INTEGRATED WATERSHED MANAGEMENT PLAN FOR BARSA WATERSHED

(Chukha Dzongkhag)

ROYAL GOVERMENT OF BHUTAN

JUNE 2018

Integrated Watershed Management Plan for Barsa Watershed

Chukha Dzongkhag

Phuentsholing Thromde
&
Watershed Management Division
Department of Forest & Park Services
Ministry of Agriculture & Forest
Royal Government of Bhutan

June 2018

Plan Preparation

1. Jamyang Phuntshok, Dy. Chief Met Officer, WMD

Field Assessment and plan development support

1. Tsering Gyeltshen, PLO, WMD
2. Sigyel Delma, Dy.CFO, WMD
3. Samten Wangchuk, Dy.CFO, WMD
4. Nidup Tshering, ALO, WMD
5. Ugyen Dema, Sr.ES, WMD
6. Kinley Dem, Sr.FR, WMD
7. Tashi Tshering, Sr. FR, Sampheling Geog
8. CM Rai, Sr. FR, Geling Geog
9. Gem Lham, Sr.ES, Sampheling Geog
10. Sonam Choki, ES, Geling Geog
11. Sangay Phuntsho, LES, Geling Geog
12. Don Gilmour, Sr. Australian Volunteer

Plan Editorial

1. Pema Wangda, PhD, CFO, WMD
2. Jamyang Phuntshok, DCMO, WMD

Citations:

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

© ***Watershed Management Division, Department of Forest & Park Services, Ministry of Agriculture & Forest, Royal Government of Bhutan***

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 preparation was funded by Phuentsholing Thromde (PT)

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.

Submitted for approval:

Planner, Watershed Management Division

Reviewed and recommended for approval:

Chief Forest Officer
Watershed Management Division

Recommended for Approval:

Director
Department of Forest & Park Services

APPROVED

Hon'ble Secretary
Ministry of Agriculture & Forests

ACKNOWLEDGEMENT

The Integrated Watershed Management Plan for Barsa Watershed is developed as a part of NAPA II project coordinated by National Environment Commission Secretariat. The plan is an outcome of a collaborative process that involved many stakeholders from agencies both at the field and national level. The process involved field visits and consultations with technical people who are working directly or indirectly in the watershed as well as local residents of Geling and Sampheling Geogs.

Watershed Management Division under Department of Forest & Park Services would like to express sincere gratitude to NAPA II coordinator NEC for giving the opportunity to develop the plan, which provided the division a new experience considering the nature of the watershed. Thanks are also due to NAPA project coordinators at Phuentsholing Thromde for their timely provision of budget for the plan development.

WMD would like to thank Dr. Don Gilmore AVID Volunteer for providing his valuable insights and guidance in developing watershed management plans for sites like Barsa Watershed and for his active involvement during the initial phase of this plan development.

Last but not least, WMD would like to thank all the individuals from Gedu Forest Division, Chukha Dzongkhag, and MoAF for their support in the development of this plan.

GLOSSARY OF BHUTANESE TERMS

Dzongkhag	District
Geog	Block/administrative unit/County
Goenpa	Hermitage
Thromde	Municipality

LIST OF ABBREVIATIONS

BCCL	Bhutan Carbide &Chemical Limited
BFAL	Bhutan Ferro Alloys Limited
BSMPL	Bhutan Silicon Metal Private Limited
BPC	Bhutan Power Corporation
DGM	Department of Geology & Mines
DoFPS	Department of Forest and Park Services
DoR	Department of Roads
FMED	Flood Engineering & Management Division
GBCL	Green Bhutan Corporation Limited
GFD	Gedu Forest Division
Ha	Hectare
HH	Household
Km	kilometer
LFA	Logical Framework Analysis
LFAM	Logical Framework Analysis Matrix
m.a.s.l	Meters above sea level
MCT	Main Central Thrust
mm	Millimeter
M & E	Monitoring & Evaluation
MoAF	Ministry of Agriculture and Forest
NAPA	National Adaptation Plan of Action
NCHMS	National Center for Hydrology & Meteorology
NEC	National Environment Commission
NWFP	Non-wood Forest Product
PIA	Pasakha Industrial Area
PT	Phuentsholing Thromde
UWICER	UgyenWangchuk Institute of Conservation, Environment & Research
WMD	Watershed Management Division

EXECUTIVE SUMMARY

Pasakha under Phuentsholing Thromde is the first planned industrial area and it is currently the industrial hub of the country. The area had been affected by numerous flash floods in the Barsa River and they have been identified as the most hazardous events of varying magnitudes at Pasakha industrial area (PIA) located close to the river. Two devastating floods of 1996 and 2000, and some small ones during the recent past had severely affected the area. Barsa watershed being the upstream of same was selected for mitigation works under National Adaptation Plan of Action, NAPA II project. The mitigation works aim to minimize the impacts of flood and sediments in the industrial and residential areas.

While mitigation works such as construction of retaining walls were carried out along the downstream, Watershed Management Division (WMD) under the Department of Forests and Park Services (DoFPS) was recommended by NEC to develop a watershed management plan for Barsa watershed to complement the activities carried out in the downstream.

The watershed management plan was developed through participatory process involving relevant stakeholders both in the field and at the central agency levels. The plan development process started with scoping visits followed by consultation meetings and field assessments. Issues were collected along the process and some the prominent issues in the watershed are landslides, geological instability, severe rainfall, dumping of debris from highways, grazing, poor drainage below the roads, etc… the issues were filtered using the logframe analysis tool and appropriate intervention activities were designed to address the goal and objectives of the plan.

The goal and objectives of the plan are:

Goal:

Barsa watershed actively managed to conserve (watershed) goods and services and reduce sedimentation and loss of properties in the downstream areas in the context of climate change.

The objectives set to attain the goal are:

Objectives:

1. To mitigate flooding along the downstream
2. Minimize degrading influences and improve watershed condition

While the plan will be implemented by various stakeholders (indicated in the LFAM), the overall ownership of the same will remain with Phuentsholing Thromde (PT). The activities of the plan should be mainstreamed in the annual and five years plans of the respective agencies and they will also carry out annual monitoring of the same. However, the overall monitoring and evaluation at the end to assess the impact will be done by PT in collaboration with WMD & NEC.

TABLE OF CONTENTS

1. Introduction

The southern foothills of Bhutan are highly prone to flashfloods and other forms of disasters which leads to loss of lives, properties and damage to natural environment(FMED, n.d)Barsa watershed as upstream of Pasakha Industrial Areas (PIA) was selected for mitigation works under National Adaptation Plan of Action, NAPA II project. Pasakha under Phuentsholing Thromde is the first planned industrial area and it is currently the industrial hub of the country.

The mitigation works under NAPA II project aim to minimize the impacts of flood and sediments in the Pasakha industrial and residential areas.

1.1 Rationale for development of Barsa Watershed Management Plan

In the last decade, there had been numerous flash floods in the Barsa River and they have been identified as the most hazardous events of varying magnitudes at Pasakha industrial area located close to the river. There have been two devastating floods in 1996 and 2000, and some small ones during the recent past (Adhikari, 2015). Those floods have damaged roads, residential buildings and bridges in Pasakha causing heavy losses to lives and properties.

