Wangchu (Upper) Watershed Management Intervention Report

Jigme Dorji National Park & Watershed Management Division

Department of Forests and Park Services

Ministry of Agriculture and Forest

Contributors;

1. Mr. YontenJamtsho, Sr. Forestry Officer, Park HQ, JDNP
2. Mr. Leki, Sr. Forest Ranger II, Lingzhi Park Range, JDNP
3. Mr. Sonam Dorji, Forest Ranger II, Lingzhi Park Range, JDNP
4. Wangchuk Phuntsho, Forest Ranger II, Lingzhi Park Range, JDNP
5. Mr. Sonam Jamtsho, Forest Ranger I, Lingzhi Park Range, JDNP

Report Editorial:

1. Mr. Jamyang Phuntshok, Dy.Chief Met Officer, WMD
2. Mr. Rinzin Dorji, Chief Forestry Officer, JDNP

Citation:
Jamtsho, Y., Leki., Dorji, S., Phuntsho, W. and Jamtsho, S. (2022). Wangchu (Upper) Watershed Management Intervention Report, Jigme Dorji National Park, Department of Forests and Park Services, Ministry of Agriculture and Forest, Gasa, Bhutan.

Acknowledgement:

The Integrated Watershed Management intervention report for upper Wangchu Watershed was developed as a part of water flagship program coordinated by Watershed Management Division (WMD), Department of Forests and Park Services. The plan is an outcome of a collaborative process that involved many stakeholders from agencies both at the field and national level. Jigme Dorji National Park under Department of Forests and Park Services would like to express sincere gratitude to WMD for giving the opportunity to develop the report, which provided the Park a new experience considering the nature of the watershed.

List of Abbreviations

DoFPS	Department of Forests and Park Services
DoL	Department of Livestock
FNCRR 2020	Forest and Nature Conservation Rules and Regulations of Bhutan 2020
FRMD	Forest Resource Management Division
FPED	Forest Protection and Enforcement Division
JDNP	Jigme Dorji National Park
WMD	Watershed Management Division
m.a.s.l	Meters above sea level
GPS	Global Position System
PA	Protected Areas
GC	Gewog Centre
TD	Divisional Forest Office-Thimphu
TT	Thimphu Thromde
TCB	Tourism Council of Bhutan
MoAF	Ministry of Agriculture and Forest
NG	Naro Gewog
GBCL	Green Bhutan Corporation Limited
ABTO	Association of Bhutanese Tour Operators
NEC	National Environment Commission
NCHM	National Center for Hydrology and Meteorology
MoAF	Ministry of Agriculture and Forest

Executive Summary

The upper Wangchu watershed has total area of 306sqkm and extends from Lingzhi and Naro Gewog in the north to Kawang in the south under Thimphu Dzongkhag. Geologically, the watershed falls under higher Himalayan zone with the majority of area occupied by Chekha formation. The landcover is dominated by alpine shrubs followed by mixed conifer forest. Thereare 193 people within 47 households living in 12 villages in the watershed area and about 1488 heads of livestock from Naro Gewog depend its grazing on it. Thiswatershed serves as one of the main water source for Thimphu Thromde.

Due to large area interspersed by varying elevation, changing landcover and landuse, it was difficult to access the condition as one watershed. Hence based on source, drainage and aspects, we divided the watershed into 16 sub-watersheds and accessed them independently. The first round of field investigation was carried out in 2014 in collaboration with relevant stakeholders and second round of field investigation was carried out in December 2021. The investigations were carried out mainly to gain firsthand understanding on the problems in the watershed and to ensure the proposed mitigation measure for problems are appropriate and feasible for implementation on the ground.

Following the watershed classification guideline 2016, upper Wangchu watershed was found degraded. This has triggered the requirement to develop a watershed management intervention report to restore the degraded watershed to its natural state.

Through wide consultations with the key stakeholders and exhaustive discussions within the staffs, the seven major issues and their possible causes were identified. Based on the impacts, the potential intervention measures to reduce and mitigate adverse impacts are detailed out and proposed in this report. This will ultimately help in minimizing the human induced impacts and enhance provision of quality water supply for Thimphu Thromde.

The progress towards achievement of strategic goal and objectives will be periodically monitored as the indicators are explicitly stated in a comprehensive logical framework in the report. It is sincerely hoped that all key collaborators and stakeholders would render optimum support towards fulfillment of the management goal and objectives.

Contents

Table of figures

1. Background

As outlined in the FNCRR (2020) a watershed management intervention report is a prerequisite for any watershed to be classified as "degraded" or "critical" following the application of the Watershed Classification Guidelines (2016). The Wangchhu basin comprises of 16sub-watersheds. One among 16 sub-watershedis classified as degraded when we considered the water use score only based on number of people residing in the sub-watershed area. However, if we consider the water use score based on all the downstream users, all sub-watersheds fall under degraded condition. This has triggered the requirement to develop a watershed management report for wangchhu basin to restore the degraded watershed to its natural state. More importantly, these watersheds ultimately drain into Wangchu which is the main water source forThimphu Thromde that comprise of little more than 35% of Bhutan's population.

As per recent socio-economic survey there are 193 people (111 male, 82 female) within 47households living in 12 villages along the Wangchu basin. Majority of the people practice subsistence farming including livestock husbandry (Dendup et al. 2021). They live in some of the harshest of conditions and unpredictable climatic conditions.

The activities undertaken by the inhabitants such as construction of road and transmission line; waste generated by people, harvesting of trees for constructions, medicinal plants collection, unregulated cattle and horse grazinghave adverse impact on the watershed conditions. Therefore, the purpose of this watershed management plan is to address the human induced impacts on the natural environment and attempt (to the greatest extent possible) to return the watersheds to a "normal" or "pristine" condition leading to sustainable flow of good quality and quantity of drinking water.

1.1 Description of watershed

1.1.1 Geographical description

The topography of landscape features in upper Wangchu watershed is generally rugged with the hills rising from south to north, and likewise the elevation changes from 2667 m.a.s.l. (meters above sea level) in the south to 5120 m.s.a.l. in the north. With the total area of 306 sqkm, it extends from 27.786417 N to 27.636511 N and 89.409055E to 89.633914E. The watershed area encompasses Naro Gewog and part of LingzhiGewog in the upstream under Lingzhi Dungkhag and part of Kawang Gewog in the downstream under Thimphu Dzongkhag (Figure 1). The entire watershed area falls in Lingzhi Park Range under Jigme Dorji National Park. This watershed fall withinwatershed No. 148 (as per WMD's delineation) and drains water into Wangchu river basin.

