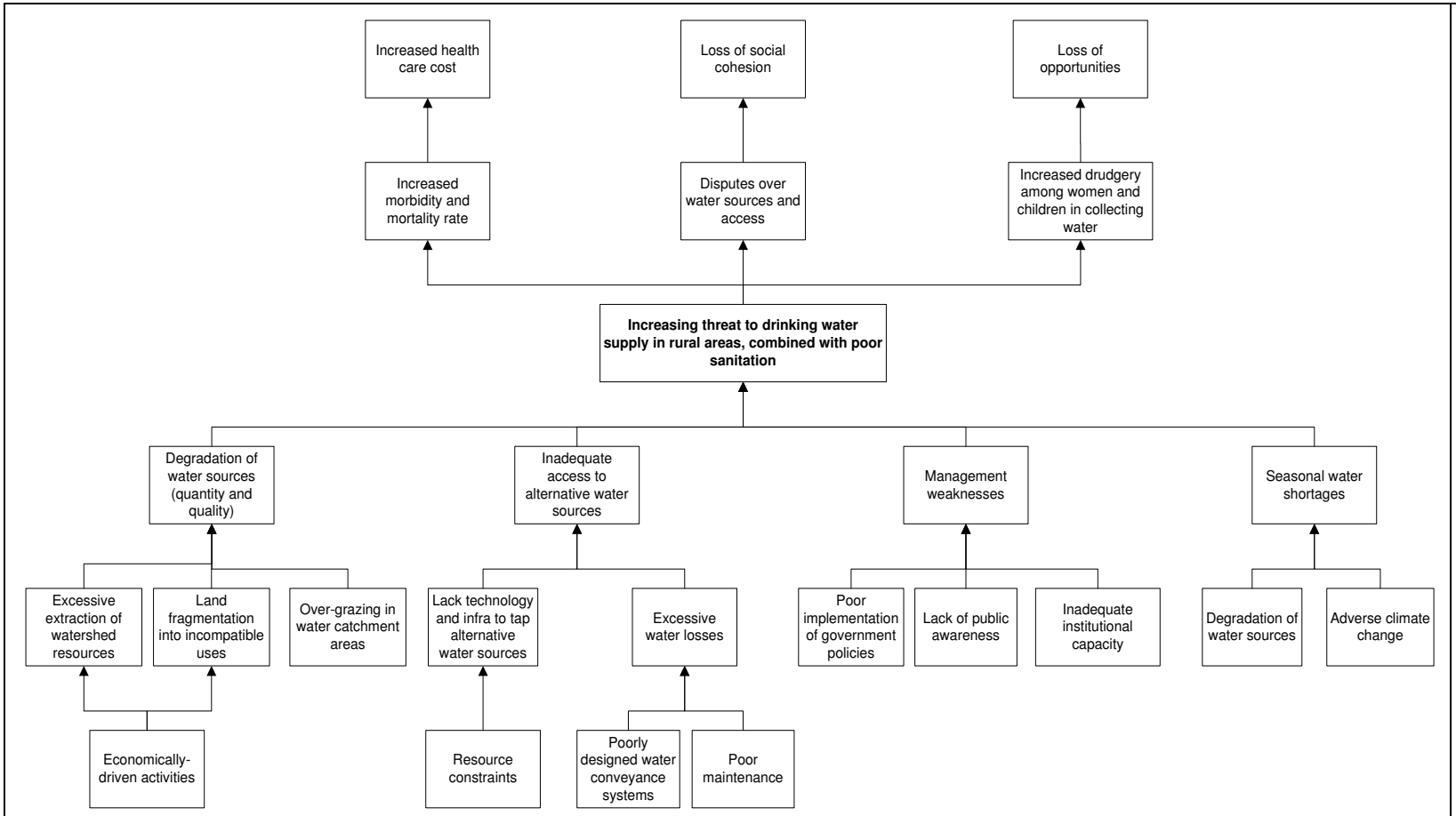


Figure 66: Problem tree for KD1; Rural household water security, sanitation and hygiene

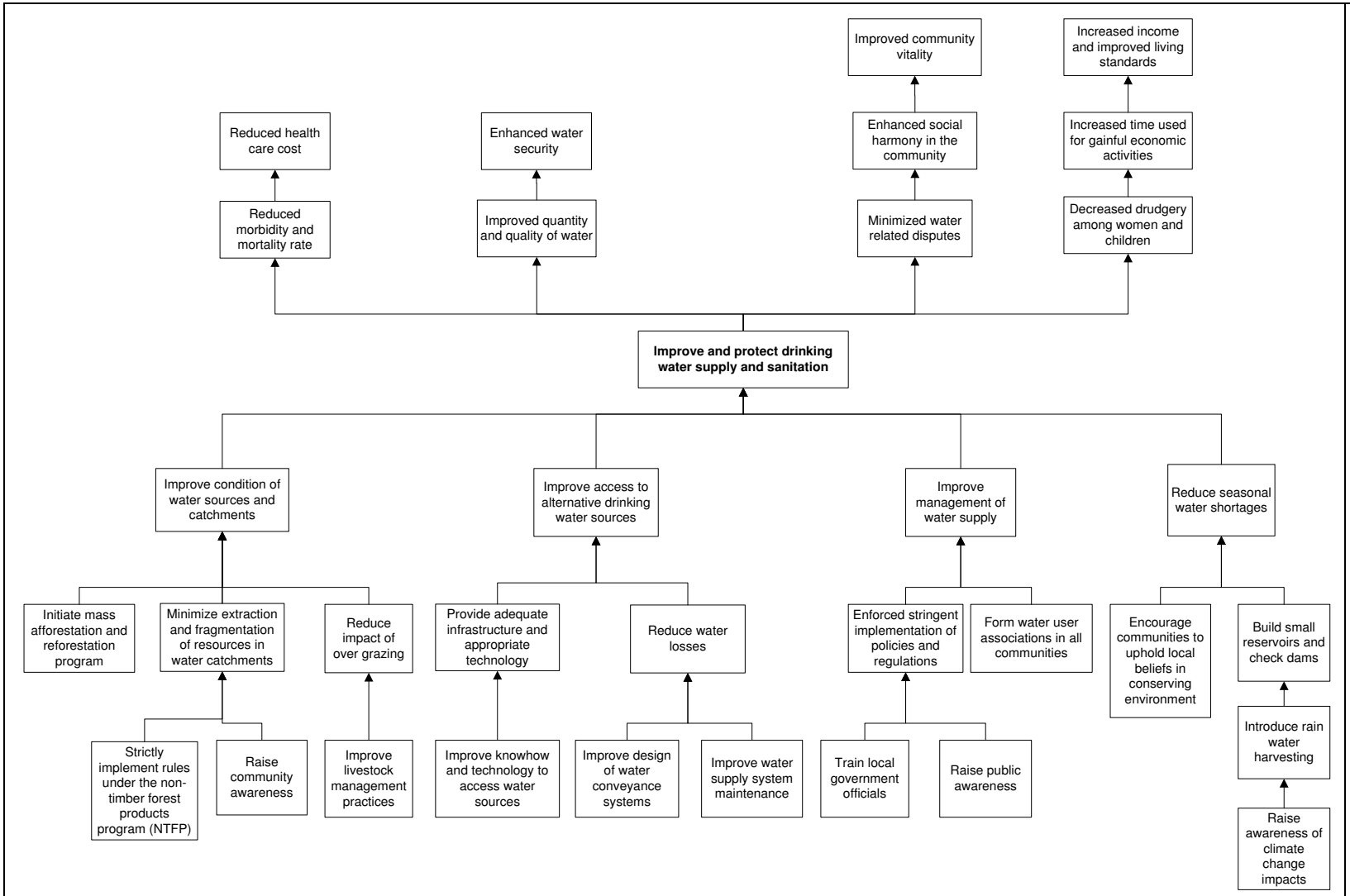


Figure 67: Strategy tree for KD1; Rural household water supply, sanitation and hygiene