Figure 1:Groynes constructed (and subsequently destroyed by high river flows) in an unsuccessful attempt to train the river away from the BFAL factory site

The water level of Barsa river have been observed to have increased during the recent past leading to severe sediment deposits in the downstream. The Association of Bhutanese Industries and individual enterprises spends substantial amounts of fund each year to alleviate the potential damages from monsoon floods. However, the ongoing risk mitigation measures are interim and piecemeal in nature. For example, the industries in Pasakha engage in dredging of river each year to remove silt transported from upstream areas during the monsoon season. The silt raises the riverbed and thus increases the risk of overflow of water during the monsoon. Private firms that are situated near the rivers also invest in more direct protection measures such as rock gabions and rudimentary manual systems of siren-based early warning. However, all of these measures do not take into consideration likely increase in peak discharge of monsoon river flows and thus these ongoing investments face a significant risk of failure as the impact of climate change becomes increasingly significant.

Figure 2: BFAL housing colony is constructed on flood plain about one km below the factory site

Therefore, the NAPA II project identified management of the Barsa watershed as it is one of the important intervention activity towards mitigating the risks associated downstream(ProDoc, 2013).Subsequently, the Watershed Management Division (WMD) under the Department of Forests and Park Services (DoFPS) was recommended to develop the watershed management plan for Barsa watershed to contribute to the mitigation works of risks associated to Barsa river, by complementing the various activities carried out in the downstream.

1.2 Description of the watershed

1.2.1 Geographical description

The Barsa watershed area extends from 26° 50' 17.90" N to 26° 55' 49.89'' N; and 89°26' 31.28'' E to 89° 32'' 14.16" E with the total area of 5833 hectares. The elevation of the watershed ranges from 293 masl (Pasakha plain) in the south to 2346 masl (Jumja top) in the north. It encompasses Jumja, Ganglakha, and Kamji areas down to the PIA covering parts of Geling Geog in the upstream and Sampheling Geog in the downstream under Chukha Dzongkhag.

Figure 3: Overview of the watershed from a google map

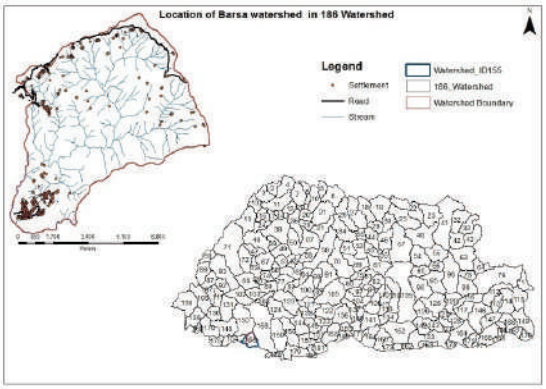

Figure 4: Location of Barsa watershed

The Barsa watershed falls within the watershed No. 155 as per WMD's delineation) (Figure 4). This watershed does not fall within any major river basins. The Barsa River is fed by three main tributaries emerging from Jumja, Kamjiand Ganglakha. The river flows through a steep gradient and is rapidly down-cutting.

Phuntsholing-Thimphu highway runs through the upper reaches of the catchment area. This stretch of highway frequently experienced landslides during the rainy seasons and the slides are still active at Jumja. Recently new slides have also been observed in Ganglakha areas. In the lower part of the Barsa watershed (Pasakha) is Phuntsholing-Manitar road and major industries like Bhutan Ferro Alloys Limited (BFAL), Bhutan Carbide and Chemicals Limited (BCCL), Bhutan Silicon Metal Private Limited (BSMPL) are located along the left bank of Barsa river.

1.2.2 Geology

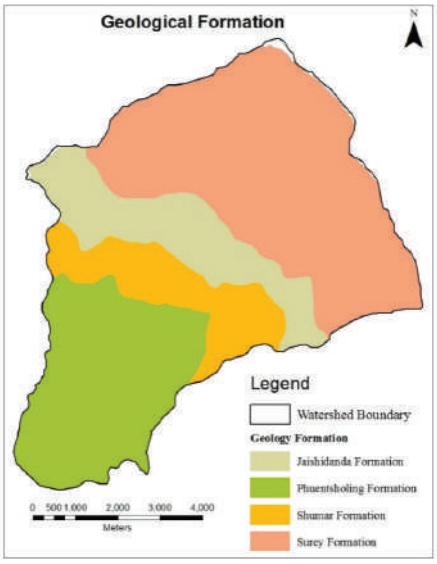

Figure 5:Geological map of the watershed

Geologically, the Barsa watershed falls along the fragile foot hills of the Bhutan Himalaya (Gannser, 1964). The majority of area is occupied by lesser Himalaya and partly by Higher Himalayan sequence in the north. The area comprises of four geological formations: i) Phuentsholing Formation occupies the lower most stratigraphic level in Barsha catchment area, ii) Shumar Formation overlays the Phuentsholing Formation, iii) it is the overlain by Jaishidanda Formation and iv) Surey Formation in the extreme north (DGM, 2017), (Figure 5)

The generalized trend of the rocks in Barsa varies from N30˚ to 70˚W with dips 25˚ to 55˚ towards north. The geology in general, can be grouped into two litho assemblage depending upon sudden change in the grade of metamorphism considering the Main Central Thrust (MCT) as base line. The area south of Main Central Thrust comprises mainly of low grade meta-sedimentary of Lesser Himalayan Sequence and overlying high grade metamorphic rock of Central Crystalline Complex. MCT is a narrow but persisting zone comprising of highly crushed coarse grain, quartz-mica schist and forms the boundary between the two sequences(DGM, 2017)

1.2.3 Climate

Climatically, Barsa watershed falls along the subtropical type of weather and generally receives heavy precipitation annually. The total mean precipitation varies from 4075. 2 mm at 250 m a.s.l along the foothills through 3773.0 mm at 1750 m a.s.l. in the mid-altitude of the watershed to 3412.4 mm at c. 2000 m a.s.l on the upper ridges of Barsa watershed respectively (Wangda et al 2017 unpublished). On the other hand, temperature decreased from 24.3 ^{o}C at 250 m a.s.l. through 13.9 ^{o}C at 1750 m a.s.l. to 13.2 ^{o}C at 2100 m a.s.l. respectively.