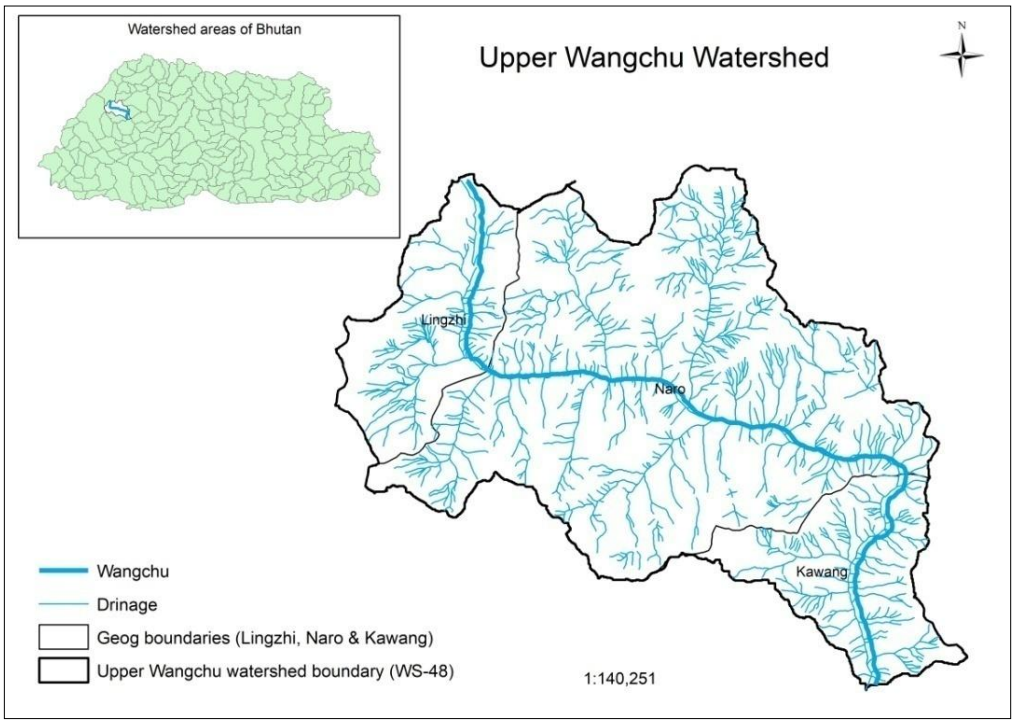

Figure 1: Location of upper Wangchu watershed in 186 watersheds in Bhutan

1.1.2 Geology

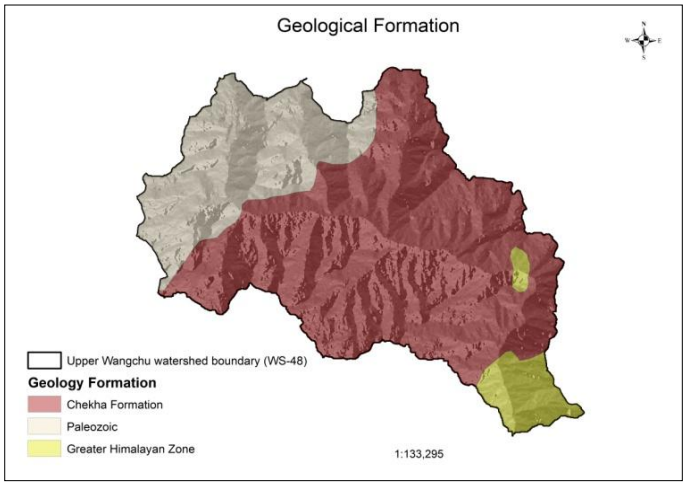

Figure 2: Geological map of watershed

Geologically, the upper Wangchu watershed falls within higher Himalayan zone. The majority of the area is occupied by Chekha formation with tan to gray, thick-bedded, fine- to medium-grained, cliff-forming micaceous quartzite. The northern area of watershed falls under Paleozoic zone with medium-gray, cliff-forming, thin-bedded, silt lamination-rich, fossiliferous limestones.The southern part of watershed falls under Greater Himalayan Zone with massive to foliated Himalayan leucogranite plutons. Leucogranite intrudes the structurally-higher and structurally-lower Greater Himalayan sections, as well as Tethyan Himalayan rocks in Lingshi region (Gansser, 1983).

1.1.3 Climate

All places inside the watershed areas experience all four seasons. The climate in the lower areas is generally warm and moist with good amount of rainfall in summer and cold and dry in winter, whereas in the uplands it is cool and moist in summer and extremely cold and snowy in winter (Figure 3).

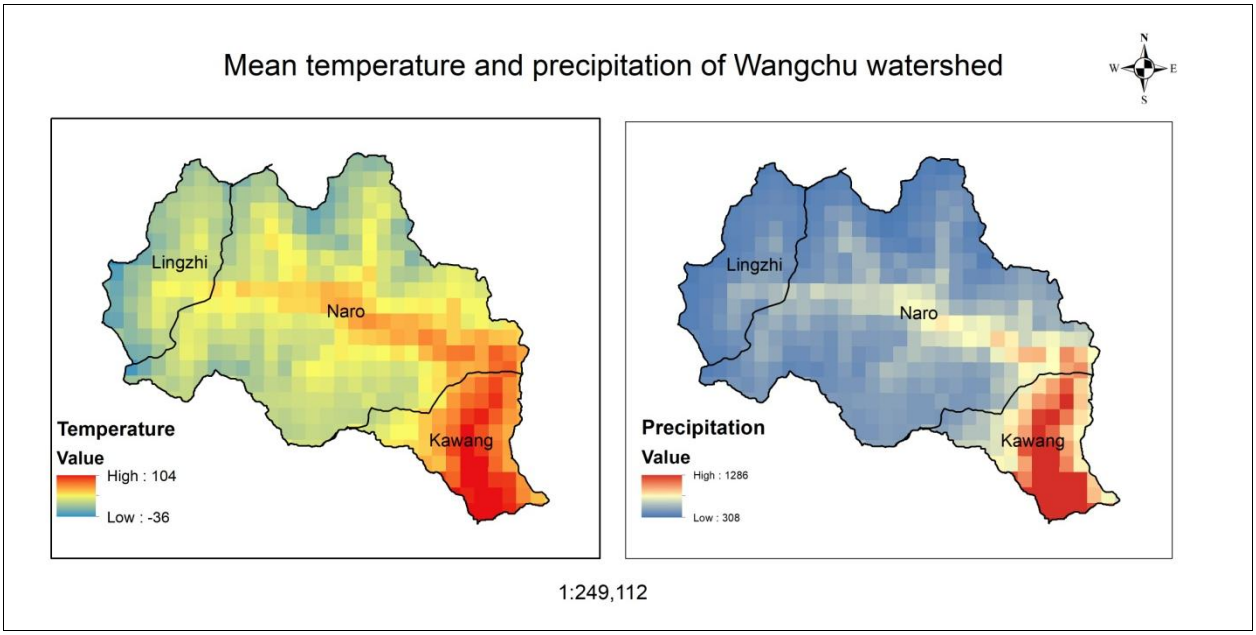

Figure 3: Annual mean temperature (Fahrenheit) and annual mean precipitation (mm) of watershed area. The data is downloaded from WorldClim-Global Climate Data

1.1.4 Landuse

The lower areas facing south with mostly dry conditions are dominated by pine forest that are usually fire prone with scanty undergrowths. Between 2,000 to 3,500 meters, one can see temperate cool broadleaved forests that are characterized by oaks, such as *Quercus semicarpifolia*, and Quercus *griffithii,* and some species of rhododendrons such as *Rhododendron arboreum*. In areas between 3,500 – 4,000 meters, the vegetation gradually transitions into mixed conifer forest interspersed by hemlock (*Tsuga dumosa*), fir (*Abies densa*), spruce (*Picea spinulosa*), and juniper (*Junipe rusindica*). Also found interspersed in these forest types are Campbell's maple (Acer campellii), Himalayan birch (Betula *utilis*), larch (*Larix griffithii*), different species of bamboos and rhododendrons. Majority of watershed area (21.7%) fall under mixed conifer forest.

