

Sustainable Water Source Management in Tshogonpa and Khaimanma villages, Lumang Gewog, Trashigang, Bhutan

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Remains of huge landslides caused by heavy downpour of 2004 monsoon threatening houses and agricultural land (Photo Credit: Tsheten Dorji).

Abstract

This paper describes about the study initiated on 'water source management' in the year 2008 to 2009 with the fund support from United Nations Environment Programme and technical guidance from Eco-Peace Leadership Center based in Kangwon National University, Republic of South Korea.

The year-long study was initiated to ensure and instill a sense of awareness and self responsibility in the mindsets of the

communities of Tshogonpa and Khaimanma villages in regards to improving the state of environment through a planned water source management system. The study also tries to stress the importance of relationship between better livelihood and healthy environment and at the same time target at community preparedness and community responsibility. The study has reached and benefited more than 300 hundred low-income community of Tshogonpa and Khaimanma villages and school children and teachers in regards

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to environmental education, ideas and techniques of forest conservation, water source management, soil erosion and landslides.

The paper begins by introducing the environmental situation of the country as a whole in connection to the study area. It then highlights the background of study and its focuses on finding the status of vegetation coverage and water sources, causes of landslides and their negative impacts. Then it describes the objectives and the methodology applied in carrying out the activities. It also emphasized on the major outcomes or result from the study, and recommendations as way-forward for undertaking future conservation programs to address problems faced by the community.

Keywords: Sustainable water source management, Bhutan

Introduction

Today, the world is passing through a dramatic phase whereby its face is being modified by cultural and technological aspects. More and more due to inhumane human activities in pursuit of materialism and individual gains have led to environmental crisis at global level, like global warming, ozone thinning, air pollution, glacier retreating, deforestation, floods, landslides and water source degradation.

Bhutan being nestled in the Himalayan region, with no exception is confronted with these problems. The problem of deforestation, floods, landslides, soil erosion and lack of proper drinking water are very much common in Bhutan. Each year the slopes are subjected to landslides and erosion putting heavy impact on degradation of water sources. The heavy rainfall during monsoon damages the connecting pipelines, and makes the region more susceptible and prone to all these natural hazards. Its valleys are prone to floods and as a result, the economy is at grave stake. It affects the rural health and

sanitation, and it's a curse for the Bhutanese who loses tracts of arable land which, metaphorically, serves as the main food bowl.

Soil erosion and landslides leading to degradation of water sources are very common in Bhutan as per the report on Status of Watershed Management in Bhutan by Wangchuk, T, 2008. And one of the major erosion and landslide prone area is Tshogonpa and Khaimanma villages under Trashigang district. The summer monsoon not only damages the arable lands of the communities but also contributes to the degradation of safe drinking water sources and always damages the drinking water system in Tshogonpa and Khaimanma villages making many ups and downs of the economy and the lives of the rural as per the Preliminary Socio-economic Report of Wamrong and Kangpara CBNRM Areas of RSPN by Dorji, T, 2007. Thus, the study on water source management is essential to understand the status of drinking water, water source and vegetation coverage. Such studies in relation to anthropogenic land use changes and diversified human activities taking place in the catchment area are keys to understanding the causes and extent of degradation of water sources. Keeping this view in mind, a study on water source management was carried out in 2008 to 2009 in Tshogonpa and Khaimanma villages. The study has further identified the causes of water source degradation and landslides, the negative impacts to livelihoods and identifies the mitigation measures. Through this study more than 300 hundred low-income community of Tshogonpa and Khaimanma villages and school children and teachers are benefited in regards to environmental education, ideas and techniques of forest conservation, water source management, soil erosion and landslides.

Objectives

The overall objective goals of this year-long study was to ensure and instill a sense

of awareness and self responsibility in the mindset of the communities of Tshogonpa and Khaimanma villages in regards to improving the state of environment through a planned water source management system. It also tries to stress importance on the relationship between better livelihood and healthy environment. Towards this end, the serious of planned activities could accomplish the objectives of a well-protected water source system. The study was also target at community preparedness and community responsibility.

