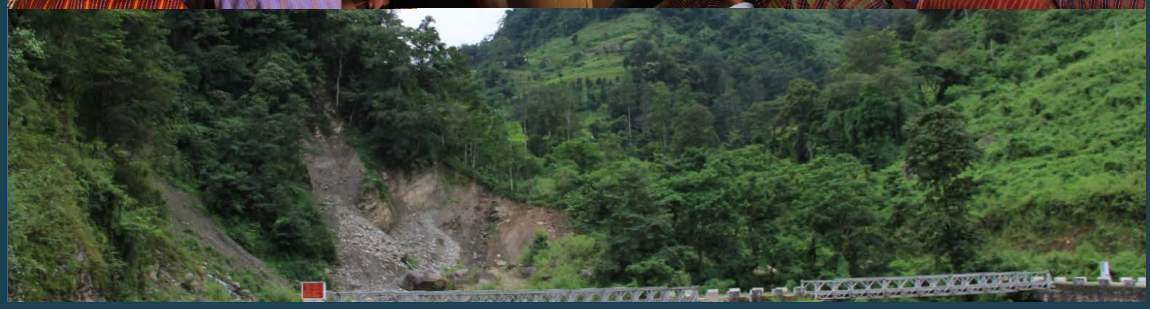
Watershed Management Plan
for
Three sub-degraded watersheds in Dagachhu sub-basin Punatsangchhu Basin
(Buedulumchhu-Balaychhu-Zharingaychhu)



WATERSHED MANAGEMENT DIVISION
Department of Forests & Park Services
Ministry of Agriculture & Forests
June 2017

Watershed Management Plan

for

Three sub-degarded watersheds in Dagachhu sub-basin
Punatsangchhu Basin
(Buedulumchhu-Balaychhu-Zharingaychhu)

June 2017

Ministry of Agriculture & Forest
Royal Government of Bhutan

© Watershed Management Division
Department of Forest & Park Services
Ministry of Agriculture & Forests, 2017

Reference/Citations:

Phuntshok, J. 2017: Watershed Management Plan for Three sub- degraded watersheds in Dagachhu sub-basin, Punatsangchhu Basin, Department of Forest & Park Services, Ministry of Agriculture & Forest.

Cover designed by: Jamyang Phuntshok
Back cover photo: Mural of bio-resource sustainability, stairways, RSPN Building

སོ་ནམ་དང་ནགས་ཚལ་ལྷན་ཁག།
ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture & Forests
Tashichhodzong, Thimphu : Bhutan

MESSAGE

The physiographic position of Bhutan renders the whole country into a mosaic of watersheds that produce a regular supply of high quality water. The combined outflow of the rivers, which is estimated at 2,238 m^3/s is the highest in the region. In spite of this, there are many incidences of water shortages and spring dryings across the country reported in the media. Such incidences were rare in the past, possibly due to the lower population pressure, less water usage and normal rainy season. As the country has undergone rapid development, the use of water has greatly increased and at the same time, the studies have shown that there was erratic rainfall pattern observed over the last two decades in number of stations spread across the country and this trend is likely to continue in the future. Nevertheless, thanks to our visionary leaders, a series of Policies, Acts, Regulations and Rules have been put in place that aim to provide maximum protection of our environment while ensuring that the country will have adequate supplies of high quality water for both national and local development in the future.

In addition to water for drinking and irrigation, Bhutan has embarked on an ambitious programme to develop its hydropower resources to substantially increase revenue from hydropower generation. This is very much dependent on a sustainable supply of high quality water. Hence, efficient and effective management of the country's watersheds is critical to this national endeavor.

Despite strong efforts to protect the nation's watersheds, the health and quality of some watersheds continue to decline. Climate change and human activities have both caused detrimental effects resulting in a reduction in the provision of watershed goods and services. For example, physical alteration of the landscape,such as the removal of riparian vegetation, can have adverse effects on the quality and quantity of water.

However, the provision of watershed goods and services is a complex issue that cannot bedealt by a single agency. We need to adopt an integrated management approach that involves multiple agencies, including local stakeholders.

PHONE: +975-2-322482, 322129(O) FAX: +975-323153

རྒྱལ་སྡེ།
MINISTER

རྒྱལ་ཡོངས་རྒྱལ་སྐོལ་ལྷན་ཁག།
ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture & Forests
Tashichhodzong, Thimphu : Bhutan

The Watershed Management Division (WMD) has delineated 186 watersheds within the five major and two minor river basins across the country and is systematically assessing them for status and condition. The Water Act of Bhutan (2011) and the Water Regulation (2014) mandates WMD to undertake watershed management. Accordingly WMD undertook to develop a watershed management plan for three degraded sub-watershed within Dagachhu sub-basin. As the first plan for degraded watershed, the lessons learned from this exercise will provide guidance in developing similar management plans in the future.

I am pleased to convey that WMD under the Department of Forest and Park Services has developed its first watershed management plan for the degraded watershed. I would like to recommend that all the relevant agencies within the Ministry of Agriculture and Forests, and beyond, to support the implementation of the activities outlined in the plan, to achieve its goal and objectives. Let me take this opportunity to particularly urge Dagana Dzongkhag Administration and other relevant agencies within the sub-basin to mainstream this plan in their respective plans within the 12thfive-year plan. I am confident that this integrated and holistic plan will enhance the provision of watershed goods and services to benefit the communities of Goshi, Gesaring and Kana Geogs.

Finally, I would like to express my appreciation to Watershed Management Division, the planning team and other stakeholders who were involved in developing this plan and I look forward to its successful implementation.

Yeshey Dorji

Minister

PHONE: +975-2-322482, 322129(O) FAX: +975-323153

ས་ནམ་དང་ནགས་ཚལ་ལྷན་ཐག།
ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture & Forests
Tashichhodzong, Thimphu : Bhutan

MESSAGE

Watersheds support habitat for plants and animals, and they provide drinking water for people and wildlife. They also provide the opportunity for recreation and enjoyment of nature. Protection of the natural resources in our watershed is essential to maintain the health and wellbeing of all living things, for now and future.

Particularly for a country like Bhutan, being a rugged mountainous country, we depend on watersheds for our livelihood. Besides agriculture, Bhutan's economy is mainly driven by hydropower and tourism, which depend on positive state of the watersheds. As such, protecting and managing watersheds to sustain their primary functions in provisioning and regulating is of utmost importance. Therefore, the watershed approach to natural resource management was adopted and watershed management became one of the priority focal areas of the Department of Forest & Park Services (DoFPS). The watershed management approach can provide a unique and effective way to assess the environment, identify problems, establish priorities for preservation, and to implement solutions based on a holistic and cross-sectoral manner. To this effect, Watershed Management Division was created with the vision "to ensure effective and integrated watershed management to maintain and improve water & watershed conditions and contribute to sustainable livelihoods through provision of watershed services".

Since its establishment, the Watershed Management Division has played its part in adopting appropriate polices and strategies to guide the process forward including the development of a Roadmap for Watershed Management in Bhutan, and a Guideline for the Classification of Watersheds, amongst others. Rapid assessment and classification of watersheds for the Wangchhu and Punatsangchhu basins was carried out in 2011 and critical watersheds were identified. As of now, WMD has completed the rapid assessments of Mangdechhu, Chmakharchhu, Kurichhu and Kholongchhu sub-basins besides the aforementioned basins. The division is currently at the various stages of developing management plans for watersheds identified as degraded in those sub-basins. The plans are being developed in

PHONE: +975-2-322379, FAX: +975-326834

consultations with Dzongkhag, Geog and other relevant agencies at regional and national levels.

I would like to congratulate Watershed Management Division for developing this watershed management plan for Buedulumchhu-Balaychhu-Zharingaychhu sub-watershed under Dagana Dzongkhag. I sincerely hope that respective stakeholders and agencies identified in the plan will successfully implement the activities and contribute to the effort of sustainably managing the watersheds.

Rinzin Dorji
SECRETARY

Watershed Management Division was created in 2009 as one of the functional divisions under the Department of Forest & Park Services with the vision "to ensure effective and integrated watershed management to maintain and improve water & watershed conditions and contribute to sustainable livelihoods through provision of watershed services".

As a competent authority under Water Act of Bhutan 2011 and Water Regulation 2014, Watershed Management Division adopted appropriate polices and strategies to guide the process forward with the development of a Roadmap for Watershed Management in Bhutan, and a Guideline for the Classification of Watersheds, amongst others. Rapid assessment and classification of watersheds was carried out since 2011 starting from Wangchhu Basin and currently, Watershed Management Division has completed the same in Mangdechhu, Chmakharchhu, Kurichhu and Kholongchhu sub-basins and Punatsangchhu Basin besides Wangchhu. Several degraded watersheds were identified in those basins/sub-basins and management planning are underway in collaboration with relevant stakeholders both at national and local levels.

Buedulumchhu-Balaychhu-Zharingaychhu sub-watershed is located within the Dagachhu sub-basin under Punatsangchhu Basin. It was identified as a degraded watershed, during the rapid assessment in 2011 prompting the development of the present watershed management plan. The plan outlines the implementation of activities based on locally appropriate strategies to ensure sustainable management of the watershed. The plan is an outcome of extensive consultations at Dzongkhag and Geog levels, as well as technical field assessments by subject matter specialists elaborated into concrete interventions in the course of write-shops and consultations at the national level.

འབྲུག་གྱལ་ཡོངས་ཀྱི་རྒྱལ་ཞབས།
ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture and Forests
ནགས་ཚལ་དང་སྐྱོང་ཀ་ཞབས་དེགས་ལས་ཁུངས།
DEPARTMENT OF FOREST & PARK SERVICES

I would like to congratulate Watershed Management Division for developing this watershed management plan. I sincerely hope that respective stakeholders and agencies identified in the plan will successfully implement the activities and contribute to the effort of sustainably managing the watersheds.