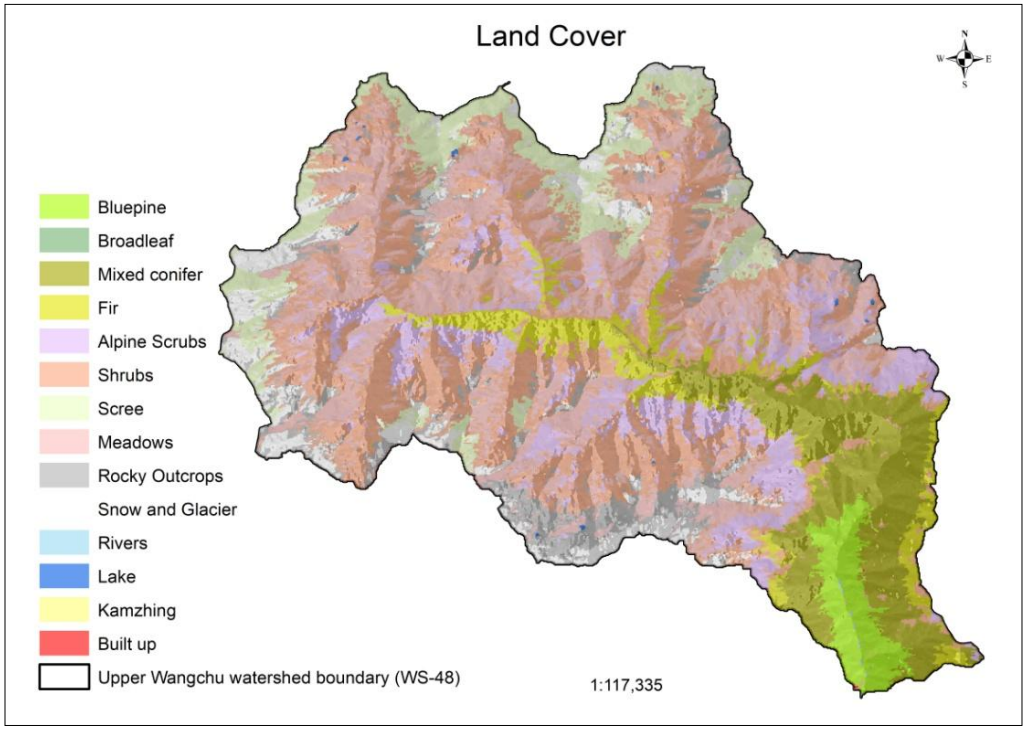

Figure 4: Landcover/landuse map of upper Wangchu watershed

Ascending above 4,000 meters until 5,000 meters, one encounters thickets of stunted junipers, small-leaved rhododendrons (such as *Rhododendron ciliatum* and *R. setosum*) and riverine willow (*Salix sikkimensis*), and *Lyonia ovalifolia*. In areas cleared for grazing, the alpine pastures and meadows are dominated by species of *Potentilla, Geranum, Primula, Juncus*, and *Pedicularis*. Areas immediately below the snow line are commonly known as alpine screes where dominant herb species of *Draba*, *Corydalis*, *Saxifraga, and Androsace are found.*

Table 1: Sum/percentage of area occupied by different landcover in watershed

landuse	Sum of area (Ha)	Area %
Alpine Scrubs	3915.9	7.5
Bluepine	7904.8	15.1
Broadleaf	0.7	0.0
Built up	2.0	0.0
Fir	1781.4	3.4
Kamzhing	4.5	0.0
Lake	20.9	0.0
Meadows	6941.4	13.2
Mixed conifer	11378.6	21.7
Rivers	14.0	0.0
Rocky Outcrops	1965.6	3.8
Scree	3877.8	7.4
Shrubs	11713.5	22.4
Snow and Glacier	2872.6	5.5
Total	52393.8	100

2. Watershed management planning process

The watershed management intervention report was developed through participatory process involving relevant stakeholders. 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 this report. The different stages of development of report are as follows:

2.1 Consultation workshop

The planning process started all the way from 2014 by holding consultative meeting with ThimphuThromde. The pertinent issues causing watershed degradations were discussed and appropriate measures to resolve them were suggested. The consultation workshop was attended by relevant stakeholders from ThimphuThromde, Tourism Council of Bhutan (TCB), Association of Bhutanese Tour Operators (ABTO), Nature Conservation Division (NCD/DoFPS), ThimphuDzongkhag, Dzongkhag Tsogdu Chairman and Naro Gewog.

2.2 Field investigation

Following the consultation meeting, field investigation was carried out in 2014 in collaboration with relevant stakeholders. To update and validate the information further, another round of field investigation was carried out in December 2021.The field investigations were carried out mainly to gain first hand understanding on the problems in the watershed and to ensure that all the proposed mitigation measure for each problem are appropriate and feasible for implementation on the ground.

Figure 5: Field data collection

During the field investigation, transect walks were done in watershed area to garner vital information's to access the health of watershed following Watershed Classification Guideline 2016. Watershed condition was assessed based on consideration of up to 28 criteria grouped into four categories; Biophysical, socio-economic, climatic and demographic.Furthermore, discharge measurements and GPS points were collected for all streams that drain water into Wangchu.

2.3 Write shops

Following the consultation meetings and field visits, in-house writeshop was conducted to discuss the contents of the report as well as to synthesize the information collected from the field. Eventually the watershed intervention measures report was drafted using the information collected and where required additional information was collected. Participants of the workshop consisted of staff from JDNP HQ and Lingzhi Park Range Office who were involved in the consultation meetings and field work.

2.4 Formulation of watershed management intervention report

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.

3. Condition of Watershed

3.1 Condition of sub-watersheds

Following the field visits, the condition of watershed was assessed using Watershed Classification Guideline (WCG) 2016. Due to large area interspersed by varying elevation, changing landcover and landuse, it was difficult to access the condition as one watershed. Hence based onsource, drainage and aspects, we have divided the watershed into 16 sub-watersheds and accessed them individually. We took into account the water use score only based on number of people residing in the sub-watershed area. Using the condition score and water use score, we found that except Barshong all other sub-watersheds were found to be in pristine condition. The Barshong sub-watershed was however found to be in degraded condition. If we include water use score based on downstream users at Thimphu Thromde, all sub-watershed will fall under degraded condition.

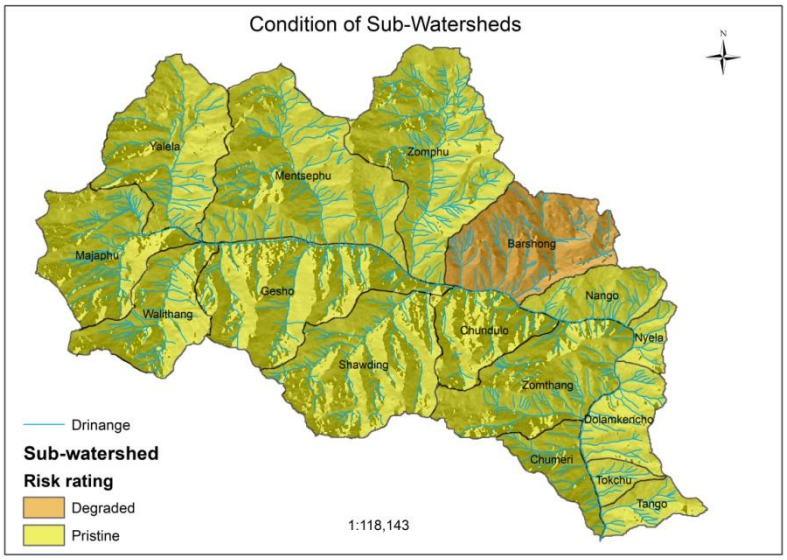

Figure 6: Condition of sub-watersheds based on condition score and water use score. Risk matrix was used to determine overall risk rating of sub-watershed condition

3.2 Streams feeding Wangchu basin

During the field visit, we found about 35 perennial streams that feed the Wangchu (Fig. 7). About 9 streams are found to be the major contributors with the discharge rate of each stream over 0.8m3/s (Fig.8). The discharge rates were measured from 06-20th December 2021 coinciding with fall season (Annexure 1). The sources of majority of streams (about 14 major streams) are either lake or glaciers. The sources of remaining streams are from forested areas. It is of paramount importance that we not just protect the forested areas but also protect the lakes as they are the main catchment/recharge areas for Wangchu.