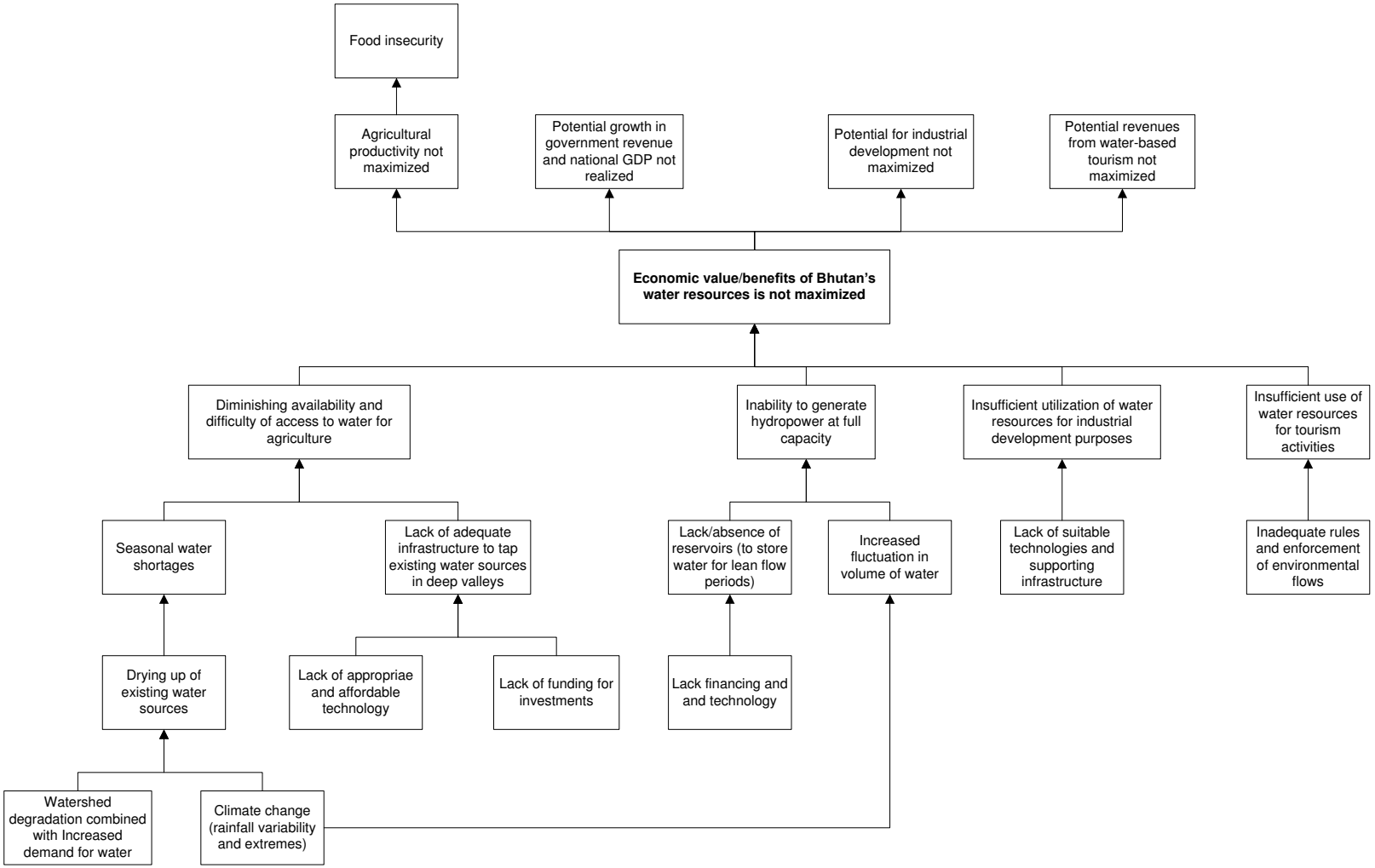


Figure 68: Problem tree for KD2; Economic water security

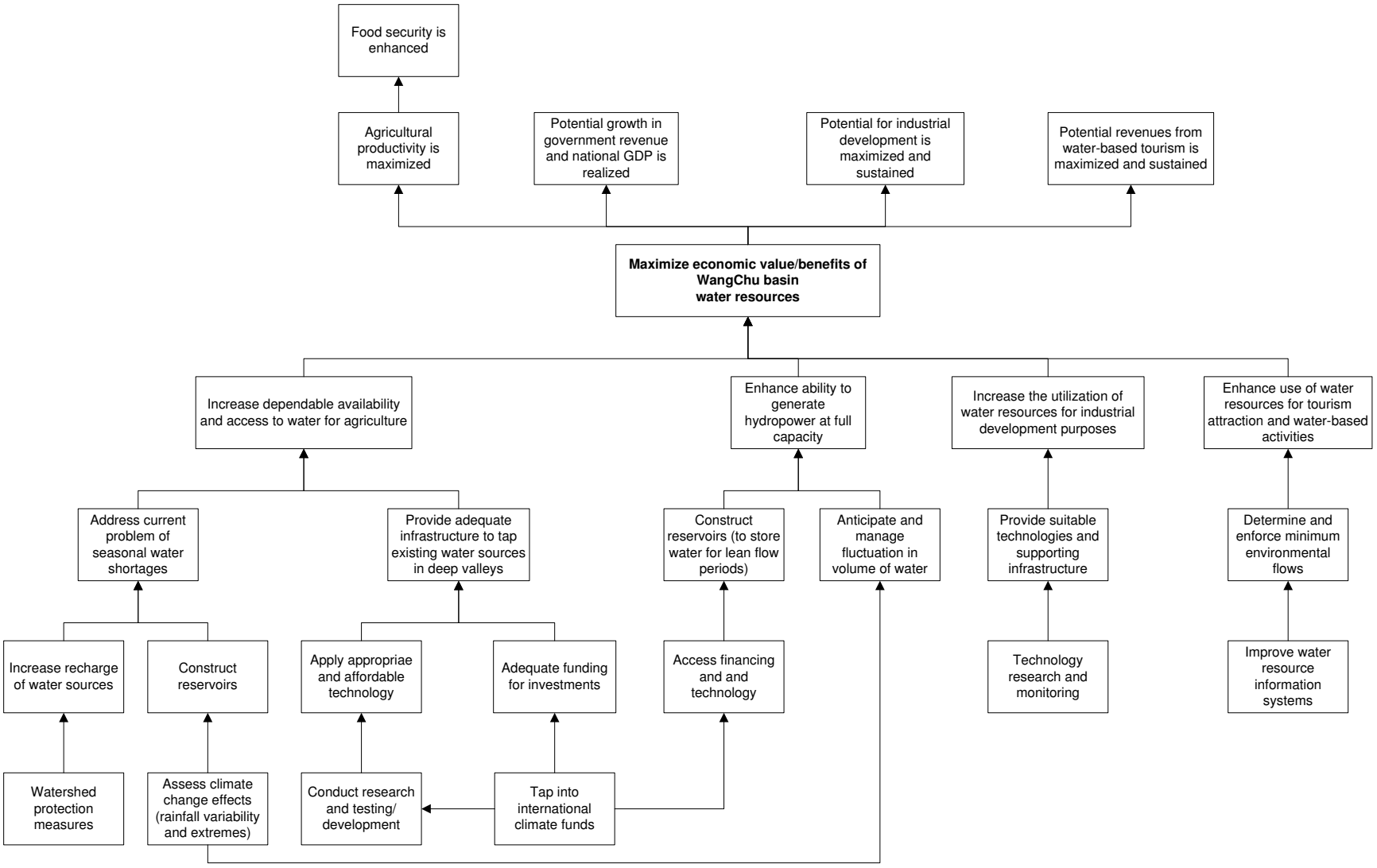


Figure 69: Strategy tree for Key Dimension 2; Economic water security.