1.2.4 Land use and Vegetation

Table 1: Landuse types and area proportions of Barsa watershed

Landuse	Sum of Area (Ha)	Area%
Broadleaf	5398.24	92.56
Built up	118.56	2.03
Kamzhing	55.67	0.95
Landslides	32.75	0.56
Meadows	10.40	0.18
Orchards	17.30	0.30
Rivers	27.57	0.47
Shrubs	171.88	2.95
Grand Total	5832.36	100.00

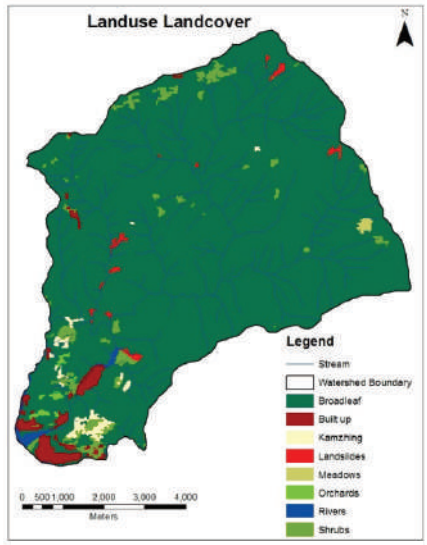

Figure 6: Land use map of Barsa watershed

Table 1, Figure 6 depicts that the Barsa watershed consists of nine landuse types dominated by broadleaved forests (92.56%). The agriculture (kamzhing& orchards) land comprise of 1.25 %. The landuse data also indicates the significant occurrence of landslides across the watersheds area (32.75 ha, 0.56%).

The forest types within the watershed corresponding to different elevation levels with prominent species are

a. Cool evergreen broadleaved forest (1700-2400masl) *Exbucklandiapopulinea, Corylopsishimalaica*
b. Warm evergreen Broadleaved forests (900-1700masl) *Cryoptocaryabhutanica, Castonopsis, Lithocarpus, Talauma, Ixonanthes,*
c. Sub-tropical evergreen broadleaved forest (300-900masl) *Taluama, Dubanga, Terminalia, Schima, Castonopsis, Persea*

Some of the understorey species (herbs and shrubs) within the watershed are *AgeratinaadenophoruaAgeratum conyzoides*, *Chromolaenaodorata*, *Lantana camara*,*Partheniumhysterophorus*. The watershed is a habitat to barking deer, porcupine, wild pig, elephants and monkey.

2. Watershed management planning process

The watershed management plan was developed through participatory process involving relevant stakeholders. The different stages of planning process are as follows:

2.1 Scoping visit

The process was initiated with a scoping visit to Industrial areas downstream of Barsa watershed where there is a problem of siltation. The purpose of the visit was to scope out the dimensions of the problems in the watershed from the perspectives of stakeholders and to make inital site inspection. The meeting was held with main stakeholders from Bhutan Ferro Alloys (BFAL), Bhutan Carbide and Chemicals Limited (BCCL) and Bhutan Silicon Manufacturing Private Limited (BSMPL) to understand the key problems on flooding and siltation, and various measures being implemented. It is learnt that activities such as dredging and monitoring of the situation in the upstream is conducted annually (Annex I).

2.2 Field investigation

Following the scoping visit, field investigation was carried out in collaboration with relevant stakeholders. The field investigation was done mainly to gain first hand understanding on the problems in the watershed (Annex II).

2.3 Consultation workshops

Several consultation workshops were carried during the formulation of this plan. At the national level, workshop was carried out with purpose of collating information on the state of knowledge of the environmental context, identify gaps in knowledge and develop a consensus on the next steps for watershed management planning for Barsa watershed.

Subsequently, a workshop was conducted at the site to create awareness on watershed management planning process, and to consolidate issues and carryout problem analysis. The workshop was able to come up with the goal and objectives of the watershed management plan. The workshop also identified data gaps and the field officials were accordingly assigned to collect the missing data (Annex III).

2.4 Field validation

The issues reflected in the draft plan were validated through field visits. It is to ensure that all the interventions proposed are appropriate and feasible for implementation on the ground.

2.5 Plan formulation

The plan was developed using Logical Framework Analysis (LFA) matrix. The process is described as in figure 18(WMD, 2018). A write shop involving relevant stakeholders was conducted to refine and improve the plan. The plan also incorporated findings from report on integrated geo-hazard risk assessment carried out by Department of Geology and Mines, Ministry of Economic Affairs in 2017.

3. Issues impacting the watershed

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

3.1 Landslides

There are 112 landslides existing in the watershed identified using satellite images and physical verification (DGM, 2017). Similarly, 8 major landslides were observed during the field visits (Figure 7, Annex II).

All the landslides have occurred in the past 16 years based on the responses received from the stakeholders (communities &Industries). The landslides occur on lower slopes of the landscape and seem to be associated with undercutting the steep toe slopes by Barsa River and its tributaries. Any natural or man induced phenomena that cause undercutting of the steep slopes, particularly when the soil mantle and underlying rocks are saturated can result in a loss of slope stability, resulting in a landslide with mass soil movement directly into the river.

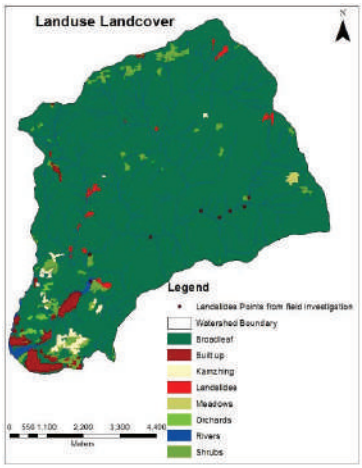

Figure 7: landuse map of Barsa watershed with location of landslides

3.2 Flood

The deposition of large quantities of soil and rock into the Barsa River from landslides, debris/waste from highway maintenance activities, combined with steep topography, unstable geology and relatively heavy rainfall (c. 4000 mm) results in substantial increase in the sediments carried by the River causing floods. This has led to a raising in the height of the river bed in the vicinity of the BFAL, BCCl, and BSMPL factories and the company's housing colony which is located on a flood plain about one km downstream of the factory (Figure 2).

3.3 Geological instability

Barsa watershed comprises of four geological formations: i) Phuentsholing Formation occupies the lower most stratigraphic level in Barsa catchment area, ii) Shumar Formation overlays the Phuentsholing Formation, iii) it is then overlain by Jaishidanda Formation and iv) Surey Formation in the extreme north. (DGM 2017).

Phyllite and mica schist are commonly found in these four Formations which are

Figure 8: landslide along Jumja river

highly crushed and crenulated in nature and found to be the most incompetent unit. The crushed carbonaceous part when dissolved in rain water during monsoon adds volume and flows along the down slope leaving deep gully erosions (Figure 8).

3.4 Rainfall

Almost 90 % of the precipitation occurs during the rainy season for about 4 months (June-September) (Figure9). Therefore, it is expected to observe certain landslides in the watershed. Further, human intervention will accelerate more severe slides leading to flash floods during the rainy season.