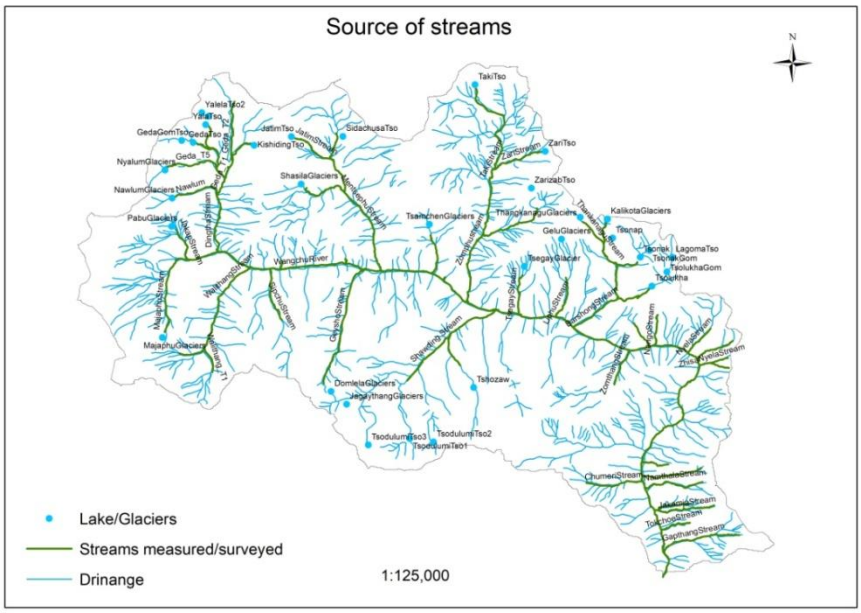

Figure 7: Map indicating streams that drain into Wangchu. The streams that are measured are indicated with dark green colour. The lakes that feed the streams are also indicated in the map.

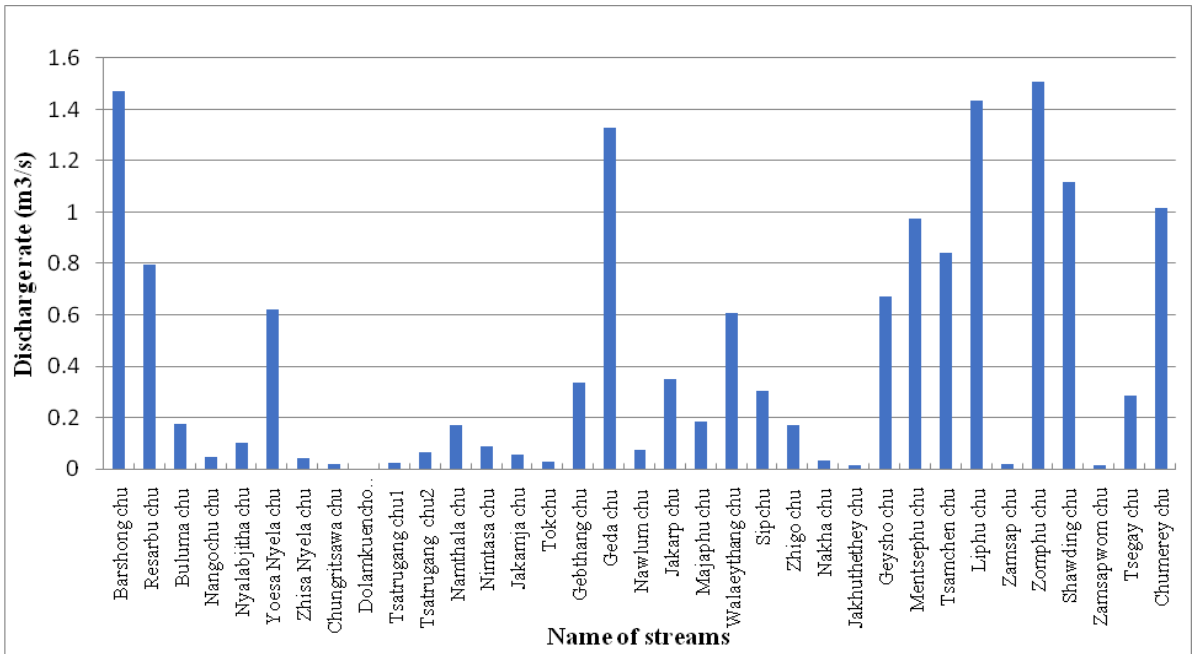

Figure 8: Discharge measurement of streams under Wangchu

3.3 Forest function map

The forest function map of upper Wangchu watershed is prepared based on guideline for zoning in protected areas of Bhutan (2021). The areas with high conservation values that are seen to provide critical services for the persistence of flora and fauna of international, national or local importance including resident or migratory fauna, and important water recharge areas are put down the core zone. The 15.9sqkm of watershed area is put under this zone. This is considered as non-negotiable zone and all activities in this zone are restricted except the scientific managements. The transition zone in watershed area covers lakes and pasturelands and also areas of interdependence between wildlife and communities wherein, traditional and legal rights for sustainable use of natural resources is permitted for a certain period (e.g., Ophiocordyceps collection areas and pasture lands). This zone consists of important habitat patches or contiguous habitat that serves as an important refuge for wildlife or movement of wildlife from core to other zones. In the Multiple-use Zone, it includes settlements, built-up areas, private registered lands and resource allocation areas for the PA residents. This zone is also termed as a 'zone of cooperation' underscoring the role of cooperation between the park management and its residents. This is a zone where stakeholders agree to work together to manage and use the area in a sustainable manner to benefit both people and wildlife. The total of 115.5 sqkm of the watershed area fall under this zone. Within the multiple use zones, Local Forest Management Plans will be made underscoring the specific resource supply sites (both present and future) and also ensuring the protection of watershed. The buffer zone in watershed area is created basically to provide a cushioning function to the core or transition zone. A 30m buffer zone is kept on both sides of main tributaries Wangchu basically to restrict or limit the resources collection along the streams.

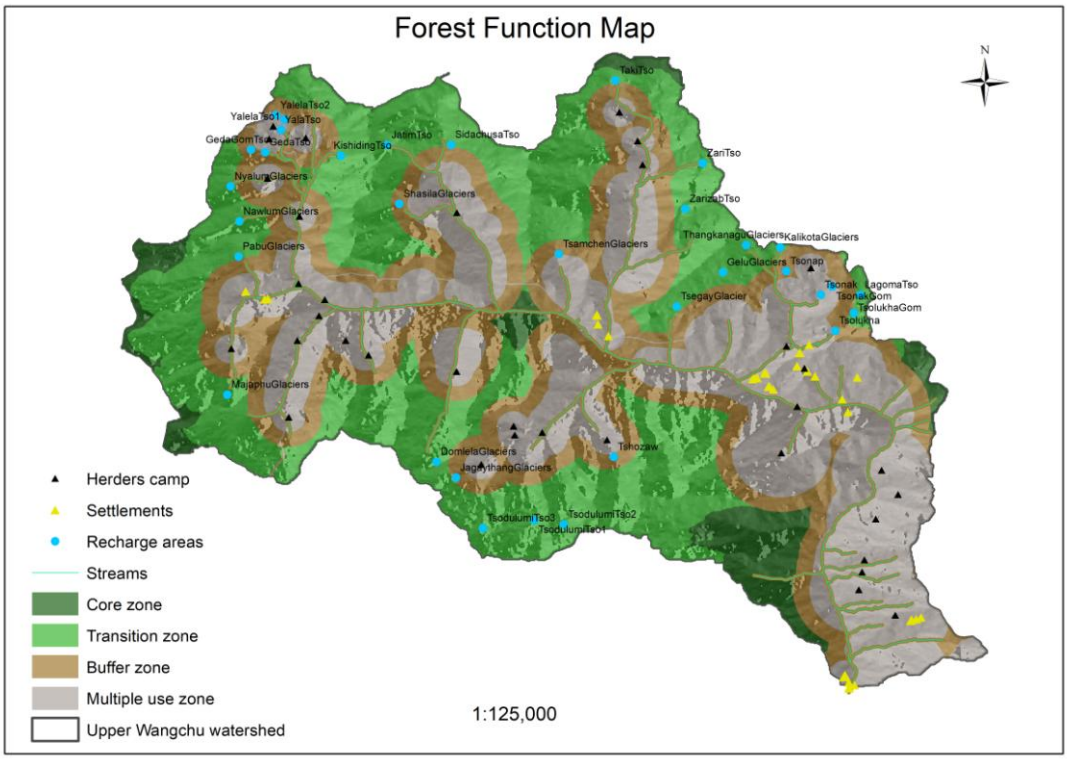

Figure 9: Forest function map of upper Wangchu watershed area

4. Issues impacting the watershed conditions

Problems and issues affecting the watershed conditions were identified at various stages during the planning process as reflected below:

4.1 Impacts due to infrastructure constructions

4.1.1. Road construction

The recently constructed 25 km Barshong GC road runs parallel to Wangchhu and cuts through many streams and tributaries, which ultimately flows into Wangchhu. The entire stretch of road falls a few meters to less than 200 meters above the wangchhu, where construction of road involved huge excavation of earth along the steep terrain and blasting of rocky outcrops. The debris and bounders from the excavation and blasting sites often fall into Wangchhu and nearby streams and increase the sediment load contributing to heavy bed loads along the downstream. Sometimes, during the peak rainy season, the debris including boulders dam the streams and tributaries and ultimately triggers landslide dammed outburst floods. This will not only contaminate the water bodies but cause flooding of the settlement and damaging of properties situated in the downstream areas.

Figure 10: Construction of Barshong GC road

4.1.2. Transmission line

The construction of 15.37km Barshong transmission line has damaged large swathes of forest across the watershed. In order to open enough space for 11KV line to pass though, a minimum of 6 meters of Right of Way (RoW) was created. As a result a total of 800 trees and poles of various species were felled within the corridor. A clearing felling of 6 meters corridor though out the alignment has exposed soil to erosion and also leads to change in vegetation composition. Moreover, most of the felling occurred along the steep slopes and difficult terrains. Therefore, in geologically unstable and landslide prone areas, these kinds of practices had led to erosions and aggravated the situation in the active landslide areas. Resulting in washing away of fine soil during rainy season and causing blockage of natural and manmade drains and subsequent flooding into wangchhu and nearby streams.

Figure 11: Felling of trees along electrical transmission line

4.1.3. Impact on water supply

Deep excavation and drilling during road construction may result in rupture or disappearance of ground water tables, resulting in reduction of the volume of water flow and eventual drying up of the streams. This will be a major issue for the people residing downstream, especially Thimphu Thromde inhabitants, who currently depend on Wangchhu for drinking water. Spillage of hazardous chemicals from the excavator, blasting materials and drilling machine may contaminate the water bodies, mainly streams and rivers flowing below the roads and the nearby ground water, and may thus render them unsafe for human consumption and domestic uses. Seeing that almost 50% of the Thimphu Thromde inhabitants use their drinking water from Wangchhu, such contamination will have severe impact and may even exacerbate the shortage of water available for human consumption where Wangchhu is predicted to meet the growing drinking water demand for next 30 years. In the

worst case scenario, there will be no drinking water source for half of Thromde population, and in such case, there is a dire need to identify drinking water source in other areas which will incur huge financial burden on the government.

Figure 12: Deep excavation along Dodena-Barshong road

4.2 Forest Degradation

The main drivers of forest degradation in the watershed are transmission line and road construction, harvesting of timber and fire wood, cattle grazing and natural hazards, such as landslides. The harvesting of timbers for Lingzhi Dzong construction and clearing of forest for Barshong road construction have heavily degraded some areas within the watershed. For instance, the ongoing Naro GC road construction is estimated to clear 3672 trees and around 24,000 Cft of timber has been allotted for Lingzhi Dzong construction. It is evident that pressure on the forests is high and has resulted in them becoming degraded where population density is highest. With the increase of human population inside the watershed, the demand for use of natural resources is expected to increase, which will place additional pressure on the remnant forests.

Forest condition has a direct effect on the provision of watershed goods and services. Degraded forests, particularly when huge chunk of forest is cleared and deep digging or excavation is carried out, which may trigger soil erosion or land slide in the area. Consequently, it may cause stream

sedimentation and pollution, 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.

Figure 13: Forest degradation in watershed area

4.3 Heavy grazing by domestic animals

These watersheds being the main summer grazing ground for yak herders, it is evident that grazing may have adverse effect on tree regeneration as it coincides with tree regeneration season which usually happen in summer, when the weather is conducive for germination. Moreover, it has been observed that the rate of regeneration was very poor in areas heavily grazed by domestic cattle and where the cattle density is high. In alpine forest, theground vegetation directly correlates to the rate of surface runoff, less ground cover means more surface runoff resulting in heavy siltation of stream and riverbed. The Naro Gewog alone has about 1488 heads of livestock. The Lingzhi Gewog has total of 3407 heads of livestock (Dendup et al. 2021) from which majority of them also come to graze in Wangchu watershed area.

Figure 14: Yak herd near Majaphu stream

Figure 15: Herd of horses used for transportation of goods in watershed area

4.4 No proper toilet with sewage system in place

The majority of households do not have flush toilet with interceptor tank to avert discharge of fecal matter into the nearby water bodies such as stream and ground water which will ultimately flow into Wangchhu. If not treated properly from the source, such contaminated liquid waste contains pathogen hazard which is unsafe for human consumption and domestic use.

4.5 Waste management issue

The number of visitors in the park has tripled in the last few decades including construction workers, both regional and international tourist, government officials and illegal poachers, as a result, there is an accumulation of solid wastes (such as plastic bags, liquor bottles, tarpaulins, concretes, steel, wooden scaffolding, and feces) and liquid wastes (such as used or spilled grease, mobile, and diesel oil) from the construction sites. These wastes will in turn lead to series of negative impacts (if not managed properly) such as loss of aesthetic beauty of the surrounding, contamination of the soil and water bodies, and soil erosion.

Figure 16: Waste collected and dumped at several sites inside the watershed area. This happened as there are no collectors even at the road head point.

4.6 Shrinking of pastureland

The reduced extent of alpine meadow or grassland is due to tree expansion in the rangelands and tree encroachment of open grassland inside forested areas, but has been difficult to track at large scales due to the slow, incremental pace of tree spread. The animal fodder is likely to be in short supply, in part, because of tree and shrub encroachment; however, it is difficult to measure the scale of tree cover expansion and its impact on forage production across the watershed areas without reliable satellite technology. The tree encroachment is thought to exacerbate declines in profitability from livestock rearing as invading trees out-compete and displace grasses and forbs which are critical foraging ground for yaks and horses. Nevertheless from hydrological point of view, alpine meadows and open areas are critical for groundwater recharge in order to maintain steady flow during the period of little recharge and dry season. Some studies had reported that alpine meadows receive a large amount of precipitation and return a relatively small amount of evapotranspiration to the atmosphere, resulting in a high potential for groundwater recharge.

4.7 Receding of snow coverage

The key observation from some locals was that a spring tended arrive later in the year, rapidly transition to summer monsoon, followed by long fall and late onset of winter. Thus the entire seasonal (temperature) calendar seems to have moved forward. This change in temperatures has been accompanied by change in snowfall, making snowfall less and unpredictable. This would also change the timing and volume of water discharge into rivers and streams within the watersheds.Moreover, groundwater discharge in alpine headwaters sustains baseflow in rivers originating from these watersheds, which is critically important for aquatic habitats, run-of-river hydropower generation, and downstream water supply. Therefore, monitoring of seasonal snow is important to understand the impact of climate change on water availability for continuous drinking water supply for the downstream settlements especially Thimphu city inhabitants that draw water from Wangchhu river. In addition, information about temporal and spatial distribution of seasonal snow cover is an important indicator of climate monitoring. Many recent studies on snow cover variabilityboth at the global and region scale have shown a decline in snow cover area, particularly in spring season.