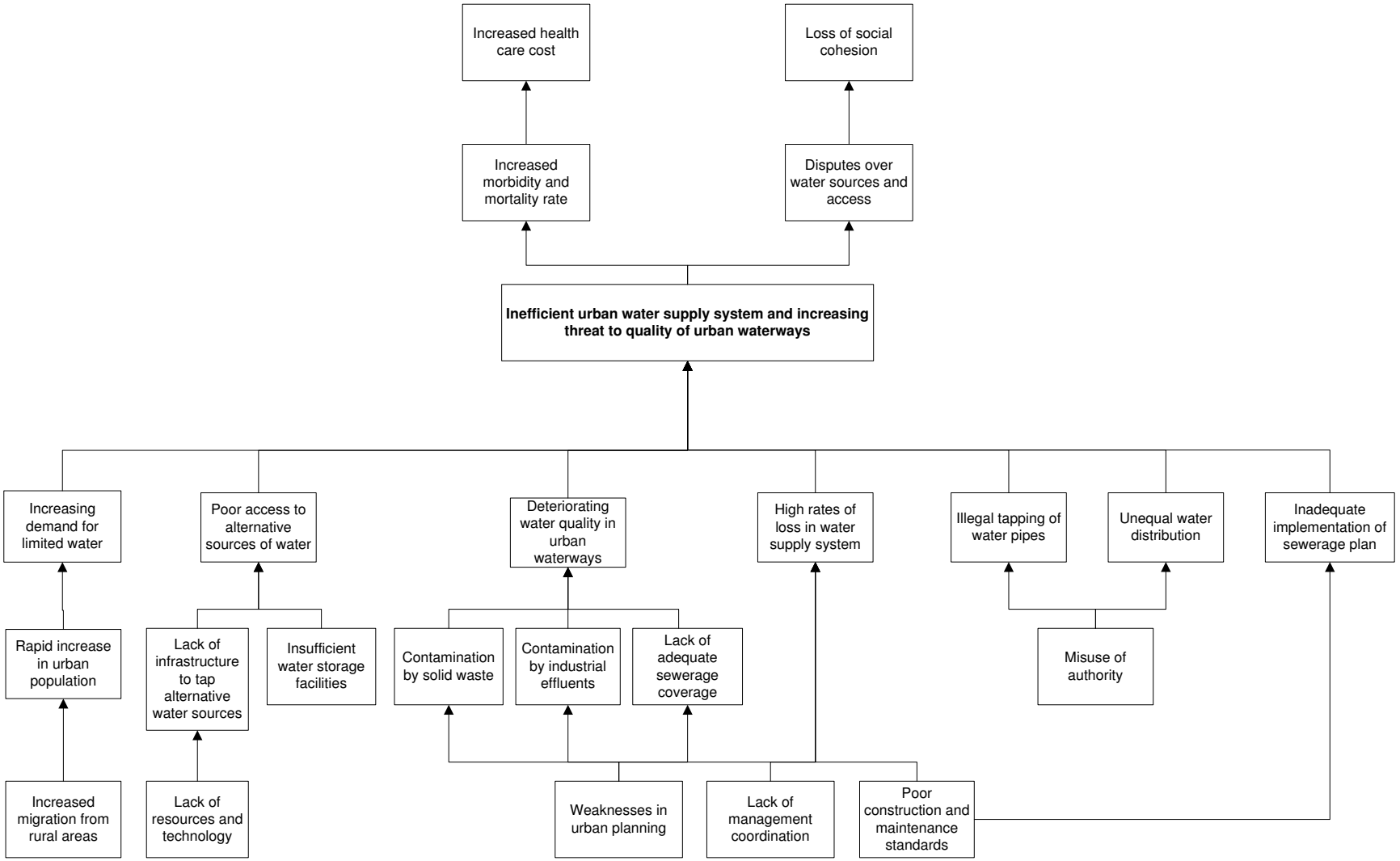


Figure 70: Problem tree KD3; Urban water security, sanitation and drainage

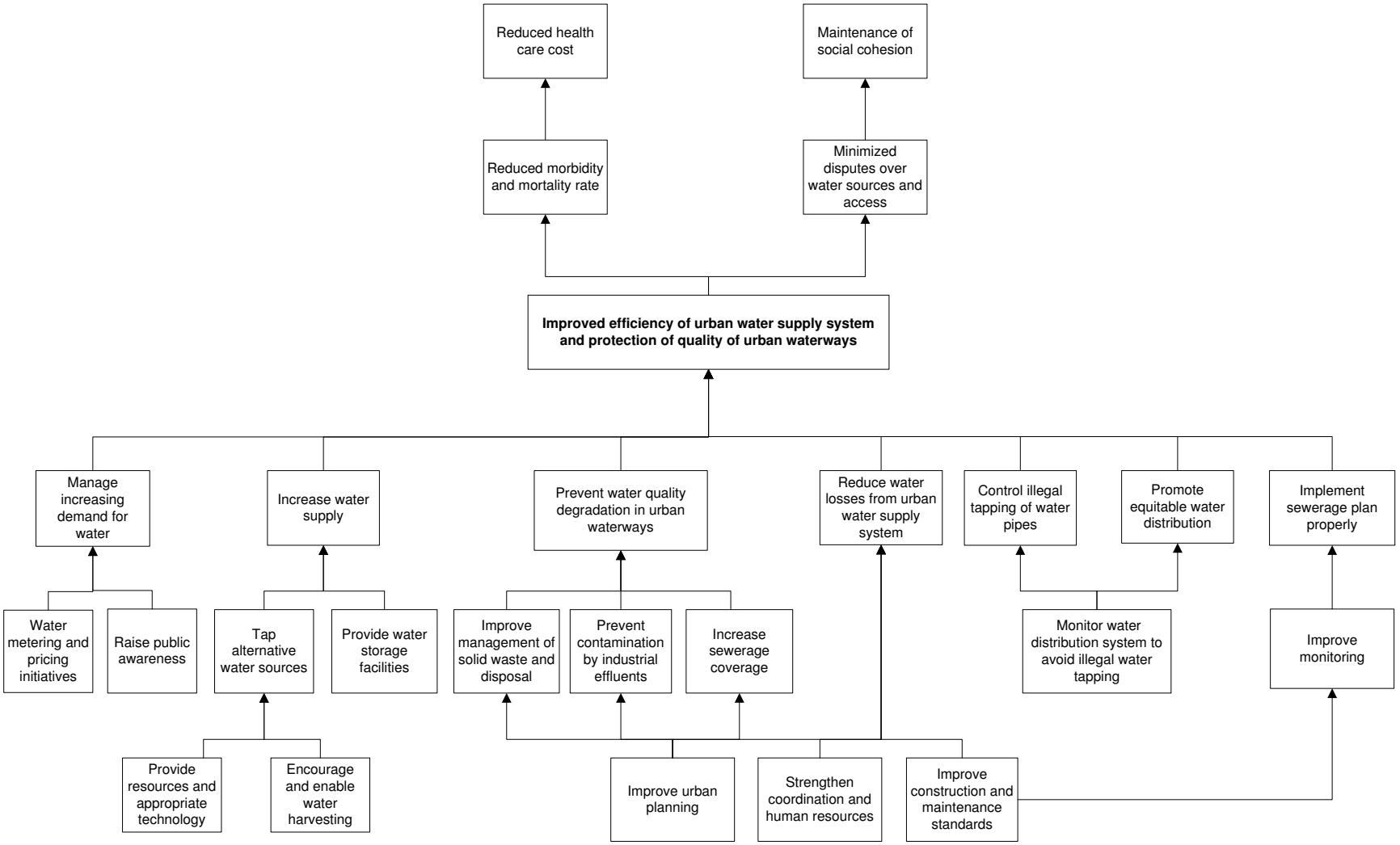


Figure 71: Strategy tree for Key Dimension 3: Urban water security, sanitation and drainage.