And some of the specific objectives are to increase the level of awareness on water source management and improve the availability and quality of water by initiating water source management programs and supplementing rural water supply schemes. It further targeted in reducing deforestation and control landslides through community management of forest and water sources, and develop alternative source of tapping water to overcome the water shortages.

Methods

The objective of the study was to obtain both qualitative and in-depth information and get a deeper understanding on the status of water source management. The study used a combination of quantitative and qualitative methods: desk review of secondary data through preliminary report and past reports; and collection of primary data (quantitative and qualitative) via 100 percent sampling. All the data were collected by the primary author. Prior to the data collection, the questionnaire was presented to advisor at Eco-Peace Leadership Centre based in Kangwon National University in South Korea.

Data were collected from June to August 2008. A total of 40 elders from 40 households above 20 years of age were interview. A structured key informant interviews (KII) were conducted

with village Tshogpa, water caretakers and school principal. In addition, a simple field survey was conducted involving few of the local communities and collected the information on status of water sources and its degradation, causes of soil erosion and landslides and its impacts. The data were summarized qualitatively and are presented descriptively in this paper.

Study Area

The study was conducted in remote villages of Tshogonpa and Khaimanma in eastern Bhutan under Lumang Gewog of Trashigang district. The study area is located at an altitude of 1500m-1800 masl., and it falls in the broadleaf forest zone with potentially high diversity of faunal and floral species (Figure 1). The villages has more than 40 households and is a home for more than 300 inhabitants who derived their livelihood from subsistence farming

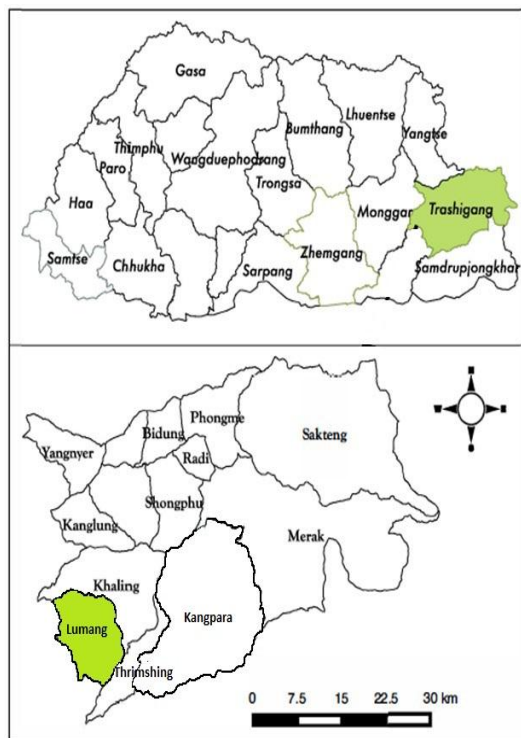


FIGURE 1 Map of study area
(Map credit: Tsheten Dorji)

and significantly relying on forest resources such as timber, bamboo and wild vegetables. The settlement is rather scattered over steep slope with maize fields surrounding each as

per the Preliminary Socio-economic Report of Wamrong and Kangpara CBNRM Areas of RSPN by Dorji.T-2007.