Figure 17: Glaciers retreating (ocular observation) as compared to past few years in the watershed area

4.8 Consolidated issues and possible causes

Table 2: Consolidated issues and possible causes in the watershed

Issues	Possible causes
Mass soil movements (landslides, mud flows and related erosion)	landslides Road construction Use of explosives and excavation during road construction Improper dumping and piling of excavated soil and rocks Poor drainage system Steep topography Heavy rainfall Unstable geology Earthquakes
Forest degradation	Felling of trees along transmission line Supply of timber for rural house construction Allotment of timber for LingzhiDzong reconstruction Collection of NWFPs Heavy grazing and poor regeneration Fuel wood collection Leaf mold or top soil collection Natural hazards such as landslides
Heavy grazing	Grazing competition with wild ungulates Shrinking of natural grazing ground Climate change Cordycep collection Presence of invasive species
No toilets with interceptor tank	Lack of awareness Lack of materials Cost of construction Lack of skilled labours
Improper management of waste	Poor implementation of waste management protocol Improper disposal of wastes Lack of waste disposal sites No waste bins along the tourist trekking routes and campsites Lack of awareness Lack of fund for waste transportation from source to landfill Lack of knowledge for waste segregation
Shrinking of pastureland	Encroachment of open areas or grassland by woody plants Landslide Soil erosion Climate change
Receding of snow cover	Global warming

4. The intervention measures

The intervention measures is one of the important aspects of the watershed management intervention report to identify measures that can mitigate the effect of degrading influences and return the watersheds to normal or pristine condition (to the greatest extent possible) . Based on the potential impacts, the intervention measures explicitly chalk out detailed course of actions that need to be carried out to mitigate and avoid potential adverse impacts on the degraded watershed resulting from human activities and natural calamities. Proper planning and implementation of the intervention measures shall enhance the watershed conditions leading to improvement of water quantity and quality.

In order for these intervention measures to be successfully implemented, it is incumbent upon all parties including the LG leaders, government regulating agencies, and government focal and partner agencies to closely collaborate and make sure that all its aspects are fully accomplished. 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)

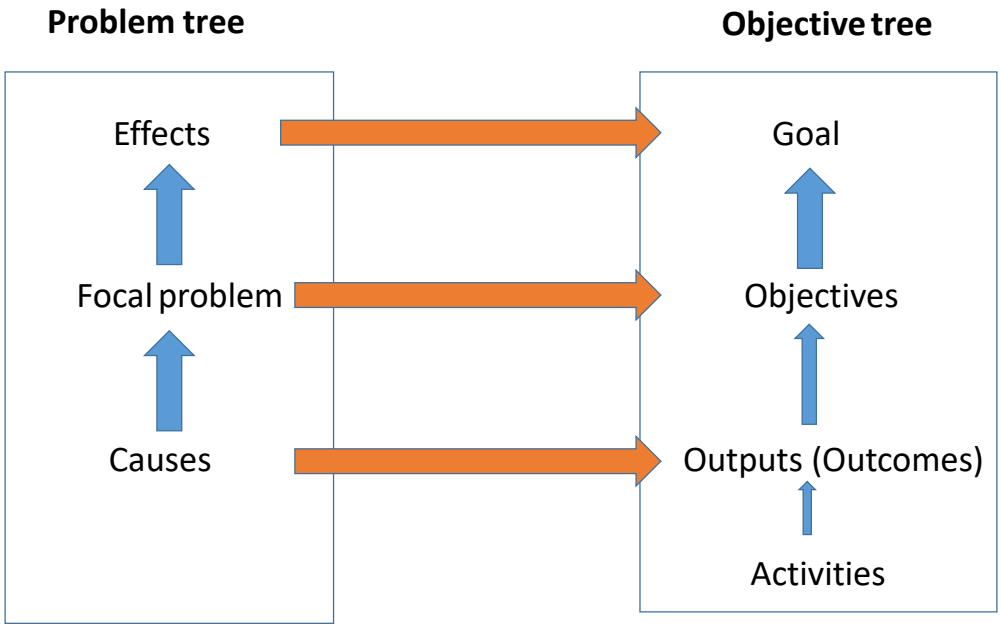

Figure 18: Problem tree and objective tree used to convert issues/problems identified during the planning process into an intervention strategy to mitigate the degrading influences

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 road and transmission line construction
- Degradation of forest caused by human activities such as harvesting of timber and fire wood, cattle grazing and natural hazards, such as landslides.
- Poor management of solid and liquid waste, generated by human especially visitors and construction labours

Along with these problems, the other important degrading influence includes issues such as unstable geology and receding of snow cover, which are beyond the ability of management interventions. However, several management interventions are designed to address issues such as mass movement of earth and forest degradation in the watershed.

Several problems were raised by local stakeholders during the various consultations, while being important in terms of impacting on their livelihoods, had no direct link to sedimentation of Wangchhuand degradation of the watershed. A "filter" was applied to ensure that only those issues/problems that contribute directly to the purpose of mitigating degrading influences were addressed in the report. 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 areexpected to addressby this plan.

The final step in the LFA process was the construction of a log frame matrix that facilitated the identification of specific activities for implementation, along with a budget to address problem in the watershed. This is shown in detail in Table 3 and a brief description of the intervention logic is given below.

5. Goal and objective of plan

Goal

To minimize human induced impacts and enhance provision of watershed good and services for continuous supply of quality water for Thimphu Thromde

The objectives set to attain the goal are:

Objectives

1. To minimize mass movement of soil and surface runoff from construction sites
2. To mitigate the degrading influences and improve watershed conditions

6. Outputs and description of activities

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

Objective 1: To minimize mass movement of soil and surface runoff from road construction sites

Output 1.1: Improve existing road in conformity to EFRC rules

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.

The excavated slopes are to be immediately planted with combination of grasses, bamboos, and legumes to anchor the soil materials on the slopes and to save them from being washed down by rainwater and being blown away by gusty wind. The seeds of these plants could be simply broadcast using hands.

Concurrently, in more erosion prone areas, gully checks, check dams, log walls, stone retaining walls are to be constructed below the extraction areas and stockpiles, and they should be complemented with other bioengineering works right below the pile of overburdens to hold soil and prevent rock slides. Such measures will avoid stream sedimentation and massive siltation of the riverbeds and consequent flooding in the downstream plains

Output 1.2 Maintaining waterways free of boulders and debris through regular monitoring

As there are numerous boulders and debris along the waterways, it is important to regularly monitor the formation of pools and dams on the rivers/streams and clear those blockage to avoid flooding in the downstream plains. If possible, there is need to monitor the dumping of debris and boulders during road construction and maintenance to lessen the problem downstream.

Output 1.3 Hydrometerological information improved

Since this watershed is considered as one of the critical watersheds in Bhutan as it being the main source of drinking water for Thimphu Thromde residents and also being situated within one of most fragile climatic areas, however there is no meteorology station in the watershed area. In order to have adequate information to better understand the different aspects of watershed, there is a need to install both meteorological and hydrological stations as well as provide training to record and maintain the stations in the watershed.

Objective 2: To mitigate the degrading influences and improve watershed conditions

Output 2.1 Ensured sustainable management of forest resources

The watershed condition depends on the health of the forest, so one way of mitigating the degraded forest is by enrichment plantation. The success of the plantation hinges on the quality of seedlings. Seedlings of native species belonging to primary succession stage of the nearby forest ecosystem shall be collected from nearby nurseries. The plantations need to be well taken care in their initial

stage with proper fencing and timely watering and addition of manure The process of natural succession is highly probable due to existence of lush forest cover in the watershed area. Moreover, the sustainable harvest of the forest is key for maintaining the watershed condition so development of LFMP especially in tree marking areas is highly recommended.