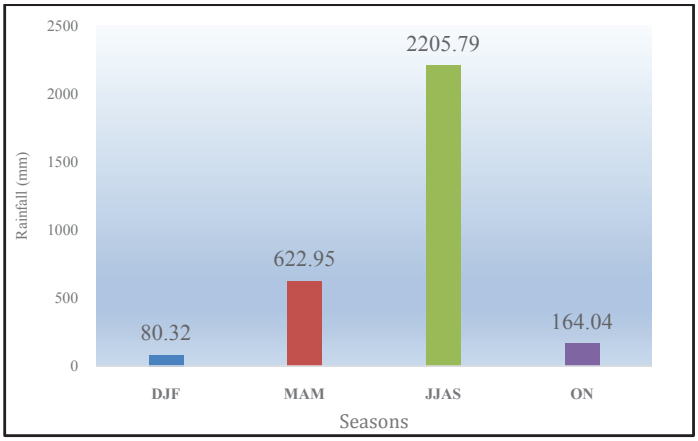

Figure 9: Mean Seasonal distribution nearby Barsa watershed

Further analysis of rainfall trends for meteorological stations in the vicinity of the Barsa watershed (Tala &Phuentsholing) over the years 1996 to 2006show more rainfall during the monsoon of year 1998 (both at Tala and Phuentsholing). In Phuentsholingstation,the rainfall was observed slightly more in the year 2000 as well while it was fairly a normal rainy season at Tala station during the same year (Figures 10&11). But most of the rains happen during the monsoon season. Those higher events of rainfall in the said stations coincide with flood events in the Pasakha Industrial areas (as per oral account of BFAL officials) of 1998 and 2000.

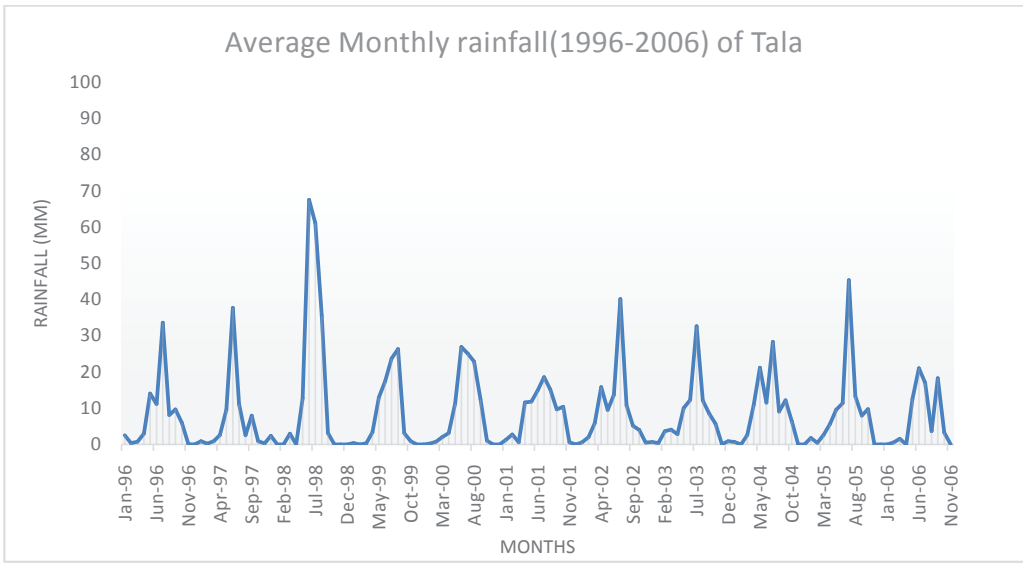

Figure 10:1996-2006 average monthly rainfall at Darla

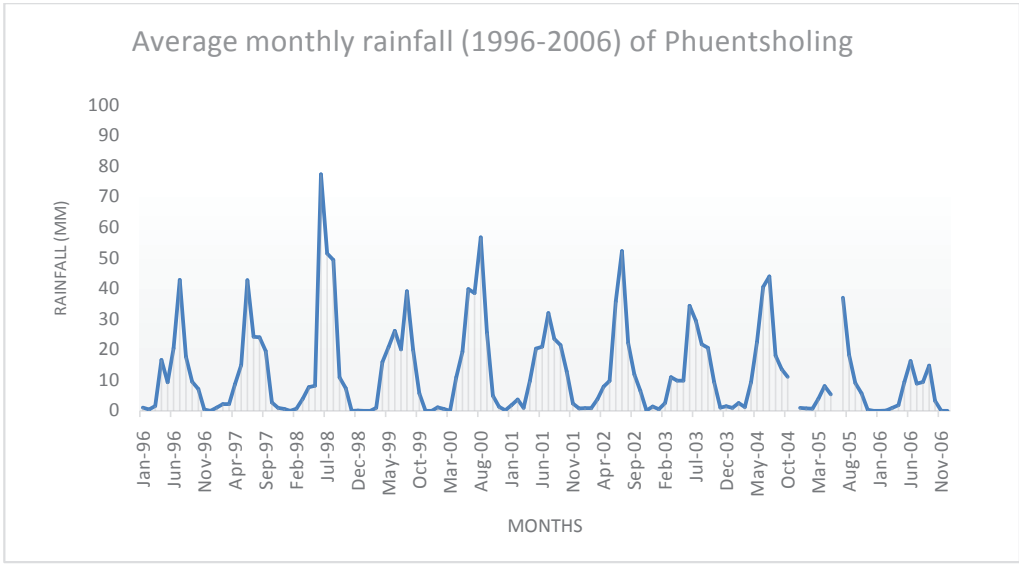

Figure 11: 1996-2006 average monthly rainfall at Phuentsholing

3.5 Cross drainages along the highway

There are numerous cross drainages constructed along the highway to divert water from the highway. These waters once crossing the road flow everywhere as no care is taken. The lack of drainage below the road accelerates soil surface runoff when there is no good vegetation cover. Therefore, in geologically unstable and landslide prone areas, these kinds of practices may lead to erosions and aggravate the situation in the active landslide areas.

3.6 Dumping of debris

Figure 12: overview of debris dumped along Phuentsholing-Thimphu road

The debris from road construction and maintenance are mostly dumped below the road (Figure 12) without proper guidance and care. The debris and boulders along the steep terrain often fall into the streams and rivers and increase the sediment load contributing to heavy bed loads along the downstream. Sometimes, during the peak rainy season, the debris including boulders dam the river and ultimately triggers landslide dammed outburst floods.

3.7 Grazing

Grazing is an important activity in the watershed. There are currently 15 herds of cattle grazing in the watershed. The average size of each herd is 29 cattle. All the herds except one migratory herd keep their cattle in the watershed throughout the year. The migratory herder keeps his herd during winter in the watershed and migrates to GelingGoenpa in the summer. Besides freely grazing in the watershed, the cow herders also collect fodder by lopping the native fodder trees (Figure 13).

Figure 13: A local cowherder carrying tree fodder

3.8 Clear felling of forest in the past

In the early 1980s and 90s, forest management units were set up across the country. Wood based industries such as plywood and particle board industries were established at Gedu and Darla, for which clear felling of trees were undertaken in upper ridges of Barsa watershed. The clear felling of

forest exposes soil to erosion and also leads to change in vegetation composition. Further, the re-forestation carried out consisted of fast growing species changing the biodiversity of the area.

3.9 Extraction of forest resources

Communities from Gelinggeog collect various Non-Wood Forest Products (NWFPs)for both home consumption and commercialization (Figure 14). Some of the commonly collected NWFPs include cane shoots, damroo (*Elatostemaspp*), ferns, mushrooms, bamboo shoots, nettles, *Tupistranutans*, pani (*piper*), wild avocado, wild banana leaves (for roofing), brooms, honey (*Apiscerana*), etc... Cane is also used for binding cowsheds and fencing.

