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Department of Water
Ministry of Energy and Natural Resources
Royal Government of Bhutan

BHUTAN
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Balukhola watershed management Intervention plan

2023

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FORWARD

Watershed management is one of the important aspects in the conservation, protection, and sustainable utilization of water resources, particularly with the economic development and growing population. This watershed plan has been developed for the Balukhola watershed in Khempagang village, Samtenling Gewog, of Gelephu Dungkhag under Sarpang Dzongkhag, with the purpose to conserve and protect the watershed, which serves as an important drinking water source for Gelephu Thromde.

The plan is funded and fulfills the water flagship program under component I, which focuses on protecting and designing interventions for crucial water sources. The plan has strategically outlined specific interventions and actions required to manage and improve the overall health and sustainability of the watershed. It encompasses elements such as land use planning, sustainable forest management, water resource management, conservation practices, financial mechanisms, community engagement, and monitoring and evaluation strategies.

The goal of this watershed management intervention plan is to ensure a reliable supply of clean drinking water and other essential ecological services through the sustainable management of natural resources and the implementation of climate change mitigation measures.

Given the significance of this plan in protecting the Balukhola water sources and the collaborative effort involved in its development, I am extremely grateful to the team for their contributions. Finally, I would like to request all relevant agencies to support the implementation of this plan and achieve our shared goal of assured access to adequate, safe and affordable water to maintain and enhance the quality of their lives and the integrity of natural ecosystems.

Dechen Yangden
Director

ACKNOWLEDGEMENTS

In the process of developing this plan, field assessment was crucial, and we would like to express our appreciation to the staff and administration of Sarpang Forest Division for their initial report, support and endurance throughout the intensive assessment.

We are also grateful to the local communities of Khempagang village for their generosity and support during the field assessment and consultation.

We extend our thanks to Mr. Dawa Zangpo, Dy. Chief Forestry Officer, and Mr. Kinga Norbu, Sr. Forestry Officer, of DoFPS for their valuable knowledge sharing on GIS and SMART programs for the plan.

We would also like to acknowledge Ms. Thinley Zangmo, Engineer of the Water and Sanitation Division, MOIT, for sharing information on the backdrop of the water flagship program.

Lastly, we would like to express our gratitude to our advisory members who provided us with valuable suggestions and contributions to the plan. We are especially grateful to Dechen Yangden, Director, DoW for her emphasis on the plan's finalization, without which it wouldn't have been possible.

We are indebted to all of them.

EXECUTIVE SUMMARY

To ensure sustainable and reliable water services for Khempagang Chiwog, Gelephu Gewog, and Gelephu Thromde, it is crucial to managing the Balukhola watershed, which covers an area of 1389.35 hectares. The designated watershed boundary includes the Khempagang village, of which 3% is non-forest and the remaining 97% is under state reserve forest land. Nearly 53% of the forested area is under forest management regimes (Biological Corridor and Community Forests), which provide an advantage in the conservation and protection of the watershed.

In light of the current reports indicating a decline in water production from all three existing sources (Mouchu, Passangchu, and borewells) currently supplying water to Gelephu Thromde, the Balukhola water source has been identified as a necessary supplementary source of drinking water for the region. It is anticipated that Gelephu Thromde will experience significant urban growth, leading to a rise in demand for water. Therefore, effective management of the Balukhola watershed is imperative at this juncture.

The watershed management intervention plan has identified a few issues and potential threats to the health of the Balukhola watershed. The plan was developed based on the current practice of watershed management plan with the core synthesis of the interventions detailed in the Logical Frame Work Analysis matrix. The assessment process revealed that the watershed requires less immediate intervention but requires protection of the land from potential threats from anthropogenic activities and climate change. To prevent and mitigate these immediate and potential issues, the plan aims to secure the watershed through sustainable forest management, building resilience to climate variability, and, most importantly, community participation in securing reliable water supply. Community participation is crucial in ensuring the sustainability of the plan and its successful implementation, as it will empower local residents to take ownership of the watershed and adopt sustainable practices.

This plan like any other watershed management plan is not a standalone plan, but is an amalgamation of the activities identified as being necessary to minimize degradation of the watershed in the future. These activities are expected to be incorporated into area based planning frameworks (Five Year Plans and Annual Plans) of Dzongkhag, Gewog and other agencies. The monitoring and evaluation of the plan will be carried out by DOW in collaboration with line agencies.

The plan involves ongoing monitoring and evaluation of management actions, including its climatic variability, and the use of feedback loops to adjust plans and strategies based on new information and changing conditions. The approach of this plan shall be adaptive management, which recognizes the inherent uncertainty and complexity of natural resource management.

TABLE OF CONTENTS

FORWARD 3
ACKNOWLEDGEMENTS 4
EXECUTIVE SUMMARY 5
TABLE OF CONTENTS 6
GLOSSARY AND ABBREVIATIONS 7
1. INTRODUCTION 8
2. PROCESS FOLLOWED IN DESIGNING THE MANAGEMENT INTERVENTION 15
3. FUNCTION MAPPING AND HYDROGEOLOGICAL EVALUATION 16
4. ISSUES CONTRIBUTING TO WATERSHED DEGRADATION 22
5. THE INTERVENTION MEASURES 24
6. ARRANGEMENTS FOR INCORPORATION AND IMPLEMENTATION OF ACTIVITIES 31
7. FUNDING IMPLEMENTATION 31
8. MONITORING AND EVALUATION 31
9. REVISION AND ADMENTMENT OF PLAN 31
10. REFERENCES 32
11. ANNEXURE 34

GLOSSARY AND ABBREVIATIONS

Chiwogs	Group of villages
Gewog	An administrative division comprising a group of villages and subdivision of District
Dzongkhag	District
Thromde	Municipality

BC	Biological Corridor
CF	Community Forest
DEM	Digital Elevation Model
DoECC	Department of Environment and Climate Change
DoFPS	Department of Forests and Park Services
DoW	Department of Water
FNCRR	Forest and Nature Conservation Rules and Regulations
FYP	Five Year Plan
GIS	Geographic Information System
Ha	Hectare
ISRIC	International Soil Reference and Information Centre
NCHM	National Centre for Hydrology and Meteorology
NLCS	National Land Commission Secretariat
NSSC	National Soil Service Centre
PES	Payment of Ecosystem Services
PRA	Potential Recharge Area
RGoB	Royal Government of Bhutan
SDSS	Spatial Decision Support System
TDS	Total Dissolved Solids

1. INTRODUCTION

Water, as an important natural resource, is entrusted to every Bhutanese for conservation and sustainable use under Article 5 of the Constitution of Bhutan. In recognition of seasonal and local water scarcity for drinking and agricultural purposes, increasing pressure from rapid socio-economic development, and threats of climate change, the Water Act of Bhutan 2011 and Water Regulation of Bhutan 2014 provide people's rights and responsibilities for the protection and management of water resources.

The Balukhola watershed located in Samtenling Gewog under Sarpang Dzongkhag which extends from $90^{O}22'48''$ E to $90^{O}22'48''$ E and $26^{O}60'00''$ N to $26^{O}56'00''$ N (Map 1) covering an area of ~1389.35 ha. It has wide range of altitude ranging from 450 to 1750 meters above sea level (masl) within a short radial distance of ~ 6.5km, characterized by steep rugged terrain. The entire watershed lies within the outer humid slope of the lesser Himalayan series that receives heavy precipitation of ~5000mm a year. This watershed harbors a number of springs/streams that cater to a wide array of populations downstream including Gelephu Geog for drinking, irrigation, and other industrial purposes.

Over the years, Gelephu Thromde have been facing acute shortage of water to meet the growing demands from sprawling population exacerbated by the drying of existing water sources due to climate change and forest degradation in the upper catchment areas. The other reasons being two major landslides located at Lhayul (Chudzom) and Ossey (Jigmecholing) that source huge sediments and debris during monsoon season deteriorating water quality for drinking.

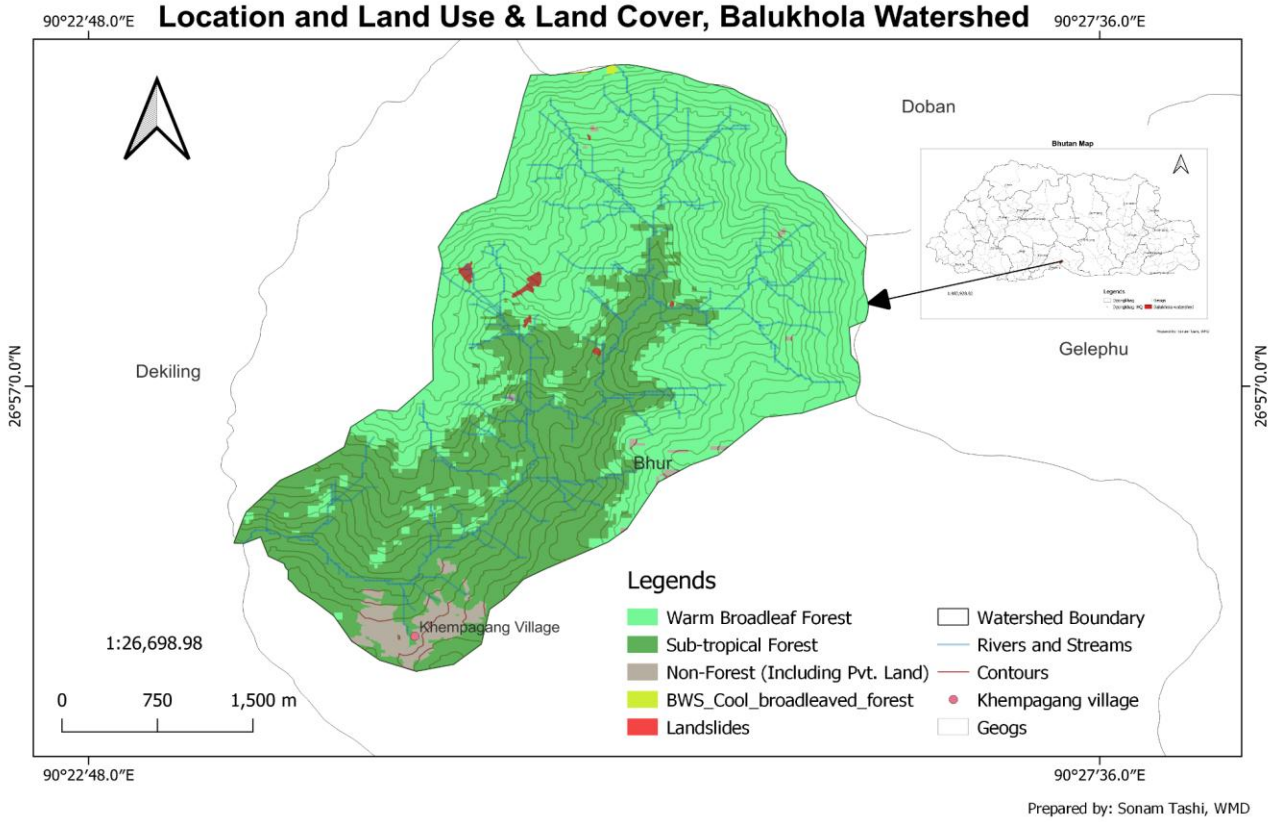
Balukhola has been identified as an additional source to supplement the water shortage in Gelephu Thromde, Gelephu Geog and Samtenling Geog. The landmark water project in Balukhola was commissioned in 2022 under the water flagship program targeting to benefit a population of more than 83,542 based on the Royal Command. The construction work on water supply from Balukhola has already begun and this water supply project is expected to meet the drinking water demand for at least 30 years down the line.

Therefore, recognizing the importance of Balukhola watershed, it is crucial to have a watershed management plan developed to address issues and prevent degrading impacts that are likely to impede water quality and quantity in line with the Water Act of Bhutan, 2011.

1.2. DESCRIPTION OF WATERSHED AREA

1.2.1. Land Use and Land Cover

As per Land Use & Land Cover Map 2016, Forest Types of Bhutan 2022 and field validation, about 97% of the area is covered by forest and only about 3% is non-forest (Table 1). The non-forest area includes settlements, denuded areas (landslides) and private registered lands.



Map 1. Land-use map of Balukhola

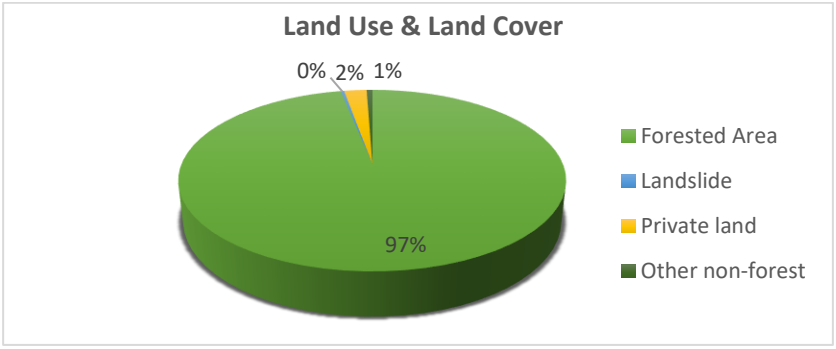


Figure 1. Detailed LULC as per 2016 data

The major chunk of forested area in the watershed is warm broadleaved forest (59.41%) with dominant species of *Terminalia tomentosa, Engelhardia spicata, Kydia calycina, Albizia procera, Castranopsis indica, Altingia excelsa,* etc. The sub-tropical forest (37.40%) consists of dominant species like *Duabanga grandiflora, Ailanthus integrifolia, Bombax ceiba, Tetrameles nudiflora,* etc. While small portion is covered with cool broadleaved forest of less than 1% with dominant species of *Castanopsis histrix* and *Quercus lamellosa,* etc.