Phento Tshering
DIRECTOR

P.O Box # 1345, Thimphu, Tele # +975 (02) 321185/322487, EPABX #: +975 (02) 334458/334487

ACKNOWLEDGEMENTS

The watershed Management Plan for three degraded sub-watershed under Dagachhu sub-basin is an outcome of a collaborative process that involved many stakeholders from field offices, ministries and other agencies at the national level. The plan has come a long way since the assessment of the sub-watershed in early 2011. The process began by undertaking a consultation workshop involving sector heads from Dagana Dzongkhag Administration followed by consultations with local leaders, RNR extension officers, communities and other agencies of Goshi, Gesarling and Kana geogs.

The draft of the watershed management plan was developed and improved through several write shops attended by specialists and senior officers from MoAF and consultation meetings with all the relevant stakeholders. WMD sincerely thanks all involved for their valuable contributions and support. It was further peer reviewed and edited by Dr. Don Gilmour, a senior Australian Volunteer attached with the Watershed Management Division. We also thank Dr. Don for his sincere and tireless effort in bringing this plan in to proper format.

While the initial planning activities were entirely through RGoB support, it was later supported by BC-CAP project funded by Government of Austria to carry out several consultation meetings and field works. Further, studies carried out by Masters and PhD students under the same project also contributed to this plan. We thank BC-CAP Project and students for their contribution.

Finally, WMD would also like to thank all the agencies and individuals involved throughout the entire process of developing this watershed Management Plan for three degraded sub-watersheds within Dagachhu sub-basin, and in particular the MoAF and the DoPFS for their continuous support and guidance.

GLOSSARY OF BHUTANESE TERMS

Chhu	River
Chiwog	Village or a group of villages
Chuzhing	Paddy field
Dzong	Fort/monastery
Dzongda	District Administrator
Dzongkhag	District
Dratshang	Monk body
Geog	Block/administrative unit/County
Gup	Elected leader of a geog
Kamzhing	Dryland
Mangmi	Deputy elected leader of a geog
RNR Tshogpa	Village agriculture/livestock cooperative
Tshogpa	Chiwog representative

LIST OF ABBREVIATIONS

a.s.l	above sea level
AI	Artificial Insemination
BNB	Bhutan National Bank
BoB	Bank of Bhutan
BPC	Bhutan Power Corporation
CF	Community Forest
CFMG	Community Forest Management Group
CFO	Chief Forest Officer
DAMC	Department of Agriculture & Marketing Cooperatives
DAO	Dzongkhag Agriculture Officer
DHMS	Department of Hydromet Services
DE	Dzongkhag Engineer
DES	Department of Engineering Services
DFO	Divisional Forest Officer
DPO	Dzongkhag Planning Officer
DoA	Department of Agriculture
DoL	Department of Livestock
DoFPS	Department of Forest and Park Services
DoR	Department of Roads
DzEdu.O	Dzongkhag Education Officer
DzEnvi.O	Dzongkhag Environment Officer
DzFO	Dzongkhag Forest Officer
DWMC	Dzongkhag Water Management Committee
EFRC	Environmentally Friendly Road Construction
FMU	Forest Management Unit
FNCR	Forest & Nature Conservation Rule
GAEO	Geog Agriculture Extension Officer
GAO	Geog Administrative Officer
GFEO	Geog Forestry Extension Officer
GLEO	Geog Livestock Extension Officer
GNH	Gross National Happiness
GRF	Government Reserve Forest
ha	Hectare
HH	Household
HP	Hydropower Plant
HWC	Human Wildlife Conflict
Km	kilometer

LRO	Land Record Officer
m	Meter
mm	Millimeter
M & E	Monitoring & Evaluation
MoAF	Ministry of Agriculture and Forest
MoH	Ministry of Health
MoE	Minisrty of Education
MoWHS	Ministry of Works & Human Settlement
MP	Management Plan
MW	Mega Watt
NDDC	National Dairy Development Cooperation
NFFDP	National Feed & Fodder Development Program
NSSC	National Soil Service Center
NPPC	National Plant Protection Center
NWFP	Non-wood Forest Product
PA	Protected Area
PER	Potential Evapo-transpiration Ratio
PES	Payment for Environmental Services
PRA	Participatory Rural Appraisal
PVC	Poly Vinyl Chloride
RBA	Royal Bhutan Army
RGoB	Royal Government of Bhutan
RBC	River Basin Committee
RBMP	River Basin Management Plan
RGoB	Royal Government of Bhutan
RDC	Research Development Center
RLDC	Regional Livestock Development Center
RNR	Renewable Natural Resource
RWSS	Rural Water Supply Scheme
SFED	Social Forestry & Extension Division
SLM	Soil & Land Management
ToR	Terms of Reference
WCD	Wildlife Conservation Division
WM	Watershed Management
WMC	Watershed Management Committee
WMD	Watershed Management Division
WMP	Watershed Management Plan
WUA	Water Users' Associations

EXECUTIVE SUMMARY

The Punatsangchhu basin is one of the most important river basins in Bhutan. It encompasses a total area of almost 10,000 km^2 and drains through west-central Bhutan and includes all or part of the Gasa, Punakha, Wangdue, Tsirang and Dagana Dzongkhgas. It covers a wide variety of agro-ecological zones from sub-tropical in the south (min altitude 100 m) to snowcapped mountains in the north (at over 7000 m).

Following a rapid assessment and classification carried out for this basin in 2011 (WMD 2010), five of the 52 watersheds were classified as "degraded" which triggered the requirement for a watershed management plan for each of them. This watershed management plan covers three sub-watersheds (Buedulumchhu, Balaychhu and Zharingaychhu), which form part of one of these degraded watersheds. They fall within the Dagachhu sub-basin.

The sub-watersheds that are subject to this management plan are in a geologically unstable area and are vulnerable to landslides and mass soil movements, particularly along the lower valleys. The terrain of the sub-watersheds is steep which contributes to soil erosion, particularly on agricultural fields, as well as damage to the irrigation system. There is high pressure on the natural resources as evidenced by degraded forest conditions. Human activities undertaken very close to stream banks and poorly constructed and drained farm roads have further exacerbated the watershed degradation problems. Human-wildlife conflict is high throughout the watershed and citrus greening is prevalent.

A participatory planning process was used to identify degrading influences and propose solutions to the problems. Consultative meetings were conducted with stakeholders at the dzongkhag, geog and chiwog levels and findings were refined through technical field assessments and expert writeshops. Information gaps were filled using information from various focal agencies/persons. A Logical Framework Analysis was carried out to identify specific outputs and activities that would address the degrading influences and, to the greatest extent possible, return the sub-watersheds to “normal” or “pristine” condition. Where possible, the activities proposed in the plan aim to enhance the livelihood of local communities in the context of climate change. The goal and objectives of the plan are:

Goal: Balaychhu-Buedulumchhu-Zharingaychhu sub-watersheds sustainably managed to minimize degradation and enhance provision of watershed goods and services for rural livelihoods in the context of climate change.

Objective 1: To minimize degrading influences and improve watershed condition.

Objective 2: To enhance supply of quality water for domestic and irrigation purposes.

The activities identified in the plan will be integrated into the area-based development and conservation plans of the sectoral programs and the decentralized Dzongkhag and Geog plans.

CONTENTS

1. BACKGROUND

In the Tenth Five-Year Plan the Punatsangchhu basin was selected for watershed management planning, because of the presence of degrading influences in several watersheds and the potential for adverse impacts on several large hydropower projects currently being commissioned within the basin.

The Punatsangchhu basin covers a total area of 9,725 km2 comprising all of Punakha, Tsirang and Dagana Dzongkhags, and part of Gasa, Wangdue, and Thimphu Dzongkhags (Table 1).

Table 1:Dzongkhags and Geogs in the Punatsangchhu basin

Dzongkhag	Geogs in WS	Area in WS(km^2)	Population	Population density [No. of people per km^2]
Gasa	4	2,940	3,116	1.1
Punakha	11	1,109	23,462	21.1
Wangdue	15	3,076	31,135	10.1
Dagana	14	1,616	22,670	14.0
Tsirang	12	635	13,419	21.1
Thimphu	1	337		

The altitude in the Punatsangchhu basin ranges from about 150m in the south to 7100 m in the north and contains different agro-ecological zones ranging from sub-tropical in the downstream parts of the basin (Tsirang, Dagana); through warm temperate in the higher hills of Wangdue and Punakha to arid alpine in the north of the basin (Gasa and higher areas of Wangdue, Punakha and Thimphu Dzongkhags). The main ridge of the Himalaya forms the northern boundary of the basin.

Basochhu and Dagachhu hydropower plants operate within the basin and two more plants (Punatsangchhu I and II) are under construction. Additionally, Sunkosh hydropower plant is being planned. Once completed, the total production capacity will reach 4950 MW of electricity. The basin also contains significant historical monuments, such as Punakha Dzong, Wangduephodrang Dzong, Gasa Dzong and Dagana Dzong.

2. INTRODUCTION

As outlined in the FNC Rules (2017) a watershed management plan is required if a watershed is classified as “degraded” or “critical” following the application of the Watershed Classification Guidelines (2016). The purpose of such watershed management plans is to address the degrading influences and attempt (to the greatest extent possible) to return the watersheds to a “normal” or “pristine” condition.

The Punatsangchhu basin comprises 52 watersheds. Using the Guideline for Classification of Watersheds (WMD, 2010), five of the 52 watersheds were classified as "critical " in 2011 (Figure 1 and Table 2), triggering the requirement to develop watershed management plans, (WMD, 2011).