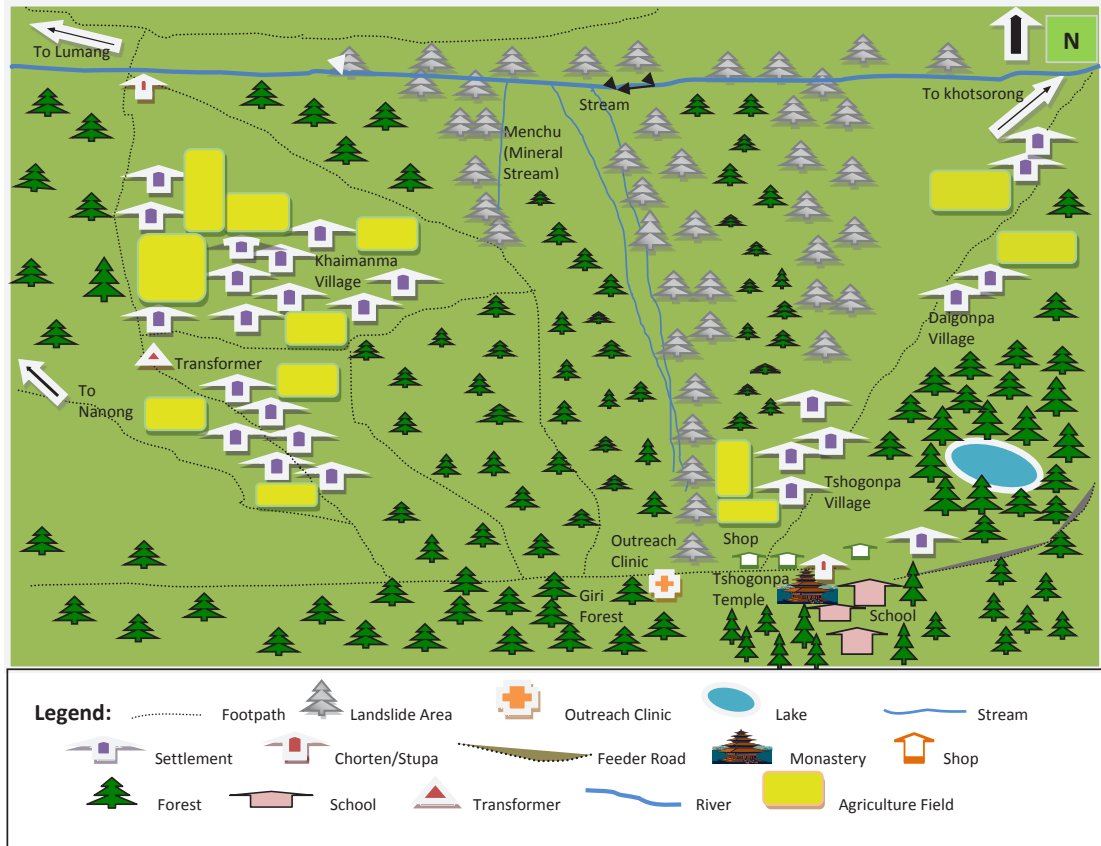


FIGURE 2 Resource map of study area (Sketch credit: Tsheten Dorji)

Results

Village Resource Use Map

The information in the resource map is the end results of the study. The map clearly indicates that Tshogonpa and Khaimanma are two adjacent villages and has close associations in terms of social and economic aspects and share of forest resources. The study has observed that the two villages have very less vegetation cover associated with shortage of safe drinking water and landslides at different directions (Figure 2).

Nevertheless, the study roughly recorded more than 30 birds (Table 5) and 20 mammal species (Table 6) that habitat in the forest of Tshogonpa and Khaimanma, and also found more than 30 different tree, shrubs and ornamental plant species (Table 7) in the study areas. The names of the mentioned species are identified using three guidebooks listed under the literature cited and confirmed the species after consultations with experts.

TABLE 5 Birds sighted in the study areas.