Table 1. Area Statements by Land Use

Sl. No.	Forest Type	Area (ha)	Percent(%)
1	Warm Broadleaved	825.39	59.41
2	Sub-tropical	519.67	37.40
3	Cool Broadleaved	0.85	0.06
4	Non-Forest	43.44	3.13
		1389.35	100.00

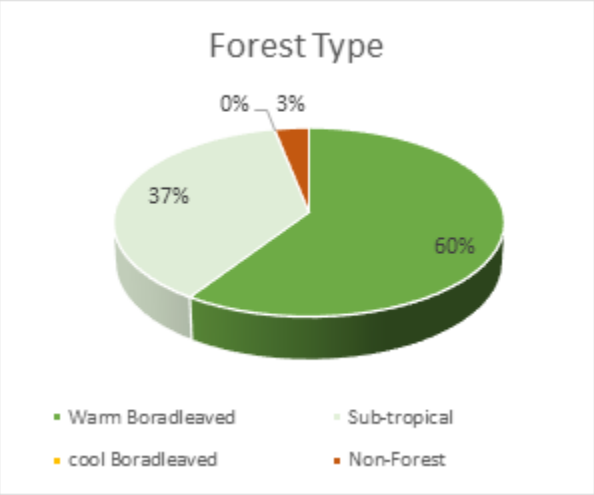


Figure 2. Forest type as per 2022 data

1.2.2. Current Forest Management Regimes

The upper part of the Balukhola watershed falls in the Biological Corridor 3 and a small area buffering Khempagang village at the lower flank falls in the Community Forest management area (Figure 2):

Community Forest: Dungkarling Community Forest (CF), which was established in 2004, is managed by 88 households covering an area of ~359.48 hectares of which 230.67 hectares falls within the watershed boundary. The CF area constitute 16.6% of the total watershed area. The primary objectives of establishing the CF are to rehabilitate barren and degraded lands, protect and preserve water sources and utilize forest resources on a sustainable basis.

Biological Corridor: The upper part of the watershed falls within the Biological Corridor-3 (BC-3) and covers an area of ~493.75 ha (36.21%) of the total Balukhola watershed area. The BC-3 connects Phibsoo Wildlife Sanctuary, Royal Manas National Park, and Jigme Singye Wangchuck National Park to facilitate wildlife movement.

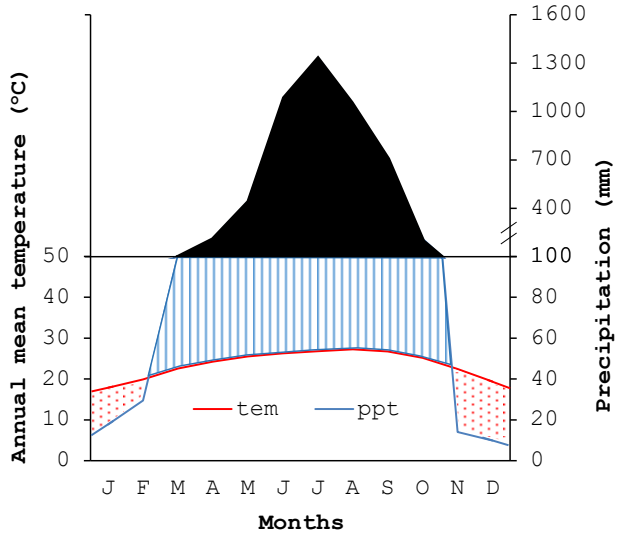
1.2.3. Geology

As per the Geologic Map of Bhutan by *Long et al*, 2011, Balukhola watershed falls under three geologic formations, which are Manas formation, Daling formation and Jaishidanda formation. Lower area of watershed is mainly Manas formation of locally conglomerate quartzite, interbedded with thin-bedded to thinly laminated phyllite and medium gray dolostone. In the middle of

watershed is Daling formation dominated by schist and phyllite, quartzite with thin to medium-bedded and medium-gray limestone interbedded. The uppermost part of the of watershed falls in Jaishidanda formation of gray, biotite-rich, locally garnet-bearing schist, interbedded with gray to tan, biotite lamination-bearing, lithic clast-rich quartzite.

1.2.4. Rainfall & air temperature

The nearest weather station located to the Bhalukhola watershed is the Bhur station at an elevation of 367 masl. The precipitation and air temperature data of about 26 years (1996 to 2022) from the National Center for Hydrology and Meteorology (NCHM) were analyzed to understand the climate indices, which plays an important role in the hydrological cycle of the area. The area receives mean annual precipitation of about 5187 mm was recorded with a maximum of 1331.4 mm in July and minimum of 9.9 mm in December. The annual mean temperature was 24^{o}C with the warmest mean of 27^{o}C and the coldest mean temperature of about 18^{o}C. The Walter's climate (precipitation – temperature) diagram (Figure 3) indicated that the watershed is very humid and surplus in water except for a few winter months. Perhaps, the potential evapotranspiration ratio (Table 2) is very minimal (0.3) compared to Bajo (1.7) in Wangdue, the inner dry valley.



Tab. 2. Comparison of climate indices of Dry and Wet climatic conditions

Location	Bhur	Bajo
Altitude(m)	367	1285
AMT(°C)	23.7	18.2
WMT(°C)	27.3	23.6
CMT(°C)	17.8	10.2
ART(°C)	9.4	13.4
PPT(mm)	5186.6	645.9
PER	0.3	1.7

Note: AMT= Annual Mean temperature, WMT= Warmest Mean Temperature, CMT= Coldest Mean Temperature, ART= Annual Range of Temperature, PPT= Total Precipitation, PER= Potential Evapotranspiration Ratio

Figure 3. Walter's climate diagram at Bhur meteorology station (367 m) relating the moisture condition. Black colour represents condensed total monthly rainfall of 300 mm interval. Blue colour vertical lines represent moisture excess while red colour doted represents the moisture deficiency.

Based on the trend analysis (Figure 4) for the last 26 years, the annual mean temperature was observed a curve shaped (Figure 4A). It declined from 26.4 ^{o}C to 22.1 ^{o}C in the year 1996 to 2007 and again increased to 25.1 ^{o}C in the year 2022. However, the general trend showed no significant raise or decrease of temperature (R^2=0.0035). The annual mean precipitation varied forming a rhythmic pattern (Figure 4B) with a maximum of 7932.1 mm and a minimum of 3885.1 mm in the year 2004 and 2006 respectively. So, a similar trend was observed (R^2=0.0037) indicating no significant change of precipitation over the years.

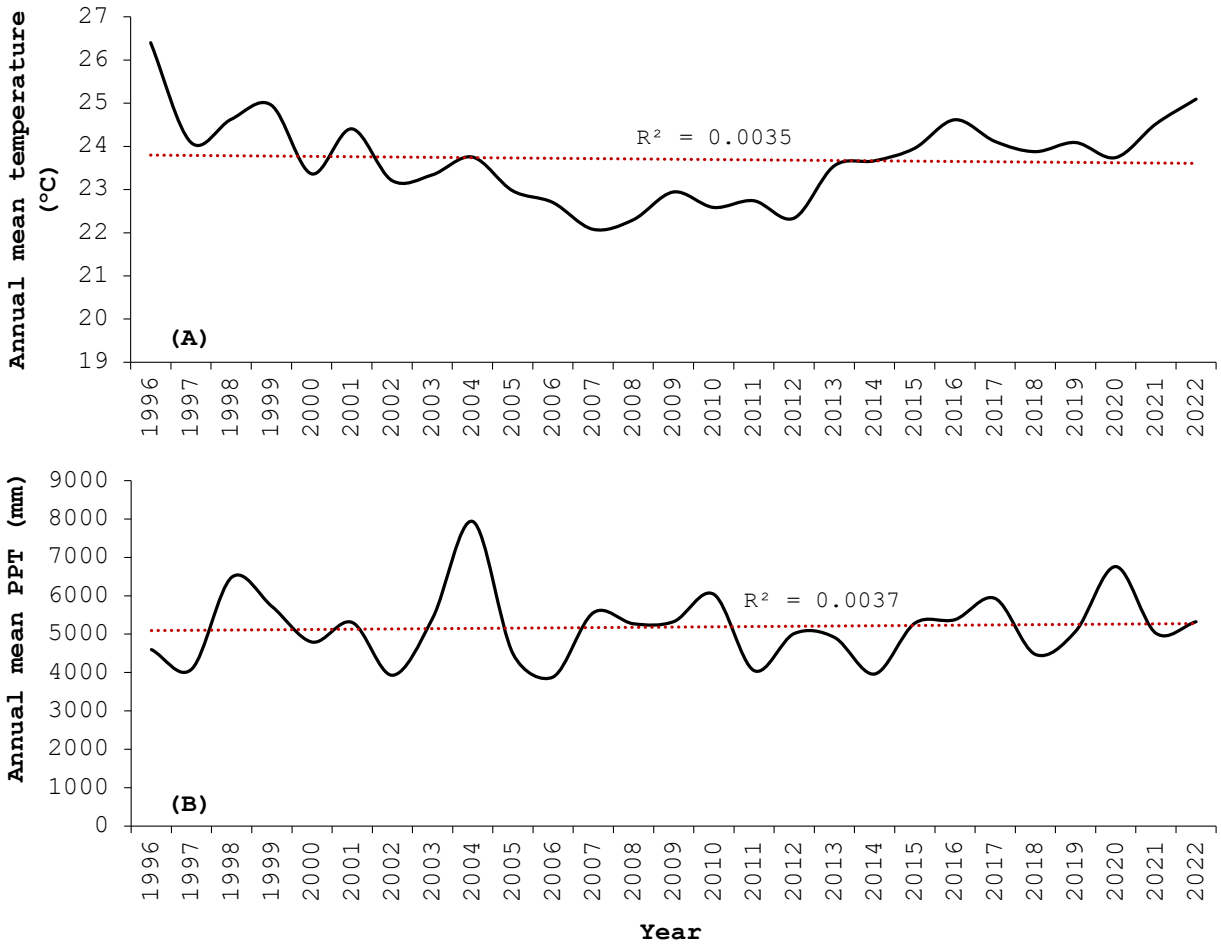


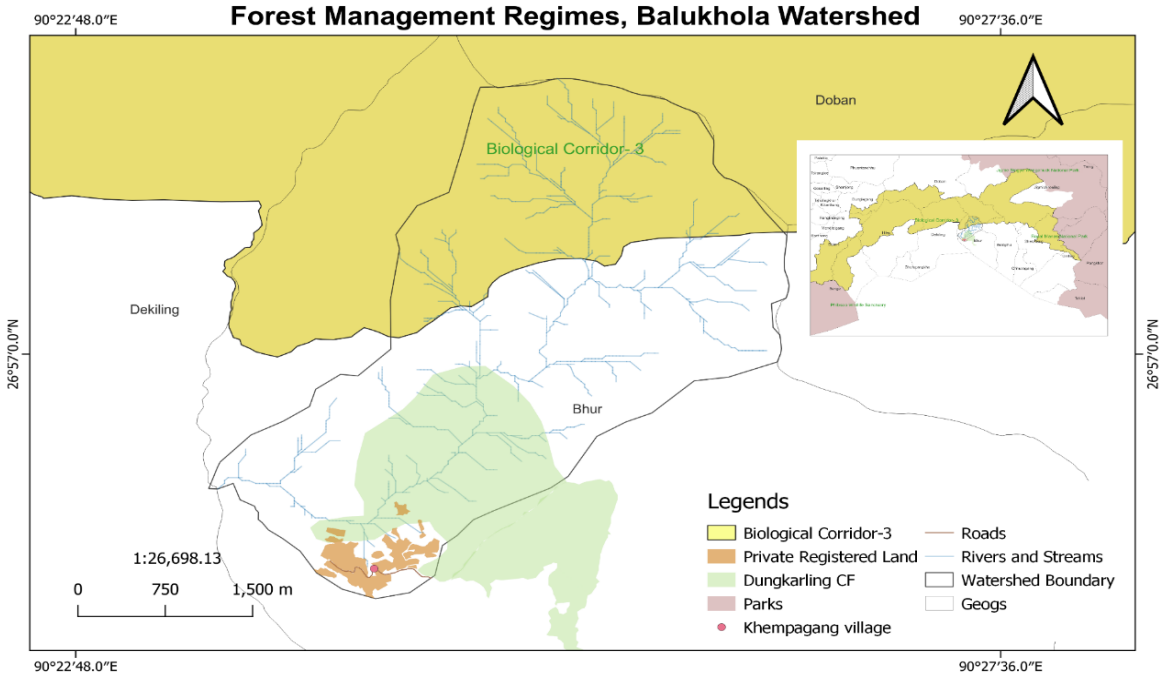
Figure 4. Climatic trend of Bhur for the last 26 years: (A) Annual mean temperature & (B) annual mean precipitation