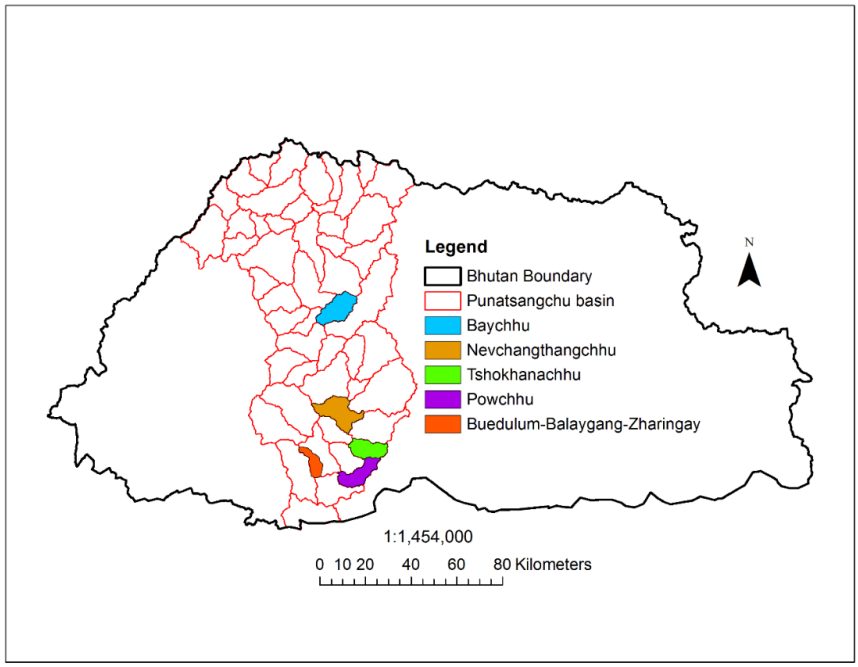


Figure 1:Punatsangchhu basin showing five watersheds classified as degraded

Table 2:Degraded watersheds/sub-watersheds within Punatsangchhu basin

Dzongkhag	Degraded Watersheds/sub-watersheds	Area [ha]
Wangdue Dzongkhag	Baychhu	14,658
Tsirang Dzongkhag	Powchhu	11,488
	Nevchanthangchhu	17,502
	Tsokhanachhu	10,997
Dagana Dzongkhag	Buedulumchhu-Balaychhu-Zharingaychhu	6,422

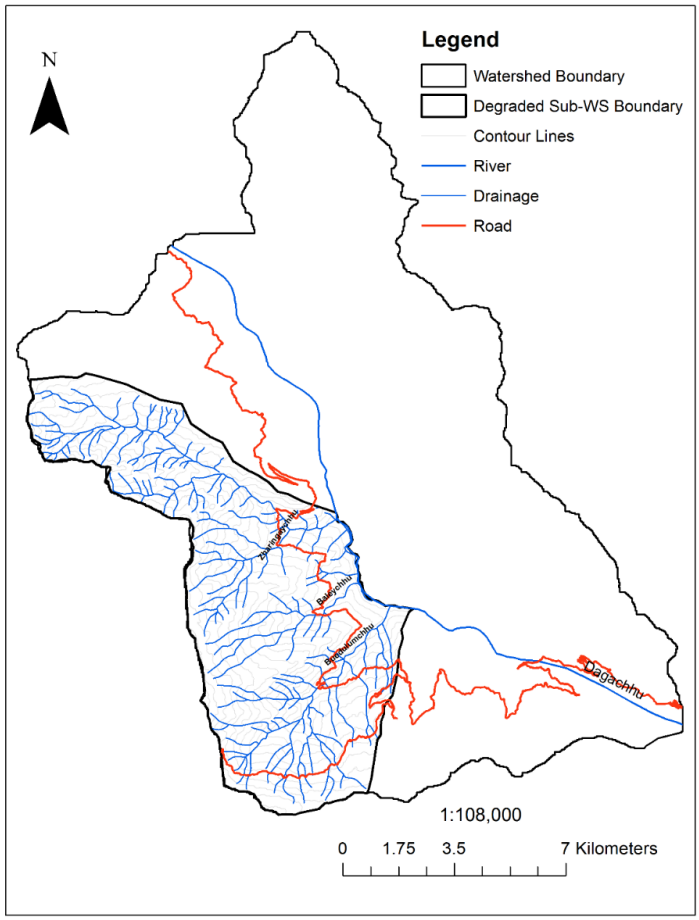


Figure 2:Watershed 144 with three degraded sub watersheds for which this plan is developed

This watershed management plan has been prepared for three degraded sub-watersheds in Dagana Dzongkhag: Buedulumchhu, Balaychhu and Zharingaychhu which form part of the Dagachhu sub-basin in the Punatsangchhu basin (Figure 2). These three sub-watersheds will be referred to through this plan as "the degraded watershed".

3. PLANNING PROCESS

A basic premise of watershed management planning in Bhutan is that the activities identified as being necessary to achieve the purpose, goal and objectives of the plan will be reflected in the operational plans of the dzongkhag, geogs and other area based management agencies operating in the watersheds. For this to be achieved, it is necessary for the plan to be developed in a participatory manner with the active involvement of key stakeholders. Accordingly, consultative meetings were conducted with stakeholders at the dzongkhag, geog and chiwog levels and findings were refined through technical field assessments and expert write shops. Information gaps were filled using information from various focal agencies/persons. A range of issues and problems that contribute to the degradation of the sub-watersheds was identified from this process, and addressing these was the basis for formulating the plan. The consultation process is outlined below.

Consultations at dzongkhag level

The planning process started by holding consultative meetings with the Dagana Dzongkhag Administration. The results of the watershed assessment in Punatsangchhu Basin and the identification of degraded watersheds were presented at the meetings. Problems causing degradation of the watersheds were discussed and measures to resolve them were suggested. The consultation workshop was attended by RNR and other sector heads at the dzongkhag.

Consultations at geog level

After the meeting with stakeholders at the dzongkhag level, meetings were held in the geogs falling within the degraded watershed to narrow down the problems and come up with possible remedial measures. The participants of the geog meeting were Gups, Geog Administration Officers, RNR-Extension Agents, staff from the Territorial Forest Division, Mangmis, Tshogpas, and some senior representatives from each geog.

During the meetings, results of the dzongkhag level meeting including an overview of problems and suggested remedial measures were presented. In addition, geog officials were asked to present the problems and suggest remedial measures from the perspective of their geogs. The meeting came up with a list of prioritized issues and relevant activities to solve those issues in the degraded watershed. For better understanding of the watershed, resource mapping of the critical watershed falling within each geog was also undertaken during the meeting.

Consultations at chiwog level and field visits

Following the field verification, prioritization of the site-specific issues and management activities were done at the chiwog level. With facilitation support from RNR geog officials accompanied the team from WMD, RDC Yusipang and Forestry Officials from Dagana Dzongkhag conducted the meetings and field visits to the respective chiwogs. At the chiwog meetings, the representatives included Chiwog Tshogpas and members from the majority of households. The chiwog level meeting was the most important one, as it helped to identify issues of each chiwog within the degraded watershed. For each issue, appropriate measures were discussed. This was followed by field visits and detailed assessments to validate the issues in the watershed.

At the chiwog level, five sets of exercises including participatory three-dimensional modelling, focus group discussions using PRA tools (participatory land use identification, land use ranking, identification of land use problems related to water, preparation of village timeline and resource mapping), transect walks, semi-structured interviews of randomly selected people, and structured questionnaires by participants were conducted (Norbu, 2015).

The participatory transect walks were combined with expert assessments by relevant officials of the Ministry of Agriculture and forests, particularly focusing on the issues raised during the participatory exercises, on road conditions (Waiba, 2015) and forest degradation (Tenzin and Hasenauer 2016).

Write shops

Following the above mentioned consultations, write shops were organized to discuss the format and contents of the plan as well as synthesizing information collected from the field. Participants of the write shops consisted of the management planning team and technical experts from relevant agencies within the Ministry of Agriculture & Forests. Additionally, GIS analysis on various issues related to watershed

management planning was carried out by the GIS Units of RNR-RDC Yusipang and WMD.

Plan formulation

The final step was the development of a Logical Framework Analysis (LFA) Matrix, building from the issues and problems (the degrading influences) identified during the various stages of the planning process. These are the influences that must be addressed or mitigated during implementation in order to return the watersheds to normal or pristine condition (to the greatest extent possible). The application of the LFA led to the development of activities, outputs, objectives and a goal for the plan.

4. ISSUES CONTRIBUTING TO WATERSHED DEGRADATION

Problems and issues that effect on the condition of the watersheds were identified at various stages of the planning process, and these are described below.

4.1. Degrading influences identified while carrying out rapid watershed assessment

As noted in Section 2, and as summarized in Table 3, numerous degrading influences were identified while carrying out the watershed assessment that, in combination, led to the watershed being classified as "degraded." These influences provide guidance to the interventions that are necessary to mitigate the degrading influences and, to the greatest extent possible, return the watershed to "normal" or "pristine" condition.

Table 3:Degrading influences identified during watershed assessment exercise

Stream	No of degrading factors	Degrading factors	Gewog
Zharingaychhu	14	Low Forest Cover, unstable Geology, high Sediment Yield, short Distance of human activities from the stream, high Presence of mass movements, numerous gullies present, high signs of overgrazing, high signs of forest degradation, heavy use of streams, poor farm roads, poor irrigation channels, high pressure on NWFPs, presence of degraded arable lands, less land management activities	Kana
Baleychhu	10	Unstable geology, high sediment yield, short distance of human activities from the steam, Numerous gullies formed, high signs of overgrazing, high use of streams, poor irrigation channels, high pressure on NWFPs, presence of mining activities, less land management activities undertaken	Goshi
Buedulumchhu	11	Unstable geology, high sediment yield, Human activities carried within the proximity of streams, high presence of mass movement, numerous gullies present, high grazing pressure, high sighs of forest degradation, poor farm roads, high pressure on NWFPs, presence degraded arable lands, No signs of land management activities carried out.	Goshi (Main user) / Gesarling (source)

4.2. Degrading influences identified during field verification missions

The following sections describe issues and problems identified throughout the planning process that contribute to watershed degradation. Some of these overlap with the issues/problems identified while carrying out the watershed assessment, and also with the issues/problems identified during community consultation

4.2.1 Geological instability

The degraded watershed partially fall within the highly unstable geological zone and high seismic hazard zone (Figure 3).