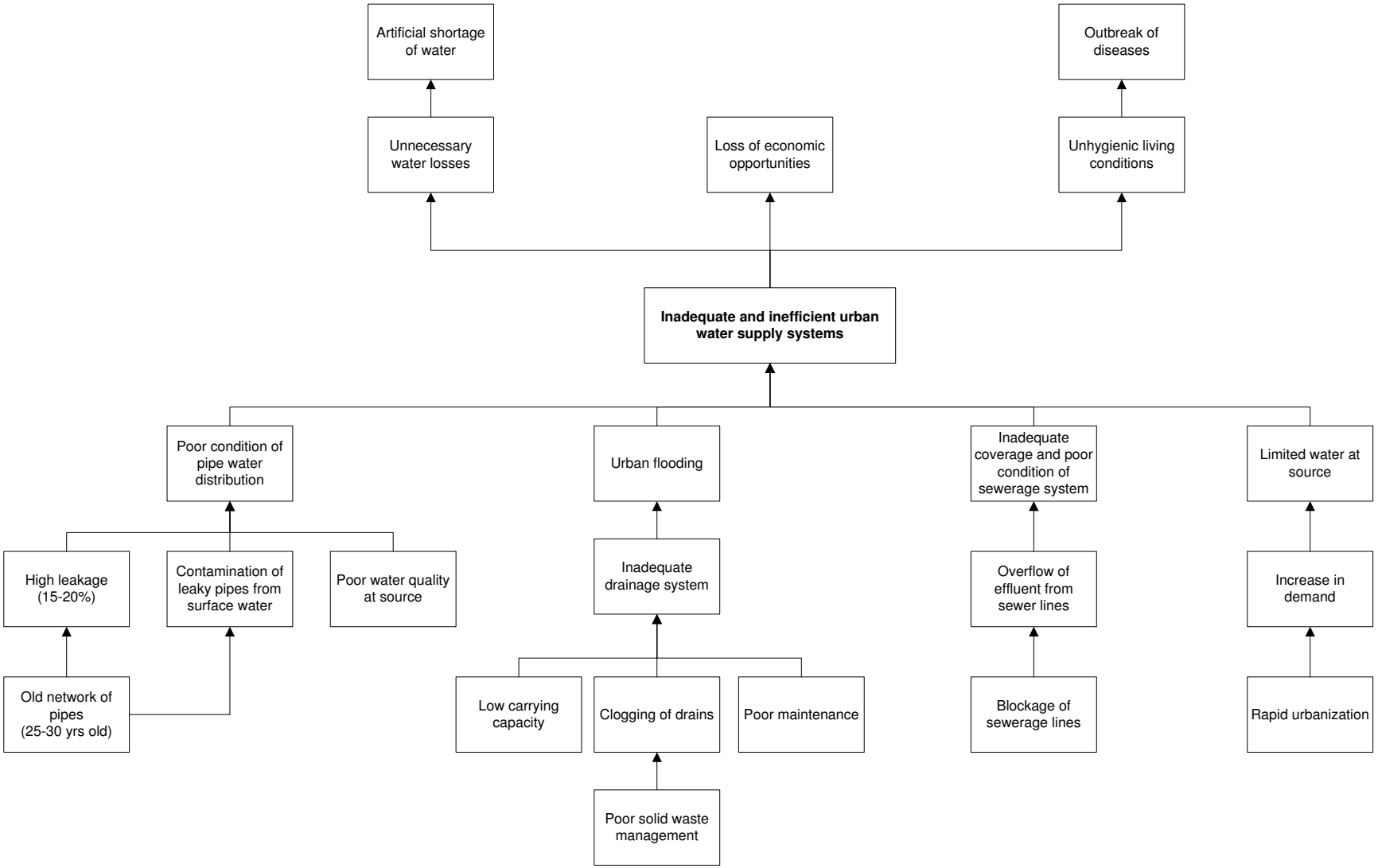


Figure 72: Problem tree; Thromde water security

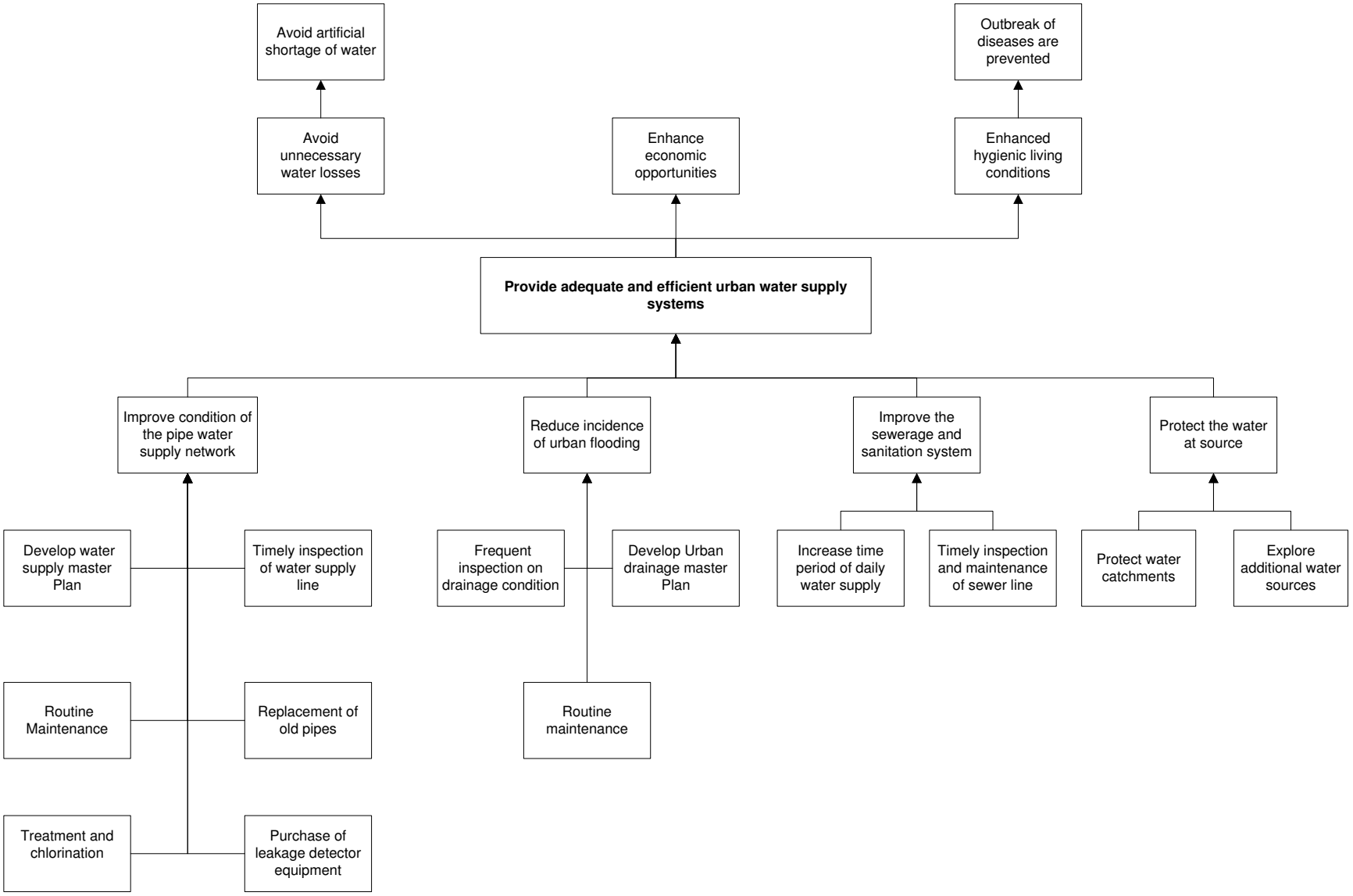


Figure 73: Strategy tree for Key Dimension 3; Thromde water security.

