Integrated Watershed Management Plan for Wangdigang- Dechugang watershed, Zhemgang, Bhutan

(July 2018 – June, 2023)
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Watershed Management Division,
Department of Forests & Park Services,
Ministry of Agriculture & Forests,
Royal Government of Bhutan.

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AUTHORITY FOR PREPARATION, REVISION AND APPROVAL

PERIOD OF THE PLAN

This plan is valid for the period of five years from July 2018 to June 2023

AUTHORITY FOR PREPARATION, REVIEW AND APPROVAL

The authority for preparation of this plan was given to the Watershed Management Division, Department of Forest & Park Services, Ministry of Agriculture & Forests, Royal Government of Bhutan. The plan was developed with financial support from Mangdechhu Hydro-electric Project Authority (MHPA).

PROVISION FOR REVIEW AND CHANGES

This plan may be revised during the period when it is in effect. If major changes occur in the watershed, or new information becomes available, that may have significant bearing on the implementation of the Plan, PT may recommend the revision of this plan.

APPROVAL

This plan has been developed in a participatory and collaborative manner involving wide section of stakeholders from field and national agencies as well as community representatives. The plan was presented and endorsed by the stakeholders and finally by Technical Advisory Committee of the DoFPS. It has been further reviewed and recommended for implementation by the Director, Department of Forest & Park Services and approved by the Honourable Secretary, Ministry of Agriculture and Forests, Royal Government of Bhutan.

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Lastly, WMD would like to thank Mangdechhu Hydro-electric Project Authority (MHPA) for their generous financial support, without which this plan would not have taken shape.

GLOSSARY OF BHUTANESE TERMS

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

LIST OF ABBREVIATIONS

AAC	Annual Allowable Cut
CF	Community Forest
CFMG	Community Forest Management Group
CFO	Chief Forest Officer
DAO	Dzongkhag Agriculture Officer
DBH	Diameter at Breast Height
DHMS	Department of Hydromet Services
DPO	Dzongkhag Planning Officer
DoA	Department of Agriculture
DoL	Department of Livestock
DoFPS	Department of Forest and Park Services
DWMC	Dzongkhag Watershed Management Committee
DWMC	Dzongkhag Watershed Management Committee
EFRC	Environmentally Friendly Road Construction
FMU	Forest Management Unit
FNCR	Forest & Nature Conservation Rule
GNH	Gross National Happiness
GRF	Government Reserve Forest
GWMC	Gedu Wood Manufacturing Company
ha	Hectare
HH	Household

HP	Hydropower Plant
Km	kilometer
m	Meter
masl	Meter above sea level
mm	Millimeter
M & E	Monitoring & Evaluation
MoAF	Ministry of Agriculture and Forest
MoH	Ministry of Health
MoE	Ministry of Education
MP	Management Plan
MW	Mega Watt
NWFP	Non-wood Forest Product
NRDCL	Natural Resource Development Corporation Limited.
PA	Protected Area
PMP	Permanent Monitoring Plots
PWS	Payment for Watershed Services
RGoB	Royal Government of Bhutan
RDC	Research Development Center
RDTC	Rural Development Training Centre
RNR	Renewable Natural Resource
RWSS	Rural Water Supply Scheme
SFED	Social Forestry & Extension Division
SLMP	Soil & Land Management Program
ToR	Terms of Reference
TFD	Territorial Forest Division
UWICER	Ugyen Wangchuck Institute for Conservation and Environmental Research
NCD	Nature Conservation Division
WSM	Watershed Management
WMD	Watershed Management Division
IWMP	Integrated Watershed Management Plan
WUA	Water Users' Associations
ZFD	Zhemgnag Forest Division

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Executive Summary

Wangdigang-Dechugang watershed falls under the administrative jurisdiction of Trong Geog of Zhemgang Dzongkhag and it is located within the defined watershed No. 109 being delineated using a threshold of 5000 ha (50 km^2), by Watershed Management Division and covers about two third of its total area with **N** $27^0$13'29.98" and **E** 90^0 41'0085" respectively. It covers about 10,192.75 hectares of humid broadleaf forest, mostly within the Wangdigang Forest Management Unit (WFMU) which constitutes about 85.93% of the watershed area.

The entire watershed area has been further divided into four sub-watersheds namely; Dechugang, Chukormani, Gurpang and Tshobrang sub-watershed in order to help design site specific management interventions based on the site conditions. The water discharge from Dechugnag is reported to have declined by more than 70% over the years. Similarly, in Chukormani sub-watershed few of the springs and Chukormani stream was reported to have dried after successive logging operations that took place in 1984, 1987 and 1988.

Gurpang sub-watershed adjoining Chukormani and Tshobrang sub-watershed harbors four major streams that source water supply to Zhemgang municipality, RDTC and Forest Colony in Zhemgang. The existence of Mithun Breeding Farm in the sub-watershed, covering about 1650 acres of the humid broadleaf forest in long run may possibly cause negative impact on the eco-system functionality and sustainance of four streams emerging from the area. Having located on a steep geographical terrain, Zhemgang (Trong) area has no other potential options to bring water from other areas and having faced with shortage of water supply, hundreds of acres paddy fields in Trong were left uncultivated for more than a decade. Therefore, this plan is aimed to revive Wangdigang-Dechugang watershed to secure sustainable supply of quality water for Trong, Dangkar, Dungbi, Wangdigang and Zhemgang with following objectives and outputs:

Objectives and outputs:

1. To minimize degrading influences and improve water supply for drinking and irrigation purposes;

Outputs:

- Wangdigang-Dechugang degraded watershed rehabilitated and forest resources utilized within sustainable limits
- Enhanced infrastructural design to minimize impact on watershed and improved supply of water
- Knowledge of status of water sources (lakes and springs) drying
- Resilient communities with capacity to adapt to natural and man-induced change in the context of climate change

2. To enhance management of waste in accordance with the Waste Management Act of Bhutan:

Outputs:

- Improved waste management practices

1. Background

As per the Memorandum of Understanding (MoU) that was signed between the GNHC and the Mangdechhu Hydro-electric Project Authority (MHPA) on the Conservation and Sustainable Management of Mangdechhu Watersheds, one of the key activity reflected in the agreement was ***"Assessment and classification of watersheds within Mangdechhu sub-basin"*** with fund appropriation of Nu. 2.2 million spread over the period of four years. The Watershed Management Division as a focal agency for coordinating watershed management programs across the country, carried out consultation meetings with the relevant agencies in May 2015, following which rapid assessment of watersheds in the upper sub-basin covering 15 defined watersheds constituting 48 streams was conducted using the Classification Guideline, 2010 (WMD).

The rapid assessment for the lower sub-basin was carried out in 2016 and covered 79 streams under Zhemgang dzongkhag. Result of the rapid assessment was then presented to Trongsa and Zhemgang Dzongkhag administration including other relevant stakeholders in June 2016. The assessment report revealed 13 catchments in pristine condition and 114 catchments in normal condition (Annex II). Wangdigang-Dechugang watershed being important source of drinking and irrigation water for Dangkar, Wangdigang, Trong including municipality and several other institution within the watershed, stakeholder meeting in Zhemgang decided to designate the watershed area as "critical by function" requiring management interventions to enhance sustainable supply of water resources.

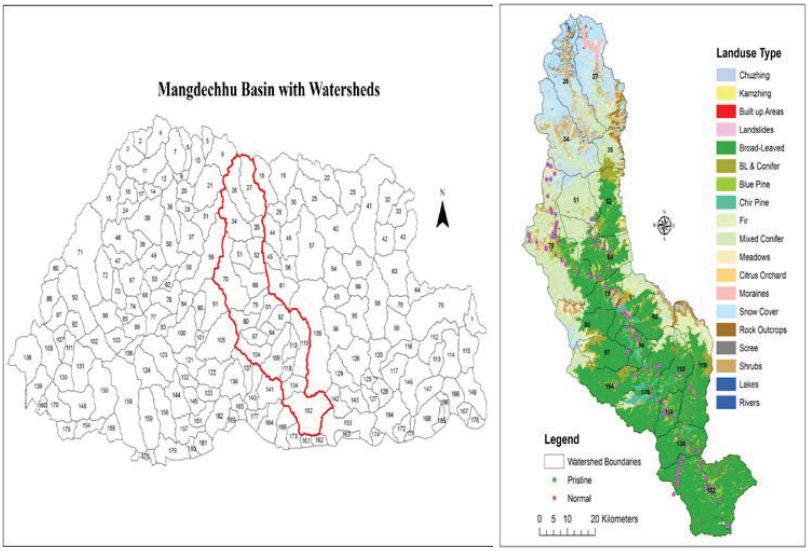

Figure 1. Map of Mangdechhu sub-basin and rapid assessment points within the sub-basin

2. Description of the Watershed Area

Wangdigang-Dechugang watershed is located within Mangdechhu sub-basin falling under the administrative jurisdiction of Trong Geog of Zhemgang Dzongkhag within the defined watershed No. 109, delineated using a threshold of 5000 ha (50 km^2) by the Watershed Management Division (WMD) located at **N** $27^0$13'29.98" and **E** 90^0 41'0085" respectively. The watershed boundary starts from Dechugang in the south-east of Zhemgang Dzong and extend until the northern ridge of Wangdigang with an altitude ranging from 750 to 3450 m in the extreme north. A total of 2177 people (PHCB, 2017) reside within the watershed inclusive of both resident and floating population.