1.2.5. Elevation, Slope and Aspect

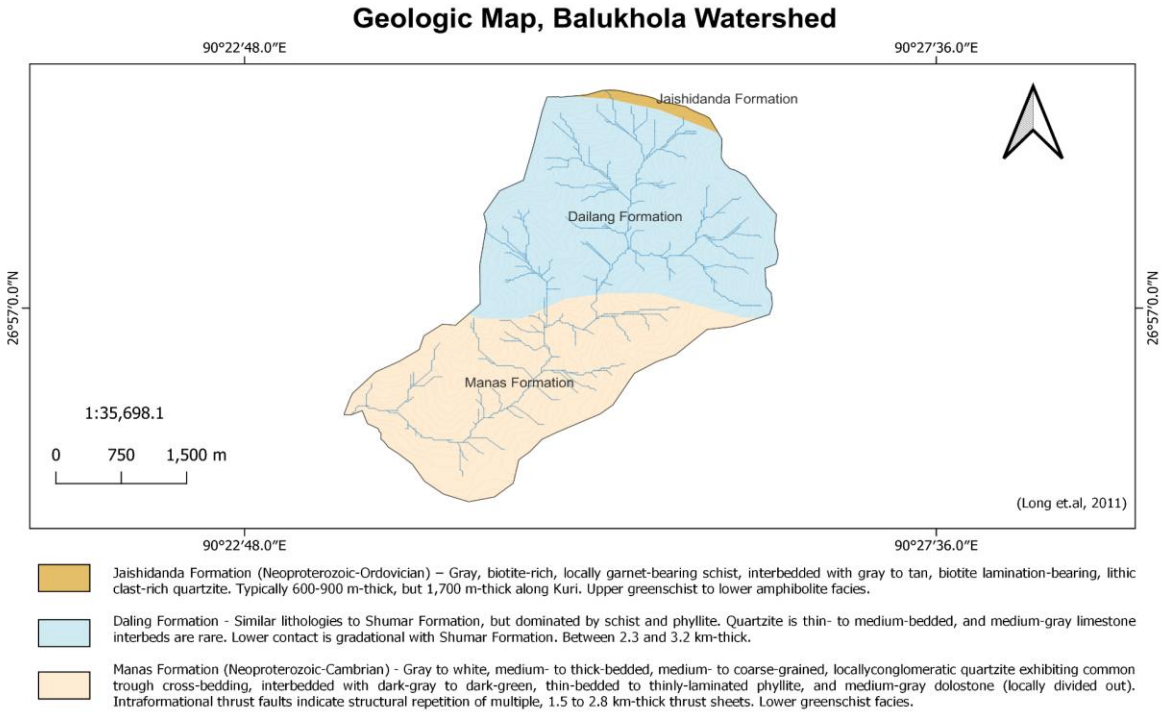
Elevation: The elevation range in the watershed area is from 597 masl to the highest peak of 1900 masl. The elevation range of 500-1900 masl within a small area of 1389 ha indicates that there is significant topographic variability within the area.

Slope: The slope range is from 4-83 degrees in the watershed area. The average slope degree is 47 and the majority of area is 65 degrees.

Aspect: The average aspect in the watershed area is South-West and majority is West facing.



Maps 2. Forest Management Regimes

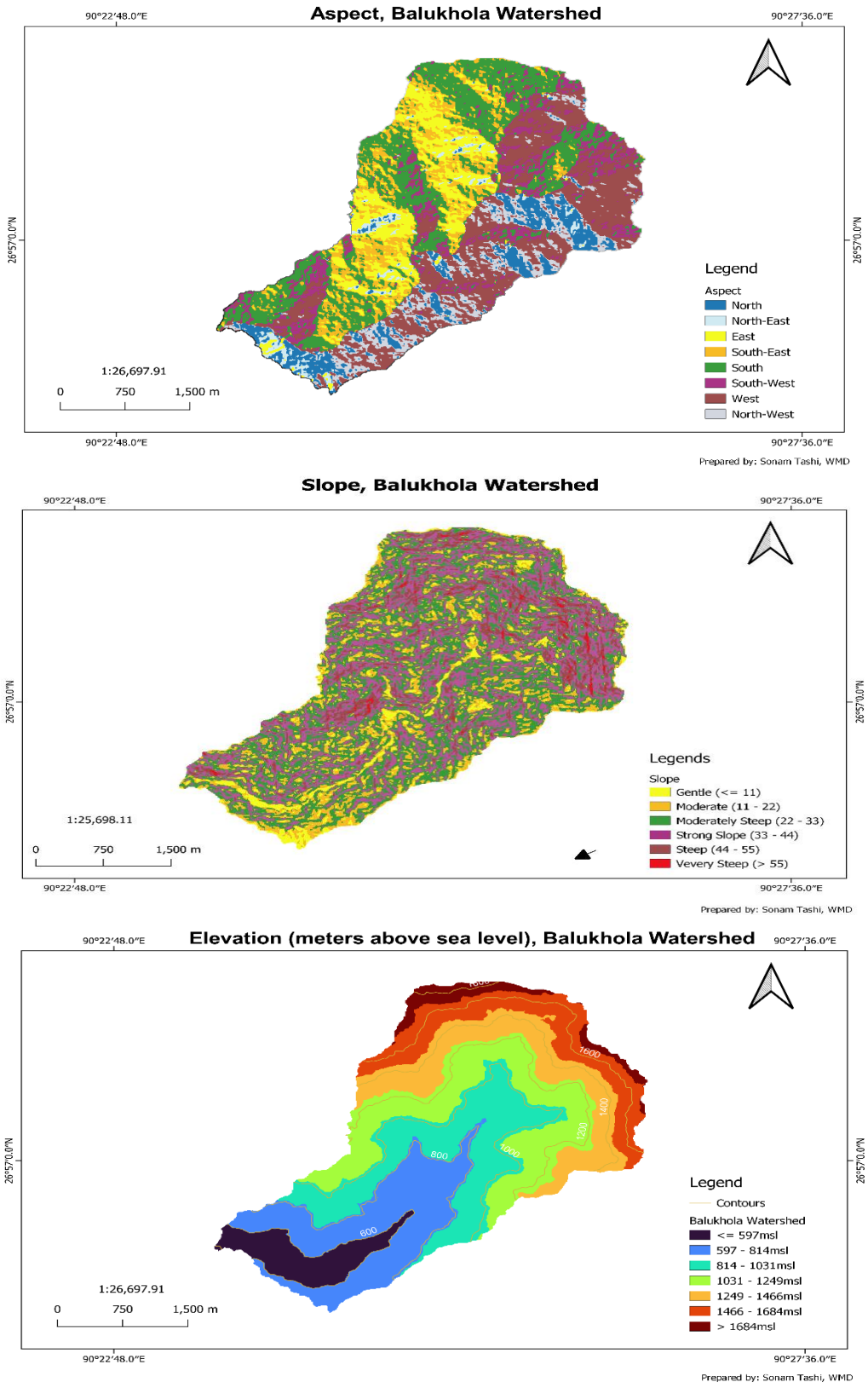


Jaishidanda Formation (Neoproterozoic-Ordovician) – Gray, biotite-rich, locally garnet-bearing schist, interbedded with gray to tan, biotite lamination-bearing, lithic clast-rich quartzite. Typically 600-900 m-thick, but 1,700 m-thick along Kuri. Upper greenschist to lower amphibolite facies.

Daling Formation - Similar lithologies to Shumar Formation, but dominated by schist and phyllite. Quartzite is thin- to medium-bedded, and medium-gray limestone interbeds are rare. Lower contact is gradational with Shumar Formation. Between 2.3 and 3.2 km-thick.

Manas Formation (Neoproterozoic-Cambrian) - Gray to white, medium- to thick-bedded, medium- to coarse-grained, locallyconglomeratic quartzite exhibiting common trough cross-bedding, interbedded with dark-gray to dark-green, thin-bedded to thinly-laminated phyllite, and medium-gray dolostone (locally divided out). Intraformational thrust faults indicate structural repetition of multiple, 1.5 to 2.8 km-thick thrust sheets. Lower greenschist facies.

Maps 3 Geologic Map



Maps 4. Aspect, Slope and Elevation

1.2.5. Water resources

The Balukhola watershed is a typical example of a dendritic drainage pattern, consisting of number of springs that converge and form Balukhola stream. The water discharge at the proposed tapping point was estimated at 1.6 m3/sec (mid-October). The table below shows the lists of springs/streams emanating from Balukhola watershed (Table 2).

Table 2. SEQ Table Basic water quality parameters,of Balukhola stream and its tributaries

Stream Location Name	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Elevation (m.a.s.l)	TDS (ppm)	Salinity (ppm)	pH	Conductivity (µS/cm)	H_2O Tem. (°C)	Remarks
Kholsey-2	26.96358	90.42373	1057	170	0.12	9	247	20.7	NA
Balukhola	26.96369	90.42478	1057	186	0.16	9.08	267	20.7	NA
Balukhola	26.95703	90.42515	840	87	0.06	8.3	123	20.7	1 m3/sec
Kholsey	26.95824	90.42536	851	119	0.07	9.47	150	21.7	NA
Balukhola	26.95841	90.42477	852	196	0.14	9.14	258	20.7	NA
side stream	26.95674	90.43248	1110	46	0.03	9.19	65.5	22	NA
Balukhola	26.95790	90.43199	1110	113	0.08	8.59	171.8	21.4	NA
Balukhola (Thromdey Tapping point)	26.95507	90.42211	732	95	0.07	8.93	156	20.7	1.6 m3/sec
Average				**126.5**	**0.09125**	**8.9625**	**179.7875**	**21.075**	

2. PROCESS FOLLOWED IN DESIGNING THE MANAGEMENT INTERVENTION

In designing of the Balukhola watershed management plan, three crucial steps based on the design process framework adopted (Figure 5).

Firstly, the planning process involved the delineation of the watershed boundary based on its significance as a drinking water supply for Thromde, achieved through a combination of DEM[1] analysis in GIS application[2] and physical verification.

Secondly, remote sensing data[3] was utilized for function and hydrological analysis.

Finally, the hydrogeological analysis was performed using the springshed concept in Google Earth and CorelDRAW2021 application. Furthermore, stakeholder consultations were conducted to identify issues and problems, which helped synthesize specific interventions.

[1] Alos Pulsar Digital Elevation Model (DEM) of 9.77 pixel

[2] Application used: QGIS 3.22, ACR10.3

[3] Data used: LULC 2016, Forest type 2022

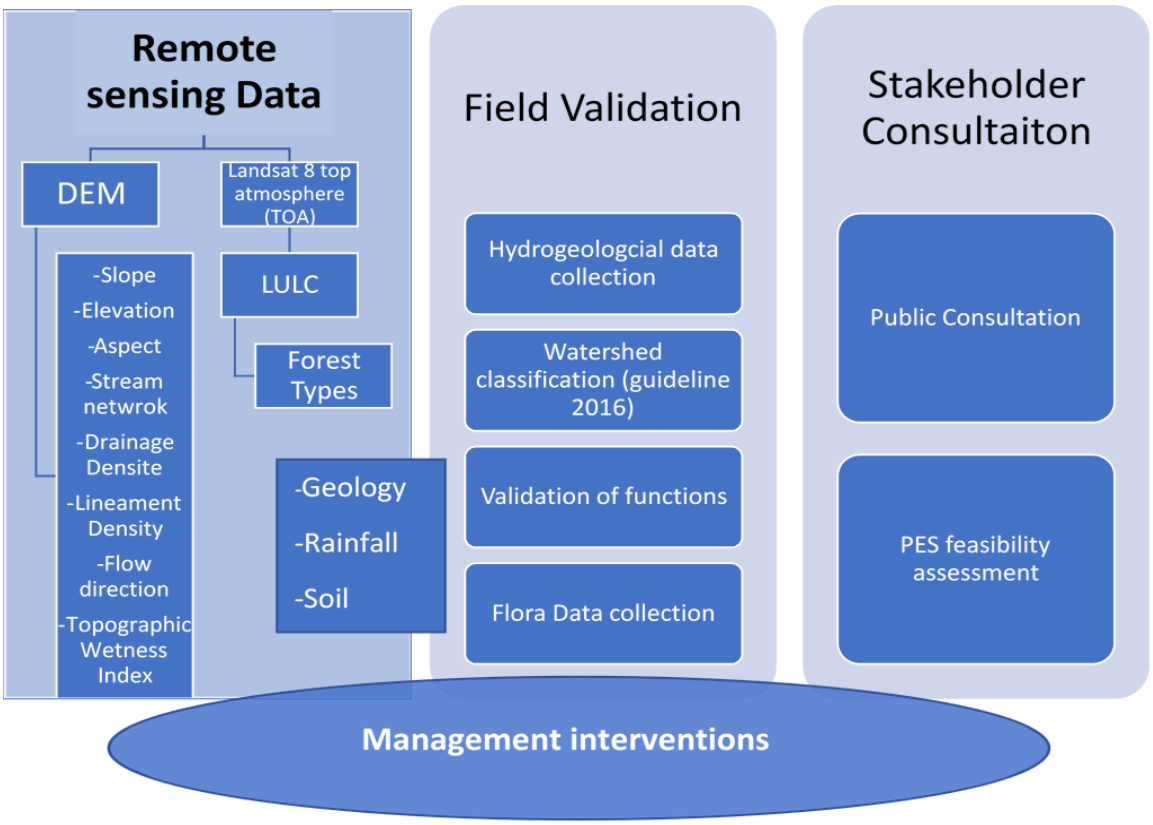


Figure 5. Framework for watershed management planning for Balukhola watershed

3. FUNCTION MAPPING AND HYDROGEOLOGICAL EVALUATION

3.1. Function Mapping

The function mapping is an essential part of the planning process. It is required to categorize an area into different zones based on its ecological, social and economic functions. The function mapping was carried out as per the Forest and Nature Conservation Code of Best Management Practices of Bhutan, Volume III, 2021 to prescribe site specific management interventions. The entire Balukhola watershed has been classified into various functional zones based on the function mapping exercise.