Figure 14: Forest products for sale at a framer's sale counter at Jumja

3.10 Cardamom plantation

Cardamom plantation in the watershed is a recent phenomenon (figure 15). About 41 HH have 31.74 acres of cardamom plantation in the watershed. These plantationsentail change in land use and also use fuel wood for drying cardamom and shed construction. Farmers use weedicides in the plantation areas and often use those that are not permitted by Department of Agriculture due to easy access from across the border (Figure 16). While there is no study carried out, it is commonly believed that the weedicides have capacity to loosen the soil and destroy the vegetation after its application.

Figure 15: Cardamom plantation in the watershed under GelingGeog

Figure 16: Some of the weedicides used by farmers

3.11 Other Issues

There are other issues which are beyond the scope and cannot be addressed by the current watershed management plan. However, as the issues are pertinent, they are listed here for future interventions:

i. Communities of Phurbaling village are not consulted while carrying out dredging and other activities carried out by industries to reducing siltation in the PIA. Those activities have negatively affected Phurbaling farm road and agriculture land in the vicinity (Figure 17). There is a concern that if the trend is continued, the activity might even affect BPC substation in the area.

ii. The effect of air pollution from the industries is a major concern in the watershed. It not only affects the health of the communities; the pollution has affected some of the major cash crops of the local people.

iii. The other concern is the dumping of waste from industries on the side of Barsa river and diverts the course of the river and affects the slope on the other side where Phurbaling village is located. While the impact of the dumping on aquatic life is not known, but the waste is directly polluting the Barsa river (Figure 17).

iv. There is also concern of hunting and fishing along the barsa river, which may or may not have impact on the scope of issues currently taken up for the watershed management planning.

Figure 16: Photo showing waste dumped from factories along the river bank (right) and affected road to Phurbaling village(left)

Table 2: Consolidated issues and possible causes in the watershed

Issues	**Possible causes**
Flood	landslides
	Use of explosives and excavation
	Poor drainage
	Steep topography
	Heavy rainfall
	Unstable geology
	Improper disposal of wastes including debris
	Earthquakes
	Construction of national highway
Forest Degradation	Grazing
	Cardamom plantation
	Collection of NWFPs
	Fodder collection
	Fuel wood collection
	Collection of fencing posts & flag poles
	Past clear felling of forest
	Weak monitoring after BBPL logging
Other issues	Lack of coordination between Industries and nearby communities
	Air Pollution from the industries
	Dumping of industrial wastes
	Use of chemicals (weedicides)
	Hunting and fishing

4. The Plan

The purpose of the plan is to identify interventions that can mitigate the effects of problems and improve the condition of the watershed. A Logical Framework Analysis (LFA) was applied, building on the issues/problems identified. This led to the construction of a problem tree with causes and effects of the issues/problems, which led in turn to the construction of an objective tree, with outputs, objectives and a goal (Figure 18).

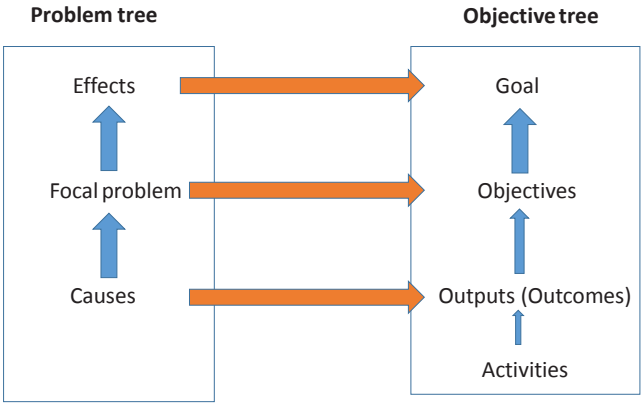

Figure 18:Problem tree and objective tree used to convert issues/problems identified during the planning process into an intervention strategy to mitigate the degrading influences.

The application of the LFA process led to the identification of two focal problems contributing to degradation of the watershed:

- Flooding caused primarily by steep topography, heavy rainfall, natural geological instability, and road construction activities along the highway.

- Forest degradation caused by mainly human activities such as logging, grazing, resource extraction along with poor monitoring.

The first of these problems while very important degrading influence also includes issues such as unstable geology and steep topography, which are beyond the ability of management interventions to address as it is part of the background mountain building processes that operate across the Himalayas. However, several management interventions are designed to address other issues contributing to flood and forest degradation in the watershed.

Several problems were raised by local stakeholders during the consultations, while being important in terms of impacting on their livelihoods, had no direct link to sedimentation in the downstream of the watershed. A "filter" was applied to ensure that only those issues/problems that contribute directly to the goal of the plan in reducing sedimentation in the PIA was addressed in the plan. For example, some of the problems that were raised by local stakeholders were pollution from the industries, lack of coordination in dealing with sediments, waste disposal from industries, use of

weedicides, hunting and fishing. While the issue is pertinent, it is not something that has a direct link tothe objective of developing this watershed management plan.

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

The goal and objectives of the plan are:

Goal:

Barsa watershed actively managed to conserve (watershed) goods and services and reduce sedimentation and loss of properties in the downstream areas in the context of climate change.

The objectives set to attain the goal are:

Objectives:

1 To mitigate flooding along the downstream
2 Minimize degrading influences and improve watershed condition

Outputs and description of activities

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

Objective 1:To mitigate flooding along the downstream

1.1 Measures to mitigate landslides put in place

The landslides in the watershed are the main cause of siltation along the downstream and it is important to explore measures to stabilize and minimize the impacts. While it may not be possible to come out with concrete measures to prevent mass movement in a place like Barsa Watershed, it may be possible to monitor slope conditions by conducting geological studies every year. In slope failures of smaller dimensions, some geo-technical methods like constructing retaining walls, drainage, bio-engineering and rock bolting could be useful to strengthen the slope stability.

1.2 Drainage and cross drainages along highways improved

Drainage and cross drainages along the highways and farm roads need to be improved. For every kilometer of road, there is a requirement of 3-4 cross drainages. There is need to study the impacts of water flowing out of cross drainages on the down slope of the watershed.

1.3 Maintaining waterways free of boulders and debris through regular monitoring

As there are numerous boulders along the waterways, it is important to regularly monitor the formation of pools and dams on the rivers/streams. If possible, there is need to monitor the dumping of debris and boulders from the highway to lessen the problem downstream.

1.4 Hydrometeorology station established

The watershed falls within one of most fragile climatic areas, yet there is no monitoring station existing in the watershed. In order to have adequate information for future scenarios, there is a need to install both meteorological and hydrological stations as well as provide training to record and maintain the stations in the watershed.

Objective 2: Minimize degrading influences and improve watershedcondition

2.1 Degraded areas improved

Extensive commercial logging was carried out in the upperparts of the watershed in the past (early 1980s-early 1990s), and large scale plantation establishment has taken place in the logged areas while the vegetation in the lower parts of the watersheds has generally remained undisturbed. There is need to address degradation through enrichment plantations, soil conservation measures and regular monitoring of extraction of resources from the forest.