The watershed area mostly falls within humid broadleaf forest dominated by oak-laurel species such *Quercus lamellosa, Belschmedia gammieana, Persea fructifera, Lithocarpus* sp. *Prunus undulata and Cinnamomum* sp. in the areas with lesser anthropogenic activities. While *Lithocarpus elegans and Castanopsis indica* dominates in areas with high anthropogenic activities with *Symplocos ramosissima, Symplocos lucida*, *Symplocos glomerata*, *Viburnum erubescens* and *Daphniphyllum himalense* as under storey species.

Wangdigang-Dechugang watershed covers about 10,192.75 hectares mostly within the Wangdigang Forest Management Unit (FMU). The first ten-year Forest Management Plan for Wangdigang FMU came into effect in 1993 with clear felling as management prescription. The earliest commercial harvesting from Wangdigang-Dechugang watershed area was carried out in 1984 when a coupe of 30 ha was operated in upper Dungbey valley on selection basis. Timber so harvested was supplied to Gedu Wood Manufacturing Corporation (GWMC) followed by another coupe of 15 ha, which was operated in the same area in 1987-88 mainly removing Champ (*Michelia velutina)* timber for the construction of the National Convention Hall (now housing the National Assembly).

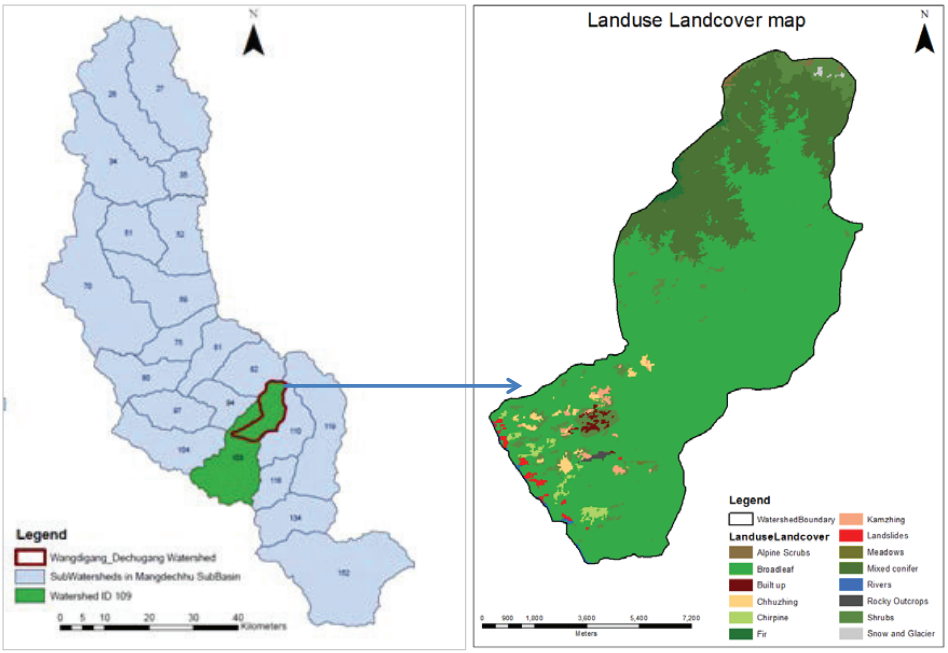

Figure 2. Map of Mangdechhu sub-basin and Wangdigang-Dechugang watershed

1.2. Land use types in Wangdigang-Dechugang watershed

1.2.1. Wangdigang FMU

Wangdigang FMU has six blocks namely; Dangkhar, Gurpang, Dungbi, Riotala, upper Wangdigang and Dechugnag falling under three compartments and four different management circles, including Production, Protection, Non Production and Non Wood Products (NWFPs) (Overlapping) management circles. The main goal of Wangdigang Forest Management Plan is to ***"Manage the Wangdigang FMU on a multiple use, sustainable basis for the production of timber, fuel wood and other forest products and for conservation of watershed, wildlife and environment.***" The current ten-year plan doesn't have an AAC prescribed for commercial use as resources in the production area are already exhausted.

1.2.2. Community forest management

Dangkhar Community Forest is also falls within the watershed boundary under Trong Geog of Zhemgang Dzongkhag. It was established in 2010 and has an area of 385.59 acres equivalent to 156.04 hectares. It has three main blocks namely: Zingerpong Block, Bjaro Norbuling Block and Broksar Thang Block with the following management objectives:

- To manage forest for sustainable supply of timber, firewood and other NWFPs.
- To rehabilitate forest conditions through better protection and development works.
- To ensure equal distribution of resources amongst user group members.
- To protect water catchments to ensure regular supply of water for drinking and irrigation purpose.
- To enhance income generation opportunities for CFMG members.

1.2.3. The Regional Mithun Breeding Centre

The Regional Mithun Breeding Farm is also located in the watershed area and covers about 668 hectares of government land. The farm was relocated from Wangkha under Chhukha dzongkhag in 2006 due to bio-security reasons. Currently there are about 125 mithuns along with an established infrastructure including office building, cattle sheds and permanent residents for the staff.

Table 1. Different Land use in Wangdinag- Dechugang Watershed

Land use type	Area (Ha)	% Coverage
Broadleaf Forest	7411.72	72.72
Chhuzhing	72.25	0.71
Kamshing	53.20	0.52
Shrubs	478.87	4.70
Chirpine forest	79.20	0.78
Built up areas	35.16	0.34
Rock outcrops	14.18	0.14
Meadows	2.74	0.03
Landslides	43.38	0.43
Fir forests	27.57	0.27
Mixed conifer	1912.45	18.76
Alpine shrubs	25.37	0.25
Snow and Glaciers	10.24	0.10
Rivers	26.41	0.26
Total Area	10192.75	100.00

3. Management Planning Process

A series of stakeholder consultation meetings were conducted at the dzongkhag and geog level to identify issues impacting watershed condition and accordingly, design management interventions to address the degrading influences impacting watershed functionality.

3.1. Consultations at Dzongkhag level

Initial consultative meeting with the Zhemgang Dzongkhag administration was conducted in May 2016, where, findings from the rapid assessment was presented and discussed. The rapid assessment identified probable issues that undermined the functionality of watersheds in securing continuous supply of high quality water and the initial consultative meeting remarked the need to classify Wangdigang-Dechugang as critical by function requiring immediate and long-term management interventions.

The second round of Dzongkahg level consultation meeting was held in November 2016 to plan and strategize implementation of mitigative measures to curtail degrading influences at the watershed through development of a logical framework. The meeting was attended by Dzongkhag sector heads and RNR staff of Trong Geog.

3.2. Consultations at geog level

A series of consultative meetings were also held with communities of Trong, Dangkar, Dungbi and Wangdignag village under Trong Geog Administration mainly to identify the key issues and discuss the way forward. The issues were further classified, and measures were planned based on the site requirements. The consultative meetings at the Geog level were attended by the Gup, Geog Administration Officers, RNR-Extension Agents, staff from the Territorial Forest Division, Mangmis, Tshogpas, and community members from Dangkar, Dungbi, Trong and Wangdigang villages.

Figure 3. Stakeholder consultations during the process of watershed management plan development

3.3. Assessment of watershed conditions

In order to congregate information on the issues impacting Wangdigang-Dechugang watershed, the entire watershed was divided into four sub-watersheds based on physical features (boundaries) namely; Dechugang, Chukhormani, Gurpang and Tshorang sub-watersheds. Each of the sub-watershed was subjectively classified into

degraded, moderately degraded and natural conditions based on physical conditions and the distance from nearest accessible point.

A total of 20 observation plots with plot size of 20 x 20m for tree, 5x5m for regeneration and 2x2m for ground cover was measured to estimate floristic composition, biomass accumulation, BA, DBH, dominance and diversity in relation to anthropogenic activities in the watershed.

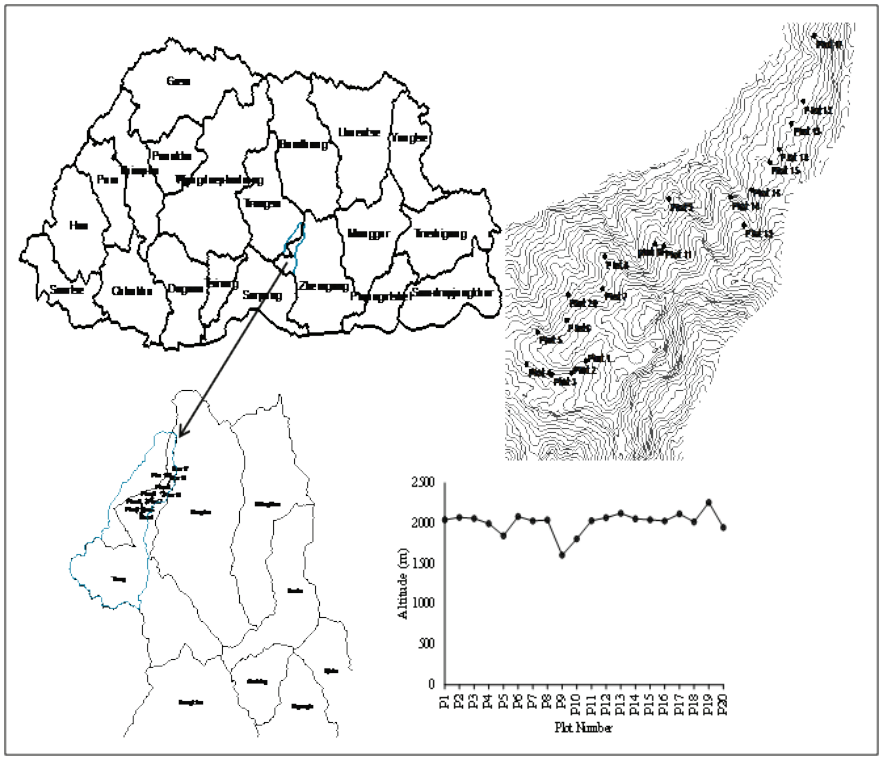

Figure 4. Wangdigang-Dechugang Watershed Map with sample plots

Figure 5. Detail assessment in the field

3.3. Climatic Conditions (rainfall and temperature)

The maximum total precipitation was observed in July with 346.8 mm followed by June with 269.4 mm, August with 230 mm, and September with 191mm, which clearly indicates that monsoon (June, July, August and September) plays an important role in recharging the watershed area. Dry spell in the area extends from mid of October till April month extending over seven months. Similarly, the maximum summer temperature recorded was 18.9 ^{o}C during the month of August and lowest during January month with 4.9 ^{o}C.