3.1.1. Social Function

In the Balukhola watershed, ~97% of the total area is State Reserve Forest land. Of the total watershed area, ~16.6% is under Dungkarling Community Forest, benefiting 88 households in meeting their resource needs such as timber, fuelwood and NWFPs.

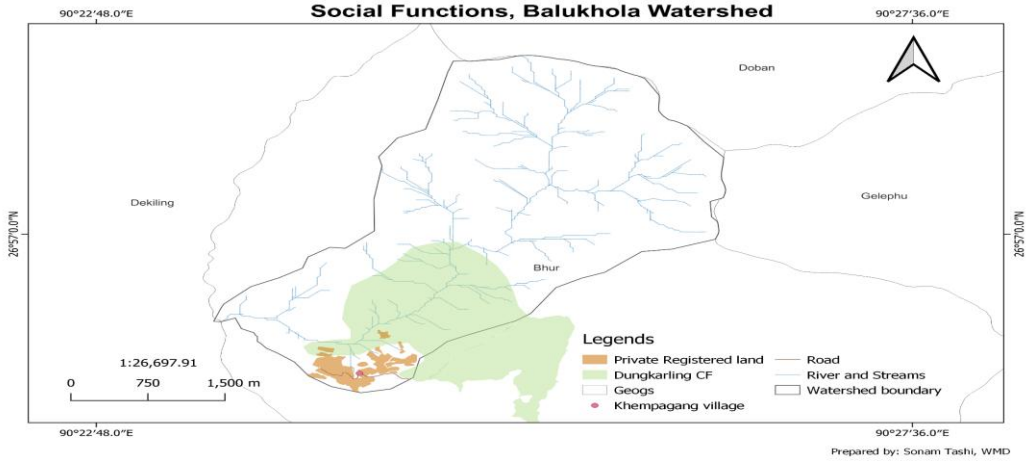
3.1.2. Soil Function

The slope classification indicated that ~67.41 ha falls above 45 degree while 269.85 ha is within the range of 35-45 degree that warrants protection and conservation.

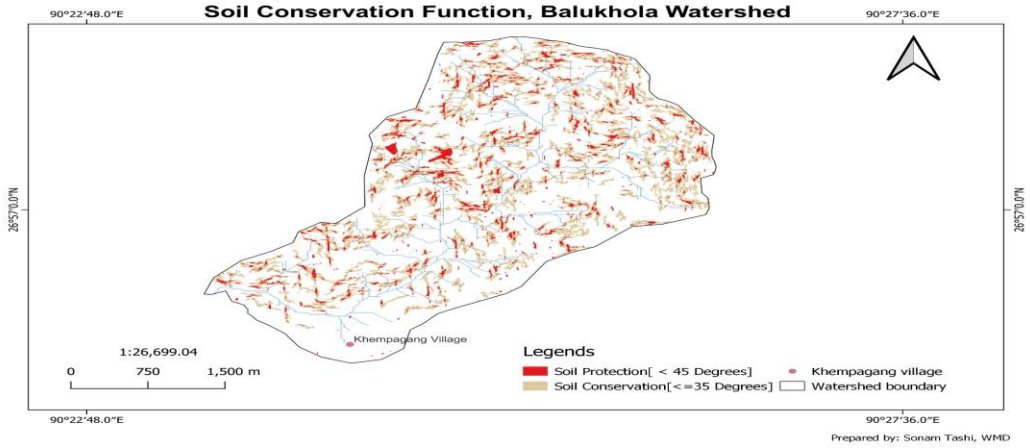
3.1.3. Water Conservation function

Through Strahler order [4]of classification from DEM (9.77pxl), a drainage network was generated. Strahler order 1-8 is present in the Balukhola watershed area. More than 5 order numbers are considered for major stream protection. Major river and stream protection area is around 52.31 ha and minor stream protection is 76.64 ha, while the total water channel protection area is 140.27 ha.

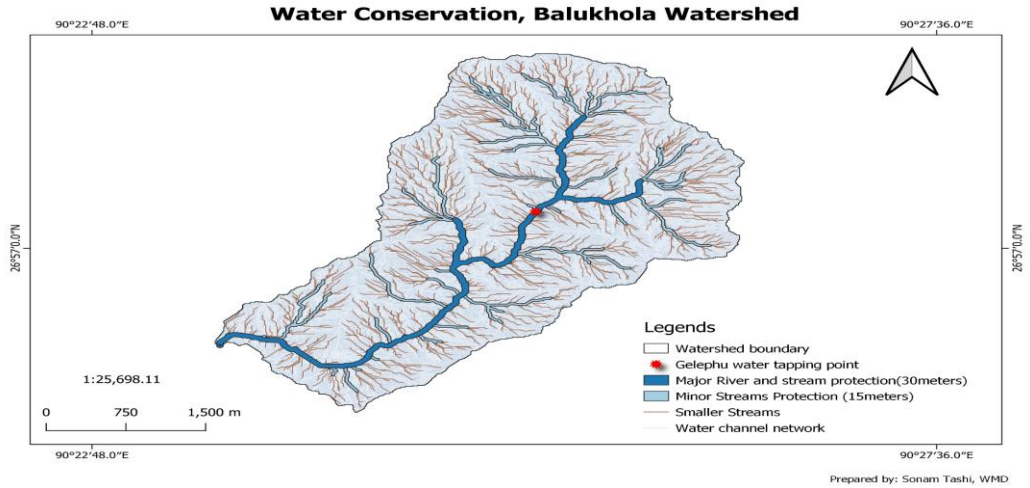
[4] Strahler stream order or Horton–Strahler order, is a method of classifying streams and rivers based on the hierarchy of their tributaries.



Maps 5. Social Functions



Maps 6. Soil Conservation Function



Maps 7. Water Conservation Function

3.2. Hydrological conditions

3.2.1 Drainage Density

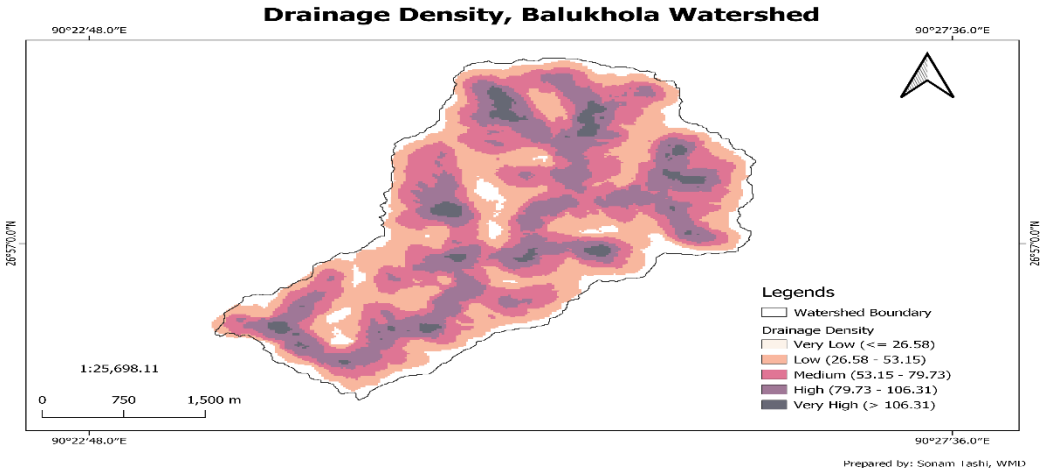
Drainage density indicates the closeness of spacing of stream channels and can be calculated as the total length of all the streams and rivers in the watershed divided by the total area of drainage watershed. The drainage density has an inverse relationship with groundwater prospect. The higher the drainage density, lower the probability of groundwater potential zone (Melese & Belay, 2022). The average drainage density of 61 m in an area of 1361 ha indicated that there is an average of 61 m of stream channel per ha of land in the area. In other words, the total length of stream or river channels in the area is approximately 81,921 m (1361 ha x 61 m/ha). This could probably mean higher drainage density indicating a more intensively developed landscape of mountainous relief (Sahu, Prasad, & Ahmad, 2022) and a higher potential for water-related problems such as flooding, landslide and erosion due to high surface flow velocity. (Map 8)

3.2.2 Lineament Density

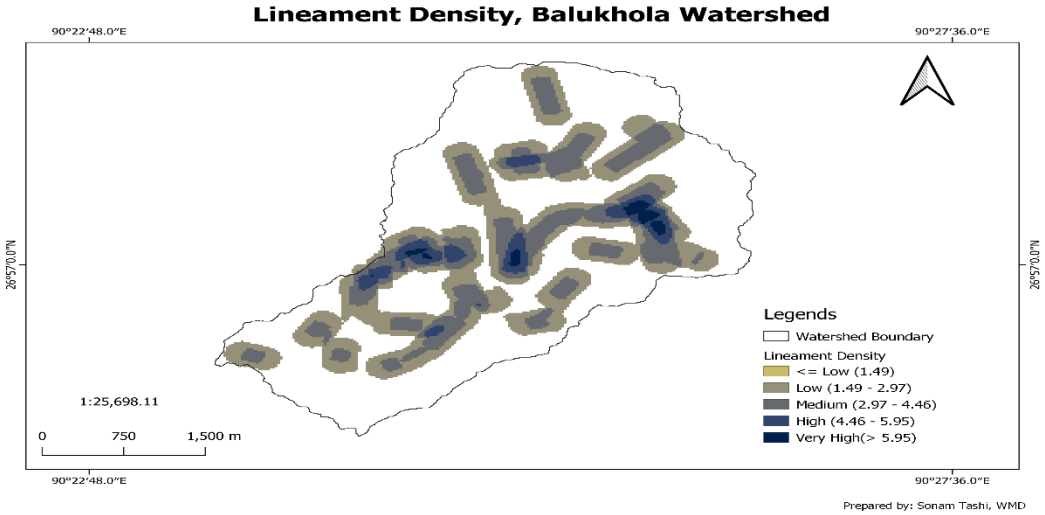
A lineament is a linear feature in a geographical landscape that is a manifestation of fundamental geological structure. The lineament density was defined as the total length of all the recorded lineaments divided by the area under consideration. Lineament density is directly proportional to the groundwater recharge zone. The purpose of the lineament analysis is to improve understanding of the relationship between the surface water penetration and fracture systems, controlling water infiltration and mobility (Melese & Belay, 2022). As per the lineament density analysis using GIS, the average is 1.3, indicating a relatively stable geological area with fewer fractures and faults. (Map 9)

3.2.3 Topographic Wetness Index (TWI)

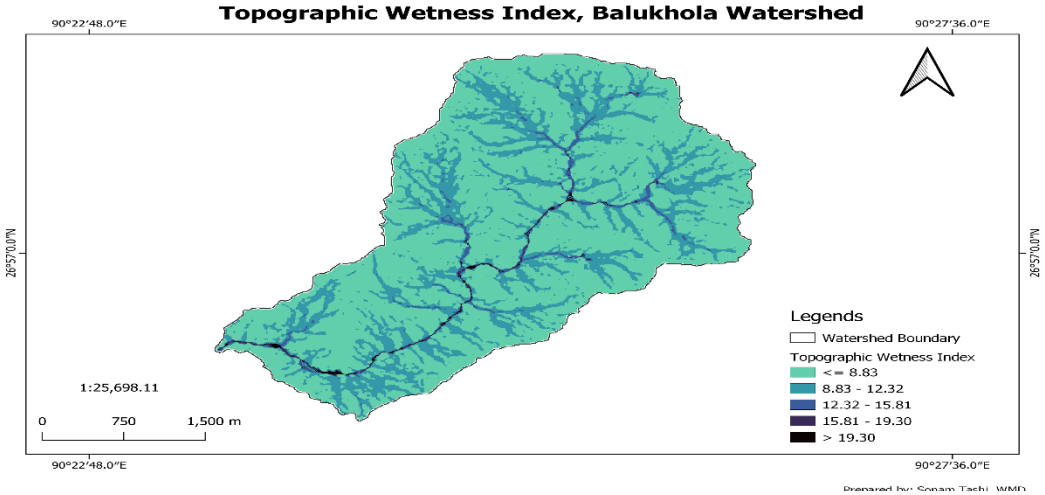
Topographic Wetness Index (TWI) plays a significant role in the hydrogeological system. TWI can explain the effect of topographic conditions on the size and location of saturated sources of surface runoff generation. On TWI analysis, it was found that average TWI is 8.3. A TWI value of 8.3 is relatively low and indicates places with small catchments, and steep slopes or hills (Sahu, Prasad, & Ahmad, 2022). This means that water is less likely to accumulate and persist in the area. (Map 10)