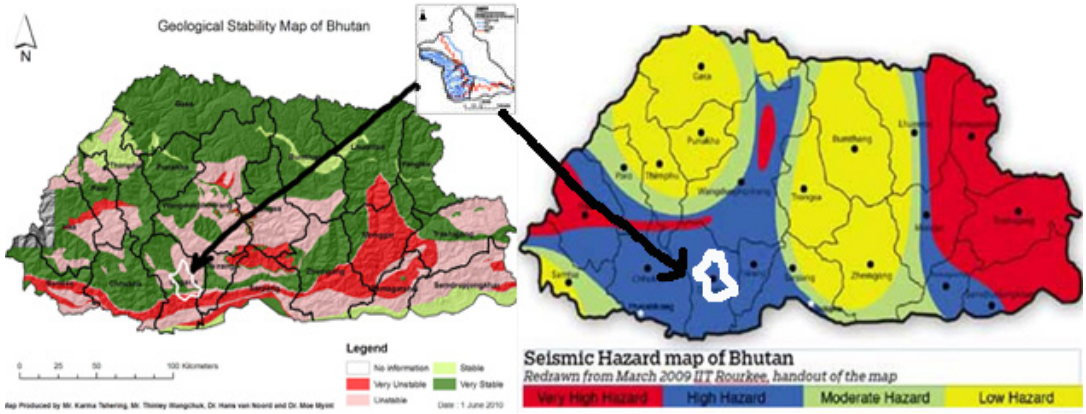


Figure 3:The geological stability map of Bhutan (left) and seismic hazard map of Bhutan (right) with location of the degraded watershed

As a consequence, landslides, mud flow and other types of mass movement are common throughout the watershed and are frequently exacerbated by improper land use practices and infrastructure development (such as inappropriate construction of roads and transmission lines). Balaychhu and its largest tributary Ghimreychhu are both heavily affected by landslides (Figure 4 to Figure 9). Due to the unfavorable geological conditions (specifically, layers of heavily weathered mica-schist acting as gliding surfaces between layers of gneiss oriented parallel to the slope) the streambed erodes rapidly, drawing loose colluvial material from the upper stream banks into the landslide. Aided by gradual caving in of stream banks, this colluvial material becomes saturated with water, which easily leads to mass movement towards the stream bed. The continuous debris flow adds considerably to stream bedload.

Another heavily affected area is along the Dagana highway in Khagochen, where a large body of fine upslope colluvial material is saturated, which leads to constant mass movement, periodically blocking the highway during monsoon seasons (Figure 7).

4.2.2. Land-use issues

a. Agricultural pests & diseases

Human-wildlife conflict is one of the most important land-use issues identified throughout the watershed. Damage of agricultural crops primarily by Assamese Macaques is the single most important problem (Figure 9), closely followed by damage inflicted by wild boar and Himalayan Black Bear.

Citrus Greening is the most important plant protection issue in the watershed. The recent rapid expansion of cardamom cultivation may bring the issue of cardamom blight once again into focus.

Figure 4: Paddy terraces on rotational slide planted with cltrus in Dogak (Nepalgaon)

Figure 5: Recent landslide along upper Balaychhu

Figure 6 : Landslide along Ghimreychhu (the main tributary of Balaychhu)

Figure 7 : Massive landslide along the highway in Khagochen

Figure 8: Landslide along upper Balaychhu

Figure 9: Farmer in Dogak lamenting crop destruction by Assamese Macaques

b. Erosion of agricultural land

Steep terrain, high precipitation and inappropriate land-use practices lead to considerable erosion of agricultural land (Figures 10 and 11). Sheet erosion occurs on steep slopes and may ultimately lead to rill erosion in places where water is channeled. In exposed locations with low vegetation cover, wind erosion may additionally exacerbate the problem. Erosion caused by inappropriate handling of irrigation water discharged from paddy terraces was observed to lead to rill and later to gully erosion in several locations.

Figure 10: Steep agricultural land with high stone cover in Pungshi

Figure11: Steep agricultural land affected by erosion in Pungshi

c. Forest degradation

A forest inventory was conducted throughout the watershed, and the area was classified into three zones based on the degradation of native vegetation and disturbance through anthropogenic activities in the watershed. These zones are:

- Settlement and Agriculture Zone
- Semi-disturbed Zone
- Natural Forest Zone

The Settlement and Agriculture Zone consists of settlements of scattered individual households surrounded by agricultural fields. This zone contains interspersed patches of private forests which are strongly protected as well as government reserve forests along stream banks.

The Semi-disturbed Zone is the most disturbed zone due to its easy accessibility and proximity to human settlements. There are clear signs of extraction of timber, fuel wood and non-wood forest products from this zone.

The Natural Forest Zone is the least disturbed zone, as there are no anthropogenic disturbances, except rare collection of non-Wood forest products and limited forest grazing. The Natural Forest Zone is not easily accessible due to the terrain and its greater distance from the Settlement and Agriculture Zone (Figure 12).

The forest inventory showed that tree density, basal area and volume were highest in the Natural Forest Zone, as were species diversity (Shannon and Simpsons) and species richness. A decline in canopy cover and lower biodiversity were apparent in the Semi-disturbed Zone. The main direct drivers of forest degradation are harvesting for timber and fire wood, cattle grazing and natural hazards, such as landslides. Cattle grazing in particular is an important driver of land degradation in certain areas within the watershed because of its adverse effect on tree regeneration, e.g. the upper Buedulumchhu sub-watershed. Land use change as an indirect driver is not prevalent within the watershed (Tenzin & Hasenauer, 2016).

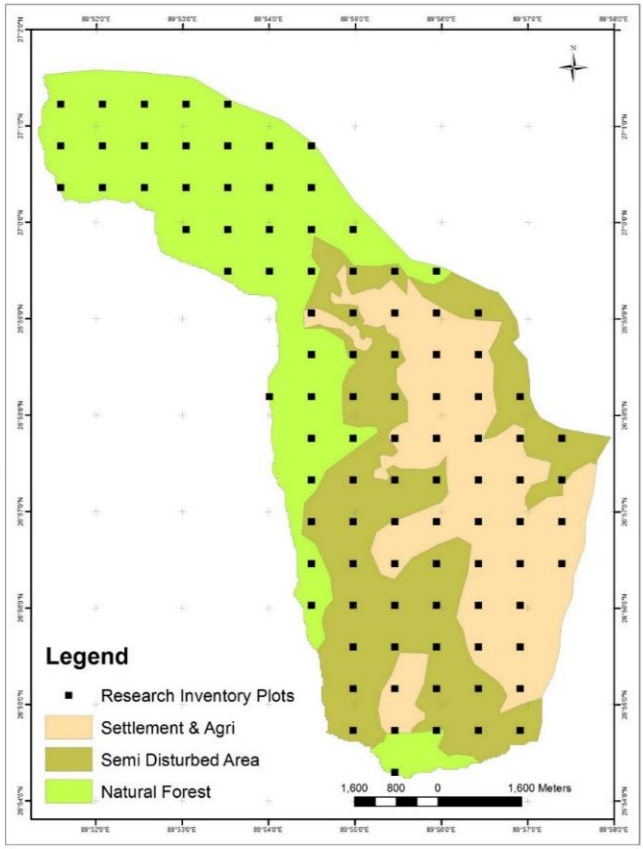


Figure 12:Degraded sub-watersheds showing zones of disturbance (Tenzin & Hasenauer, 2016)

It is evident that pressure on the forests is high and has resulted in them becoming degraded where population density is highest (Figure 13). Landslides and landslips have also increased along the lower valleys. With the advent of development activities within the watershed, the demand for use of natural resources is expected to increase, which will place additional pressure on the remaining forests.

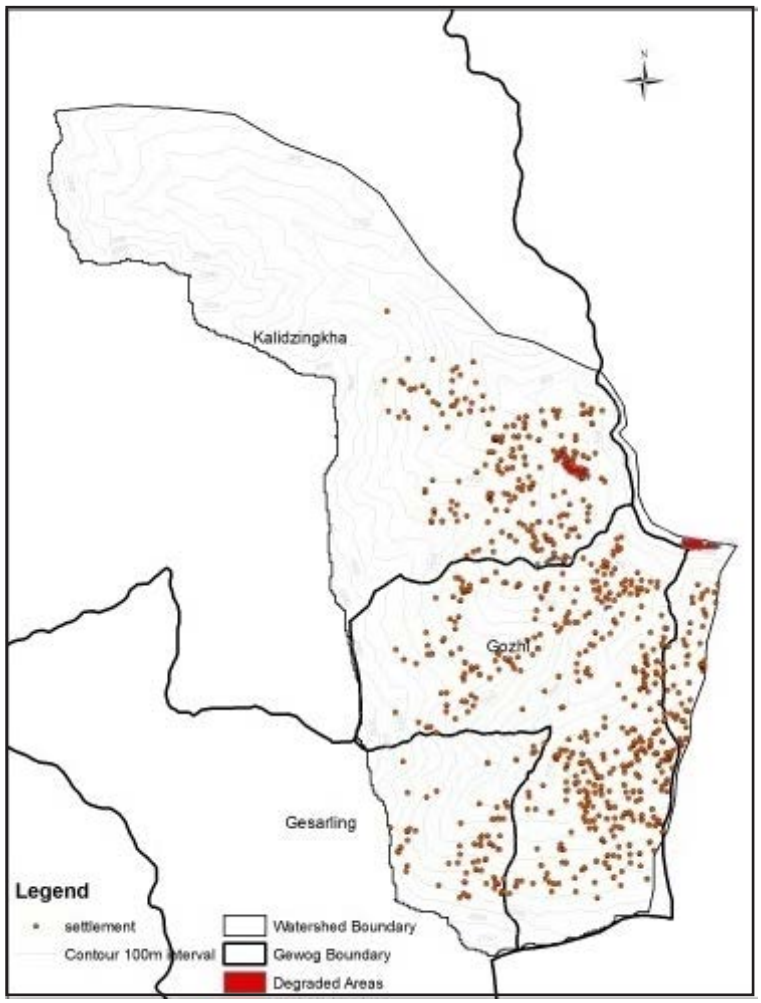


Figure 13: Settlement map

Forest condition has a direct effect on the provision of watershed goods and services. Degraded forests, particularly if heavy grazing also occurs, tend to be prone to soil erosion and consequent stream sedimentation, as well as depletion of plant nutrients. In addition, degraded forests lack resilience and are less able to withstand shocks, such as those associated with climate change, than forests in sound ecological condition.