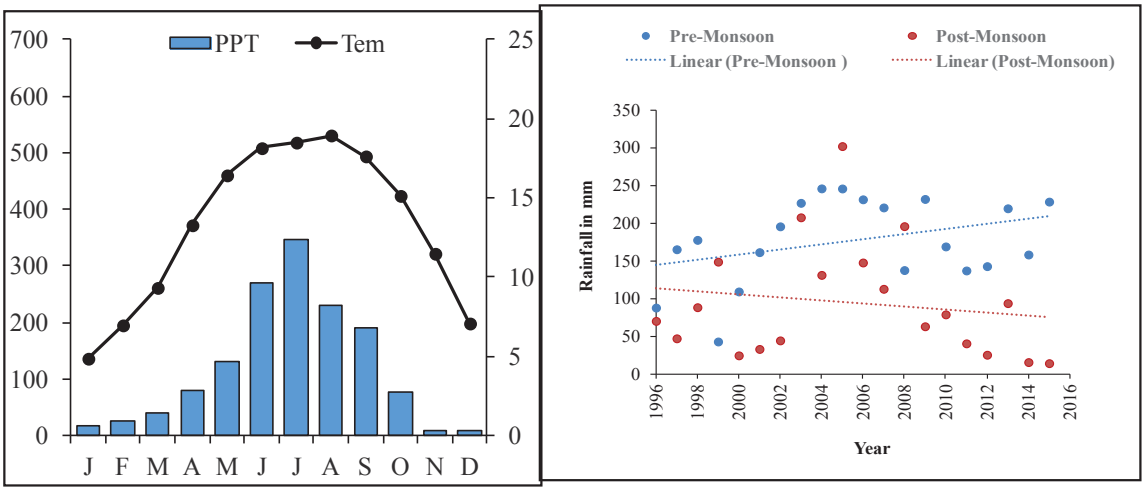

Figure 6. Annual mean Precipitation, Temperature, pre-monsoon and post monsoon variation in Wangdigang-Dechugang watershed

The figure above depicts slight increase in pre-monsoon and decrease in post-monsoon over the years from 1996 to 2016 in the watershed area.

4. Dechugang sub-watershed

Dechugang covers an approximate area of **2474.68** acres constituting of different land use as detailed in the table 3. It has slope aspect mostly facing south to south-east and south-west indicating moderately arid condition. The vegetation cover close to settlements is mostly disturbed and consists of secondary forests including 10 acres forest plantation planted in 1974. The dominant tree species *Lyionia ovalifolia*, *Quercus grifithii*, *Exbucklandia populnea*, and *Rhodendron arboreum* followed by *Lithocarpus fenestratus, Castanopsis indica, Myrsine semiserrata, Eurya cerasifolia,* etc. The relatively high proportion of pioneer species within 5-10 cm DBH class indicates high anthropogenic disturbance either form grazing, shifting cultivation or excessive resource use in the past.

Similarly, in the transition belt between disturbed and undisturbed areas, *Quercus lamellosa, Beilschmiedia gammieana* were the dominant species followed by *Symplocos lucida, Symplocos ramosissima, Viburnum erubescens,* etc. with moderate number of trees within 5-10 cm DBH class. While in undisturbed condition, *Castanopsis indica* and *Castanopsis tribuloides* were dominant species followed by *Cinnamomum impressinervium, Beilschmiedia gammieana, Lithocarpus* sp.etc.

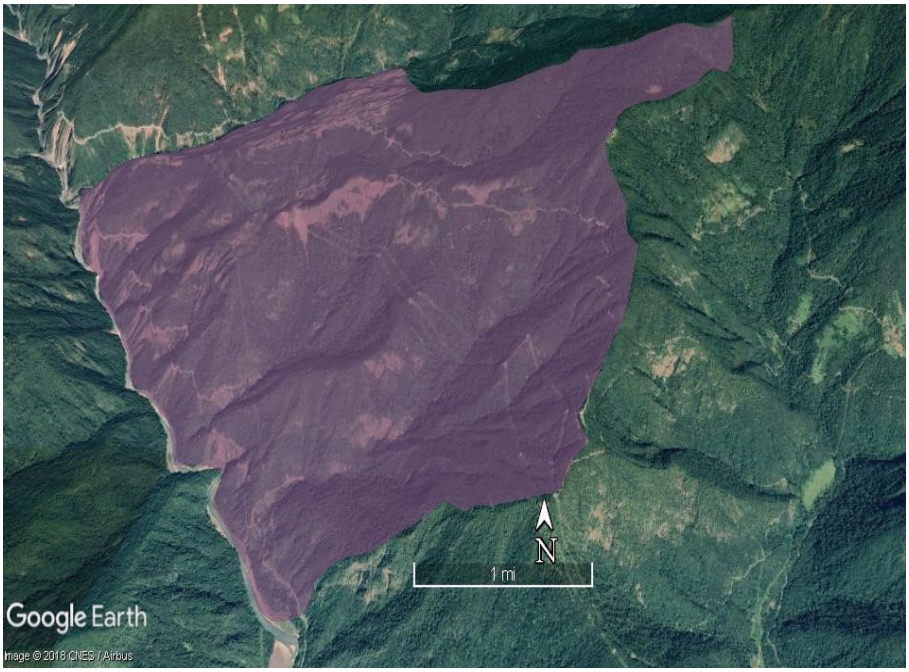

Figure 7. Google Earth view and Land use map of Dechugang sub-watershed

Table 2. Land use types in Dechugang sub-watershed.

Land use	Area (Acre)	Area %
Agriculture Chhuzhing	21.11	0.85
Agriculture Kamzhing	162.14	6.55
Built Up Areas	40.82	1.65
Landslides	3.67	0.15
Broadleaf Forest	2138.73	86.42
Chirpine Forest	1.01	0.04
Meadows	35.23	1.42
Rock Outcrops	0.14	0.01
Shrubs	71.83	2.90
Total area	**2474.68**	**100.00**

4.1. Issues in Dechugang sub-watershed

4.1.1. Drying of water source (Dechugang stream)

The Dechugang stream that used to cater water requirement for Trong, Dangkar, Tingbipam and town area is reported over the years. The considerable decline in water discharge started since early 1980's mainly attributed to climate change and change in landuse over the years.

Figure 8. Fallow paddy fields (A) and abandoned irrigation channel (B) to Dangkar village

4.1.2. Pollution from the municipal waste disposal and a private sawmill

The municipality waste disposal site located within the sub-watershed above Tingbipam village, does not have proper segregation facility and enclosures to prevent entrance of animals from rummaging the waste. Further, a sawmill belonging to a private individual is located right on the natural channel adjoining the waste disposal site. Existence of such infrastructures along the natural channel poses risks of effluent and other hazardous substances leaching into the stream and contaminate water for downstream users.

Figure 9. A Private Sawmill and the Municipal Waste Disposal site at Dechugang sub-watershed

5. Chukhormani sub-watershed

Chukhormani sub-watershed constitutes about 1443 acres of different land uses and forest cover accounts to 97.32 percent of the sub-watershed. The vegetation is dominated by *Beilschmiedia gammieana, Persea fructifera, Acer campbellii, Quercus lamellosa and Castanopsis tribuloides in areas with* minimal human interference. While, in the disturbed areas, the dominant species are *Beilschmiedia gammieana, Castanopsis indica, Persia* sp., *Prunus napaulensis, Daphniphyllum himalense, Symplocos lucida, and Symplocos ramosissima,* associated with *Viburnum erubescens and Lithocarpus fenestratus.*

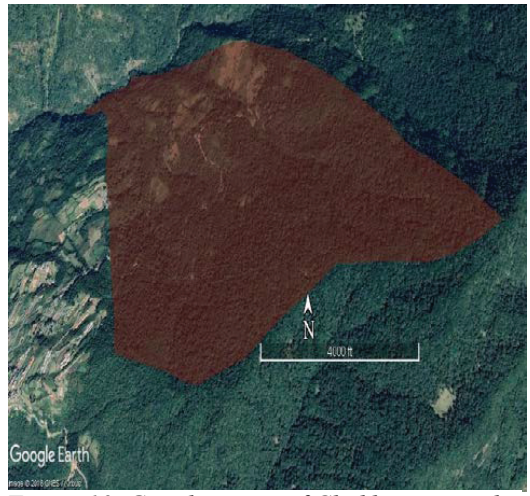

Figure 10. Google image of Chukharmani sub-watershed

Table 3.Different land use in Chukhormani sub-watershed.