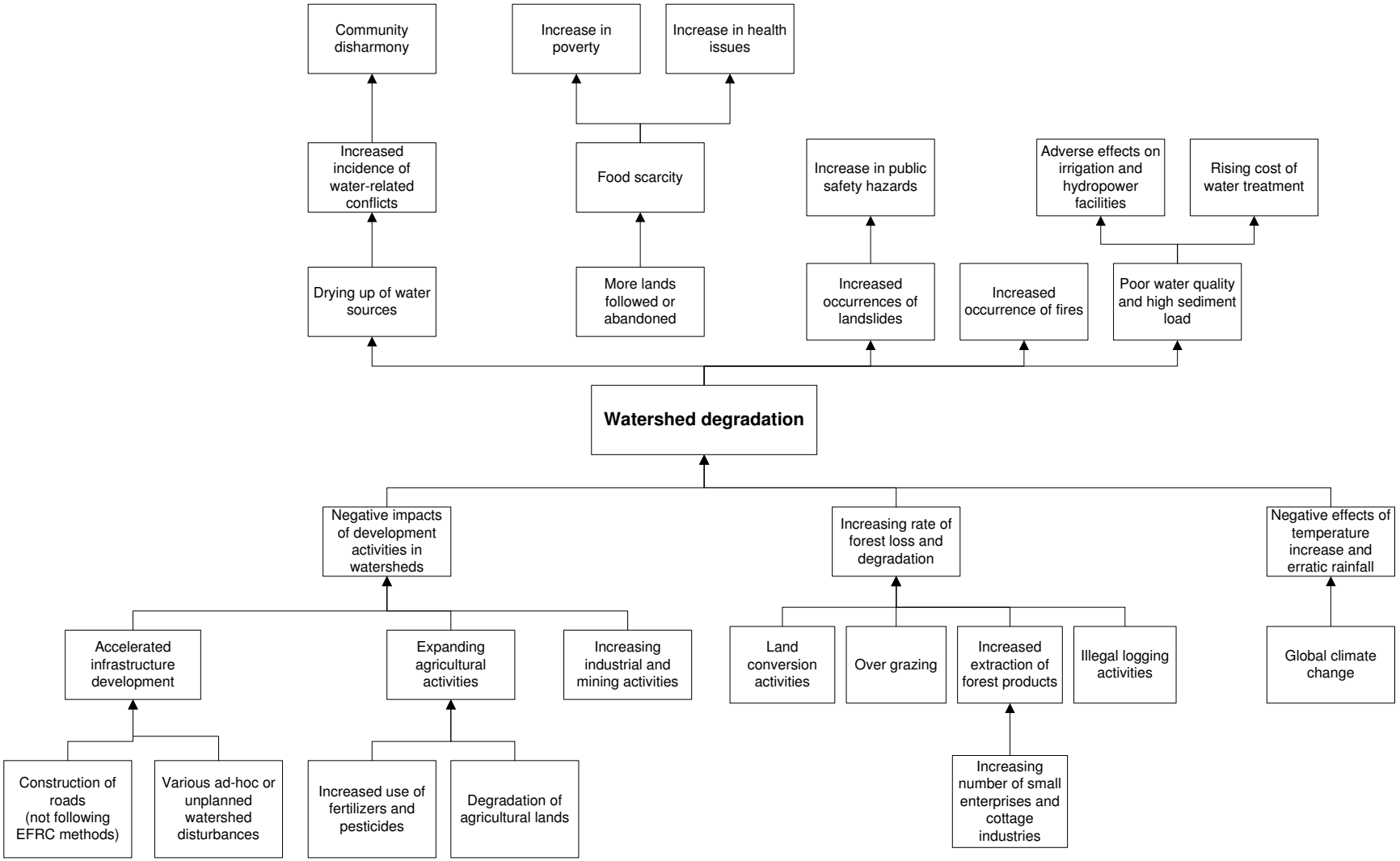


Figure 74: Problem tree KD4; Environmental water security

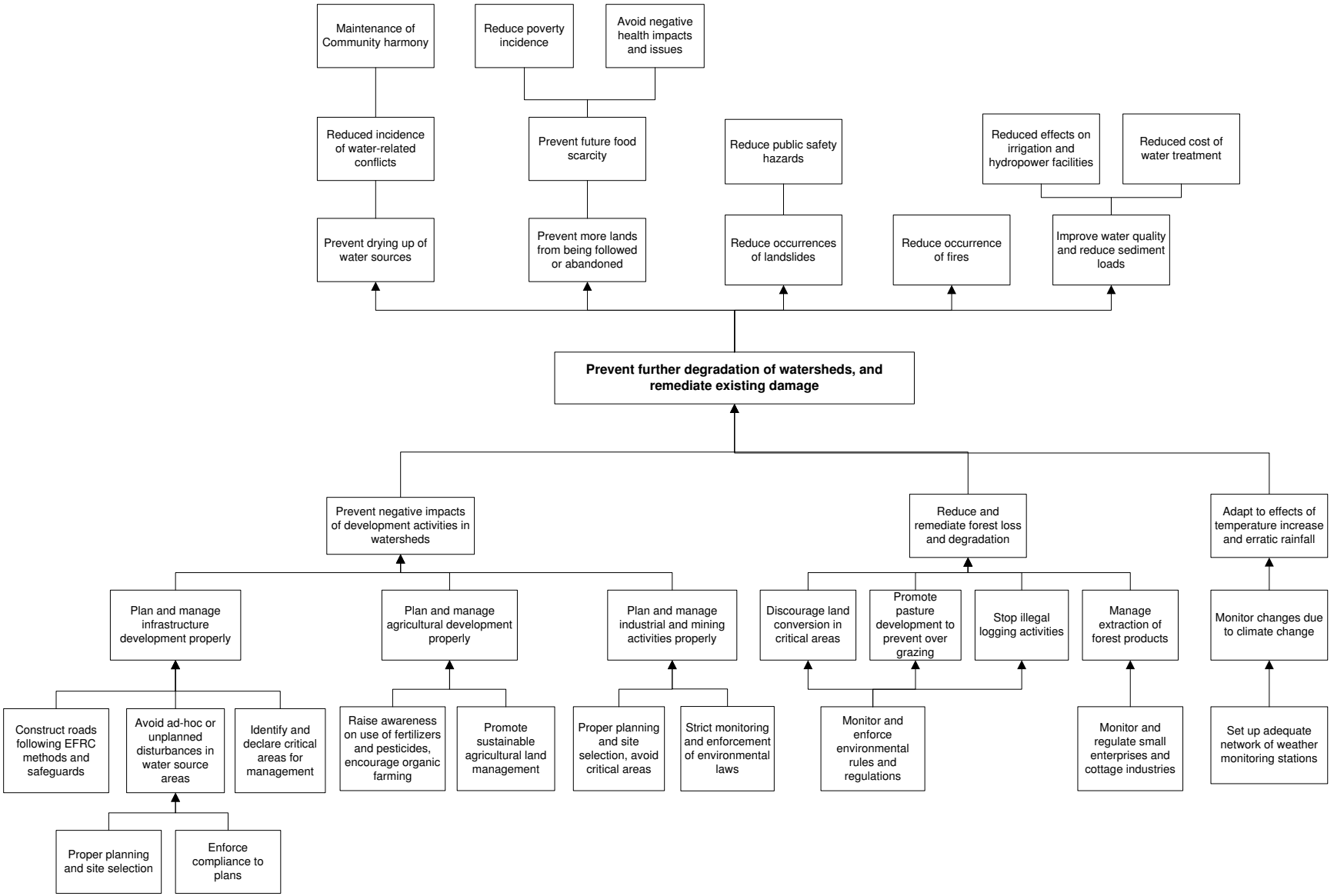


Figure 75: Strategy tree for Key Dimension 4: Environmental water security.