Sl.#	English	Scientific Name
1	White-Crested Laughingthrush	<i>Garrulax leucolophus</i>
2	Orange-Bellied Leafbird	<i>Chloropsis hardwickii</i>
3	Eurasian Sparrow Hawk	<i>Accipiter nisus</i>
4	Blue-Whistling Thrush	<i>Myophonus caeruleus</i>
5	Yellow-billed blue Magpie	<i>Urocissa flavirostris</i>
6	Rufous-bellied Woodpecker	<i>Dendrocopos hyperythrus</i>
7	Great barbet	<i>Megalaima virens</i>
8	Ashy Drongo	<i>Dicrurus leucophaeus</i>
9	Red-vented Bul bul	<i>Pycnonotus cafer</i>
10	Golden-throated Barbet	<i>Megalaima franklinii</i>
11	Crested serpent Eagle	<i>Spilornis cheela</i>
12	Long- tailed Shrike	<i>Lanius schach</i>
13	Grey-backed Shrike	<i>Lanius tephronotus</i>
14	Oriental Turtle Dove	<i>Streptopelia orientalis</i>
15	Black Eagle	<i>Ictinaetus malayensis</i>
16	Green- tailed Sunbird	<i>Aethopyga nipalensis</i>
17	Green-backed tit	<i>Parus monticolus</i>
18	Hill Partridge	<i>Arborophila torqueola</i>
19	Grey Treepie	<i>Dendrocitta formosae</i>
20	Kalij Pheasant	<i>Lophura leucomelanos</i>
21	Striated Laughing thrush	<i>Garrulax striatus</i>
22	Nepal house Martin	<i>Delichon nipalensis</i>
23	Eurasian Jay	<i>Garrulous glandarius</i>
24	Streaked Laughingthrush	<i>Garrulax lineatus</i>
25	Dark-breasted Rosefinch	<i>Carpodacus nipalensis</i>
26	Grey-winged Black Bird	<i>Turdus bouboul</i>
27	Little Pied Flycatcher	<i>Ficedula westermanni</i>
28	Rufous Sibia	<i>Heterophasia capistrata</i>
29	Large-billed Crow	<i>Corvus macrorhynchos</i>
30	Black Bulbul	<i>Hypsipetes leucocephalus</i>
31	Hodgson's Redstart	<i>Phoenicurus hodgsoni</i>
32	White-capped Water Redstart	<i>Chaimarrornis leucocephalus</i>
33	Rufous-necked Hornbill	<i>Aceros nipalensis</i>
34	Great Hornbill	<i>Buceros bicornis</i>

TABLE 6 Common mammal species recorded in the study areas (both wild and domestic).

Sl.#	Local Name (Sharchop)	English Name	Latin Name
1	Kotsoktang	Orange-bellied Squirrel	<i>Dremomys lokriah</i>
2	Phechurba	White-bellied Rat	<i>Niviventer niviventer</i>
3	Zala	Monkey/Assamese Macaque	<i>Maccaca assamensis</i>
4	Roksha	Capped Langur	<i>Trachypithecus pileatus</i>
5	Borang Khu	Dhole/Wild Dog	<i>Cuon alpinus primaevus</i>
6	Omsa	Himalayan Black Bear	<i>Ursus thibetanus laniger</i>
7	Gagongma	Himalayan Yellow-Throated Marten	<i>Martes flavigula</i>
8	Borang Dani	Jungle Cat	<i>Felis chaus</i>
9	Phagpa	Wild Pig	<i>Sus scrofa</i>
10	Shawa	Sambar	<i>Cervus unicolor</i>
11	Gasha	Barking Deer/Muntjac	<i>Muntiacus mutjak</i>
12	Basha	Goral	<i>Nemorhaedus goral</i>
13	Shanhsha	Himalayan Serow	<i>Capricornis sumatraensis</i>
14	Zumphi	Himalayan Crestless Porcupine	<i>Hysterix brachyura</i>
15	Zumphi	Indian Porcupine	<i>Hysterix indica</i>
16	Shokha	Spotted Giant Flying Squirrel	<i>Peturista elegans</i>
17	Tsetpa	House Mouse	<i>Mus musculus</i>
18	Kotsoktang	Malayan Giant Squirrel	<i>Ratufa bicolor</i>
19	Wa	Cattle	<i>Bos Taurus</i>
20	Kurta	Horse	<i>Equus caballus</i>
21	Shesha	Sheep	<i>Ovis aries</i>
22	Raba	Goat	<i>Capra aegagrus hircus</i>
23	Drey	Mule	<i>Equus asinus</i> × <i>Equus caballus</i>
24	Menchu	Mithun/Gayal	<i>Bos frontalis</i>

TABLE 7 Recorded common plants, shrubs and ornamental plant species in the study areas.