2.2 Impact of cattle grazing on the watershed reduced

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

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

Goal: Barsa watershed effectively managed to conserve (watershed) goods and services and reduce sedimentation and loss of properties along the downstream in the context of climate change

Outputs	Activities	Verifiable indicators	Collaborating Agency	Lead Agency	Budget (M Nu)
1. Objective 1: To mitigate flooding along the downstream					
1.1. Measures to mitigate landslides put in place	1.1.1. Broadcast seeds of grasses & plants along the land slips and the exposed landslides areas (8 sites)	Kg(s) of grass and plant seeds broadcasted/transplanted	GFD/DoR/PT	GFD	1.0
	1.1.2. Plantation of shrubs and bamboos to stabilize the landslides (15 Ha)	No of seedlings	GFD/GBCL/PT	GFD	1.2
	1.1.3. Maintenance of plantation created in 1.1.2	No of seedlings	GFD/GBCL/PT	GFD	0.6
	1.1.4. Construction of effective retaining walls (Jumja slide): 300 meters.	No of retaining walls built	DoR/ NEC/PT	DoR/DANTAT	5.0
	1.1.5. Construction of effective retaining walls (Phurbaling farm road: 100 meters)	No of retaining walls built	Geog/PT	Geog	2.0
	1.1.6. Construction of check-dams near Phurbaling (100 NOs)	No. of check-dams constructed	Geog/GFD	GFD/Geog	0.2
	1.1.7. Monitoring of excavation along highways	Monitoring protocol put in place	DoR/NEC/PT	DoR/DANTAK	0.5
1.2. Drainage and cross drainages along highways improved	1.2.1. Construct drainage from the upper portion of the landslides along highways to divert runoffs (approximately 400 meters at Jumja slide)	Length of drainage in the upper portion of landslides	DoR/NEC/PT	DoR/DANTAK	0.5

	2.2.1 Study the impact of cross drainages on the down slope	Study report	UWICER/DGM/PT/DoR	UWICER	1.0
	2.2.2 Improve farm road drainages (Phurbaling-3km)	Length of farm road drainage improved	Geog/PT	Geog	1.5
1.3. Maintaining waterways free of boulders and debris through regular monitoring	1.3.1. Conduct awareness campaign on dumping of debris along highways from Jumja to Kamji	Awareness report	Geog/GFD	Geog	0.5
	1.3.2. Installation of waste management signages(can combine with 1.3.1)	No. of signages installed club with above	Geog/GFD	GFD	0.1
	1.3.3. Construct disposal pits near market sheds (6 sites) can combine with earlier	No of disposal pits club with above	GFD/Geog	GFD	0.1
	1.3.4. Monitoring of boulders and debris along the waterways to avoid formation of pools and dams	Monitoring report	PT/Industries	Industries	As per need
1.4.Hydrometeorology station established	1.4.1. Install meteorological and hydrological stations in the watershed	No of stations installed	NCHM/PT	PT	
	1.4.2. Training and record keeping of data to generate long term information	Training and record keeping report	NCHM/PT	PT	0.2

2. Objective 2: Minimize degrading influences and improve watershed condition					
2.1. Degraded areas improved	2.1.1. Enrichment plantation in the degraded areas (20 Ha)	Plantation in Ha	GFD/GBCL/PT	GFD	1.0
	2.1.2. Monitoring the extraction of forest resources during the plan implementation period (upstream)	Monitoring report	GFD	GFD	0.5
	2.1.3. Study the impacts of land use conversion (cardamom plantation) and mono plantation in the BBPL logging areas	Study report	UWICER-Darla/Dzongkhag Adm	UWICER-Darla	1.0
2.2. Impact of cattle grazing on the watershed reduced	2.2.1. Fodder development in the watershed (pasture: 20 acres & fodder trees: 1000 seedlings) (10HH-Phurbaling & 30 HH Geling) with fencing and transportation of inputs.	Acreage of fodder developed and No of tree fodder planted	Geog	Geog	0.8
	2.2.2. Support breed improvement	No of AI/breeding bull supplied	Geog	Geog	0.2
	2.2.3. Sensitization of cow herders on breed improvement and impacts of over grazing on the watershed (6 times)	Sensitization report	Geog/GFD	Geog	0.3
	2.2.4. Documentation of cattle migratory system in the watershed	Study report	UWICER-Darla/Geog/GFD	UWICER Darla	0.4
Total Budget					18.6

5. Implementation strategy and mechanism

It is important that the watershed management plan is implemented in a manner that is consistent with other natural resource and water related policies. The watershed management activities proposed in the plan should be prioritized and internalized to the existing area-based planning frameworks(Tsering, 2011). The agencies identified are urged to refer this plan and extract activities while carrying out annual and five-year planning for the respective agencies.

As the plan duration coincides with the12FYP (July 2018-June 2023), the implementation of the plan should be aligned with the same. The activities in the plan should be mainstreamed in to five year and annual plans of the Sampheling and Geling geogs, Department of Forest & Park Services, Phuentsholing Thromde, and Department of Roads, as indicated in the logframe matrix. Phuentsholing Thromde will take the overall ownership of the plan and coordinate with respective agencies for incorporation in the respective plans. The total fund required for implementation of the plan is estimated at Nu18.6 million.

6. Funding Mechanism

The implementation of planned watershed activities will be funded from the regular government budget. However, in case of insufficient funds for implementing watershed management activities, the management plan can be used as a basis to solicit funds from donors. As the coordinating agency, PT will facilitate the relevant agencies to incorporate watershed activities in their plans and accordingly seek budgetary provisions from RGoB during the annual and five yearly planning processes. The incorporation of activities of the watershed management plan into respective plans and budgets of local administration will be monitored by PT in collaboration with NEC and WMD.

7. 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 respective area-based plans of a variety of agencies and organizations' (indicated in the logframe) annual and 5-year plans. These implementing organizations will monitor the implementation of activities. The verifiable indicators given in the logframe matrix (Table 3) will assist in the monitoring task.

Evaluation of the impact of the management plan and the extent to which it has achieved its objectives and contributed to attaining the goal should be carried out by PT in collaboration with NEC and WMD towards the end of the plan period.

9. References

Adhikari, K. (2015). Modelling and slimulation of flood in Barsa River near Pasakha, Bhutan. *Climate Change, Environemnt and Development in Bhutan* (pp. 79-84). Thimphu: Royal University of Bhutan.

DGM. (2017). *Report on Integarted Geo-hazard Risk assessment at Barsa watershed under Chukha dzongkhag.* Thimphu: Department of Geology & Mines.

FMED. (n.d). *Pasakha Flood Mitigation Proposal.* Thimphu: Flood Engineering Management Division, MoWHS.

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

ProDoc, N. 2. (2013). *Bhutan NAPA II Project Document.* Thimphu: UNDP/GEF/LDCF.

Tsering, K. (2011). *A Roadmap for watershed management in Bhutan: From policy to practice. .* Thimphu: WMD, DOFPS-MOA.

WMD. (2018). *A Manual for Planners.* Thimphu: Watershed Management Division.

Annex I. Barsa watershed scoping visit: November 2016

A team from Watershed Management Division carried out field visit to Barsa watershed at Pasakha, Phuentsholing in November 2016.