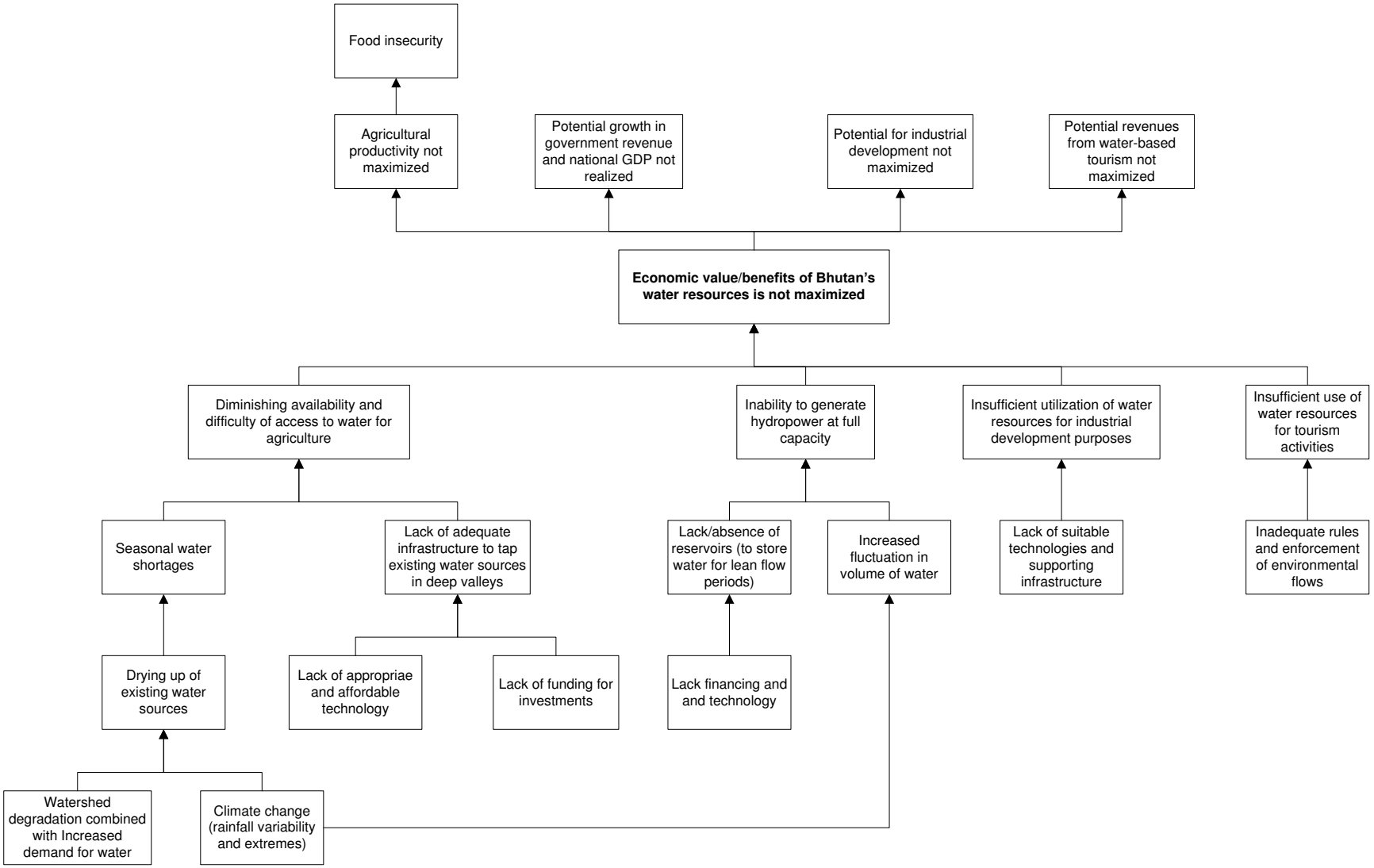


Figure 76: Problem tree KD5; Resilience to climate change and water-related disasters

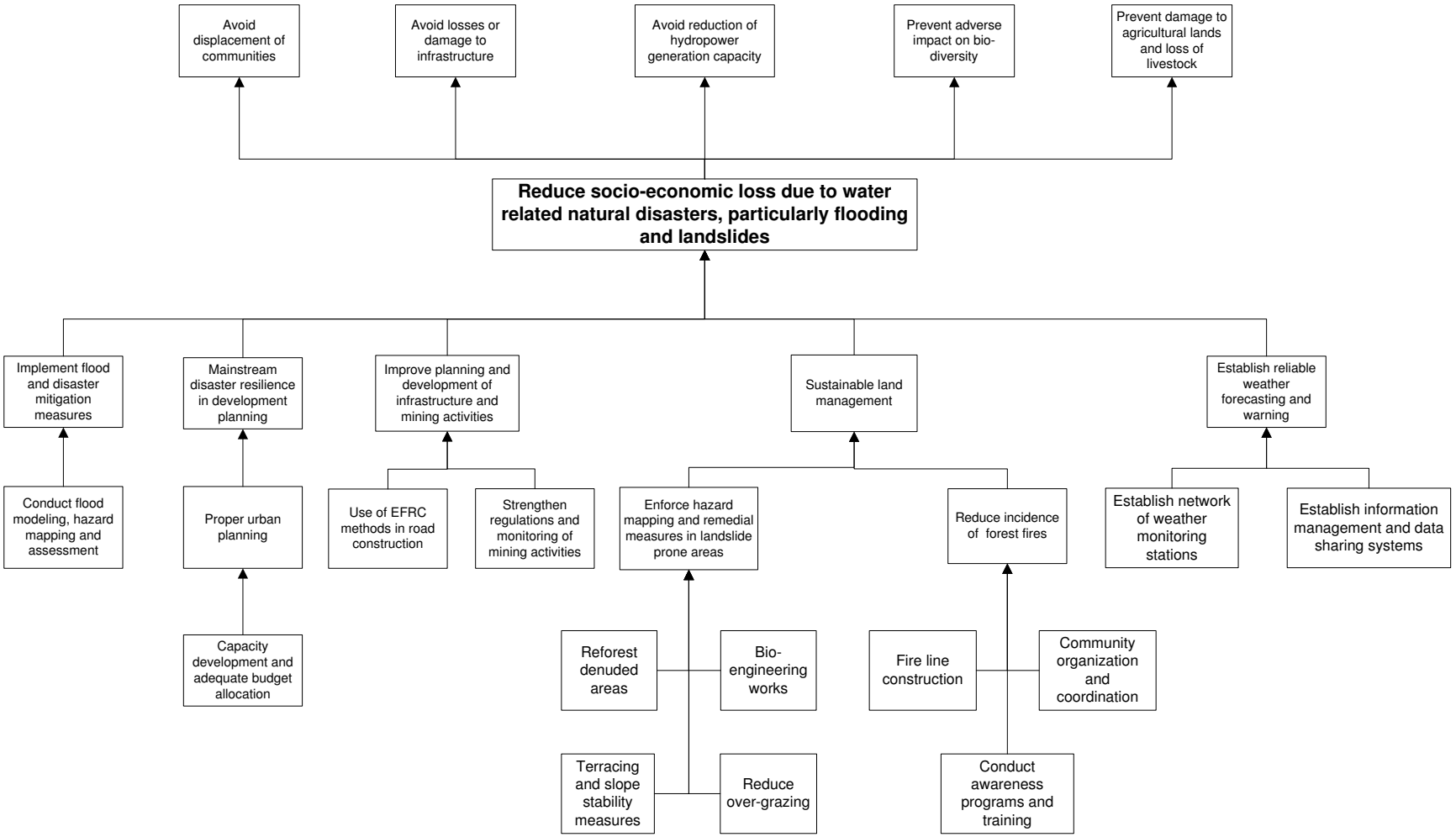


Figure 77: Strategy tree for Key Dimension 5: Resilience to climate change and water-related disaster