Maps 8. Drainage Density



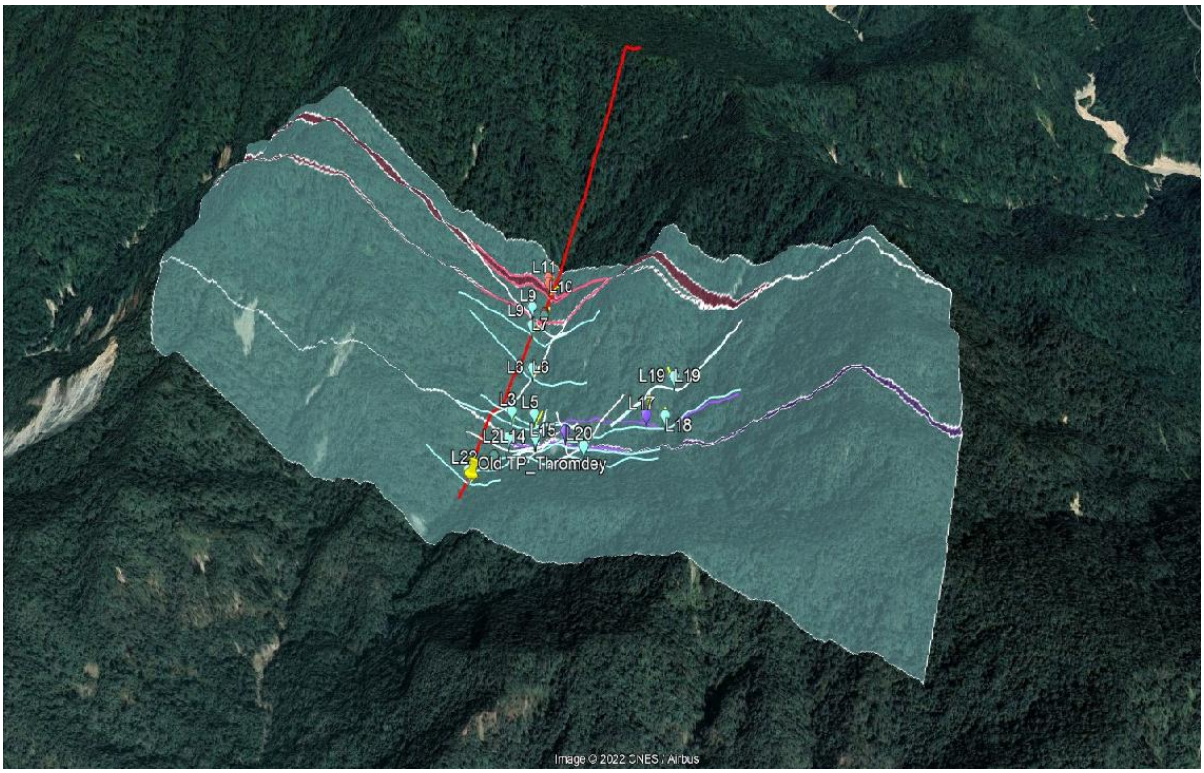
Maps 9. Lineament Density



Maps 10. Topographic Wetness Index

3.3. Hydro-geological mapping

The rock data such as dip direction, dip amount and strikes were measured along the feasible areas to examine different lithological settings (Map 11), and to draw a cross section profile to develop a 3D conceptual layout (Figure 6) that delineates potential recharge zone. However, data could not be collected from the upper catchments as it was inaccessible. The dominant litho's are phyllite with limestone inter-bonding (width of about 4-5 m) and was expected extending from the mid to the upper catchment area based on the Dalim formation.



Maps 11. Hydrogeological mapping process

The phyletic strike runs from east to west with foliation plane dips towards north with a dipping amount of 50º. The limestone inter-bonding strike extends from south east to north-west with a dipping amount of 45º. A single quartzite band was observed along south east to north west with its foliation plane dipping towards north east with a dip amount of 47º. About 6 major fractures and several minor fractures were recorded. Fractures in the lower catchment were mostly striking from north-east to south-west with dipping amount ranging from 46º to 80º mostly towards south south-west following the stream direction. In the upper catchment, fractures were observed striking from south-east to north-west with dipping amount ranging from 60º to 65º,

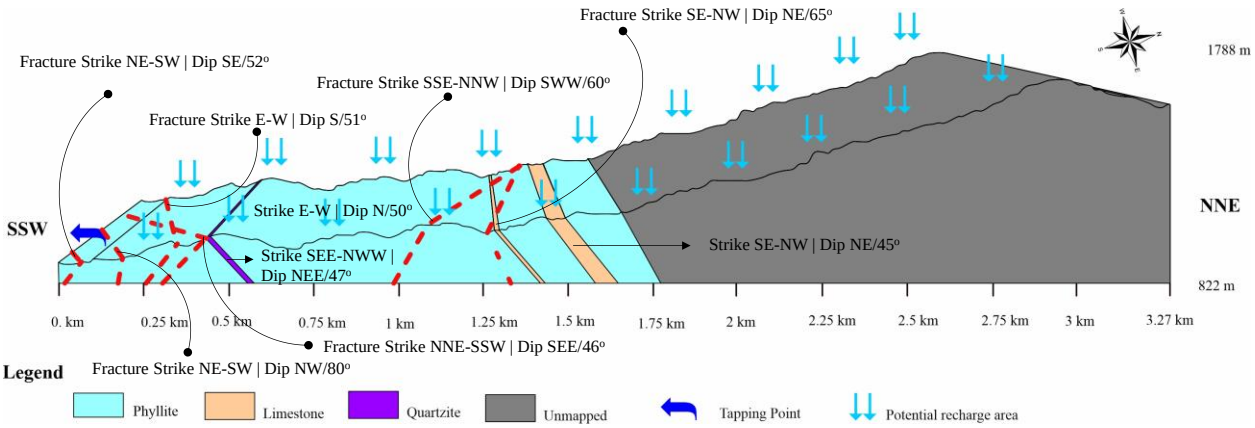
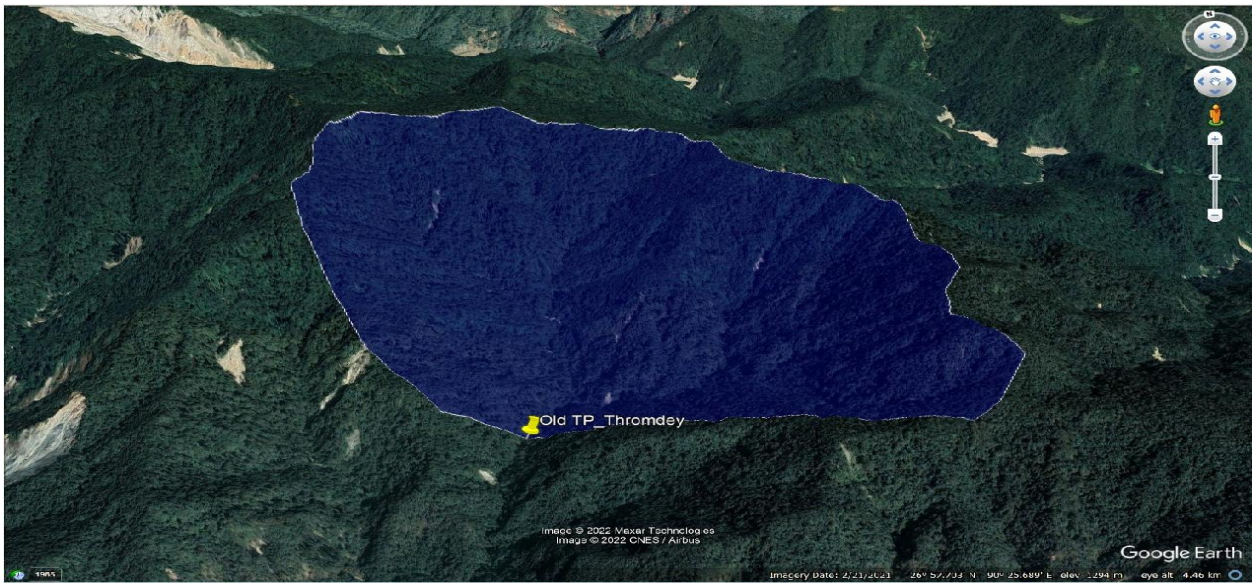


Figure 6. Conceptual layout of PRA (3D)

Based on the 3D conceptual layout, the potential recharge area is confined within the watershed boundary (Map 12). The stream/spring typology could be classified under depression spring.



Maps 12. Showing Potential Recharge Area

4. ISSUES CONTRIBUTING TO WATERSHED DEGRADATION

1. Landslides

Owing to steep terrain and unstable geology, frequent landslides are common sights. The landslide area constitutes ~4.42 hectares spread across the watershed area causes of which are mostly natural, while in the lower part of the watershed, there are few denuded areas, which were caused by road construction for 400KB transmission tower construction.

Hydrological assessments of the drainage density, lineament density, and topographic wetness index , existence of fractures, faults, and low surface wetness, all indicated potential threats related to surface runoffs, erosion, and landslides.

Figure 7. Natural Landslide (pic taken in Nov,2022)

2. Developmental activities (road construction)

The 4 km approach road construction to intake point has already begun to facilitate transportation of materials to the site. Abetted by steep fragile topography and heavy precipitation during monsoon, it is likely to cause mass landslides in absence of appropriate precautionary measures.

Figure 8. New Road for water Infrastructure

3. Resource extraction

The forest in the watershed area is currently in good health, with 97% forest cover and minimal resource extraction. The approximate deforestation rate (average) is 0.63ha over the period 2000-2021 (Annexure-4). However, during the public consultation, it was noted that there is a potential threat from mounting pressure on timber. Although there is a community forest to cater to the

resource needs of its members, however, CF area has limited timber species and resources needs has to be supplemented from the areas outside CF. Such pressure on timber resources is likely to increase with sprawling urbanization and population increase in the near future.

4. Climate Change impact

The effects of climate change in the region may include altered patterns of precipitation, increased frequency and intensity of extreme weather events, and changes in the distribution of plant and animal species. The uncertain and erratic precipitation may trigger drying of water sources as the only means to recharge ground aquifers in the region is through rainwater (Fig.4).

Given the critical role of the watershed area in supporting local communities and ecosystems, it is essential to consider the potential impacts of climate change when managing and conserving the area. This requires a proactive and adaptive approach to address the challenges posed by climate change and ensure the long-term sustainability of the region.

5. THE INTERVENTION MEASURES

The purpose of the intervention is to mitigate degrading influences and revive the watershed to the greatest extent possible. A Logical Framework Analysis (LFA) approach was used to derive focal problems, their underlying causes, effects and intervention measures (figure 9).

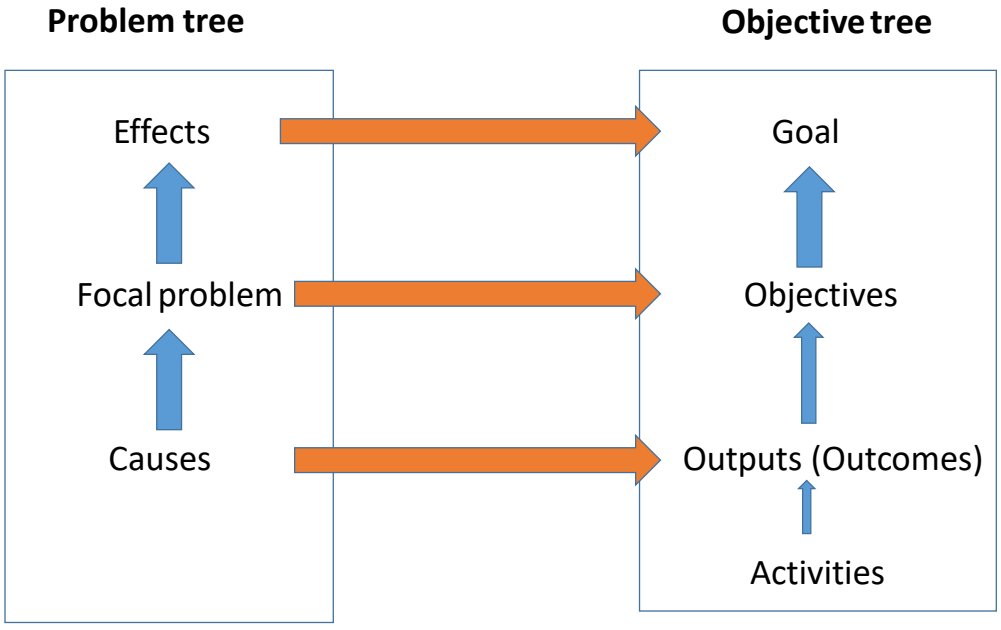


Figure 9. Problem tree and objective tree used to convert issues/problems identified during the planning process into an intervention strategy to mitigate the degrading influences.

The application of the LFA process identified three main focal problems that contribute to degradation of Balukhola watershed:

Goal:

The Balukhola watershed managed to provide a reliable supply of clean drinking water and other essential ecological services through sustainable management of natural resources and implementing climate change mitigation measures.