Land cover	Area(Ha)	Area in Acre	Area(%)
Broadleaf	553.5	1367.1	94.8
Chhuzhing	16.1	39.8	2.8
Kamzhing	2.7	6.7	0.5
Shrubs	11.8	29.3	2.0
Grand Total	**584.15**	**1442.9**	**100**

5.1. Issues impacting Chukhormani sub-watershed

5.1.1. Drying of water sources

Until 1980's, communities of Dangkar, Dungbi and Wandigang used to get enough water from Chukhormani throughout the year for drinking and irrigation purpose. However, over the years water discharge from the area has also declined by over three folds resulting shortage of water for drinking and irrigation purposes. The local elders remarked drying of water sources to successive logging operations in the area in 1984 (34 Ha) and 1988 (15 Ha). Timber harvested from this watershed was supplied to Gedu Wood Manufacturing Corporation and construction of the National Convention Center.

In 2010, about 385.59 acres of forest land in the watershed was handed over to Dangkar village as a Community Forest with an intent to manage forest on a sustainable basis and enhance equitable distribution of forest resources. One of the objectives of the CF management plan was to protect water sources to ensure regular supply of water for both drinking and irrigation purposes. Despite clear articulation in CFMP, there are evidences of rampant resource extraction from the water sources and riparian buffers. Similarly, the vegetation analysis report indicates relatively low number of timber species in the entire CF area and this contradicts the annual harvesting limit of the CF plan (table 5) and over harvesting is also indicated by presence of *Symplocus lucida, Symplocus ramosissima* and *Eurya* as dominant species with maximum number of trees within DBH class ranging from 5-10 cm.

Table 4. Annual harvesting limit and demand from CF

Annual Harvesting Limit	**Dangchung**	**Tsim**	**Cham**	**Drashing**
Broksar	1664	520	208	208
Bjaro	4635	824	721	1030
Zingarpong	2688	1008	1008	1232
Total annual Harvesting Limit	179	35	19	73
Annual demand	**140**	**140**	**160**	**24**

Figure 11. Evidence of logging operations at water sources

6. Gurpang Sub-watershed

Gurpang sub-watershed adjoins Chukhromani towards the north and constitutes about 7043,26 acres under different land use types. It harbors four major streams which are drinking water sources for Zhemgang town, RDTC and Territorial Forest Division (Table 8). The sub-watershed is dominated by humid broadleaf forest on a mostly north-west facing slope. Some parts of Gurpang were commercially harvested for timber during the first FMU plan period from 1994-2002 with clear felling as the silvicultural system.

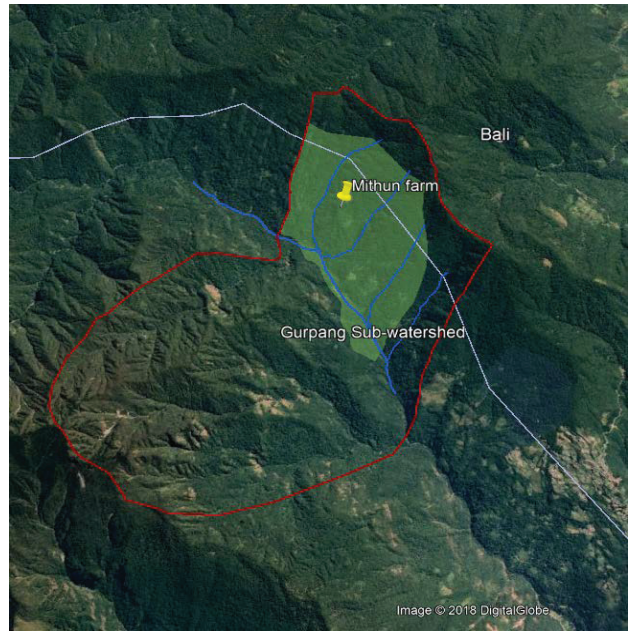

Figure 12. Google Earth view of Gurpang Sub-watershed

In 2006, the Mithun Breeding

Farm was relocated from Wangkha under Chukha Dzongkhag to Gurpang sub-watershed due to bio-security reasons. The farm covers 1628 acres of forest land which is about 50 percent of the total area of Gurpang sub-watershed.

Table 5. Different land cover types in Gurpang sub-watershed

Land cover	Area(Ha)	Area (Acre)	Area(%)
Broadleaf	2295.27	5669.32	80.49
Fir	28.96	71.53	1.02
Mixed conifer	480.42	1186.64	16.85
Shrubs	46.87	115.77	1.64
Grand Total	**2851.52**	**7043.26**	**100**

Figure 13. Water resources in Gurpang Sub-watershed

6.1. Issues impacting Gurpang Watershed

6.1.1. Conversion of forest area into pasture

More than 70 percent of watershed area on the right flank of Wangdigang main stream harboring four streams belong Mithun farm management with established infrastructure including staff quarters, office buildings, cattle sheds and storage facilities. Currently there are about 125 mithuns including young calves to meet the growing demand for breeding bulls in the country. The farm management has a mandate to convert 10 acres of forest land to improved pasture annually. As of June 2017, about 58 acres of humid forest land has been converted to pasture without considering adequate riparian buffer and slope gradient. While some of the pasture developed areas were poorly managed invaded by *Ageratina adenophora* and other invasive species.

Figure 14. Forest land converted for infrastructure and pasture development

Currently about 125 mithuns continuously graze the watershed area and this has altered vegetation structure in the extensively grazed areas besides, development of numerous trails in the watershed. There are also evidences of nitrate (NO3) content in all four streams originating from the sub-watershed.

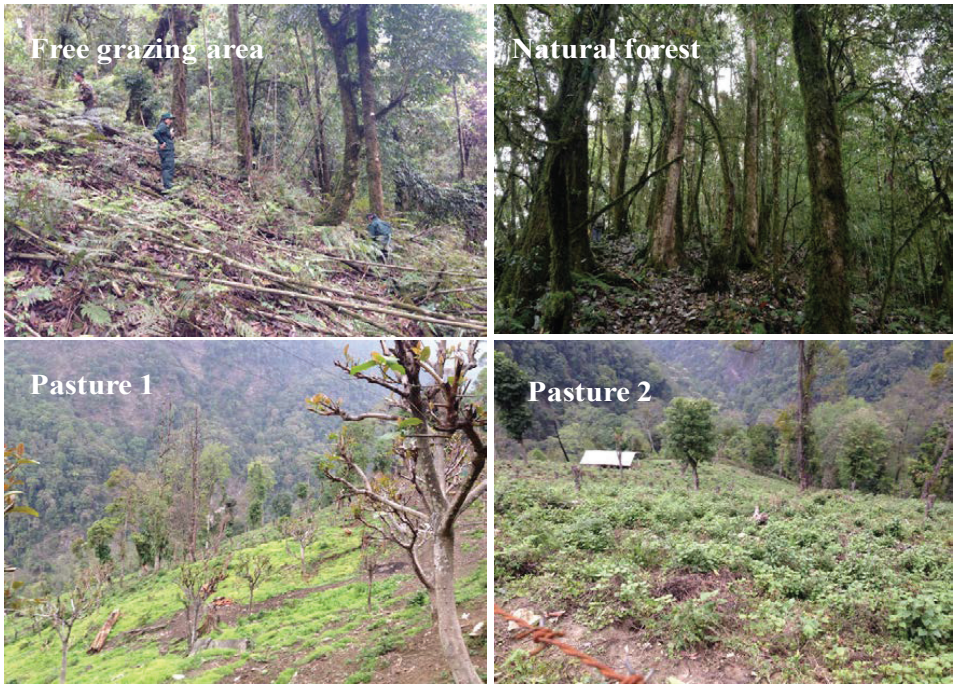

Figure 15. Grazing impacts in Gurpang

7. Tshobrang sub-watershed

Thsobrang, located in the extreme north, is the largest of the four sub-watersheds within Wangdigang-Dechugang watershed and has about 10,533.91 acres of land dominated laurel cool broadleaf forest. Dominant plant species are *Castanopsis tribuloides, Persea clarkeana, Persia fructifera, Prunus undulata, Quercus lamellosa, Symplocos ramosissima, Cinnamomum impressinervium,* and *Stereospermum colais*. The lower part of -Tshobrang adjoining Gurpang sub-watershed was operated for commercial logging with clear felling along corridors of 50 meters during the second FMU plan from 2004 to 2014.

Figure 16. The Google Earth Image of Tshobrang sub-watershed

From times immemorial, migratory cattle herders from Bumthang, Trongsa, and Zhemgang Dzongkhags used to graze in nine different sites within the Tshobrang sub-watershed. However, this trend is on the decline following government policy to

reduce local unproductive cattle heads. Currently there are five herds of cattle following the same practice comprising about 290 cattle heads (2017).

Table 6. Land cover in Tshobrang sub-watershed

Land use	Area (Ha)	Area (Acre)	Area %
Landslides	1.69	4.18	0.04
Broadleaf forest	2,229.6	5507.22	52.28
Broadleaf & Conifer Forest	137.38	339.33	3.22
Fir Forest	232.16	573.44	5.44
Mixed Conifer Forest	1,510.89	3731.90	35.43
Meadows	54.55	134.76	1.28
Rock Outcrops	13.91	37.56	0.36
Shrubs	83.20	205.51	1.95
Total	**4,263.38**	**10533.91**	**100.00**

7.1. Issues impacting Tshrobrang sub-watershed

7.1.1. Drying of lakes

Tshobrang watershed has four small lakes namely Sershongtsho, Tshobrang, Tshoshou and Kibulatsho in different locations. Forest surrounding these water bodies were operated for commercial logging from 2004-2014 without maintaining adequate riparian buffer. Following the logging operation, local communities observed decline in water level in Tshobrang and Sershongtsho over the years.