4.2.3 Infrastructure issues

a. Irrigation

Paddy cultivation is the farming practice that requires most water. Additionally, the recent rapid expansion of intensive cardamom production using irrigation draws heavily on water resources. The intake of irrigation channels is frequently destroyed by landslides, requiring farmers to construct temporary intake facilities, which are often damaged or destroyed by monsoon floods (Figure 14). Most irrigation water is piped in PVC pipes for the first critical stretch between the intakes and the edges of riparian areas. After this, irrigation water is mostly channelled along concrete or earthen channels with traditional systems of water distribution and overflow limitation (Figure 15). Nevertheless, more than 75% of the length of irrigation canals is earthen channels, which are prone to seepage. In addition, saturated soil often causes land slips, thereby disrupting irrigation infrastructure (Figure 16). To date, the local water management committee and water user associations have not been effective in managing the degradation issues related to irrigation in the watershed. Additionally, the newly established farm road network frequently disrupts the irrigation network due to the absence of appropriate structures (culverts, drainage, etc.).

Figure 14:Temporary irrigation channel intake in landslide along upper Balaychhu

Figure15:Earthen irrigation channel with distribution point and overflow limitation

The establishment of the high tension power lines has resulted in considerable erosion caused both by clearing of land and the associated construction of electric masts, as well as the establishment of the access road network to service the high tension lines.

Figure 16: Landslips along irrigation channels

b. Drinking water

The rapidly urbanizing centre of Dagapela is located just on the boundary of the Buedulumchhu sub-watershed and will in future likely require water from the watershed. The Ministry of Works and Human Settlement plans to tap Lemichhu and pipe its water to Dagapela to secure the town's water supply. Rural households within the watershed obtain drinking water through the Rural Water Supply scheme.

c. Roads

Farm roads are usually constructed with no soling (solid foundation) and lack roadside drainage and cross drainage facilities. The average road gradient is 5.2% with maximum pitches up to 11% gradient. Sixteen percent of the road network has been assessed as being in a bad condition and 12.7% in a very bad condition, leading to considerable problems of erosion, as well as to the partial disruption of the irrigation infrastructure (Waiba, 2015) (Table 4). Water channels (roadside ditches) are missing on 30% of the road network and are of inadequate depth on a further 32%. Due to missing or inadequate diversion of water from the road surface, erosion

channels in the road surface are present on 19.8% of the entire road length with depths sometimes exceeding 20 cm (Figures 17, 18, 19, 20).

Some of the major problems observed in the bad to very bad sections of the roads are (Waiba, 2015):

1. Excessive water erosion channels with depths ranging from 5 to 40 cm often on steep gradients

2. Steep gradients (> 8 %).

3. Absence of drainage facilities such as side drains, culverts and fords leading to excessive runoff over the road surface rendering it unusable for vehicles during rainy season.

4. Altered natural drainage patterns of the water resources in the watershed leading to landslides and erosion.

5. Excessive sedimentation of streams due to soil erosion from the road surface as well as the disturbed slopes. Stream water turbidity is highly affected.

6. Unstable cut and fill slopes due to acute steepness of the slopes and absence of stabilization measures lead to excessive fill slope/cut slope erosion and landslides.

7. Frequent road blockage due to cut slope and fill slope failure.

8. Absence of infrastructure such as pavement grading, retaining walls and proper crossing of irrigation channels, often contributes to excessive runoff and erosion.

9. Road alignment has been designed to optimize household access and limit the loss of private property at the cost of destruction of natural forests and degradation of landscapes.

Table 4:Quality of roads in the critical watershed

Condition	Length [km]	Percent [%]
Very Good	0.2	0.5
Good	30.2	70.9
Bad	6.8	16.0
Very Bad	5.5	12.7
Total	42.6	100.0

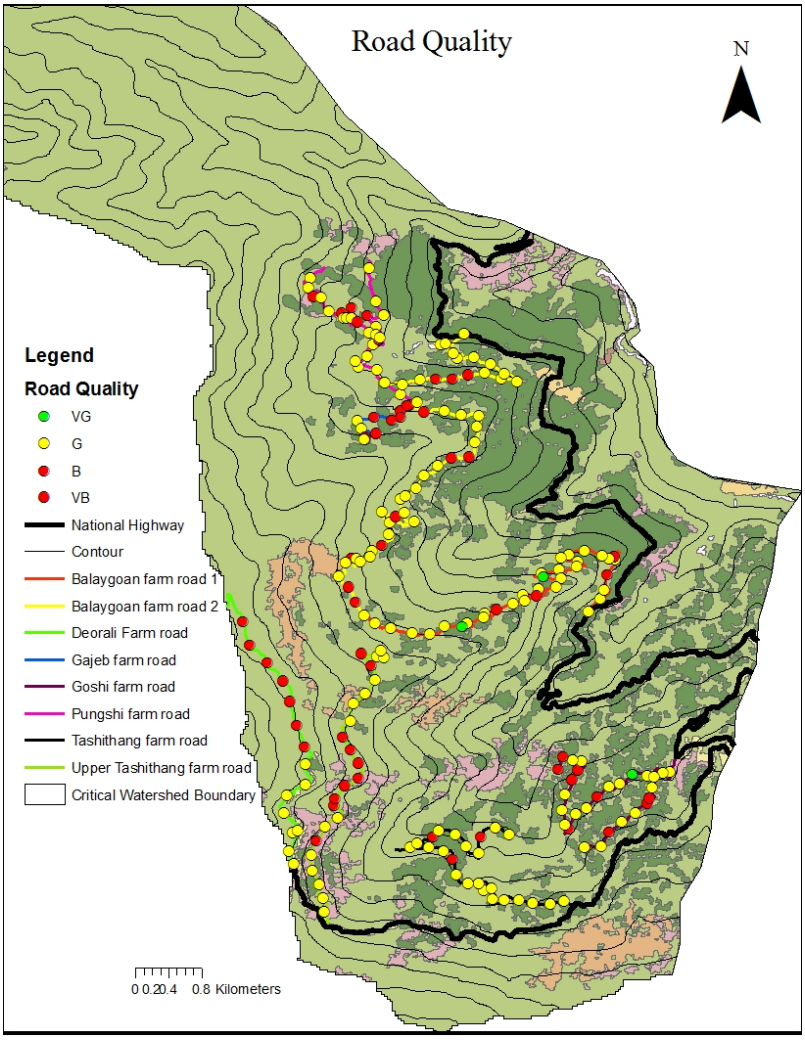


Figure 17:Quality of the road network in the degraded Watershed (Waiba 2015)

The Gajeb road is in the worst condition, followed by the Deorali, Upper Tashithang and Goshi roads, all of which are in particularly bad condition. The Balaygang I and II, as well as the Pungshi roads are intermediate with about 20-25% of the road length in bad or very bad conditions. The Tashitang road is relatively intact with only 13% of the road length in bad condition (Table 5).

Table 5:Condition of individual farm roads within degraded sub-watersheds

Condition	Tashitang	Pungshi	Balaygang I	Balaygang II	Goshi	Upper Tashitang	Deorali	Gajeb
Very good	0%	0%	0%	0%	3.6%	0%	0%	0%
Good	87.5%	76.9%	79.5%	76.1%	64.3%	58.3%	53.3%	36.4%
Bad	12.5%	11.5%	5.1%	10.9%	17.9%	29.2%	33.3%	36.4%
Very bad	0%	11.5%	15.4%	13%	14.3%	12.5%	13.3%	27.3%

Figure 18: farm road cut slope failure

Figure 19:Improper water drainage

Figure 20:Disrupted irrigation channel

The establishment of the high tension power lines has resulted in considerable erosion caused both by clearing of land and the associated construction of electric masts, as well as the establishment of the access road network to service the high tension lines.

4.3 Degrading influences identified during community consultations

The community consultations commenced with a presentation to the community of the issues and problems that led to the sub-watersheds being classified as degraded. These formed the basis of subsequent discussion. The main issues raised by community groups are listed in Table 6. Field visits by staff of WMD were carried out to validate the relevance of these issues.

Table 6:Degrading influences identified during community consultation

Geog	Issues
Gesarling	• Drying of drinking water sources • Mass land slides • Shortage of irrigation water • Drying of lakes
Goshi	• Drying water sources • Landslides, soil erosion and formation of gullies • Agriculture land degradation
Kana	• Landslides and soil erosion • Drying of streams • Degradation of farm land • Poor water quality

4.3.1 Geographic distribution of issues identified during stakeholder consultation

Table 7:Main land degradation types and their prevalence in various chiwogs within the watershed

Issue	Chiwog								
	Pungshi	Khagochen	Balaygang	Dogak	Lower Goshi	Mid Goshi	Upper Goshi	Punsumgang	Tashitang
Shortage of drinking water	X	X	X				X		X
Polluted drinking water		X							
Shortage of irrigation water	X	X	X	X	X	X	X	X	X
Land slide		X	X		X			X	
Erosion				X		X			
Collapse of paddy terraces						X			
Decreased soil fertility			X	X	X			X	
Crop depredation by wildlife	X		X	X	X		X	X	X
Insufficient timber / decreasing forest productivity	X	X	X	X				X	
Forest overgrazing					X				

While some issues are common to all chiwogs, others show considerable variation based on local circumstances (Table 7).

Overall, a perceived decline in availability of water for domestic and irrigation use, combined with the disruption and inefficiency of irrigation networks, are seen by local stakeholders as the main issues of concern to them, closely followed by human-wildlife conflict.