Objective:

1. To strengthen implementation of sustainable forest management practices
2. To enhance the resilience of Balukhola watershed against the impacts of increasing climatic variability.
3. To conserve critical recharge areas for reliable drinking water supply and to encourage community participation through sustainable financing mechanism.

Outputs:

Objectives 1: To strengthen implementation of sustainable forest management practices

1.1: Territorial division staff and communities with capacity to plan, implement, and monitor Community forest Plan and PA plans.

Around 52.81% of the total watershed area is under forest management regimes, with Dungkarling CF accounting for 16.6% and BC-3 accounting for 36.21%. Therefore, it is imperative to further strengthen the forestry officials' capacity and CF members' capacity to manage the respective area for sustainable forest management. Frequent refresher courses on silviculture system training should be initiated for Sarpang Forest Division staff and CF members.

The activities that are captured in the existing CF management plan does not include explicit water resource protection measures such as maintenance of buffer area, exclusion of resource use from the potential recharge areas, zonation of CF based on functions, etc. As such, it is crucial to include such activities in the CF management plan.

In addition, forestry staff and CF members should manage the protected water recharge area and illegal activities by conducting frequent monitoring of the area. With road construction for water supply, now due to accessibility, more frequent monitoring is required.

1.2: Water sources in Watershed protected

Managing the entire Blaukhola watershed sustainably is crucial, and it is essential to strictly protect the Potential Recharge Area, river and stream buffers as per FNCRR 2022, as well as areas above a 45-degree slope. The mapped protected areas (Annexure-1) should be incorporated into the decision support system of DoFPS for forestry clearance and resource allocation, and NLCS system for land allocation, and DoECC for environmental clearances and climate adaptation

programs. Furthermore, nearby communities and general stakeholders should be informed about the importance of protecting these areas, and they should be encouraged to comply with the protection measures.

1.3. Developed the capacity of relevant stakeholders to plan, implement, and monitor watershed/ springshed activities.

Currently, the capacity to assess, design and implement plan activities rests with few individuals, many of the field staff lack skills to conduct hydrogeological mapping to identify potential recharge areas for the springs. Thus, it is crucial to build capacity of the relevant stakeholders' field staff on hydrogeology, climate data collection and analysis, function mapping, water discharge and water quality monitoring.

Objective 2: To enhance the resilience of Balukhola watershed against the impacts of increasing climatic variability.

2.1: Microclimate monitored and data generated to understand climatic variability.

Maintaining the homeostasis of the watershed is imperative, and monitoring climate variability through measurements of temperature, rainfall, and humidity is fundamental. Therefore, weather stations will be installed and periodic monitoring and compilation of data will be conducted to understand the climatic variability so that appropriate and timely adaptive interventions can be initiated.

2.2: Communities advocated on climate change and watershed management

As springshed and watershed management concepts are relatively new to Bhutan, it is essential to create awareness and advocate communities on, springshed and watershed management through in the face of global climate change.

Objective 3: To conserve critical recharge areas for reliable drinking water supply and to encourage community participation through sustainable financing mechanism.

3.1: Rehabilitated watershed areas degraded by road construction for drinking water supply.

The construction of 4.6 km approach road has led to soil excavation and removal of vegetation that is likely to trigger soil erosion and landslides during rainy seasons in the watershed area. To mitigate the likely impact, soil conservation measures including bioengineering work should be carried out along the road stretch where ever necessary. Furthermore, it is advisable to maintain proper road's drainage system to prevent erosion and gully formations.

3.2: Instituted sustainable financing mechanism to support conservation of Balukhola watershed.

Gelephu Thromde has signed a Payment for Environmental Service Scheme (PES) on the protection and conservation of water resources with the communities of Raidara and Lahyul village who shall carryout conditional conservation activities to secure the water resources used by the Thromde. Inclusion of Balukhola under the current PES scheme would significantly help sustain implementation of planned activities without having to depend on limited government resources and donor funding.

LFA Matrix

Outputs	Activities	Verifiable indicators	Responsible agency	Local Area Plans	Budget (millions)
Objectives 1: To strengthen implementation of sustainable forest management practices					
1.1: Incorporated springshed and watershed activities in Dungkarling CF	Review of CF management plan for Dungkarling CF	Reports	Sarpang Forest Division, DoFPS	Dungkarling CF	0.30
	Conduct surveillance (SMART patrolling)	SMART reports	Sarpang Forest Division, DoFPS		0.50
	Plantation of desired timber species in the CF area	Reports	SFD,	Dungkarling CF	1.00
1.2: Water sources in watershed area protected (Annexure-1)	Integration of protection sites in the decision support system in DoFPS and NLCS system with awareness to DoECC	System reports	DoW	SDSS(DoFPS), NLCS decision support system, DoECC	0.50
	Awareness to stakeholders the watershed/springshed	Reports	DoW and DoFPS	DoW, DoFPS	0.30
1.3. Developed the capacity of relevant stakeholders to plan,	Training of Trainers on hydro-geological assessments	Reports	DoW	DoW	2.00

implement, and monitor watershed/ springshed activities.	Training on basic hydro-geological concepts, mapping and monitoring	Reports	DoW	DoW	1.00
Objective 2: To enhance the resilience of Balukhola Watershed Management against the impacts of increasing climatic variability.					
2.1: Microclimate monitored and data generated to understand climatic variability.	Installation of weather station in Balukhola	Constructed/reports	DoFPS/DoW	SFD	0.200
	Capacity building for the field staffs on weather data analysis	Reports	DoW	DoW	0.150
2.2: Communities advocated on climate change and watershed management	Awareness through public gathering	Reports	DoFPS	DoFPS	0.200
	TV advocacy through short documentary	Reports	DoW	DoW	0.200
Objective 3: To provide reliable drinking water supply and to encourage community participation through sustainable financing mechanism.					
3.1: Rehabilitated watershed areas degraded by road construction for drinking water supply.	Soil conservation activities and bioengineering works along the slide and erosion prone areas	Reports	DoFPS	SFD, DoFPS	1.00
	Maintenance of road drainage systems	4 Km	Thromde	Thromde	1.00

3.2: Instituted sustainable financing mechanism to support conservation of Balukhola watershed.	Carryout Feasibility study on PES Scheme	Reports	SFD, DoW, Thromde	Thromde, SFD	0.30
Total					**8.65**

6. ARRANGEMENTS FOR INCORPORATION AND IMPLEMENTATION OF ACTIVITIES

The interventions from this plan will be mainstreamed into 13th FYP and 14th FYP of the relavent agency. The Department of Water, in collaboration with the Department of Forests and Park Services, will lead the implementation of the interventions. Given the importance of the watershed for drinking water supply, Samtenling Gewog, Gelephu Thromde, and Sarpang Dzongkhag will also be involved in coordinating the implementation of the identified interventions.

7. FUNDING IMPLEMENTATION

Given that the watershed plan is an integral part of the Water flagship program, which aims to ensure a dependable drinking water supply, the initial funding for the plan will be sourced from the Water flagship program. The Department of Water (DoW), being the coordinating agency for the water sector, will assist the relevant agencies in integrating watershed activities into their plans and securing the necessary budgetary provisions from projects and the Royal Government of Bhutan (RGoB). However, if PES could be instituted, the implementation of intervention measures will be funded through annual PES fee.

8. MONITORING AND EVALUATION

Given its importance in supplying drinking water to the Gelephu Thromde and Gewog, the watershed will require continuous monitoring by relevant agencies as well as the Department of Water and the Department of Forests and Park Services, who are the responsible authorities for managing water and forest resources.

To assess the effectiveness of the interventions, the Department of Water shall conduct annual, if not biannual, evaluations of the plan and its benefits resulting from the implementation of the interventions.

9. REVISION AND ADMENTMENT OF PLAN

The plan will involve continuous monitoring and evaluation of management actions, including their response to climatic variability, and the use of feedback loops to adjust plans and strategies based on changing conditions and new information. The approach of this plan shall be adaptive management, which acknowledges the inherent complexity and uncertainty of natural resource management. Therefore, the plan shall be revised and amended based on immediate requirements to ensure its effectiveness in achieving its objectives.

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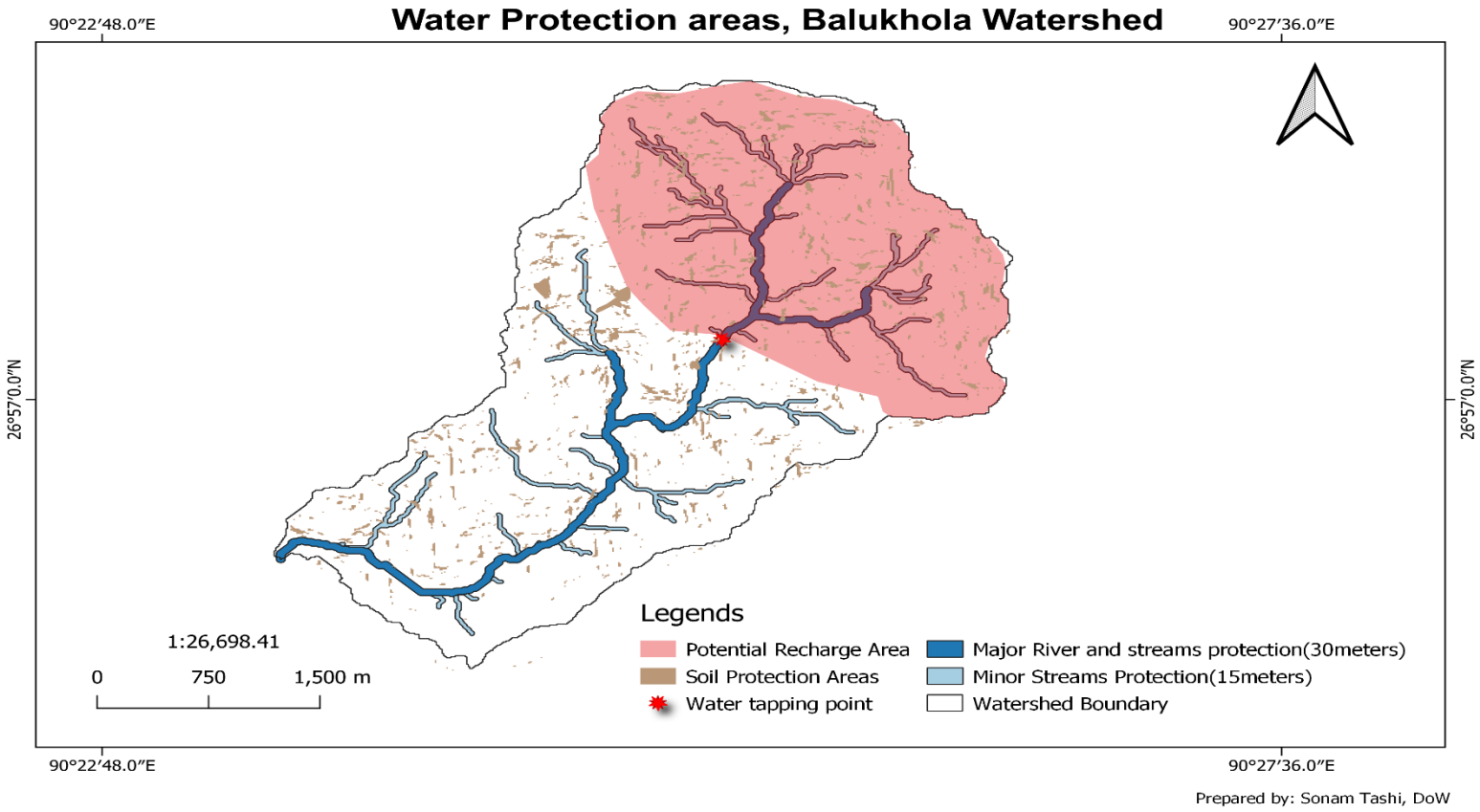
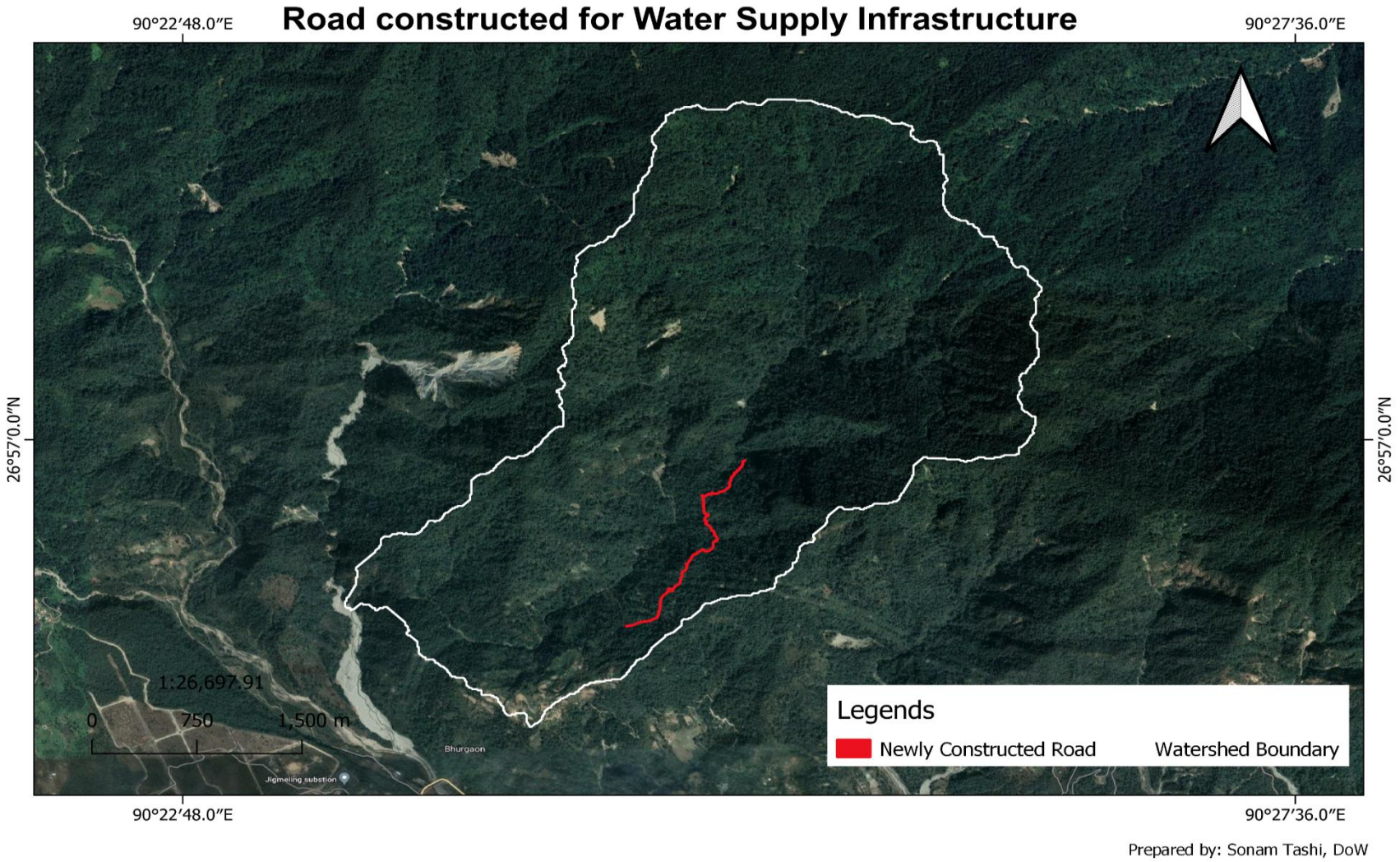
11. ANNEXURE