Output 2.2 Managed free flow of sewerage water

The domestic sewage water and waste water originating from the villages and sewage tanks need to be first routed through soak pits from where they could be directed towards a treatment pit where proper treatments could be done before releasing to the nearby water bodies.

Sewage tanks on the verge of overflowing are to be emptied and dumped at the safe dumpsites.

Output 2.3 Waste management practice enhanced

Leaching of toxic solid and liquid effluents from the construction sites and waste along the human trails as well as from human settlements can contaminate the water sources and water bodies, thereby rendering them non-potable and uninhabitable for aquatic creatures and downstream settlements.

In the current era of climate change with impending risks of droughts and drying up of water sources, it is imperative to protect and save water sources from contamination so that there is continuous supply of water for various uses especially those residing downstream. Hence it has become important to create awareness and further strengthen the implementation of existing waste management protocol. Installation of waste bins at strategic points where we can collect and dispose it designated sites has also become paramount of importance.

Output 2.4 Improved pastureland for local communities

Alpine meadows and open areas are critical for groundwater recharge in order to maintain steady flow during the period of little recharge and dry season. The activity is aimed at practicing a prescribed burning with the technical support from Department of Forest and Park Services for clearing of unwanted plant species in areas that were known to be open and recently encroached by woody plants using the indigenous knowledge and past satellite images.

The upper slopes of the watershed have been subjected to extensive cattle grazing, although cattle numbers have declined substantially in the watershed over the past few decades. The cattle migratory system is still prevalent and there is need to improve fodder resources and cattle breed in the watershed to reduce the numbers of unproductive local breed.

Output 2.5 PES scheme established

As most of the settlements in Naro Geog are situated right in the headwaters, the activities undertaken up there will have direct implication on sustainable flow of quality and quantity of drinking water for downstream usersparticularly Thimphu Thromde residents. In order to protect the watershed for long-term sustainability, PES scheme establishment may encourage upstream

communities to carryout activities to secure the water resources for which the burden of doing the same may be shared by downstream users through payment of fees based on PES agreement.

7. Funding implementation

All activities are included in the LFAM with specific details of locations, verifiable indicators, collaborating and lead agencies. To properly implement the scheduled activities of the plan, funding needs to be sought from RGoB and other potential donors. The activities should be reflected in the local area management plans of the lead agencies, for instance activities led by JDNP should be reflected in Park Management Plan of JDNP. For the key collaborators to be available during the implementation of activities, the the lead agencies shall inform the collaborators much in advance, preferable during the start of the financial year. If activities are not implemented in a scheduled plan year, the lead agencies shall attempt to implement them in the succeeding plan year to be able to guarantee the maximum implementation of planned activities.

The total amount required to fully implement the plan stands at Nu. 9.425 million

Table 3: Logical Framework Analysis Matrix (LFAM) for Naro watershed Management Plan

Output	Activities	Verifiable indicators	Collaborating Agency	Lead Agency	Budget (M Nu)
Objective 1: To minimize mass movement of soil and surface runoff from road construction sites					
1.1. Improve the existing roads in conformity to EFRC rules	1.1.1. Broadcast native seeds of grasses & plants along the excavated slops and landslips as well as on the exposed landslide areas (12 sites)	Kgs of grass and plant seeds	JDNP/NG/TD/TT	JDNP	1.5
	1.1.2.Plantation of trees and bamboos to stabilize the landslides (5 Ha)	No of seedlings	JDNP/NG/TD/TT	JDNP	0.4
	1.1.3.Maintenance of plantation created in 1.1.2	No of seedlings	JDNP/NG/TD/TT	JDNP	0.2
	1.1.4.Construction of effective retaining walls (85 meters) below Barshong GC road (Tokchu– 25m,Domshisa – 42m,Gentsa– 10m, and Eusa – 8)	Length of retaining walls build	NG/TD/TT	NG	1.4
	1.1.6. Construction of 19 check-dams below Barshong GC road (Tsebgang- 5, Dolamkencho-3, Gyentsa-5, and Ngala Bjitha-6)	No of check-dams constructed	NG/TD/TT	NG	0.25
	1.1.7. Monitoring of excavation and	Monitoring protocol put	NG/JDNP/TT/TD	JDNP	0.12

	dumping of overburdens	in place			
1.2. Maintaining waterways free of boulders and debris through regular monitoring	1.2.1. Conduct awareness campaign on dumping of debris along Barshong GC road	Awareness report	NG/JDNP/TT	NG	0.5
	1.2.2. Installation of waste management signage at strategic locations along GC roads	No of signage installed	TCB/NG/JDNP	JDNP	0.1
	1.2.3. Construct disposal pits at strategic locations along GC roads	No of disposal pits	TCB/NG/JDNP	JDNP	0.25
	1.2.4. Monitoring of boulders and debris along the waterways to avoid formation of pools and dams	Monitoring report	NG/JDNP/TT	NG	0.15
1.3. Hydrometerological information improved	13.1.Install meteorological and hydrological stations in the watershed	A database for hydro-meterological information maintained	NCHM/JDNP	JDNP	0.5
Objective 2: To mitigate degraded influences and improve watershed conditions					
2.1 Ensured sustainable management of forest resources	2.1.1.Enrichment plantation in the degraded areas	Plantation established in 10 Ha of degraded area	GBCL/JDNP/NG	GBCL	0.6
	2.1.3. Development of LFMP	% of the geographical area brought under scientific forest management	JDNP/NG/FRMD	JDNP	0.5
	2.1.4.Monitoring the extraction of forest resources during the plan implementation period (upstream)	Compliance monitoring report of LFMP produced annually	JDNP/NG	JDNP	0.2
	2.1.5. Removal of invasive plants	Total area of invasive plants removed	JDNP/NG	JDNP	0.15
2.2 Managed free flow of sewerage water	2.2.1. Purchase of construction materials for toilet, septic tank, soak pit and treatment pit for 47 HHs on cost sharing basis	100% of the households have access to toilets and treatment pits	NG/TT/TD	NG	0.75
2.3 Waste management practice enhanced	2.3.1. Install 13 waste bins at campsites and lunch points along tourist trekking routes from Barshong till Yaklila	100% of households and government institutions involved in waste management	NG/TT/ TD/JDNP/TCB	JDNP	0.055

	2.3.2. Installation of waste management signage at strategic locations along the tourist trekking routes	No of signage installed	TCB/NG/JDNP	JDNP	0.1
	2.3.3. Revised the current Waste Management protocol	Waste management protocol developed	NG/TD/TT/JDNP	JDNP	0.25
2.4 Improved pastureland for local communities	2.4.1 Pasture land management	5 Ha of pastureland improved			
	2.4.2. Development of private pastureland for with fencing and transportation of inputs	Private pastureland improved for 24 households	NG/JDNP/TD/DoL	NG	0.4
	2.4.3. Support breed improvement for yaks	Scrub cattle reduced by 50 %	DoL/NG	NG	0.2
	2.4.4. Regulate cattle grazing and delineate grazing areas	Grazing agreement drawn	NG/JDNP/TD	JDNP	0.15
2.5 PES scheme established	2.6.2. Identification of PES activities and fee negotiation including formulation of bylaw and signing of agreement	Endorsed PES agreement for implementation	TT/TD/JDNP/TCB /ABTO/NG/WMD	JDNP	0.5
	2.6.3. Monitoring and evaluation	Monitoring report	TT/TD/JDNP/TCB /ABTO/NG/WMD	JDNP	0.2
			Estimated budget		**9.425**

8. Funding mechanism

The implementation of planned watershed activities should be funded from the regular government budget. However, in case of insufficient funds for implementing watershed management activities, the management plan can be used as a basis to solicit funds from donors. As the coordinating agency, JDNP 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. Payment to Ecosystem Services can be one of the means to solicit the fund and implement the activities reflected in this report in part or full. The incorporation of activities of the watershed management plan into respective plans and budgets of local administration will be monitored by JDNP in collaboration with WMD and Thimphu Thromde.