Sl.#	Local Name (Sharchop)	English/Dzongkha Name	Botanical Name	Use
1	Giskang Momnang	Tshema Meto	Hedychium densiflorum	Ornamental
2	Shakhor-shing	-	Lithocarpus elegans	Firewood
3	Bashing (planted)	Ba-shing	Cryptomeria japonica	Timber
4	Tsheden (planted)	Tsheden/Weeping cypress	Cupressus corneyana	Timber
5	Roptang-shing	-	Rhus chinesis/simialata	Firewood
6	Shadeling-shing	-	Persea odoratissima	Firewood
7	Kumchum-shing	-	Tephrosia candida	Tool Handel
8	Khar-shing	-	Erythrina arborescens	Pole
9	Zala-shing	-	Schima wallichii/ chinesis	Timber
10	Khay-shing	Walnut/Tago	Juglans regia	Timber
11	Dom-shing	-	Symplocos rememasai	Pole
12	Golonang-shing	-	Beilschmiedia gammieana	Pole
13	Gonsenang-shing	Gama-shing	Alnus nepalensis	Timber
14	Banang-shing	Oak	Quercus griffithii	Firewood
15	Betsinang-shing	Oak	Quercus lanata	Firewood
16	Thongpa-shing	Oak	Quercus galuca	Firewood
17	Tshay-shing	-	Castanopsis hysteria	Timber & firewood
18	Maminpashing	Dog-plant	Benthamida capitata	Fruit
19	Thungchurpa-shing	Monkey apple	Malus baccata	Fruit
20	Leng-shing	Peach/Kham-shing	Prunus persica	Fruit
21	Lethung-shing	Pear/Lee	Pyrus pashia	Fruit
22	Choma-shing	Fig tree	Ficus hispida/ auriculata/ roxburghii	Fodder
23	Bara-chongma	Fig tree	Ficus semichordata (cunia)	Fodder
24	Borang-Chongma	Wild-Fig	Ficus oligodon	Fodder
25	Raynang-shing	Cheer pine/Tongphu	Pinus roxburghii	Timber
26	Chang-shing	Bhutan Pine/Tongphu	Pinus bhutanica	Timber
27	Murshing	-	Engelhardia spicata	Timber

28	Yedang Meto	Rhododendron/Ato Meto	Rhododendron arboreum.....	Firewood
29	Mezom-shing	(attached leaves)	Brassaiopsis mitis	Fodder
30	Mezom-shing	(separate leaves)	Schefflera impressa	Fodder
31	Jaza	Nettle/Zochak	Girardinia diversifolia	Thread, Rope
32	Dremom	Damru	Elatostema sessile	Vegetable
33	Tsakushabu	Tsakusha	Thysanolaena maxima	Fodder
34	Branglu	-	Raphidophora decursiva	Fodder
35	Borang-Joktang	Wild Potato	Dioscorea bulbifera	Food
36	Krepsay	Kerpa-tsang	Berberis lyceum/ insignis/mucrifolia.	Firewood
37	Khayjar-shing	-	Rhus wallichii	Pole
38	Nonchanglu	Amartala	Eupatorium adenophorum	-
39	Merangma	Khempa-shing	Artemisia dubia/ myriantha	Animal-Bedding
40	Saw	Pak-shing	Dendrocalamus himaltoni	Pole, raw-material for bamboo Crafts

Status of water sources and biodiversity

The study discovered that Tshogonpa and Khaimanma areas once have a lush green forest but over the decades the forest has been over used and exposed to natural factors like rain and human factor like animal grazing. This area has seen one of the worst landslide and soil erosion in the year 2004 because of deforestation and no proper water source management. Over the years due to increase in the population of Tshogonpa and Khaimanma as well as the population of the peripheral villages the pressure on the limited forest has increased (Table 1). This has impacted adversely both on the forest resources and the water resources as they are interlinked. Since, the local community depends on the stream flowing from the forest and the spring water in the forest becomes a serious threat to the community as this will leave them without water. Since the

community practice mixed farming they raise cattle especially cows and they freely graze in the nearby forest as they don't have any designated grazing land or community forest. In the process the small stream flowing from this area has been shrinking in its volume. It was informed by the communities that over the years the stream is said to have reduced almost by 20 percent, thus, reducing the water supply to the inhabitants who depended solely on it. Due to the reduction of vegetative area the area is more exposed to external factors like rain, leading to topsoil erosion, landslides and mudflow during the monsoon. These chains of activities and process have the following impacts of water source degradation, impact on health and sanitation due to reduced domestic water supply, and loss of arable land and livelihood due to landslide and erosion.

TABLE 1 Status of vegetation of the study areas (Credit: Socio-economic and Biodiversity survey reports of the Wamrong-Kangpara CBNRM Programme Areas of RSPN by Dorji, T. 2008).