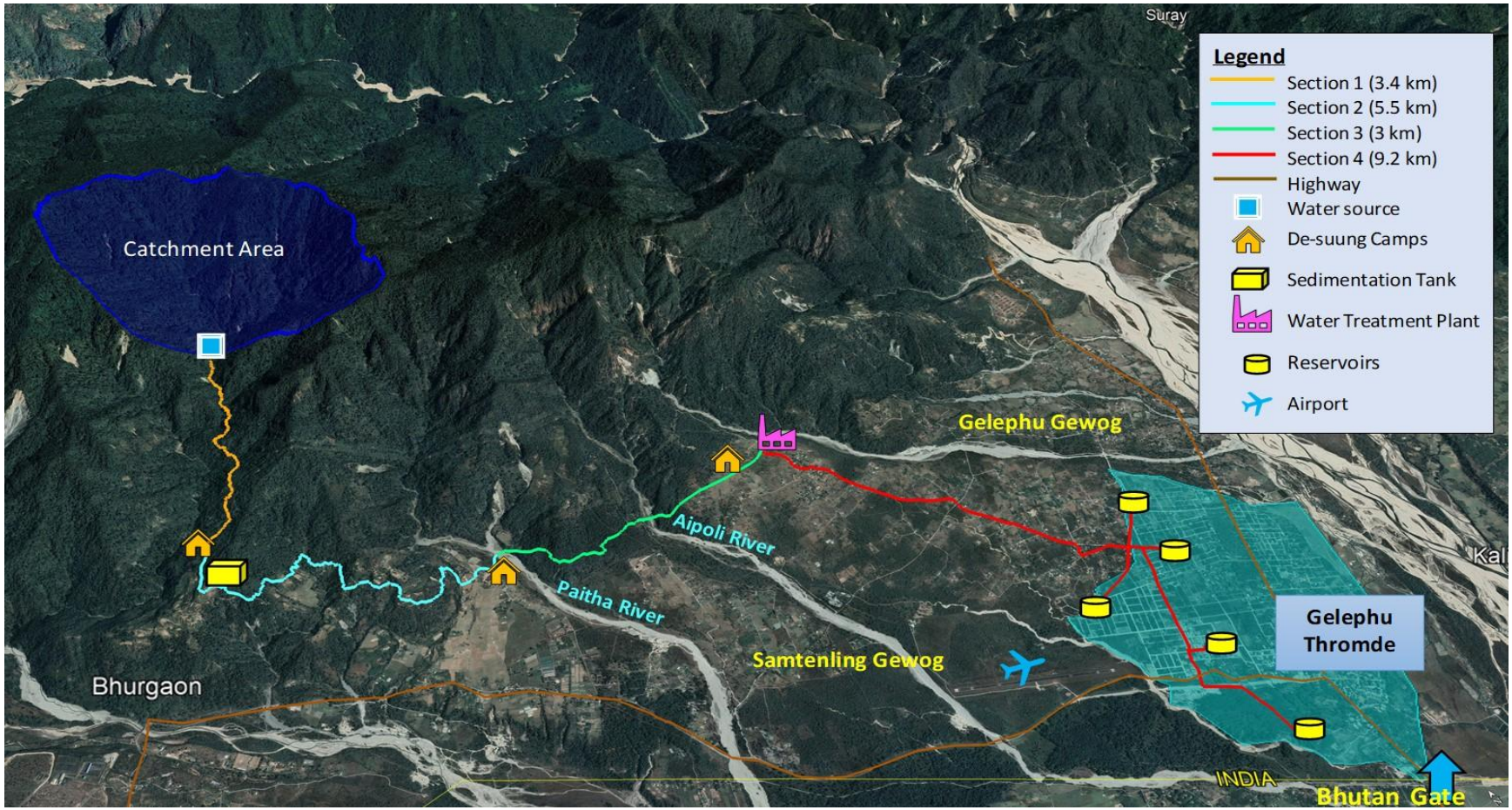
ANNEXURE-1



ANNEXURE-2


Road constructed for Water Supply Infrastructure
90°22′48.0″E
90°27′36.0″E
26°57′0.0″N
1:26,697.91
0
750
1,500 m
Bhurgaon
Jigmeling substation
Legends
Newly Constructed Road
Watershed Boundary
Prepared by: Sonam Tashi, DoW

ANNEXURE-3



Maps 12. @Water and Sanitation Division || DoID || MoIT

ANNEXURE-4

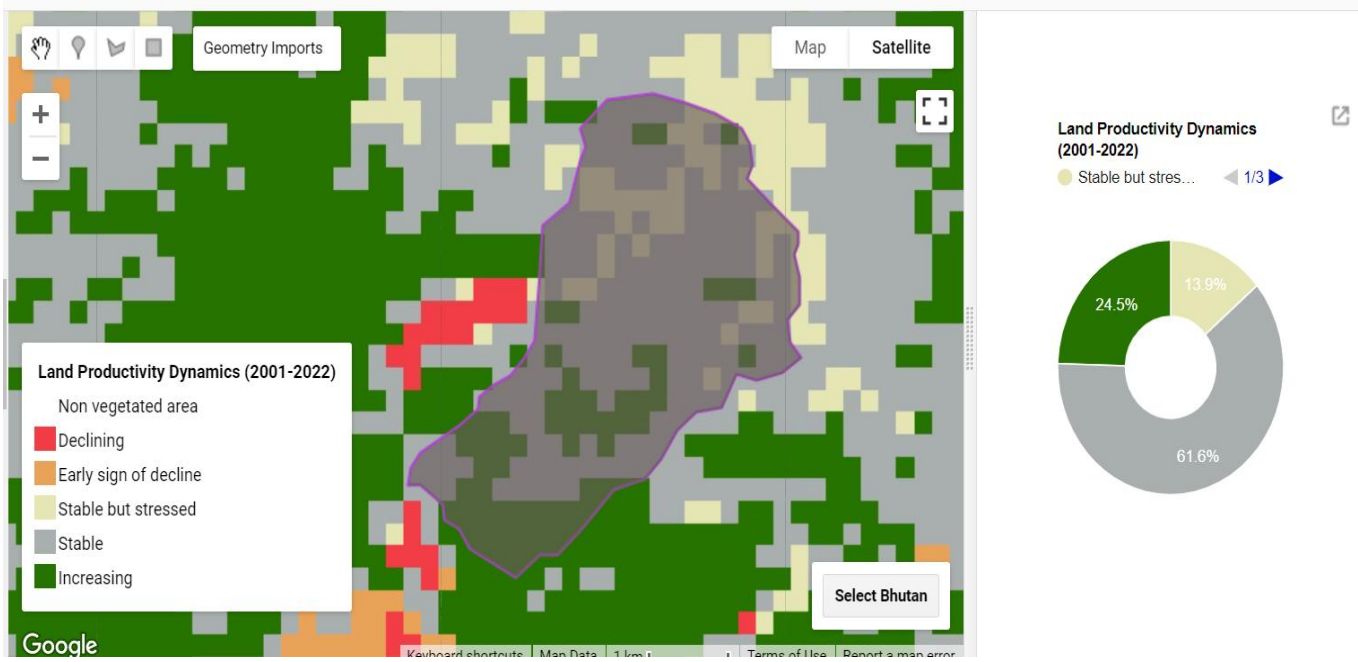


Figure 10. Land Productivity Dynamics (National Soil Service Centre, 2023)

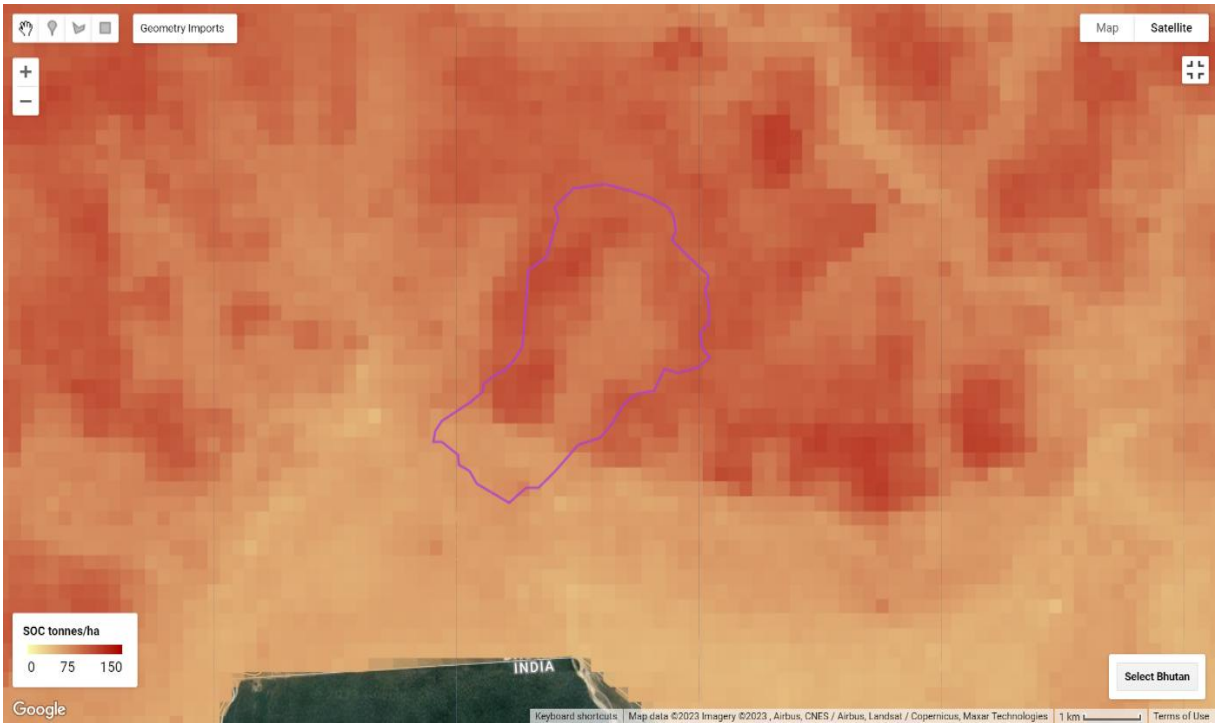


Figure 11. Soil organic carbon tonnes/ha (National Soil Service Centre, 2023)