Figure 17. Tshobrang (A), and Sershongtsho (B)

7.1.2. Failure of forest plantations

Tshobrang still serve as winter grazing ground for a considerable number of migratory cattle from Bumthang, Trongsa and Zhemgang Dzongkhags. Many people are of opinion that failure of forest plantation in Tshobrang areas are due to grazing pressure. The NRDCL has carried out plantations in more than 148.2 acres of logged area incurring more than 3 million Ngultrum over the period of 10 years. There seems to be some misapprehension between cattle herders and NRDCL regarding poor survival of plantations. The NRDCL and DoFPS blame local community (herders) for poor plantation perfomanance while, local people are of opinion that plantation has reduced their traditional grazing areas.

Table 7. List of Grazing areas in Tshobrang

Sl. No	**Name of Grazing area**
01	Chumuluti
02	Yubri
03	Tshobrang
04	Yoesera
06	Shomgang
07	Keling
08	Dolepchen
09	Gangrim
10	Gangu

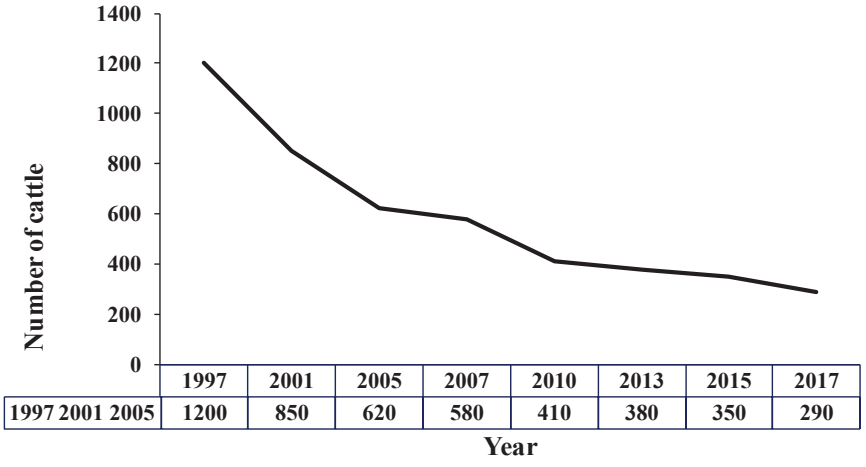

Figure 18. Cattle population trend in Tshobrang area

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

Degradations	**Divers of Degradation**	**Effect on watershed**	**Location /sub-watershed**
Watershed degradation	Logging operations	Drying water sources	Dangkar, Chukormani and Tshobrang
	Pasture development /Grazing pressure	Surface runoffs / erosions	Gurpang
	NWFP collections (Guli)	Alter structure/ composition	Gurpang
	Poor waste management (waste disposal and sawmill)	Unsafe water quality and pollution	Dechugang
	Poor infrastructural design (water pipes)	Trigger erosion /landslides	Chukormani, Gurpang

8. The Plan/Management interventions in Wangdigang-Dechugang watershed

The purpose of the plan is to identify and implement mitigative measures against each of the degrading influences in the sub-watershed and enhance watershed condition to the greatest extent possible to secure continuous supply of water in Zhemgang. A Logical Framework Analysis (LFA) was developed, building on the issues/problems identified. The construction of problem tree and objective tree has helped identification of activities, outcomes, objectives and the goal of the management intervention.

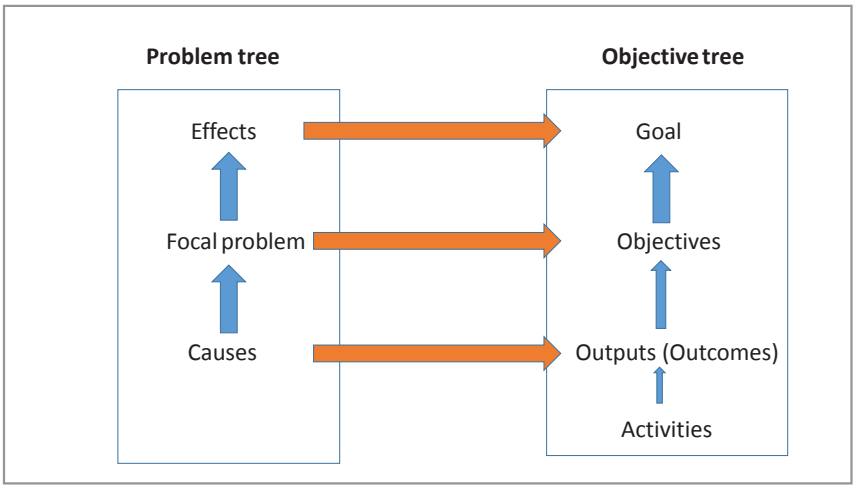

Figure 19. Problem tree and objective tree used to convert issues/problems identified during the planning process into an intervention strategy to mitigate the degrading influences

8.1. Goal and Objectives

Goal: **Goal:** Wangdigang-Dechugang- watershed sustainably managed to secure sustainable supply of quality water for Trong, Dangkar, Dungbi, Wangdigang and Zhemgang areas

.

Objectives and outputs:

1. To minimize degrading influences and improve water supply for drinking and irrigation purposes;

Outputs:

- Wangdigang-Dechugang degraded watershed rehabilitated and forest resources utilized within sustainable limits
- Enhanced infrastructural design to minimize impact on watershed and improved supply of water
- Knowledge of status of water sources (lakes and springs) drying
- Resilient communities with capacity to adapt to natural and man-induced change in the context of climate change

2. To enhance management of waste in accordance with the Waste Management Act of Bhutan:

Outputs:

- Improved waste management practices

8.2. Management intervention in Dechugang Sub-watershed

The management interventions that are needed to be implemented in Dechugang sub-watershed includes:

8.2.1. Relocate the existing municipal waste disposal site to a safer distance:

The concerned authorities shall explore better areas away from settlements and waterways with potential for future expansion considering the increasing amount of garbage and population growth. The new waste disposal site will be well equipped with amenities to segregate bio-degradable and non-degradable wastes.

8.2.2. Relocate a private sawmill

Since it is located in the upper watershed close to natural water channel, wastes including other effluents such as oil and outlets from residents drain into the channel defecating water quality for downstream users. Thereby, it's crucial to relocate the sawmill to a safer place.

8.2.3. Afforeststion/plantation program

Upon removal of waste disposal and the private sawmill from Dechugang, the area will be rehabilitated through plantation of native species on an annual basis.

8.3. Management Intervention in Chukhormani sub-watershed.

The management intervention for Chukhormani sub-watershed includes:

8.3.1. Survey and mapping of catchment's for Tashi Namgay, Jaro, Tarala and Chukhormani springs

To facilitate better recharge of underground aquifers for Tashi Namgay, Jaro, Tarala and Chhukhormani springs, recharge zones for those springs will be identified and demarcated. Further, use of forest resources from recharge areas will be prohibited to improve vegetation structure and composition.

8.3.2. Review Community forest management plan (CF plan):

According to Community Forest Management Plan for Dangkar village developed in 2010, the CF area was estimated with adequate composition of valuable timber species within 385.59 acres. However, this estimate contradicts the vegetation analysis report conducted in 2017. Thus, the CF management plan for Dangkar will be reviewed and renewed upon conducting a comprehensive resource inventory.

8.4. Management Intervention in Gurpang/Mithun Farm Area

The management intervention in Gurpang includes:

8.4.1. Re-locate Mithun breeding farm to some other place

The four main streams; Zartangphai, Charkhey, Broaksar and Sershong all originates from the Gurpang sub-watershed area. Broaksar, Sershong and Zartangphai streams are important source of water supply for Zhemgang municipality, RDTC and Zhemgang Forestry colony. Over the years, the farm management have cleared more than 58 acres of humid broadleaf forest to pasture with a vested mandate to develop 10 acres of pasture annually. Besides pasture development, about 125 mithuns including young calves continuously graze throughout the catchment of four streams inciting both short term and long term impact on the watershed functionality in securing watershed goods and services. Therefore, concerned authority in collaboration with relevant agencies will explore the possibility of relocating the farm to some other areas.

8.4.2. Re-forestation / plantation

The degraded watershed areas in Gurpang sub-watershed will be re-vegetated through artificial means yearly with planting of native species to the extent possible.

8.5. Management interventions in Tshobrang sub-watershed

8.5.1. Re-forestation program

To sustain and enhance water volume in these lakes, one key activity is to improve surrounding vegetation cover either through artificial means or by inducing natural regeneration on an annual basis with native species. Further, a clear and safer riparian boundary shall be marked and maintained to avoid resource exploitation from the area.

8.5.2. Removal of old barbed wire's

One key issue in the area was large plantation area with barbed wire fencing in clear felled corridors. Many a times, cattle were reported to have injured by old barbed wire, sometimes leading to the death of animals. Therefore, it's crucial to remove those old fencing materials for the benefit of wild animals. Existence of old barbed wire fencing would not only hinder animal movement, but also create a better avenue for poachers and hunters as they could easily use these materials.

8.5.3. Re-forestation program

Although NRDCL has created large plantations after logging operations across the lower belt, the survival rate was found minimal in most cases. Therefore, it's crucial to strategically plan a plantation program on a yearly basis which includes annual maintenance until seedlings are well established.

8.6. General interventions

8.6.1. Awareness on watershed and wetlands

One focus area of intervention is strengthening institutional and social capacity on watershed management. The knowledge of key partners including forestry personnel is superficial, when it come to watershed management. Therefore, a mass awareness on watershed and wetland management is a key to success of watershed interventions and ultimately gearing towards securing water for all times to come.