Purpose of visit

The purpose of the visit was to scope out the dimensions of the watershed management problems of the Barsa watershed from the perspectives of stakeholders and to make a site inspection.

A meeting was held in BFAL's meeting room and key participants from Bhutan Ferro Alloys, BFAL, Bhutan Carbide and Chemicals Limited, BCCL and Bhutan Silicon Manufacturing Private Limited, BSMPL. The following information is a summary of material provided mainly by staff of BFAL's Environment Section. Field visits were carried out on the following days to landslide site upstream of the factories and colonies downstream of the factories.

Information obtained

Prior to 1994 the Barsa watershed was in pristine condition and there were no major landslides. In 1998 a flash flood occurred that caused some downstream damage. In 2000 a major flash flood occurred, and it was thought to be caused by a large landslide upstream that dammed the river and the dam subsequently burst (a Landslide and Dammed Outburst Flood). Such events are now a common occurrence.

A total of five large landslides and many small ones have opened up in the watershed (see attached photos for some examples). The subsequent deposition of large quantities of soil and rock into the Barsa River has resulted in a substantial increase in the bed load carried by the River. This has led to a raising in the height of the river bed in the vicinity of the BFAL, BCCl, and BSMPL factories and the company's housing colony which is located on a flood plain about one km downstream of the factory. **The main problem associated with the recent changes to the river morphology and the watershed geomorphology is an increase in flooding of BFAL and BCCL's housing colony.**

The company currently spends about 0.3 million Nu per year on dredging the river bed to keep it low enough to minimise flooding in the vicinity of the housing colony. Two groynes were constructed several years ago, below the large landslide close to the factory, in an attempt to train the river and prevent bank erosion. Both groynes were destroyed in subsequent monsoon season floods (see attached photos).

Initial observations and speculation on landscape instability and changes to watershedgeomorphology

The Barsa River which is fed by three main tributaries coming Jumja, Kmaji and Ganglakha has a steep gradient and is rapidly down-cutting. The landscape of the watershed is very steep and the underlying geology consists of metamorphosed fine sediments. The soil mantle is shallow, and the rocks lack cohesive strength, particularly when saturated, as is evidenced in other locations in the foothills east and west of Phuentsholing (see Figure 7). Any natural or man induced phenomena that cause undercutting of the steep slopes, particularly when the soil mantle and underlying rocks are saturated) can result in a loss of slope stability, resulting in a landslide with mass soil movement directly into the river. A similar situation occurred in the upper part of the Barsa watershed where the Phuentsholing-Thimphu road triggered large scale landslides by undercutting the slope.

All landslides, large and small, that are the focus of this inquiry have occurred in the past 16 years. All of them occur on lower slopes of the landscape and seem to be associated with undercutting the steep toe slopes

by a change in the Barsa River and its tributaries. According toMr. TashiWangdi from BFAL, the problem is mostly from one tributary coming from Jumja area, and they trek annually before rainy season to observe the situation and allocate fund accordingly. However, when viewed in google earth, we see landslide areas along the tributary form Kamji area also, Figure 8. It does not appear that there are any land management issues that have triggered the changes, although this needs to be verified. What has caused this relatively sudden change in the geomorphology of the watershed is a matter of speculation at this stage. In other parts of the Himalaya, similar situations can be observed where landslides are triggered by natural changes such as shifts in the tectonic plates (minor or major earthquakes). The resulting change in the morphology of the river (particularly the river gradient) can cause a consequent increase in stream velocity, and hence its erosive capacity, that can trigger landslides in several places. In such situations instability (landslides and mass soil movement) can continue for several years and even decades until a state of dynamic equilibrium returns. Little can be done prevent such occurrences.

One of the BFAL factory staff suggested that there has been a substantial increase in rainfall in recent years and this may be linked to an increase in the incidence of landslides and consequent increase in bed load in the river and flooding of BFAL & BCCL's housing colony. No data were available to support this assertion.

Information gaps

Further background material is needed for the development of a management plan. This includes:

Trends in rainfall over past decades

Geology and geomorphology of the watershed

Land use changes over time

Copy of consultant's report on Barsa watershed

Annex II. Field Investigation and observation report

1. Background

Watershed Management Division (WMD) carried out initial scoping visit in November 2016. During the visit, the WMD team met with stakeholders to learn about the watershed and also made field visit in the areas near the Industries. The discussions and the field visit pointed out the need to undertake filed visit along entire stretch of river to understand the situation better.

In light of the above, WMD in collaboration with stakeholders carried out the field visit along Jumja river from Jumja to Pasakha Industrial Area (PIA). Barsa River has three main tributaries and the tributary coming from Jumja area is considered as most problematic from the three as per the PIA stakeholders. With this view the field investigation was carried out for this tributary currently, at the same time filed investigation along other two tributaries are also planned to be carried out.

Figure 7: Upstream of Jumja River

2. Purpose of the visit

The purpose of the visit was to trek along the Jumja tributary and get first hand information of the watershed management problems from the perspective of this tributary.

3. Observations

The upstream of Jumja River is right above the Phuentshling-Thimphu highway and it fairly a rocky area with scanty vegetative cover (figure 1). As the river marches down picking size and intensity, it is first met by tributary from Ganglakha and then by tributary from Kamji about a kilometer above the PIA. The observations related to following features are made during the visit.

3.1 Vegetation

The vegetation in the watershed is predominantly a broad leaf forest (figure 2).

Figure 8: Glimpse of vegetation in the watershed

However, along the riverbanks across the whole stretch, the vegetation is dominated by alnusnepalensis (figure 3).

Figure 9: Riparian vegetation

3.2 Watershed Disturbances

Thimphu-Phuentsholoing highway and the cattle grazing are the main disturbances in the watershed. Along the road, maintenance works are carried out frequently and debris are being dumped below the road.

About five cattle herds visit the watershed annually (figure 4). While one cattle herd of about 16 cattle is kept in the watershed throughout the year, other herds migrate to other locations for most part of the year.

Figure 10: Cattle sheds in the watershed

3.3 Landslides

Landslides are the major issues along the tributary. There are about eight major landslides active along the river. In the initial scoping report it was reflected as five as this was the number provided to us by the Industries people, however in this report it is reflected as eight because there are eight major slides contributing to the river at different points even though some slides originates from same point. Some landslides from past rehabilitated while new ones have surfaced along the river (figure 5).

Figure 11: New and old landslides

3.3.1. Landslide 1

The baseline of all these information is from year 2000 as staff from Environment Unit under BFAL lead by Mr. TashiWangdi trekked along this river annually before monsoon to look at the upstream situation to prepare accordingly. Prior to year 2000, we have not been able to get any information yet.

Figure 12:Landslide 1

In light of the above, the landslide 1 is active since 2000. The Flash flood event in 2000 was believed to be triggered by this slide. There is a huge boulder on the river path at this site and it has the potential to create dams in the future if there are mass movements upstream. The movement of fishes and other aquatic animals from downstream probably cannot go beyond the point as the landslide has created a blockage.

3.3.2. Landslide 2

This landslide appeared since 2016. While it originates from the same place that of landslide 1, it affects the river about few hundred meter downstream.