4.4 Consolidated summary of degrading influences

Issues that have contributed to degradation of the watersheds were collated from the three sources: (i) watershed assessment, (ii) expert assessment and field missions, and (iii) community consultations. A consolidated summary of the degrading influences is shown in Table 8

Table 8:Consolidated list of degrading influences, and possible causes of degradation

Group	Degrading influences	Cause of degradation
Geological instability	Mass movement (landslides, mud flows and erosion)	• Unfavorable geological condition (heavily weathered mica-schist layers acting as gliding surfaces is oriented parallel to slope). • Availability of colluvial materials
	Soil erosion	• Steep terrain • Surface runoff
	Excessive sedimentation	• Soil erosion • Disturbed slope
	Forest degradation	• Heavy Cattle grazing • Low vegetation cover • Excessive Resource extraction in terms of

Land use issues		timber, fuel wood and non-timber forest products • Natural hazards, such as landslides
	Soil erosion	• Farm road with poor drainage system • Steep terrain • High amount of precipitation • Inappropriate land-use practices (vertical ploughing, excessive use of chemicals, no raised seed bed) • Low vegetation cover
	Human wildlife conflict	• Land use change (land encroachment) • Habitat destruction • Human settlement close to natural forest
	Agriculture land degradation (arable land)	• Continuous cultivation • Monoculture • Erosion • Poor drainage system
	Decreased soil fertility	Insufficient information for assessment
	Collapse of paddy terraces	Insufficient information for assessment
Infrastructure and developmental activities	Erosion	• Bad condition of farm road (Poor drainage system, no soling & culvert). • Construction of transmission line and mining activities in steep terrain and landslide prone zone. • Destruction of irrigation channel by monsoon flood.

	landslides	• Construction activities • Seepage from irrigation channel • Deforestation
	Polluted drinking water	Pollution (leaching from agriculture land and waste disposal site).
	Poor water quality	Poor management of source.
	Shortage of drinking water and irrigation water	• Degraded source • Leakage from the pipe. • Increase in population density. • Stone quarry. • Improper utilization of irrigation facilities
Other issues	Agriculture pest and diseases	• Outbreak of cardamom blight • Monoculture
	Drying of lakes and streams	• Deforestation • Change in climate pattern (untimely rainfall/storms)
	Insufficient timber / decreasing forest productivity	• Excessive usage of resources (firewood, timber)

5. THE PLAN

The purpose of the plan is to identify interventions that can mitigate the effect of degrading influences and return the watersheds to normal or pristine condition (to the greatest extent possible). A Logical Framework Analysis (LFA) was applied, building on the issues/problems identified. This led to the construction of a problem tree with causes and effects of the issues/problems, which led in turn to the construction of an objective tree, with outputs, objectives and a goal (Figure 21).

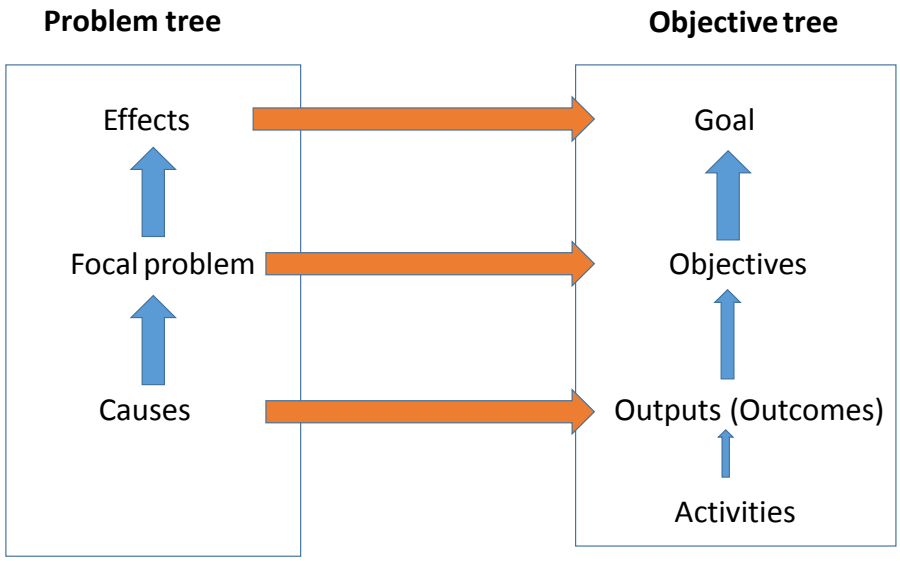


Figure 21: Problem tree and objective tree used to convert issues/ problems identified during the planning process into an intervention strategy to mitigate the degrading influences.

The application of the LFA process led to the identification of three focal problems that contribute to watershed degradation:

- Mass soil movements (landslides, mud flows and related erosion), caused primarily by natural geological instability.
- Degradation of forest and agricultural lands, caused by human activities.
- Poor quality drinking water and shortage of water for domestic and irrigation purposes, caused primarily by human activities, but exacerbated by natural geological instability.

While it was recognized that the first of these problems is an important degrading influence, it is beyond the ability of management interventions to address as it is part of the background mountain building processes that operate across the Himalayas. However, the other two problems can be addressed (at least in part) by management interventions, and these became the core problems around which the plan was framed.

Several problems were raised by local stakeholders during the various consultations that, while being important in terms of impacting on their livelihoods, had no direct link to degradation of the watershed. A "filter" was applied to ensure that only those issues/problems that contribute directly to the purpose of removing or mitigating degrading influences were addressed in the plan. For example, one problem that was raised by most local stakeholders was human-wildlife conflict. This seems to be ubiquitous and was clearly a concern across the watershed. However, it is not something that has a direct link to watershed degradation and, as a result, was not included among the problems that were addressed within the context of the watershed management plan.

The final step in the LFA process was the construction of a logframe matrix that facilitated the identification of specific activities for implementation, along with a budget, to address the degrading influences. This is shown in detail in Annex 2 and a brief description of the intervention logic is given below.

5.1 Goal and objectives

The goal and objectives of the plan are:

Goal: The degraded watershed sustainably managed to minimize degradation and enhance provision of watershed goods and services for rural livelihoods in the context of climate change.

The objectives set to attain the goal are:

Objective 1. To minimize degrading influences and improve watershed condition.

Objective 2. To enhance supply of quality water for domestic and irrigation purposes.

5.2 Outputs

The key outputs needed to achieve the objectives and contribute to the goal are outlined and discussed below.

Objective 1. To minimize degrading influences and improve watershed condition.

Outputs 1.1 All farm roads in watersheds conforming to EFRC rules.

Farm roads were found to be major sources of erosion in the watersheds because of poor drainage and exposed cut and fill slopes. Activities to improve cross drainage and rehabilitate cut and fill areas will decrease erosion and consequent stream sedimentation.

Output 1.2 All agricultural lands managed to minimize soil and nutrient erosion

Some sloping agricultural lands exhibit surface and rill erosion that results in loss of agricultural productivity and increase in soil loss and consequent stream sedimentation. Activities aimed at stabilizing the soil surface will mitigate this degrading influence.

Output 1.3 Degraded forest rehabilitated and forest resources utilized within sustainable limits

There are large areas of degraded forests, particularly close to settlements, that are prone to soil erosion and consequent stream sedimentation. Some of these degraded areas are recently established as community forests (Annex 5) and handed over to the communities and few more are in pipeline to handover in the near future. These forests areas lack resilience and have limited ability to withstand shocks, such as those associated with climate change. Activities aimed at rehabilitating degraded forests and reducing grazing pressure will minimize erosion and stream sedimentation and build resilience in the natural ecosystems.

Output 1.4 Resilient communities with capacity to adapt to natural and man-induced perturbations in the context of climate change

Local level institutions in the watersheds are not well organized and lack the strength to be resilient to natural and anthropogenic shocks. Activities aimed at institutional strengthening of key organizations will contribute to their resilience to adapt to shocks, including those associated with climate change.

Objective 2. To enhance supply of quality water for domestic and irrigation purposes.

Outputs 2.1 Irrigation channels operating efficiently to minimize seepage/ water loss

Many irrigation channels are old and inefficient resulting in substantial water loss and erosion. Repair of these channels will increase efficiency of water use and reduce erosion.

Output 2.2 Water collection reservoir/settling tanks and distribution adequate for domestic use

Much of the domestic water supply infrastructure is old and damaged, leading to inefficiencies in water use and poor supply to some users. Activities to improve domestic water infrastructure will result in improved efficiency in water use.

Output 2.3 Functional water users association (WUA) in place

The Water Users Associations (WUA) in the watershed are not functional and lack the capacity to operate effectively. Activities aimed at strengthening their capacity will result in improved coordination and improved efficiency of water allocation and use.

Output 2.4 Knowledge of status of water sources (lakes and springs) drying

Drying of water sources is a recurring issue raised by local stakeholders, but little empirical information is available to enable decisions to be taken to address the issue. Activities aimed at obtaining factual information on the status of water sources and trends over time will enable future decisions to be based on facts rather than unauthenticated perceptions.

6. INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTATION

Activities proposed in watershed management plans will be integrated into area-based development and conservation plans in the sub-watersheds – that is, relevant sectoral programs, dzongkhag and geog plans. Feedback from the field will be encouraged and will inform successive planning cycles and guide future decisions in planning at the national level.

It is important that the watershed management plan is implemented in a manner that is consistent with other natural resource and water related policies. The watershed management activities proposed in the plan will be prioritized and internalized to the existing area-based planning frameworks. The operational and organizational framework involving relevant institutions and agencies to implement the plan is shown in Figure 22.

To ensure effective implementation of the plan, it is also imperative to operationalize watershed management committees at various government levels. Key stakeholders include the relevant Watershed Management Committees (WMC) and Dzongkhag Water Management Committees (DWMC), as well as the River Basin Management Committees (RBMC).