APPENDIX 4

Overview Of Plans, Targets and Cost Estimates

KD1 Rural household water security

INDICATORS						ASSUMPTIONS	TOTAL WORKLOAD			TOTAL COST ESTIMATES		REMARKS	WORKLOAD			COST		
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**	**Assumptions**				**Unit Cost**	**Total Cost in Mln Ngu**	**Remarks**	**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
1	% households with piped water supply by investments	% invest	% invest	% invest	% invest	100% coverage achievable in 12th FYP - based on investments	Nr. HHs 2015	Add'l HHs 2033	Nr of HH to connect by 2033	Cost per HH in Mln Ngu	Total Cost in Mln Ngu		Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	92.0	100	100	100		8,146	1,888	2,540	0.063	160.8		847	847	847	53.6	53.6	53.6
31%	Haa	96.4	100	100	100		2,060	728	802	0.031	24.9		267	267	267	8.3	8.3	8.3
100%	Paro	96.5	100	100	100		8,383	1,184	1,477	0.100	147.7		492	492	492	49.2	49.2	49.2
81%	Thimphu	96.3	100	100	100		2,503	520	612	0.081	49.7		204	204	204	16.6	16.6	16.6
							21,092	4,319	5,431	0.071	383.0		1810	1810	1810	127.7	127.7	127.7
2	% households with *functional* piped water supply	% function	% function	% function	% function	100% coverage achievable in 14th FYP - based on functionality	Nr. HHs	Add'l HHs 2033	Nr of connections to improve by 2033	Cost of rehab/ HH in Mln Ngu	Total Cost in Mln Ngu		Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	63.0	75	88	100	Gap proportionally closed over time	8,146	1,888	4,902	0.025	77.6		1634	1634	1634	25.9	25.9	25.9
31%	Haa	43.0	62	81	100		2,060	728	1,902	0.025	14.7		634	634	634	4.9	4.9	4.9
100%	Paro	27.0	51	76	100		8,383	1,184	7,303	0.025	182.6		2434	2434	2434	60.9	60.9	60.9
81%	Thimphu	99.0	99	100	100		2,503	520	545	0.025	11.1		182	182	182	3.7	3.7	3.7
							21,092	4,319	14,652	0.020	286.0		4884	4884	4884	95.3	95.3	95.3
3	% households with water-sealed sanitation	%	%	%	%	90% coverage achievable in 14th FYP	Nr. HHs	Add'l HHs 2033	Nr of sealed toilets to put in by 2033	Unit Cost in Mln Ngu	Total Cost in Mln Ngu		Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	58.2	69	79	90	Gap proportionally closed over time	8,146	1,888	4,479	0.18	510.3		1493	1493	1493	170.1	170.1	170.1
31%	Haa	32.5	52	71	90	presently pit + improved latrines	2,060	728	1,912	0.18	106.7	cost to be borne by private individuals. RGOB cost on subsidy @ 50%	637	637	637	35.6	35.6	35.6
100%	Paro	61.2	71	80	90	baseline figures to be checked	8,383	1,184	3,598	0.18	647.6		1199	1199	1199	215.9	215.9	215.9
81%	Thimphu	79.7	83	87	90		2,503	520	777	0.18	113.6		259	259	259	37.9	37.9	37.9
							21,092	4,319	10,766	0.128017428	1378.2		3589	3589	3589	459.4	459.4	459.4
											689.1	RGOB subsidy @ 50%						
SUB TOTAL KD1											**1358.1**		**6,694**	**6,694**	**6,694**	**223**	**223**	**223**

KD2 Economic water security

INDICATORS						ASSUMPTIONS	TOTAL WORKLOAD			TOTAL COST ESTIMATES		REMARKS	WORKLOAD			COST		
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**	**Assumptions**					**Total Cost in Mln Ngu**		**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
1	% arable land irrigated	%	%	%	%	Irrigated area increased by 50% in 14th FYP - as per NIMP	Irrigated area, in acres		Increase in acres	Unit Cost in Ngu/ acre	Total Cost Mln BTN		Acres	Acres	Acres	Mln Ngu	Mln Ngu	Mln Ngu
63%	Chukha	16.2	19	22	24.3	Gap proportionally closed over time	4443.53		2,222	95,000	133.61	NIMP: 95000 per acre	741	741	741	44.5	44.5	44.5
31%	Haa	14.2	17	19	21.3		219.83		110	95,000	3.24		37	37	37	1.1	1.1	1.1
100%	Paro	28	33	37	42		4329.91		2,165	95,000	205.67		722	722	722	68.6	68.6	68.6
81%	Thimphu	20.9	24	28	31.35		1131.26		566	95,000	43.63		189	189	189	14.5	14.5	14.5
									5,062		386.15		1687	1687	1687	128.7	128.7	128.7
2	% of potential hydropower developed	%	%	%	%	Follow plans MOEA	see plans DHPS-MOEA		Unit cost in Mln Ngu		Total Cost in Mln Ngu					Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	60	73	87	100	Wangchhu (570 MW) + Bunakha (180 MW)			40,608 + 29,527		70,135					23378.3	23378.3	23378.3
100%	Haa	0	0	0	0											0.0	0.0	0.0
100%	Paro	0	33	67	100	Pachhu (114 MW)			18,000		18,000					6000.0	6000.0	6000.0
100%	Thimphu	0	33	67	100	Thimphuchhu (57 MW) + Cherichhu (76 MW)			9,000 + 12,000		21,000					7000.0	7000.0	7000.0
											109,135					36378.3	36378.3	36378.3
3 TOTAL KD2											**109,521**					**36,507**	**36,507**	**36,507**