Figure 13: Landslide 2

3.3.3. Landslide 3

This used to be a small slide before but picked up size since 2016.

Figure 14: landslide 3

3.3.4. Landslide 4

This landslide affects the river below landslide 3 and it is active since 2016.

Figure 15: Landslide 4

3.3.5. Landslide 5

This slide was there since 2000 and it rehabilitated naturally once but started sliding again in 2013. There is a small stream from this landslide.

3.3.6. Landslide 6

Figure 16: Landslide 5

This landslide is active since 2000.

Figure 17: Landslide 6

3.3.7. Landslide 7

This landslide is active and located beside the confluence of Jumja and Kamji rivers

Figure 18: landslide 7

3.3.8. Landslide 8

Figure 19: Landslide 8

This is a huge landslide Above Bhutan Silicon Manufacturing Private Limited. The slide is active since 2013 this slide has choked the river with debris in 2012-2013

3.4 Boulders on the river path

Figure 20: Sight of clean boulders

The risk from the landslides are further amplified by the presence of boulders along the river path. Throughout river path, the riverbed is filled with very clean boulders of various sizes(figure 14). Some of these boulders have potential of blocking the river and forming dams if there is high debris flow from upstream. Formation of such dams would have devastating effects downstream.

Figure 21: Boulders capable of blocking the river

3.5 Lowering of riverbed in the upper catchment

Figure 22: Sight of riverbed levels in 2000 and present

As visible in figure 16, the riverbed level in the year 2000 is much higher than the current level. It is obvious that the aggrading event downstream is the direct result of these changes in riverbed morphology upstream and it has at least cost industries Nu.03 million annually.

4. Conclusion

The trek along the Jumja tributary was a very challenging trek from both walking perspective and understanding of the watershed. The landslides and other problems along the river seems to be happening for long time and continuing. The landslides, boulders, riparian vegetation all indicate all indicate that the problem is old but active.

There is minimal anthropogenic or other disturbances physically visible that might be triggering the problems. All the problems are physically connected to the river and not to any triggering factors. Therefore, without having information on geology and seismology of the watershed, it will be a huge challenge for WMD to design interventions. The core problem of the watershed is increase in riverbed from aggrading and associated flooding downstream. The normal watershed management planning looking at the holistic picture from the sustainability lenses might not necessarily minimize the siltation downstream. As such, there is need to have consensus from the stakeholders and funders as to how the watershed management planning activity for Barsa watershed should be undertaken.

Annex III. Report of inception workshop

The workshop was divided in to two parts. The first session was confined to presentations by WMD and NCHMS followed by discussions and the second session was a plenary coordinated by Dr. Donald Gilmour to enhance our understanding of the Barsa watershed.

There were three presentations from WMD. The first presentation of the workshop was by Mr. Jamyang Phuntshok from WMD, who is also coordinating the watershed management planning for the Barsa watershed. His presentation reported the activities carried out so far with regard to the watershed management planning in Barsa watershed.

The presentation mainly highlighted the presence of several landslide areas and potential areas for forming Landslide dams along Jumja River. He pointed out that most of this slides may be occurring naturally, as there are hardly any disturbances visible currently. Further, he reported that the riverbed may be continuously lowering and highlighted the difference in riverbed level between the current and the post flash flood event in Pasakha Industrial Areas in the year 2000 (Annex II).

Some of the reactions to the first presentation from the floor were the following.

i. Which among the three tributaries is more critical and if there can be enough time for evacuation or preparation if early warning system is established along the critical tributary.
ii. If the boulders which might cause the formation of dams can be blasted to clear the river ways.
iii. Use of satellite images to further understand the watershed.

The second presentation from WMD was by DrLungtenNorbu, whose presentation was titled “Land cover and land use change in Barsa upstream: Observation and Construction of Forest utilization /management change through time”.

The presentation highlighted the chronology of events that has undergone in the evolution of forest utilization and management in Bhutan. The presentation touched on what types of forest are prevalent at different altitudes of the country and how human interact with the forest through implantation of different activities. In the presentation, Dr. Lungten shared the results of his studies carried in areas near the upstream of Barsa watershed for his studies and also highlighted land cover and land use changes that has undergone in some of the Barsa upstream areas in 1980s and 1990s with the support of historical images from Google Earth. To end the presentation, he highlighted some of the triggering factors for natural disasters and proposed several intervention measures in the context of integrated watershed management planning.
There was not much comments from the floor but suggested the use of other satellite images than google earth images from understanding the watershed.

The third presentation was by Dr Pema Wangda, Chief of WMD. His presentation mainly focused on the need to consider holistic picture in undertaking watershed management planning. To this end, Dr. Pema presented the different climate regimes existing along the Himalayas and forest regimes existing along these climatic regimes and why these forests are important to be managed. He touched on the forest types existing in nearby areas ofBarsa upstream and importance of managing this forest as life line for downstream communities including PIA.

From the stakeholders' side, presentation was requested from DGM and NCHMS. Since DGM could not come, Mr. Tshencho Dorji from NCHMS was the lone presenter. Mr. Tshencho presented on the rainfall trends from nearby areas of Barsa watershed, as there are no meteorological existing in the Barsa watershed. The presentation highlighted that majority of the rainfall is received in the months of June, July, August and September and there is very little rainfall during the winter months of December, January and February. However, the rainfall in those areas show negative trend over the years (1996-2009) with peaks in 1998 and 2000. Those peaks coincide with flood events in PIA.

The second part of the workshop was plenary facilitated by Dr. Don, an AVID volunteer attached with WMD. In order to guide the discussion Don provided the following questions:

i. Points of clarifications from presentations?
ii. What has changed in Barsa watershed to trigger changes?
iii. What can be done to mitigate adverse impacts?
iv. What additional information is required?

Discussion highlighted that the area is ecologically dynamic and geology is very fragile. While the overall rainfall trend is decreasing, it is observed that the rainfall intensity is on the rise. Landslides in in the watershed are all linked to the streams and there is rapid down cutting of riverbed in the rivers.

While extensive logging was carried out in the past in the upstream areas, there are no physically visible connection with the landslides. The only disturbances visible now are Thimphu-Phuentsholing highway and the grazing that is extensive but not very intensive and it is on the decline as per some locals.

Understanding the geological condition and rainfall situation of the watershed has been pointed out as important. Over all the point from the floor was to look beyond debris flows and consider sustainable management of the whole watershed.

The plenary of the workshop pointed out the need to carry out the following:

i. Connect with DGM and have bilateral discussions on geology and geomorphic processes operating in the Barsa watershed
ii. Collect the additional information (as suggested by workshop participants)
iii. Prepare a status report with options for the future management of the barsa watershed management planning

Some of the information required for collection are the following:

i. Grazing pattern and changes over time
ii. Land use patterns and changes over time
iii. Rainfall pattern: intensity and duration
iv. Geological information including seismic activities

Watershed Management Division
Department of Forests and Park Services
Post Box No: 1345
Ministry of Agriculture and Forests
Tel:02-323568, Fax:02-321462
Website: www.dofps.gov.bt/wmd