At the dzongkhag level, the DWMC will be established as per Water Regulation of Bhutan (National Environment Commission, 2014) and will facilitate the implementation of this plan. Similarly, at the watershed level, the WMC will be instituted to coordinate the implementation of this plan. This committee will be consulted for various activities within the watershed.

These institutional arrangements have yet to be tested in practice. Table 9 proposes ToR for the various committees and institutional partners and Annex 3 outlines the responsibilities of different agencies.

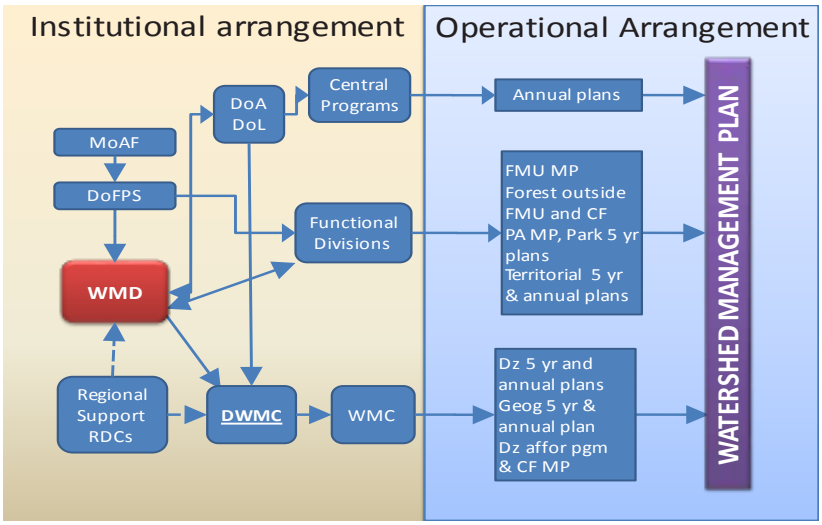


Figure 22:Implementation arrangement

Coordination between different line agencies at the dzongkhag and geog levels will be critical to ensure overall implementation of this plan. In particular, the central agencies under MoAF such as the Territorial Divisions, Parks, RDCs, and RLDCs inter alia will be involved to ensure that the planning and implementation of watershed activities are harmonized with other land uses within the watershed.

In view of area-based planning, the geog level plan becomes the major vehicle for bringing together the different interests of the various sectors (including livestock, agriculture, forestry and others) irrespective of land ownership. The dzongkhag watershed management committee will ensure coordination and integration between geogs.

This watershed management plan will come into force following endorsement by the MoAF and will be valid for a period of five years. Incorporation of high priority activities into dzongkhag and geog annual plans should commence during the preparation of annual work plans and associated budgets in the financial year following endorsement.

Table 9:Terms of reference for committees

Committee	Members	Roles and responsibilities
Watershed Management Committee (WMC)	Gups, GAOs GAEOs, GLEOs, Forest Ranger Officer, tshogpas, school principals, CF chairpersons, WUA representatives	1. Plan and implement watershed management related activities in the Geog. 2. Mediate conflicts in implementation of WM plans and activities. 3. Ensure reporting of watershed activities of WMD through DzWMC.
Dzongkhag Water Management Committee (DWMC)	Dzongda, DAO, DLO, DzEdu.O, DE, DzEnvi.O, LRO, DPO, CFO, BPC, DoR, WMD	1. Identify, plan, and implement watershed management activities involving more than one geog 2. Administer linkages with the WMD and the RBMC 3. Integrate and synchronize watershed related activities into annual geog plans 4. Mediate conflicts in implementation of WM plans/activities 5. Ensure reporting of watershed activities annually to WMD
WMD		1. Facilitate periodic watershed and dzongkhag level committee meetings 2. Coordinate with relevant agencies and ensure that prioritized watershed activities are integrated into sectoral plans 3. Discharge any entrusted tasks related to ToR of the committees from time to time 4. Facilitate the provision of technical backstopping on watershed planning and management

7. FUNDING IMPLEMENTATION

Implementation of planned watershed activities will be funded from the regular government budget. However, in case this is insufficient or unavailable, the management plan can be used as a basis to solicit funds from hydro-power projects or other donors. As the coordinating agency, the DWMCs will facilitate the relevant agencies to incorporate watershed activities in their plans and accordingly seek budgetary provisions from RGoB during the annual and five yearly planning processes. The incorporation of activities of the watershed management plan into respective plans and budgets of local administration will be done in consultation with the WMD.

The possibility to apply Payment for Environmental Services (PES) mechanisms as a financial strategy could be explored in order to ensure sustainable funding to support watershed management activities. Under such a scheme, downstream water users such as hydropower plants and other major water users benefiting from watershed management activities are encouraged to contribute financially to implement remedial activities under an appropriate and mutually agreed framework.

8. MONITORING AND EVALUATION

The activities identified in this management plan as being necessary to achieve the goal and objectives of the plan are designed to be integrated into the area based management plans of a variety of agencies and organisations, particularly the geog and Dzongkhag annual and 5-year plans. These organisations will monitor implementation. The verifiable indicators given in the logframe matrix in Annex 2 will assist in the monitoring task.

Evaluation of the impact of the management plan and the extent to which it has achieved its objectives and contribute to attaining the goal should be carried out by the WMD towards the end of the plan period.

9. REVISION AND AMENDMENT OF PLANS

The mandate to revise and amend this plan rests with the WMD. The final impact evaluation will be the basis for revising the plan in the next planning cycle.

10.REFERENCES

2007. The Land Act of Bhutan. p. 86.

2008. Constitution of the Kingdom of Bhutan. p. 66.

2011. The Water Act of Bhutan.

Department of Agriculture, 1986. Irrigation Design Manual. Thimphu.

Gansser, A., 1983. Geology of the Bhutan Himalaya. Birkhäuser, Basel.

Gross National Happiness Commission, 2008. Tenth Five Year Plan (2008-2013). Royal Government of Bhutan, Thimphu, p. 170.

Ministry of Agriculture and Forests, 2011. Land cover atlas of Bhutan 1:250000. MoAF, Thimphu, p. 21.
National Environment Commission, Bhutan Water Vision and Bhutan Water Policy. Thimphu, p. 38.

National Environment Commission, 2014. The Water Regulation of Bhutan. NEC, Thimphu, p. 51.

Norbu, Y., 2015. Assessment of Participatory Land Use Planning for Watershed Management in a selected Watershed in Bhutan. p. 59.

Planning Commission, 1999. Bhutan 2020 - a vision for peace, prosperity and happiness. Thimphu, p. 77.

Royal Government of Bhutan, M.o.A., 1995. Forest and Nature Conservation Act of Bhutan. In: Royal Government of Bhutan, M.o.A. (Ed.). Royal Government of Bhutan, Ministry of Agriculture, Thimphu, p. 19.

Royal Government of Bhutan, M.o.A., 2010. National Forest Policy - draft. In: Royal Government of Bhutan, M.o.A. (Ed.). Royal Government of Bhutan, Ministry of Agriculture, Thimphu, p. 19.

Tenzin, J., Hasenauer, H., Tree species composition and diversity along the disturbance pattern in a watershed in Bhutan.

Tsering, K., 2011. A roadmap for watershed management in Bhutan: from policy to practice. Watershed Management Division, Department of Forest and Park Services, Ministry of Agriculture and Forests, Thimphu, p. 77.

Waiba, T.N., 2015. Evaluation of old and recently built farm roads in the selected watershed of Bhutan-an evaluation from the prospective of assessing environmental impacts. Department of Forest and Soil Sciences. BOKU University, Vienna, Austria.

Wangchuk, K., Darabant, A., Gratzer, G., Wurzinger, M., Zollitsch, W., 2015. Forage yield and cattle carrying capacity differ by understory type in conifer forest gaps. Livestock Science
.
WMD, 2010. Guideline for classification of watersheds. Watershed Management Division, Thimphu, p. 29.

WMD, 2011. Rapid classification of watersheds in the Punatsangchhubasin. Thimphu, p. 33.

LUPP (1997). Atlas of Bhutan - 1:250,000 - Land Cover and Area Statistics of 20 Dzongkhags. LUPP, Ministry of Agriculture, Thimphu, Bhutan.

LUPP (1997). Atlas of Bhutan - 1:250,000 - Land Cover and Area Statistics of 20 Dzongkhags. LUPP, Ministry of Agriculture, Thimphu, Bhutan.

11. ANNEXES

Annex 1. Stand characteristics of forests at increasing distance from settlements

Mean, minimum (Min), maximum (Max) and standard deviation (Sd) of (i) site characteristics elevation, slope and aspect as well as (ii) the stand characteristics density, basal area, volume, mean DBH and mean height (Source : Tenzin and Hasenauer, 2016)

	Natural Forest (n=36)				Semi-Disturbed (n=31)				Settlement & Agric (n=29)			
	Mean	**Min**	**Max**	**SD**	**Mean**	**Min**	**Max**	**SD**	**Mean**	**Min**	**Max**	**SD**
Elevation [m]	1951	1392	2413	231	1429	675	1848	326	1229	906	1788	248
Slope [º]	27.5	3	61	13	26.8	5	44.5	7.8	22.5	5	39	7.7
Mean tree height [m]	16.93	9.3	28.2	4.3	10,8	0	24	5.77	7.8	0	16.1	5.4
Trees [N*ha^{-1}]	376	40	1080	236	183	0	820	200	116	0	540	145
Saplings [N*ha^{-1}]	305	0	1220	277	241	0	1500	329	80	0	620	140
Established seedlings [N*ha^{-1}]	1181	0	6250	1659	1427	0	8000	1950	655	0	3250	960
Non-established seedlings [N*ha^{-1}]	2250	0	9750	2621	2161	0	40500	7196	1362	0	11750	2560
Seedling recruits [N*ha^{-1}]	2021	0	14000	3313	1395	0	2100	4072	500	0	6750	4072
Basal area [m^2*ha^{-1}]	37.89	2.38	98.2	23.9	9.63	0	45.84	12.73	5.71	0	27.63	7.19
Volume [m^3*ha^{-1}]	418.87	13.19	1376.46	324.29	84.77	0	480.01	124.4	49.8	0	274.59	69.1

Annex 2. Logframe matrix

Goal: Balaychhu-Buedulumchhu-Zharingaychhu sub-watersheds sustainably managed to minimize degradation and enhance provision of watershed goods and services for rural livelihoods in the context of climate change.