KD3	Urban water security and drainage																		
INDICATORS						ASSUMPTIONS	TOTAL WORKLOAD			TOTAL COST ESTIMATES		REMARKS	WORKLOAD			COST			
Nr.	Indicator	Baseline	12th FYP	13th FYP	14th FYP	Assumptions					Total Cost in Mln Ngu		12th FYP	13th FYP	14th FYP	12th FYP	13th FYP	14th FYP	
1	% of urban households with piped water supply	%	%	%	%	100% coverage is possible in 14th FYP - based on investments	Nr of HHs 2015	Add'l HHs by 2033	Nr HH to be connected	Cost per HH in Mln Ngu	Total Cost in Mln Ngu		Nr HHs	Nr HHs	Nr HHs	Mln Ngu	Mln Ngu	Mln Ngu	
100%	Chukha	92	95	97	100	Gap proportionally closed over time	1,854	341	490	0.02	9.80		163	163	163	3.3	3.3	3.3	
100%	Haa	96	97	99	100		646	220	245	0.02	4.91		82	82	82	1.6	1.6	1.6	
100%	Paro	96	97	99	100		732	244	273	0.02	5.46		91	91	91	1.8	1.8	1.8	
100%	Thimphu	96	97	99	100		23,902	3,171	4,127	0.02	82.54		1376	1376	1376	27.5	27.5	27.5	
							27,134	3,976	5,135	0.02	102.70		1712	1712	1712	34.2	34.2	34.2	
2	% of households with *treated* piped water supply	%	%	%	%	90% coverage is possible in 14th FYP - based on investments	Nr of HHs	Add'l HHs by 2033	Nr HH to have treated water	Unit Cost in Mln Ngu	Total Cost in Mln Ngu	Remarks	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu	
100%	Chukha	56	67	79	90	Gap proportionally closed over time	1,854	341	1,157	5	5	Nu. 5 million for One Treament Plant (2 to 2.5 MLD for 6,800 HHs)	386	386	386	1.67	1.67	1.67	
100%	Haa	27	48	69	90		646	220	691	5	5		230	230	230	1.67	1.67	1.67	
100%	Paro	7	35	62	90		732	244	924	5	5		308	308	308	1.67	1.67	1.67	
100%	Thimphu	90	90	90	90		23,902	3,171	5,561	5	5		1854	1854	1854	1.67	1.67	1.67	
							27,134	3,976	8,334	0.002	20	Total figure	2778	2778	2778	6.7	6.7	6.7	
							6,784		2,083	**0.002**	**5**	**Average figure**							
3	Urban water lost (not accounted for)	%	%	%	%	No baseline data available.	Nr of HHs	Add'l HHs by 2033	Target	Cost/ yr in Mln Ngu	Total cost in Mln Ngu	Remarks	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu	
100%	Chukha	?					1,854	341	2,195	0.675	10.125	An average of Nu. 0.30 m for Annual maintenance (WSP) Paro with 7,000 inhabitants - includes metering	732	732	732	3.4	3.4	3.4	
100%	Haa	?					646	220	866	0.27	4.0		289	289	289	1.3	1.3	1.3	
100%	Paro	?					732	244	976	0.3	4.5		325	325	325	1.5	1.5	1.5	
100%	Thimphu	?					23,902	3,171	27,073	8.33	124.9		9024	9024	9024	41.6	41.6	41.6	
							27,134	3,976	31,110		143.5	assuming immediate installation	10370	10370	10370	47.8	47.8	47.8	
4	% households without sewage treatment	%	%	%	%	Bring figure below 10% by 14th FYP	Nr of HHs	Add'l HHs by 2033	Nr HHs to be connected	Unit Cost	Total Cost in Mln Ngu	Remarks	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu	
100%	Chukha	22	18	14	10	Gap proportionally closed over time	1,854	341	564	20	1.66	A sewage network and treatment plant cost for single town. The cost of the structure is on average of four towns	188	188	188	0.6	0.6	0.6	
100%	Haa	18	15	13	10		646	220	271	20	0.80		90	90	90	0.3	0.3	0.3	
100%	Paro	2			2		732	244	244	20	0.72		81	81	81	0.2	0.2	0.2	
100%	Thimphu	7			7		23,902	3,171	3,171	20	9.35		1057	1057	1057	3.1	3.1	3.1	
							6,784			**20**		**Average figure**							
							27,134	3,976	4,250		12.53	Total figure	1417	1417	1417	4.2	4.2	4.2	
5	% households with solid waste disposal	%	%	%	%	Increase figure by 10%-point by 14th FYP	Nr of HHs	Add'l HHs by 2033	Nr HHs to be served	Unit Cost	Total Cost in Mln Ngu	Remarks	Nr. HHs	Nr. HHs	Nr. HHs	Mln Ngu	Mln Ngu	Mln Ngu	
100%	Chukha	34	37	41	44	Gap proportionally closed over time	1,854	341	527	10	0.78	Cost for one sanitary landfill for single town including collection system. Recurrent cost of collection system?	176	176	176	0.3	0.3	0.3	
100%	Haa	25	28	32	35		646	220	284	10	0.42		95	95	95	0.1	0.1	0.1	
100%	Paro	16	19	23	26		732	244	317	10	0.47		106	106	106	0.2	0.2	0.2	
100%	Thimphu	7	10	14	17		23,902	3,171	5,561	10	8.20		1854	1854	1854	2.7	2.7	2.7	
							6,784			**10**		**Average figure**	2230	2230	2230	3.3	3.3	3.3	
							27,134	3,976	6,689		9.86	Total figure							
TOTAL KD3											**289**		**18506**	**18506**	**18506**	**96**	**96**	**96**	

NB: KD4 - Environmental water security indicators are presently not actionable, hence used for monitoring only

KD5	Resilience to water-related disaster																	
INDICATORS						ASSUMPTIONS	TOTAL WORKLOAD		TOTAL COST ESTIMATES		REMARKS	WORKLOAD			COST			
Nr.	**Indicator**	**Baseline**	**12th FYP**	**13th FYP**	**14th FYP**	**Assumptions**				**Total Cost in Mln Ngu**		**12th FYP**	**13th FYP**	**14th FYP**	**12th FYP**	**13th FYP**	**14th FYP**
4	Emergency response Mechanism	Nr.	Nr.	Nr.	Nr.	Basin-level revolving fund @ Ngu 5 million	Nr. EOCs to set-up		Unit Cost	Total Cost in Mln Ngu					Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	0								5	Alternative approach - to be elaborated				1.67	1.67	1.67
100%	Haa	0															
100%	Paro	7															
100%	Thimphu	0															
5	(Rural) water storage	MCM	MCM	MCM	MCM	Create storage for 10% needy HHs for 2 months domestic water supply	Storage Volume m3		Unit Cost	Total Cost in Mln Ngu		Storage Volume m3			Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha		17,361	to be determined			17,361		see worksheet	174	includes restoration of lakes	17,361			174		
100%	Haa		6,763				6,763			68		6,763			68		
100%	Paro		35,249				35,249			352		35,249			352		
100%	Thimphu		144				144			1		144			1		
			59,517				59,517			595		59,517			595		
6	Flood hazard zonation	Nr.				Flood hazard zonation maps done by Bhu-8623 to be elaborated	X	X	X	X		ha	ha	ha	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	1				More detailed elaboration needed		Basin figure			Departmental work, no major cost involved?						
100%	Haa	1				Demarkation on the ground needed											
100%	Paro	1				Action ranks under flood protection measures											
100%	Thimphu	1				pending											
7	Flood protection mesasures pending	Nr.				Implement flood-protection measures based on flood-prone areas assessed under Bhu-8623			Unit Cost in Mln Ngu/m	Total Cost in Mln Ngu		m length	m length	m length	Mln Ngu	Mln Ngu	Mln Ngu
100%	Chukha	0							0.126	tba		tba	tba	tba	tba	tba	tba
100%	Haa	1				depending on workload/ cost				tba	Gabion wall, on average 2m wide, 3m high @ 0.021 mln/ m3						
100%	Paro	1				by 12th, 13th or 14th FYP				133.6		4500			133.6		
100%	Thimphu	1								tba							
										133.6		4500			133.6		
8	Flood/ GLOF Early Warning					Implement Early Warning System(s)				Total Cost in Mln Ngu							
100%	Chukha	3	1	2	3	depending on workload/ cost		See DHMS activities									
100%	Haa	0				by 12th, 13th or 14th FYP											
100%	Paro	0															
100%	Thimphu	0															
3 TOTAL KD5										**734**					**730.4**	**1.7**	**1.7**
GRAND TOTAL OF PLANNED EXPENDITURES TILL 2033 IN FOUR DZONGKHAGS (INCLUDING INCREASE OF POPULATION) IN MILLION NGULTRUM										**111,902**					**37,557**	**36,828**	**36,828**