8.6.2. Proper infrastructural design and common water distribution facilities

Despite having two parallel water supply from Dechugang and Sershong area; Zhemgang hardly gets two hours of water supply in a day, attributed to poor infrastructural designs and individual trappings. Pipeline connecting water supply from Sershong to Zhemgang wasn't properly installed and in many places GI pipes were left uncovered supported by wooden posts, subject to damage by any forces including falling boulders. Such damages might trigger landslides downstream and further deteriorate the watershed condition. Thereby, proper designing and installation of infrastructures would immensely help solve the water scarcity issue in Zhemgang.

8.6.3. Climate change adaptation programs

The livelihood and food security of communities in Dangkar and Tingbi Pam were severely hampered, when Dechugang and Chukormani streams started drying up with less water for irrigation purpose. Over the years, 73 households in Dangkar,

Tingbipam, and Trong villages left about 100 acres paddy land and 13 acres of dry land uncultivated. While, dependence on monsoon for paddy plantation has also become erratic and unpredictable over the years. Thus, to cope up with the changing climatic condition, and to build community resilience against such events; SALT and SLM technologies will be promoted in Dangkar, Wangdigang, Dungbi and Tingbi Pam areas on a pilot basis.

8.6.4. Establishment of permanent monitoring plots (PMP):

Watershed planning is a continuous and ongoing process, there is need to establish an accurate base line information to gauge the impact of implementing management activities over the period. Thus, setting up of permanent monitoring plots (PMP) encompassing rain-gauge, RH & temperature sensors including water discharge measurement in the watershed will help design future management needs.

8.6.5. Exploring of PES and PWS

To secure sustainable financing mechanism for conservation of Wangdigang-Dechugang watershed, one possible option is to explore the possibility for Payment for Environmental Service (PES) and Payment for Watershed Service schemes (PWS); whereby upstream communities have the potential to generate some cash income for carrying out conditional conservation activities from the downstream water users such as; Municipal authority, RDTC, etc.

9. Institutional Arrangement for Plan Implementation

Based on the relevance of management interventions, activities proposed in the watershed management plan will be mainstreamed into area-based Five Year and Annual sectoral programs, of the dzongkhag, geog and TFD's plans. The watershed management activities proposed in the plan will be prioritized and internalized to the existing area-based planning frameworks. The operational and organizational framework involving relevant institutions and agencies to implement the plan is shown in Figure 30.

Further, to ensure effective implementation of the plan, it is also imperative to form and operationalize Dzongkhag Watershed Management Committees at the dzongkhag level (DWMC). Key stakeholders include the Dzongkhag and Geog administration, Thromdey, TFD, RDTC, etc.

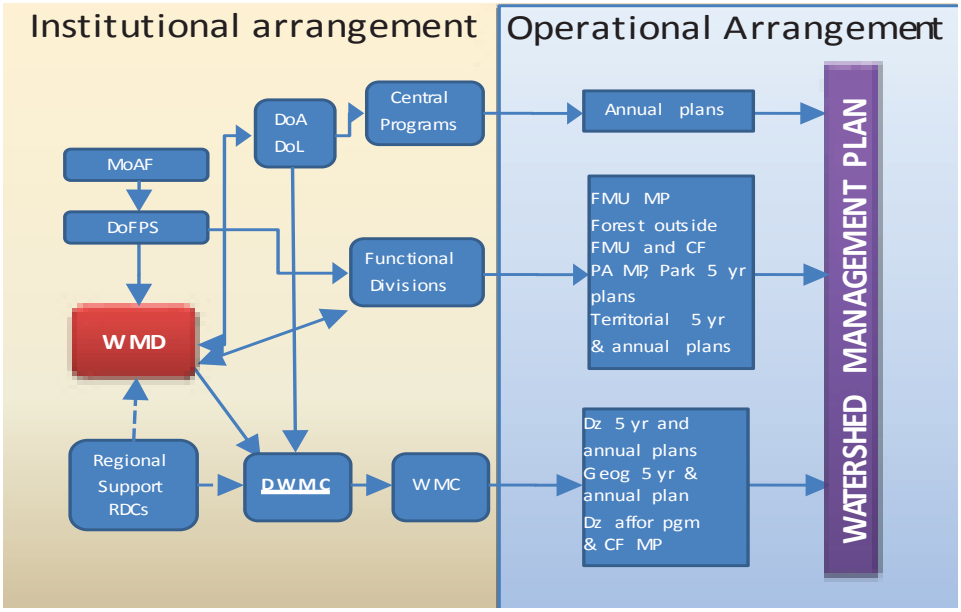

Figure 20. Implementation arrangement

Proper coordination among different agencies within the watershed will be crucial to ensure overall implementation of this plan. For the successful implementation of the plan activities, the Territorial Forest Divisions, Zhemgang, will serve as focal point for coordination and formation DWMC.

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

10. Fund Mobilization

Implementation of planned watershed activities will be funded from the regular RGoB budget and GEF-LDCF project. As the coordinating agency, the DWMCs will facilitate the relevant agencies to incorporate watershed activities in their plans and accordingly seek budgetary provisions from RGoB during the annual and five yearly planning processes.

11. Monitoring & Evaluation

The activities identified in this management plan as being necessary to achieve the goal and objectives of the plan are designed to be integrated into the area-based

management plans of a variety of agencies and organisations, particularly the geog and Dzongkhag annual and 5-year plans. These organisations will monitor implementation. The verifiable indicators given in the logframe matrix in Annex 1 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 the WMD towards the end of the plan period.

12. Revision & Amendment of Plan

The current plan is for a period of five years and the Watershed Management Division in collaboration with Zhemgang DWMC, will revise and amend this plan prior to completion of its first plan period (Jan 2018-Dec 2022). The final impact evaluation will be the basis for revising the plan in the next planning cycle.

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Annexure I

Goal: Wangdigang-Dechugang- watershed sustainably managed to secure sustainable supply of quality water for Trong, Dangkar, Dungbi, Wangdigang and Zhemgang areas.

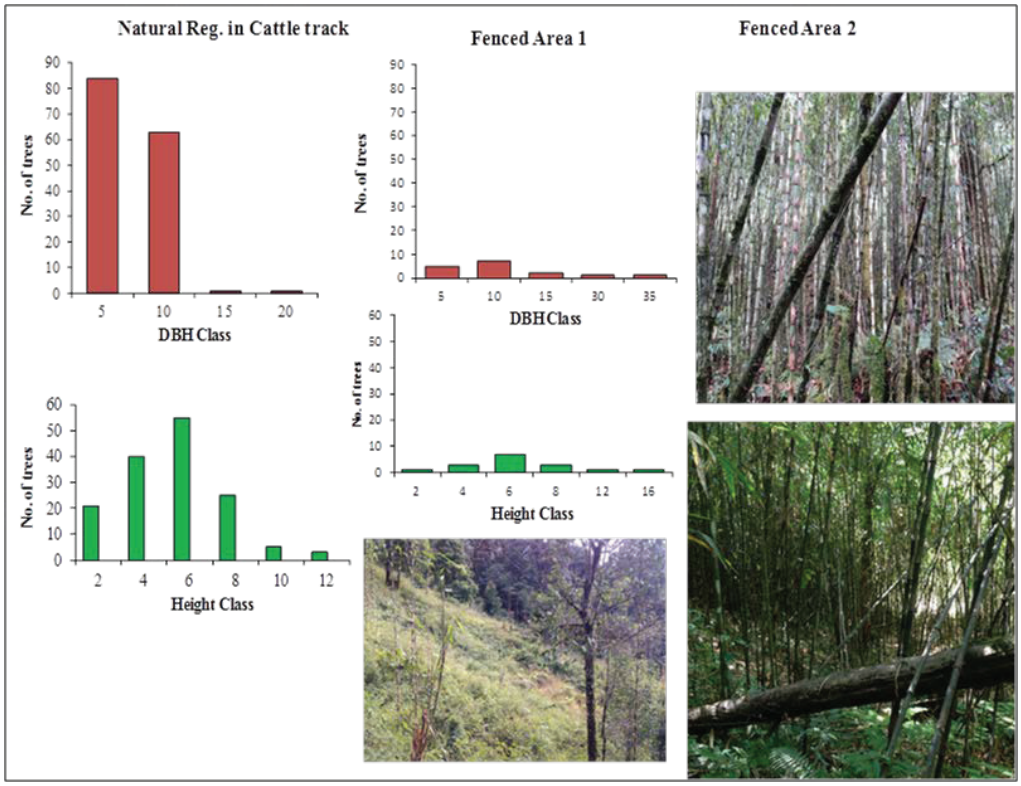
LFA Matrix (Outputs, activities and budget)

Output	Activities	Verifiable indicators	Responsible Agency for implementation	Local area based plan	Budget (M Nu)
Objective 1. To minimize degrading influences and improve water supply for drinking and irrigation purposes					
1.1. Wangdigang-Dechugang degraded watershed rehabilitated and forest resources utilized within sustainable limits	1.1.1. Plantation /enrichment plantation in degraded areas • Dechugang • Chhukormani • Tshobrang • Gurpang	5 Ha 3 Ha 10 Ha 25 Ha	ZFD, Zhemgang and CFMG. ZFD ZFD ZFD	ZFD ZFD ZFD ZFD	0.500m 0.300 1.000 2.000
	1.1.2. Survey and map catchment buffers for lakes, springs and streams. • Phaktartsho and Dechugangchhu • Jarala, Taro and Chukhormani catchments • Sergang, Broksar, Charkhey and Zartangphai springs in Gurpang sub-watershed • Tshobrang, Kibula, Tshoshou and Sershong lake in Tshobrang sub-watershed.	Reports and Map	ZFD, WMD	ZFD	0.200m