Outputs	**Activities**	**Verifiable indicators**	**Responsible agency/person for implementation**	**Local area based plan**	**Budget (M Nu)**
1. Objective 1. To minimize degrading influences and improve watershed condition.					
1.1. All farm roads in watersheds conforming to EFRC rules	1.1.1. Carry out drainage works of 86.9 kilometers of farm roads	86.9 KM of farm roads with adequate drainage	Dzongkhag/ Geog Administration/TD	Geog AWP/TD Workplan	6.8 (.078/KM)
	1.1.2. Rehabilitate (bio-engineering works) 22 acres	22 acres of land rehabilitated	Dzongkhag/Geog administration in collaboration with Dagana TD	Geog AWP/TDworkplan	11
1.2. All agricultural lands managed to minimize soil and nutrient erosion	1.2.1. Build capacity of 45 community representatives on Sloping Agriculture Land Technology (SALT) a. Two training workshops	Training and field visit reports	UWICER-Yusipang with WMD/TD/Geog	Yusipang & WMD AWPs	0.5

	b. One famers visit to demonstration site				
	1.2.2.Implement SALT approaches in one prioritized chiwog	Status report	UWICER-Yusipang in collaboration with WMD &TD	Yusipang, WMD & TD AWPs	0.5
1.3. Degraded forest rehabilitated and forest resources utilized within sustainable limits	1.3.1. Assist in development of community forest management plan and rehabilitation of timber and fodder species in CFs (to regulate sustainable use)	Management Plan	Dagana TD in consultation with SFED and WMD	TD and WMD AWPs	1.51
	1.3.2. Prepare a discussion a paper to analyze issues associated with forest degradation and propose solutions particularly institutional aspects	Discussion report	WMD in collaboration with FRMD	WMD AWP	0.05

	1.3.3. Improve cattle breed (through one AI & three bulls) to reduce cattle population	No. of AI facilities estd. and bulls supplied	Dzongkhag/geog Livestock sector	Dzongkhag/geog AWP	0.5
	1.3.4. develop fodder (including tree fodder) for forest cattle graziers and encourage stall feeding: a. provide improved fodder seeds/seedlings	No. of cattle graziers adopting stall feeding	Dzongkhag/geog Livestock sector	Dzongkhag/geog AWP	0.058 (Seed & fertilizer/acre: Nu5500) 0.075(Tree seedling:Nu 15/seedling)
1.4. Resilient communities with capacity to adapt to natural and man-induced perturbations in the context of climate change	1.4.1. Provide support to local institutions (CFMGs, WUAs and other farmers groups) to build their capacity to develop strong social system to manage their affairs effectively and efficiently: a. Carryout Training Needs	Record of the capacity building provided Frequency of meetings and minutes of the meetings & decisions made.	Dzongkhag administration (WUA and other farmer's group) & TD(CFMG)	Dzongkhag & TD AWPs	1.0

	Assessment (TNA) b. Carryout training based on results of TNA. Indicative trainings could be: (i. developing & implementing CF, management plans & operation plans of WUA and farmer's group, ii. record and book keeping)				
	1.4.2. Pilot climate smart approaches in prioritized chiwog: a. Diagnostic study on social, natural, financial and human capital needs	Diagnostic study report, Implementation plan and implemented activities	WMD,TD and Dzongkhag	WMD, TD, Dzongkhag AWP	1.0

	b. Design & implement appropriate interventions to strengthen community capacity				
2. ***Objective 2.*** To enhance supply of quality water for domestic and irrigation purposes.					
2.1. Irrigation channels operating efficiently to minimize seepage/ water loss	2.1.1. Repair 10 kilometers of damaged irrigation channels	10 kilometers of irrigation channels repaired	Dzongkhag, Geog	Dzongkhag, geog AWP	15 (10 x 1.5)
	2.1.2. Replace 12.06 kilometers of earthen irrigation channel with concrete	12.06 kilometers of earthen irrigation channel concretized	Dzongkhag, Geog	Dzongkhag, geog AWP	18.09
	2.1.3. Implement bio-engineering works along seepage and landslide areas	No. of seepage & landslide areas stabilized with bio-engineering works	Dzongkhag/Geog administration in collaboration with Dagana TD	Geog AWP	9

2.2. Water collection reservoir's/settling tanks and distribution adequate for domestic use	2.2.1. Construct 5 numbers of settling tanks in Gozhi geog	No. of water tanks constructed	Dzongkhag, Geog	Geog AWP	7.5
	2.2.2. Construct 2 numbers of water tanks in Kana geog	No. of water tanks constructed	Dzongkhag, Geog	Geog AWP	3
	2.2.3. Construct one number of water tank in Gesarling geog	No. of water tanks constructed	Dzongkhag, Geog	Geog AWP	1.5
	2.2.4. Replace multiple small distribution pipes with fewer number of larger pipes (16 kilometers of 75mm pipes)	No. of small pipes replaced by large pipes	Dzongkhag, Goeg	Geog AWP	5.6
2.3. Functional water users association (WUA) in place	2.3.1. Assess the status of WUA across the watershed	Status report	Dzongkhag, Geog	Geog AWP	0.0
	2.3.2. Facilitate establishment/revival of WUA(s) in all geogs/chiwogs in the watershed	No. of WUAs functional	Dzongkhag, Geog	Geog AWP	0.1 (linked to activity 1.4.1)

2.4. Knowledge of status of water sources (lakes & springs) drying	2.4.1. Carry out scoping study of the causes of drying of water sources(springs and lakes) in the watershed	Study report	WMD in collaboration with TD & Dzongkhag	WMD AWP	0.2
	2.4.2. Take stock of the existing water sources (springs & lakes)	Inventory report	TD in collaboration with WMD	TD AWP	0.1
					Total Budget Nu. 83.183 m

Annex 3. Stakeholders

Sl	Main Stakeholder	Roles & responsibilities
1	GT of the 3 Geogs	• Preparation of annual work plan based on WSM plan • Implementation of the plan • Monitoring & evaluation
2	Geog RNR sectors	• Support in preparation of the annual work plan WSM plan • Support & implement WSM plan • Report WSM activities to Dzongkhag RNR Sector Heads
3	Divisional Forest Office, Dagana	• Regulate access to natural resources in critical watersheds • Assist in establishing private & community forests • Assist in managing the natural grazing land • Assist in riparian protection of the streams
4	Dagana Dzongkhag RNR Sectors	• Support the GT in preparation of the WSM plan • Support in implementation of the WSM plan • Mobilize funds & other assistances for the WSM plan • Monitoring & evaluation of the overall plan by the Dzongkhag WSM Committee • Report WSM activities to WMD
5	WMD	• Conduct awareness programs on the importance of WSM • Support in preparation of WSM Plan • Mobilize funds to implement the WSM plan • Investigate possibilities to initiate PES programs • Monitoring & Evaluation • Provide overall guidance
6	Dagachhu HP	• Provide fund for implementing WSM plans
7	Communities	• Cooperate with GT in conserving the watersheds

Annex 4: Materials required for enhancing supply of quality water for domestic and irrigation purposes.

Sl/No	Particulars	Geogs			Total
		Goshi	Kana	Geasrling	
1	**Farm Roads**				
	Length for drainage construcion/improvement (km)	30	38.5	18.4	86.9
	Area for bioengineering works(acres)	10	7	5	22
2	**Fodder Development**				0
	Area in acre	5	5.5		10.5
	No. of fodder saplings	2000	2000	1000	5000
3	**Irrigation channels**				0
	Length of channel require repair(km)	3	7		10
	Length for concretization (km)	5	6.5	0.56	12.06
	Area for bioengineering works (acre)	10	8		
4	**Drinking water**				
	No. of new settling tanks	5	2	1	8
	Large pipe required to replace small pipes(km)	8	8		16

Annex 5: List of community forest established and under process

Sl/No	Name of CF	Geog	Status
1	Tashithang CF	Gesarling	approved
2	Phuensum CF	Goshi	approved
3	Balaygang Gongphel CF	Goshi	approved
4	Khagochen CF	Kana	Under process
5	Pungshi CF	Kana	Under process
6	Phuensumgang CF	Gesarling	Under process
7	Dogak CF	Goshi	Under Process

Annex 6: Officials involved through various stages in development of this Plan

1. Dr. Pema Wangda, CFO, WMD
2. Dr. Lungten Norbu, Specialist, WMD
3. Mr. Tsering Gyeltshen, PLO, WMD
4. Mrs. Sigyel Delma, Dy. CFO, WMD
5. Mr. Jamyang Phuntshok, Dy. CMO WMD& Focal Official for this plan development
6. Mr. Samten Wangchuk, Dy. CFO, WMD
7. Mrs. Sonam Choden, Sr. FO, WMD
8. Dr. Jigme Tenzin, Sr. FO, WMD
9. Ms. Kuenzang Om Sr. AO, WMD
10. Mr. Dorji Gyeltshen, FO, WMD
11. Mr. Kaka, FO, WMD
12. Mr. Nidup Tshering, SSA, WMD
13. Mrs. Ugyen Dema, SSA, WMD
14. Ms. Kinley Dem, FR-I, WMD
15. Dr. Purna Bahadur Chhetri, Program Officer, RNR-RC, Yusipang
16. Dr. Don Gilmour, Sr. Australian Volunteer,2016-2017, WMD
17. Mr. Jordi Bates (Australian Volunteer,2014-2015, WMD)
18. Dr. András Darabant, BC-CAP Project

Watershed Management Division | Post Box No: 1345 | Department of Forests & Park Services