ANNEXURE-5

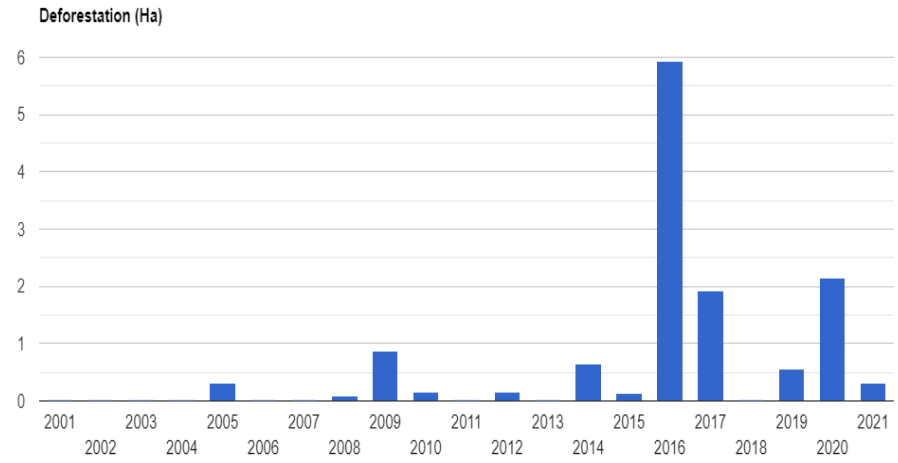
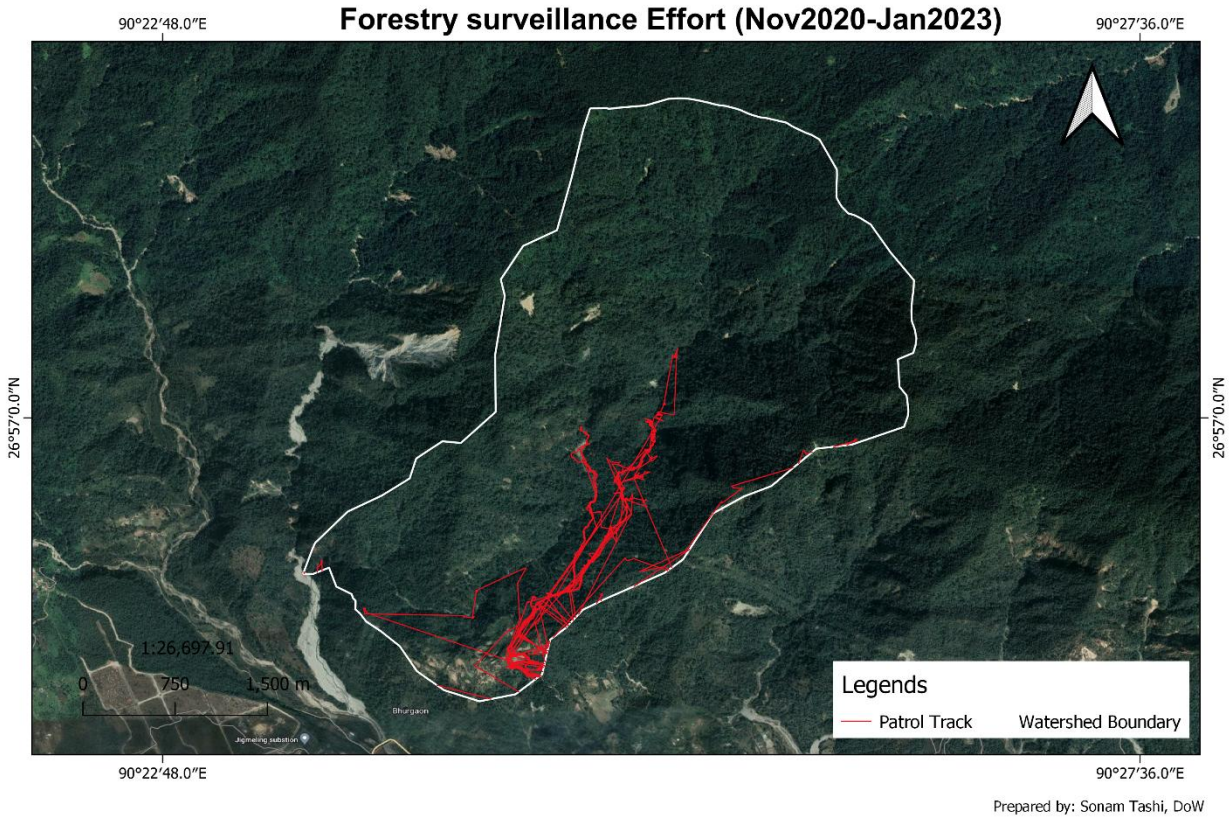
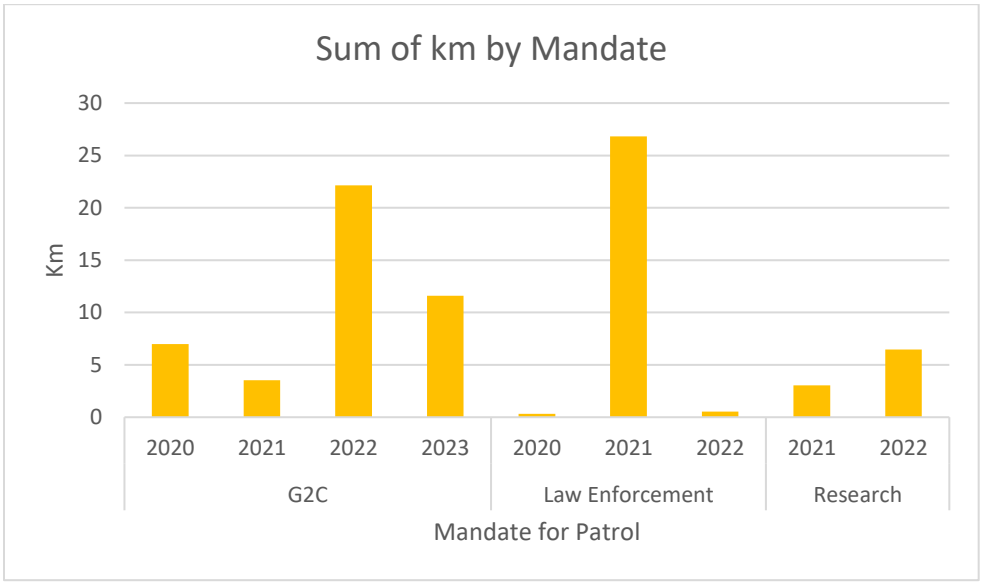


Figure 12. Hansen Global Forest Change v1.9 (2000-2021) extracted from (National Soil Service Centre, 2023)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Area (Ha)	0	0	0	0	0.32	0	0	0.08	0.879	0.16	0	0.16	0	0.639	0.127	5.937	1.918	0	0.559	2.157	0.32

ANNEXURE-6


Forestry surveillance Effort (Nov2020-Jan2023)
90°22′48.0″E
90°27′36.0″E
26°57′0.0″N
1:26,697.91
0
750
1,500 m
Legends
Patrol Track
Watershed Boundary
Prepared by: Sonam Tashi, DoW


Sum of km by Mandate
Km
30
25
20
15
10
5
0
2020
2021
2022
2023
2020
2021
2022
2021
2022
G2C
Law Enforcement
Research
Mandate for Patrol

ANNEXURE-7

Samtenling Gewog Information

General Information

Details	Number
Area (sq.km)	: 55
Forest coverage (%)	: 88.6
Elevation above sea level (masl)	: 190-380
Distance from Dzongkhag HQ (km)	: 25
Chiwog	: 05
Households	: 467
Population	: 3068
Male	: 1545
Female	: 1523
Drinking water coverage (%)	: 100
Electricity coverage (%)	: 100
Mobile network coverage (%)	: 100

Health

Details	Number
Hospital	: 00
Primary Health Center	: 00
Outreach Clinic	: 01
Sub-Post	: 00
Village health workers	: 04
RWSS	: 22

RNR

Details	Number
Total wetland (acres)	: 313.2
Cultivated (acres)	: 209.1
Fallow (acres)	: 104.1
Total dryland (acres)	: 2394.94
Cultivated (acres)	: 1000.00
Fallow (acres)	: 1394.94
Irrigation channel	: 16
Length of irrigation channel (km)	: 50.82
Electric fencing	: 10
Length of electric fencing (km)	: 23.59
Vegetable group	: 05
Informal	: 00
Registered	: 05
Mushroom group	: 04
Informal	: 04
Registered	: 00
Others (specify)	: 00
Informal	: 00
Registered	: 00
Cooperatives (functional)	: 02
Farm Road users group (functional)	: 05
Irrigation water users group (functional)	: 02
Electric fencing group (functional):	: 03
Layers	
Poultry layers' groups	: 24
Informal	: 15
Registered	: 09
Layers cooperatives	: 00
Broilers	
Broiler groups	
Informal	: 05
Registered	: 00
Broiler cooperatives	: 00

Piggery	
Piggery groups	
Informal	: 23
Registered	: 08
Piggery cooperatives	: 00
Fishery	
Fishery ponds	: 19
Production capacity per pond (MT/year)	: 5.5
No of fishery groups	: 00
Informal	: 00
Registered	: 00
No. of fishery cooperatives	: 00
Dairy	
Dairy groups	
Informal	: 23
Registered	: 00
Dairy cooperatives	: 00
HHs with functional biogas	: 73
Forestry	
Community Forest Group	: 03
NWFP group	: 00

Education

Details	Number
Central School	: 00
Higher Secondary School	: 00
Middle Secondary School	: 00
Primary School	: 02
ECR	: 00
ECCD Center	: 02
NFE Center	: 02
Dechenpelri PS	
Teachers	: 13
Male	: 09
Female	: 04
Students	: 143
Male	: 70
Female	: 73
Samtenling PS	
Teachers	: 16
Male	: 12
Female	: 04
Students	: 264
Male	: 144
Female	: 120
Samtenling ECCD Center	
Teachers	: 02
Male	: 00
Female	: 02
Students	: 39
Male	: 17
Female	: 22

Note: Information as of 18/10/2022 (Sarpang Dzongkhag, 2023)

Gelephu Gewog Information

General Information

Details	Number
Area (sq.km)	: 54
Forest coverage (%)	: 79.8
Elevation above sea level (masl)	: 200-800
Distance from Dzongkhag HQ (km)	: 37 km
Chiwog	: 05
Households	: 1027
Population	: 4461
Male	: 2171
Female	: 2290
Drinking water coverage (%)	: 100
Electricity coverage (%)	: 100
Mobile network coverage (%)	: 100

Health

Details	Number
Hospital	: 00
Primary Health Center	: 01
Outreach Clinic	: 00
Sub-Post	: 00
Village health workers	: 01
RWSS	: 05

RNR

Details	Number
Total wetland (acres)	: 621.05
Cultivated (acres)	: 406.91
Fallow (acres)	: 107.07
Total dryland (acres)	: 1113.45
Cultivated (acres)	: 558.8
Fallow (acres)	: 192.03
Irrigation channel	: 04
Length of irrigation channel(km)	: 9.8
Electric fencing	: 06
Length of electric fencing (km)	: 12.86
Vegetable group	: 00
Informal	: 00
Registered	: 00
Mushroom group	: 00
Informal	: 00
Registered	: 00
Others (specify)	: 00
Informal	: 00
Registered	: 00
Cooperatives (functional)	: 00
Farm Road users group (functional)	: 04
Irrigation water users group (functional)	: 00
Electric fencing group (functional):	: 00
Layers	
Poultry layers' groups	: 02
Informal	: 02
Registered	: 00
Layers cooperatives	: 01
Broilers	
Broiler groups	: 00
Informal	: 00
Registered	: 00
Broiler cooperatives	: 03

Piggery	
Piggery groups	: 00
Informal	: 06
Registered	: 05
Piggery cooperatives	: 00
Fishery	
Fishery ponds	: 00
Production capacity per pond (MT/year)	: 00
No of fishery groups	: 00
Informal	: 00
Registered	: 00
No. of fishery cooperatives	: 00
Dairy	
Dairy groups	: 01
Informal	: 00
Registered	: 01
Dairy cooperatives	: 00
HHs with functional biogas	: 55
Forestry	
Community Forest Group	: 01
NWFP group	: 00

Education

Details	Number
Central School	: 00
Higher Secondary School	: 02
Middle Secondary School	: 00
Primary School	: 00
ECR	: 00
ECCD Center	: 02
NFE Center	: 08
Pelrithang HSS	
Teachers	: 59
Male	: 28
Female	: 31
Students	: 924
Male	: 442
Female	: 482
Losel Gatsho Academy	
Teachers	: 40
Male	: 19
Female	: 21
Students	: 632
Male	: 305
Female	: 331
Lekidthang ECCD Center	
Teachers	: 01
Male	: 00
Female	: 01
Students	: 33
Male	: 11
Female	: 12

Gelephu Thromde Information

Distance from Dzongkhag(Approx.)	:	33 Kms
Thromde Area (Sq. Kilometer)	:	11. 52sq.km
Altitude Range	:	221m
Climate	:	Subtropical(wet)
No.of Demkhongs	:	6
No.of Households	:	2847(Survey2020)
Total Population	:	12072(Survey2020)
No.of Schools	:	4
No.of Hospital	:	1(CRRH,Gelephu)
No.of Regional Offices	:	21
No.of Financial Institutions	:	9
No.of Religious Institutions	:	3
No.of Fuel Stations	:	3
No.of Sport Facilities	:	8
No.of Taxi stands	:	2
No.of Bus Terminals	:	1
No.of Airport	:	1 (Domestic Airport)

(Gelephu Thromde, 2022)