Output	Activities	Verifiable indicators	Responsible Agency for implementation	Local area based plan	Budget (M Nu)
	1.1.3. Remove old barbed wire fencing along cable crane corridor in Gurpang and Tshobrang sub-watershed.	Reports	ZFD	ZFD	0.500m
	1.1.4. Form watershed management core team/ committee and develop ToR	Committee formed and ToR developed.	ZFD, WMD, Dzongkhag	ZFD	0.100m
	1.1.5. Train /create awareness program on watershed management	Training report	ZFD, Dzongkhag and WMD	WMD	1.000m
	1.1.6. Review community forest management plan for Dangkar CF	CF Plan / report	ZFD, CFMG Dzongkhag	ZFD	0.200m
	1.1.7. Re-assess resources in the watershed and categorize entire watershed into different function zones (catchments, resource use and other important ecological functions)	Reports and Maps	ZFD, Dzongkhag	ZFD	0.500m
	1.1.8. Relocate mithun farm to some other area	Reports	Mithun farm, ZFD, Dzongkhag	Mithun farm	5.000m
1.2. Enhanced infrastructural design to minimize impact on watershed and improved supply of water	1.2.1. Properly align water supply infrastructure from Sergang and Broaksar to Zhemgang to reduce landslides	Reports	Dzongkhag, ZFD	Dzongkhag	5.000m
	1.2.2. Install common water reservoir and distribution tanks	Reports	Dzongkhag, RDTC, ZFD	Dzongkhag	2.000m

Output	Activities	Verifiable indicators	Responsible Agency for implementation	Local area based plan	Budget (M Nu)
1.3. Knowledge of status of water sources (lakes and springs) drying	1.3.1. Carryout scoping study of the causes of drying water sources.	Reports /publications	WMD, ZFD, Dzongkhag	WMD	1.500m
	1.3.2. Establish permanent monitoring plots in each sub-watersheds and install rain gauge, digital HOBO for temperature and RH including discharge measurements	Reports	WMD, ZFD, UICER	UICER	1.000m
1.4. Resilient communities with capacity to adapt to natural and man-induced change in the context of climate change	1.4.1. Pilot climate smart approaches in prioritized areas in watershed (SLM activities, Water harvesting technologies, etc.)	Diagnostic study report, Implementation plan and reports	Dzongkhag	DAO	1.000m
Objective 2. To enhance management of waste in accordance with the Waste Management Act of Bhutan					
2.1. Improved waste management practices	2.1.1. Relocate Dechugang sawmill and a waste disposal site to safer location with proper waste segregation facilities.	Reports	Dzongkhag, ZFD	Dzongkhag	5.000m
	2.1.2. Create awareness on waste management and creation of waste collection points.	Reports	ZFD, Dzongkhag	ZFD	0.500m
Total Plan Outlay					**26.800**

Annexure II: Regeneration pattern in different area in Tshobrang.

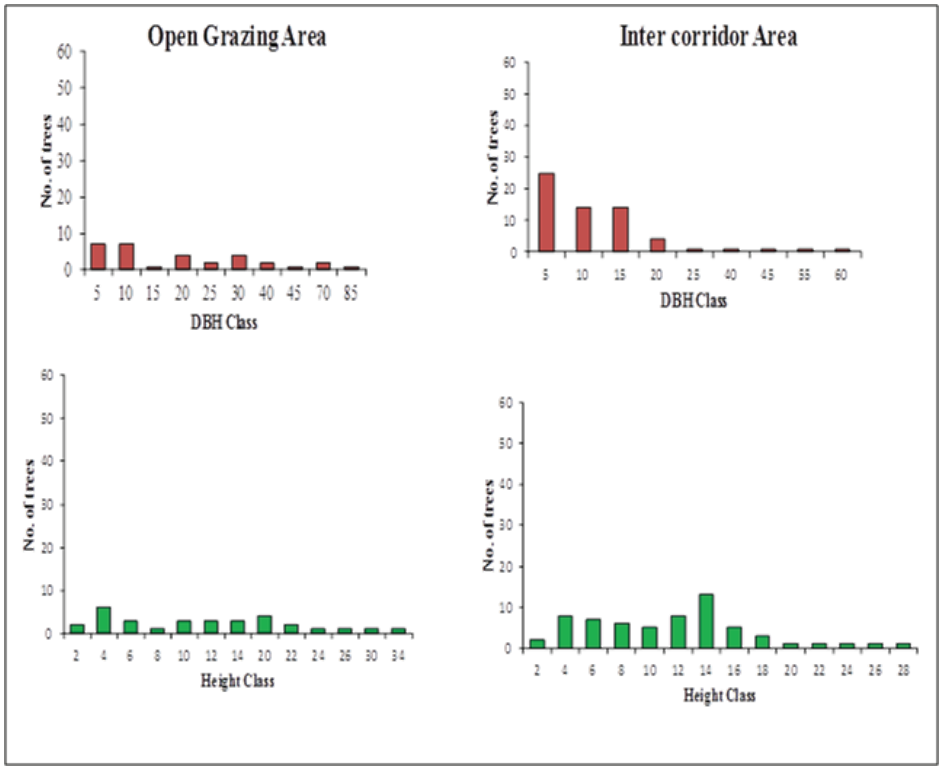


As to validate the grazing issue in Tshobrang sub-watershed area, a simple Vegetational analysis was conducted in forest plantations and along open cattle tracks that were left to facilitate cattle movement after logging operation. The survey clearly revealed that the open cattle tracks that were left to facilitate cattle movement showed highest record of natural regenerations dominated by *Simplocus ramosissima,* with DBH class ranging from 5 to 20 cm, while in the recently fenced areas, there are only few number of *Perscia* and *Magnolia* species with few naturally regenerated *Simplocus ramosissima.*

In areas where plantation was done from 2004 to 2009, were covered with thickets of monopodial bamboo species scientifically known as *Chimonobambusa callosa* with rare number of trees. Therefore, failure of forest plantation is rather due to lack of proper coordination among the stakeholders and partly because of technical lipases.

Analysis was also done to compare grazing impact between areas that were freely grazed from times immemorial and inter-corridors in logged areas. The result showed not much significant difference in terms of structure, dynamics and species

composition, except some edge effect from the logging operations in inter-corridor areas with bamboos and *simplocus species.*



DBH and height class distribution in openly grazed area and inter-corridor

Annexure III: List of Streams assessed in Mangdechhu sub-basin

Sl/No	Lat_DD	Lon_DD	Name	Altitude	Q_m3/sec	Q_l/s	Class	Place
1	27.5756	90.3176	Do lawa	2873	0.208	208.0	Normal	Nikachu
2	27.5701	90.3170	Beci gyem chu	2875	0.244	244.4	Normal	Nikachu
3	27.5612	90.3146	Lubzurchu	2812	0.389	388.6	Normal	Nikachu
4	27.5509	90.3045	Bacha gang chu	2693	9.533	9533.1	Normal	Nikachu
5	27.5526	90.3096	Nimdro khang chu	2717	0.253	253.4	Normal	Nikachu
6	27.5479	90.2163	Gangchukha chu	3297	0.159	159.4	Normal	Nikachu
7	27.5435	90.2177	Homagangchu	3253	0.167	167.3	Normal	Nikachu
8	27.5326	90.2179	Longtoe chu	3199	0.154	153.6	Normal	Nikachu
9	27.5291	90.2447	Longmay chu	3090	1.040	1039.5	Normal	Nikachu
10	27.5129	90.2795	Pelai chu	2733	2.531	2531.4	Normal	Nikachu
11	27.5159	90.2781	Bjibe chu	2746	1.434	1434.2	Normal	Nikachu
12	27.5118	90.2975	Zerechhu	2585	10.818	10818.2	Normal	Nikachu
13	27.5612	90.3121	Luptse chu	2767	0.974	973.6	Normal	Nikachu
14	27.5489	90.3128	Sangchu chu	2758	0.181	181.2	Normal	Nikachu
15	27.5414	90.3129	Wangdigangchu	2856	0.078	78.0	Normal	Nikachu
16	27.5414	90.3014	Tshochu hoka chu	2694	0.060	60.1	Normal	Nikachu
17	27.5303	90.3229	Rabu Chu	2847	0.239	239.4	Normal	Nikachu
18	27.5287	90.3238	Gangrim chu	2881	1.365	1364.6	Normal	Nikachu
19	27.5270	90.3242	Churagang chu	2882	0.322	321.6	Normal	Nikachu
20	27.6784	90.2813	Gentsa chu	3670	6.324	6323.8	Normal	Nikachu
21	27.7136	90.2865	Umta Tertsho	4300	3.198	3198.4	Normal	Nikachu
22	27.7092	90.2973	Umtsho Tsho	4250	0.400	400.0	Normal	Nikachu