9. Monitoring and evaluation

The activities identified in this management report as being necessary to achieve the goal and objectives of the plan are designed to be integrated into the respective area-based plans of a variety of agencies and organizations' (indicated in the logframe) annual and 5-year plans. These implementing organizations will monitor the implementation of activities. The verifiable indicators given in the logframe matrix (Table 3) 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 contributed to attaining the goal should be carried out by JDNP in collaboration with WMD and Thimphu Thromde towards the end of the plan period.

10. References

Gannser, A. (1964). Geology of the Himalayas. London, New York, Sydney: Interscience.

Phuntshok, J. (2018). Integrated Watershed Management Plan for Barsa Watershed, Department of Forest & Park Services, MoAF, Royal Government of Bhutan.

WMD (2016). Watershed Classification Guideline. Department of Forests and Park Services, Ministry of Agriculture and Forest, Thimphu, Bhutan.

Dendup, P., Dorji, R., Jamtsho, Y., Wangchuk, W., Gyeltshen, J., Tenzin, S., Tenzin, S. and Dorji, R. (2021). People and Livelihood in Jigme Dorji National Park: A Socio-Economic Survey Report. Department of Forest and Park Services, Ministry of Agriculture and Forests. Royal Government of Bhutan. Damji: Gasa.

Thinley, P and Tharchen, L. (2014). Conservation management plan of Jigme Dorji National Park for the period January 2015 – December 2019: protecting the legacy of the visionary monarch's for the happiness of the citizens. Department of Forests and Park Services, Thimphu, Bhutan

Table 4: Annexure1-Water source information

Sl. No.	Village	Chiwog	Gewog	Dzongkhag	Name of water source	Type of water source *	Northing	Easting	Elevation (masl)	Uses	Nos. of household dependent	Discharge (m3/s)	Distance from village (minutes)	Perennial / Seasonal
1	Barshong	Barshong	Naro	Thimphu	Barshong river	1	27.69162	89.60167	3789	1	57	1.4714	5	Parennial
2	Zomthang	Barshong	Naro	Thimphu	Resarbu Stream	3	27.681437	89.599647	3652	1	1	0.7977	180	Parennial
3	Barshong	Barshong	Naro	Thimphu	BulumaChuu	2	27.68359	89.62186	3630	1	5	0.1767	120	Parennial
4	Barshong	Barshong	Naro	Thimphu	Nangochu	2	27.68326	89.62647	3612	1		0.047	40	Parennial
5	Barshong	Barshong	Naro	Thimphu	Nyalabjithachu	2	27.6822	89.6418	3554	1		0.1012	80	Parennial
6	Barshong	Barshong	Naro	Thimphu	YoesaNyelachu	2	27.67907	89.64505	3845	1		0.6185	115	Parennial
7	Barshong	Barshong	Naro	Thimphu	ZhisaNyelachu	2	27.67498	89.64922	3536	1		0.0394	115	Parennial
8	Barshong	Barshong	Naro	Thimphu	Chungritsawachu	2	27.67392	89.64862	3536	1		0.0162	120	Parennial
9	Dolamkuechoo	Begana	Kawang	Thimphu	Dolamkuenchho	2	27.63555	89.62757	3395	1		0.6020	180	Parennial
10	Tsatrugang	Begana	Kawang	Thimphu	Tsatrugang 1	2	27.63217	89.63196	3322	1	1	0.0225	130	Parennial
11	Tsatrugang	Begana	Kawang	Thimphu	Tsatrugang2	2	27.63217	89.63196	3322	1	1	0.0632	135	Parennial
12	Namthala	Begana	Kawang	Thimphu	Namthala	2	27.62892	89.63178	3321	1	1	0.1684	130	Parennial
13	Nimtasa	Begana	Kawang	Thimphu	Nimtasa	2	27.62052	89.63295	3190	1	1	0.0877	140	Parennial
14	Jakamja	Begana	Kawang	Thimphu	Jakamja	2	27.61864	89.63286	3166	1	1	0.0533	80	Parennial
15	Tokchu	Begana	Kawang	Thimphu	Tokchu	2	27.61326	89.63711	3240	1	15	0.027	40	Parennial
16	Wangchu	Begana	Kawang	Thimphu	Wangchu		27.60598	89.629	2698	1		6.2483	5	Parennial
17	Gebthang	Begana	Kawang	Thimphu	Gebthang	2	27.60296	89.62945	2667	1		0.3351	5	Parennial
18	Dingtha	Chakphu	Lingshi	Thimphu	Geda Chu	1	27.73941	89.46002	4333	1	6	1.3273	240	Parennial
19	Dingtha	Chakphu	Lingshi	Thimphu	Nawlum	2	27.73829	89.45886	4322	1	3	0.0727	240	Parennial

20	Bashithang	Chakphu	Lingshi	Thimphu	Jakarp	1	27.71501	89.44715	4189	1	3	0.3496	45	Parennial
21	Bashithang	Chakphu	Lingshi	Thimphu	Majaphu	1	27.71391	89.44611	4175	1	3	0.185	5	Parennial
22	Walethang	pagay	Naro	Thimphu	Walaeythang	6	27.71023	89.47134	3998	1	3	0.6055	1	Parennial
23	Sipchu	Pagay	Naro	Thimphu	Sipchu	1	27.70727	89.48	4090	1	1	0.3013	15	Parennial
24	Zhigo	pagay	Naro	Thimphu	Zhigo	2	27.71041	89.4834	4025	1	1	0.1717	10	Parennial
25	Nakha	Barshong	Naro	Thimphu	Nakha	2	27.71163	89.50386	3803	1	0	0.0316	240	Parennial
26	Jakhuthethey	Barshong	Naro	Thimphu	Jakhuthethey	2	27.71219	89.50785	3792	1		0.0146	260	Parennial
27	Geysho	pagay	Naro	Thimphu	Geysho	2	27.70975	89.51506	3778	1	2	0.6701	15	Parennial
28	Mentsephu	Mentseph u	Naro	Thimphu	Mentsephu	1	27.70971	89.515	3753	1	3	0.9747	2	Parennial
29	Tsamchen	Barshong	Naro	Thimphu	Tsamchen	2	27.70819	89.54055	3679	1	1	0.8435	60	Parennial
30	Liphu	Barshong	Naro	Thimphu	Liphu	1	27.69472	89.59077	3743	1	1	1.4339	10	Parennial
31	ZamSarp	Barshong	Naro	Thimphu	ZamSarp	2	27.70582	89.54475	3708	1	1	0.0194	30	Parennial
32	Zomphu	Barshong	Naro	Thimphu	Zomphu	1	27.69763	89.55471	3648	1	5	1.5083	180	Parennial
33	Shawing	pagay	Naro	Thimphu	Shawding	2	27.69414	89.5647	3648	1	7	1.1178	280	Parennial
34	ZamSarp	Barshong	Naro	Thimphu	ZamSarpWo m	2	27.69348	89.57	3679	1	1	0.0124	40	Parennial
35	Tsegay	Barshong	Naro	Thimphu	Tsegay	1	27.69288	89.57384	3590	1	1	0.2851	120	Parennial
36	Chumeree	Barshong	Naro	Thimphu	Chumerey	1	27.64304 2	89.60966 5	3396	1	1	1.01410	140	Parennial
* Type: 1. Lake, 2.Spring, 3.Streams, 4.River, 5.Pond, 6.Marshes														