Sl/No	Lat_DD	Lon_DD	Name	Altitude	Q_m3/sec	Q_l/s	Class	Place
23	27.6925	90.3109	Passibu Tsho	4245	0.500	500.0	Normal	Nikachu
24	27.6789	90.2963	Khegachuzhi chu	3831	2.851	2851.5	Normal	Nikachu
25	27.6388	90.2853	Sombji chhu	3550	6.461	6460.8	Normal	Nikachu
26	27.6088	90.2950	Yedha Karchu	3178	1.929	1929.1	Normal	Nikachu
27	27.5994	90.3003	Rubji Thangchu	3064	4.023	4023.2	Normal	Nikachu
28	27.5955	90.3140	Repa Thangchu	3065	4.616	4615.6	Normal	Nikachu
29	27.4991	90.3143	Chuserbu	2507	1.870	1870.1	Normal	Nikachu
30	27.4755	90.3501	Chendebji chu	2449	3.025	3025.4	Normal	Nikachu
31	27.4860	90.3360	Khebar chu	2496	3.980	3979.6	Normal	Nikachu
32	27.4579	90.3871	Pemji chu	2491	0.840	840.2	Normal	Nikachu
33	27.4500	90.4387	Zalam chu	2418	2.360	2360.4	Normal	Nikachu
34	27.4509	90.4434	Tsheringma Drupchu	2391	0.006	6.0	Normal	Nikachu
35	27.3665	90.5357	Yuro chu				Normal	Upper Mangdue
36	27.3622	90.5624	Karti chu				Normal	Upper Mangdue
37	27.3124	90.6026	Zarganggrok				Normal	Upper Mangdue
38	27.2979	90.6106	Parkhey chu				Normal	Upper Mangdue
39	27.3347	90.5939	Thresachu				Normal	Upper Mangdue
40	27.4229	90.4932	Yesheygang chu				Normal	Upper Mangdue
41	27.4446	90.4745	Lekpa chu				Normal	Upper Mangdue
42	27.4446	90.4745	Rayling chu				Normal	Upper Mangdue
43	27.4632	90.5011	Dzongluchu				Normal	Upper Mangdue
44	27.3124	90.6025	Dungichu				Normal	Upper Mangdue
45	27.3801	90.5395	Zarchen				Normal	Upper Mangdue
46	27.4128	90.5344	Yargang chu				Normal	Upper Mangdue

Sl/No	Lat_DD	Lon_DD	Name	Altitude	Q_m3/sec	Q_l/s	Class	Place
47	27.4144	90.5101	Drupchu				Normal	Upper Mangdue
48	27.5220	90.4579	Chadagang chu				Normal	Upper Mangdue
49	27.5405	90.4426	Yangtsa chu				Normal	Upper Mangdue
50	27.5833	90.4446	Sinphu Rongchu				Normal	Upper Mangdue
51	27.5848	90.4534	Kakachura chu				Normal	Upper Mangdue
52	27.5603	90.4431	Kakaling Rongchu				Normal	Upper Mangdue
53	27.5190	90.4908	Chapchi rongchu				Normal	Upper Mangdue
54	27.5190	90.4908	Endru chu				Normal	Upper Mangdue
55	27.5365	90.4679	Lai Tsachu				Normal	Upper Mangdue
56	25.5539	90.4850	Hadogang chu				Normal	Upper Mangdue
57	25.5660	90.4926	Churalu chu				Normal	Upper Mangdue
58	25.5660	90.4926	Thruesipang chu				Normal	Upper Mangdue
59	27.2116	90.5994	Nishongchu				Normal	Upper Mangdue
60	27.5091	90.5096	Thruepangchu				Normal	Upper Mangdue
61	27.1861	90.5351	Zhilichu				Normal	Upper Mangdue
62	27.3489	90.5803	Burigang chu				Normal	Upper Mangdue
63	27.3560	90.5694	Sertila chu				Normal	Upper Mangdue
64	27.3026	90.5899	Jungchichu				Normal	Upper Mangdue
65	27.3269	90.5931	Chupigang chu				Normal	Upper Mangdue
66	27.3254	90.5735	Balitang chu				Normal	Upper Mangdue
67	27.2749	90.5814	Phruzur chu				Normal	Upper Mangdue
68	27.2626	90.5733	Rangala chu				Normal	Upper Mangdue
69	27.2128	90.6817	Denchugang				Normal	Lower Mangdue
70	27.2305	90.6781	Chokorani Dungbee				Normal	Lower Mangdue

Sl/No	Lat_DD	Lon_DD	Name	Altitude	Q_m3/sec	Q_l/s	Class	Place
71	27.2349	90.6896	Wangdigang, near ithun far.				Normal	Lower Mangdue
72	27.2278	90.6410	Wangduegang chhu				Normal	Lower Mangdue
73	27.1847	90.6561	Stream before Betri chuu				Normal	Lower Mangdue
74	27.1646	90.6647	Betrichhu				Normal	Lower Mangdue
75	27.1489	90.6893	Tagbichhu				Normal	Lower Mangdue
76	27.0052	90.8358	Ridigang chhu				Normal	Lower Mangdue
77	26.9456	90.8791	Morangchhu				Normal	Lower Mangdue
78	26.9439	90.8560	Panabee				Normal	Lower Mangdue
79	26.8527	90.9418	Bjirang chhu				Normal	Lower Mangdue
80	27.1258	90.7042	Brubichhu				Normal	Lower Mangdue
81	27.1209	90.7076	Phobichhu				Normal	Lower Mangdue
82	27.2143	90.7548	Burigangchhu				Normal	Lower Mangdue
83	27.1809	90.7989	Budelingchhu				Normal	Lower Mangdue
84	27.2160	90.7744	Shongdigang				Normal	Lower Mangdue
85	27.1171	90.7081	Chukhoranichhu				Normal	Lower Mangdue
86	27.1156	90.7361	Udigangchhu				Normal	Lower Mangdue
87	27.0494	90.7885	Jingarchhu				Normal	Lower Mangdue
88	27.0337	90.8075	Bragang chhu				Normal	Lower Mangdue
89	26.9903	90.8392	Kernagchhu				Normal	Lower Mangdue
90	27.0694	90.7641	Subrangchhu				Normal	Lower Mangdue
91	26.9661	90.8571	Pantangchhu				Normal	Lower Mangdue
92	26.9661	90.8571	Dagpai watershed				Normal	Lower Mangdue
93	26.9661	90.8571	Buli watershed (whole)				Normal	Lower Mangdue

Sl/No	Lat_DD	Lon_DD	Name	Altitude	Q_m3/sec	Q_l/s	Class	Place
94	27.2090	90.7483	Dakphel chhu				Normal	Lower Mangdue
95	27.1263	90.7141	Wangdharchhu/ Golingchhu				Normal	Lower Mangdue
96	27.0319	90.8317	Dunmang watershed				Normal	Lower Mangdue
97	26.9285	90.7402	Dralangchhu				Normal	Lower Mangdue
98	26.9339	90.8719	Wangdigang				Normal	Lower Mangdue
99	26.9124	90.9046	Darangchhu				Normal	Lower Mangdue
100	27.0157	90.7754	Tanchalagang				Normal	Lower Mangdue
101	27.0076	90.7668	Zhidigang				Normal	Lower Mangdue
102	27.0040	90.7664	Chandagang				Normal	Lower Mangdue
103	27.0027	90.7676	Citrubrang				Normal	Lower Mangdue
104	26.9873	90.7609	Naraling				Normal	Lower Mangdue
105	26.9825	90.7582	Gujong				Normal	Lower Mangdue
106	26.9753	90.7541	Cepong Jua				Normal	Lower Mangdue
107	26.9715	90.7527	Weregangchhu				Normal	Lower Mangdue
108	26.9684	90.7532	Rindagang				Normal	Lower Mangdue
109	26.9498	90.7531	Youngba				Normal	Lower Mangdue
110	26.9557	90.7526	Kharigang (Chabgang)				Normal	Lower Mangdue
111	26.9581	90.7543	Redijong				Normal	Lower Mangdue
112	26.9554	90.7525	Paitheypong chhu				Normal	Lower Mangdue
113	27.1641	90.8178	Buli Tsho watershed				Normal	Lower Mangdue
114	27.1792	90.8042	Bulichhu				Normal	Lower Mangdue

Annexure IV. List of Water Resources in Wangdigang-Dechugang Watershed

Water Resources in Dechugang sub-watershed with Lab result

Name	Na^+ (mg/L)	K^+ (mg/L)	Mg^{2+} (mg/L)	Ca^{2+} (mg/L)	Li^+ (mg/L)	NH_4^+ (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	HCO_3^- (mg/L)	NO_3^- (mg/L)	F^- (mg/L)	SiO_2 (mg/L)
Dechugang_up-stream	2.10	0.76	0.42	0.96	N.D.	N.D.	0.22	2.11	8.54	0.79	0.04	14.60
Dechugang_down-stream	2.04	0.71	0.39	0.87	N.D.	0.01	0.22	2.08	7.93	0.71	0.04	16.00

Water resources in Chukormani sub-watershed (instant result).

Stream Name	Discharge	pH	Salt	TDS	Conductivity	Temp
Tashi Namja & Jaro	1.9 L/s	5.91	21.7	20.1	28.2	14.2
Rulingkhoe (Below Tarila)	6.1/ L/s	5.96	38.2		55	16.5
Chukhormanichhu	4.5 L/s	5.87	30.9	31.6	44.6	13.8
Barkhoe	6.15 L/s	5.8	48.3	51.5	72.6	16.5
Zarangkhoe	2.8 L/s	5.45	43.3	45.1	63.5	15.4
Menchu		5.45	65	70	98.8	15.8

Water resources in Gurpang sub-watershed with instant quality result

Stream Name	Discharge	pH	EC	TH	COD	NO3 (mg/L)	NH4 (mg/L)	Bacteria	Coli form
Sershong	18.36 L/s	8.2	68	10	2	1	0	16	12
Broaksar	14.37 L/s	8.4	78	10	2	1	0	60 +	45+
Charkhey	6.24 L/s	8.5	50	10	2	1	0	0	10
Zartangphai	22.1 L/s	8.1	68	10	2	1	0	36	16

Water resources in Tshobrang sub-watershed

Location / name	Status/ types
Sershongtsho	Pond/lake
Tshobrang	Pond / lake
Tshoshou	Pond / lake
Kibula	Pond /lake
Wangdigangchhu	Stream