Year	Status of vegetation	Causes
.... 1985	Abundant (70%-90%)	a) Less population depending on forest b) Less livestock grazing in the forest
1985-1994	Moderate (40%-70%)	a) Shifting cultivation reduced the forest cover b) Upcoming of new settlement
1994-2008	Scarce/Limited (<40%)	a) Over exploitation by increasing population b) Uncontrolled livestock grazing

Capacity building and mitigation measures

The study has reached more than 300 low-income communities of Tshogonpa and Khaimanma villages in educating them the ideas and technical skills of forest conservation, water source management and sustainable land management for better livelihoods and self organization. The study further identified the causes of water source degradation, landslide and erosion, the negative impacts to livelihoods of the people in the area and identified the mitigation measures through demonstration of bioengineering techniques to control landslide in one of the affected area such as brush layering, hedgerows plantation to form barrier and dug drainage system to channel the rainwater to stop additional landslides. The mitigation measures were undertaken involving the local communities and techniques were used as per the guidelines provided in the book – ‘Traditional Knowledge for Soil Erosion Control in Republic of Korea (et al. Dr. LEE. C.Y, and Dr. CHOI. K,2001)’. Through this study the communities and local Leaders are benefited in understanding the importance of having Environment Management Plan by the contractors and Environment Impact Assessment conducted by the concern departments before starting any developmental activity in their area to avoid serious natural hazards sooner or later.

Plantation and demonstration on alternative sources of tapping water

Through this study, plantation of 500 fast growing saplings was carried out in one of the affected landslide area and degraded water source by the communities and students of Tshogonpa Community School. Similarly, the communities were demonstrated the techniques on alternative source of tapping water. The process of harvesting rainwater was demonstrated and the rehabilitation of nearby spring was also carried out as part of alternative source of tapping water to overcome the water shortage in the village.

Discussion

Causes of forest degradation and landslides

Through the simple inventory/survey of the study area’s water sources and forest, the area has been noticed as most affected by the landslides of 2004, which has greatly disturbed the ecology of the area and threatened the livelihoods of the people. “The natural causes of landslides are geology, steepness of slope and orientation of the rocks as per the report on landslides and depression of Tshogonpa (et al. Wangchuk, T, Baeumler, R., Caspari, T., and Tshering, K, 2003). The study further identified some of the anthropogenic causes of forest degradation and landslides are: deforestation due to overexploitation of forest and non-wood forest products by increasing population, intensive shifting cultivation to grow food crops, uncontrolled livestock grazing in the degraded areas and poor water management (Table 2).

TABLE 2 Threats to vegetation of study areas.

Threats	Causes	Solutions
Deforestation	Shifting cultivation and forest resource exploited by people outside the village.	Afforestation and regular patrolling by forest officials and the local people.
Overgrazing	Increase in number of cattle	Introduce hybrid cattle (Jersey), plant fodder trees and designate grazing areas.
Overexploitation of forest and non-wood forest products	Use of firewood, fencing, uncontrolled harvesting and increased use of bamboo.	Plant bamboo and trees, and regulate the collection of NWFP.
Poor Management of Water	Old drinking water supply system (RWSS), inconsistent rainfall, overgrazing and landslides.	Repair and maintenance of RWSS, prevent and fencing of degraded areas, and control overgrazing.

The study observed that landslide and erosion are not a new phenomenon in the area around Tshogonpa Khaimanma villages. There are many old ones, which have stabilized over the years and are now covered by vegetation again,

which may make it harder to recognize them as former landslides. However, there are 4 fairly fresh major ravines, which are still unstable and many smaller ones scattered over the face of the slope (Figure 3).



FIGURE 3 Huge portion of landslides threatening houses and agricultural land

Causes of Water Source Degradation

Through the study, it was concluded that the main causes of water source degradation in Tshogonpa and Khaimanma was due to increase in population in early 2000. This increases pressure on the natural resources such as land

through land intensification and conversion of forest land into arable land and direct pressure on forest products. The area was observed that the quality and quantity of water has been decreased resulting to water shortage to the communities in the last few years (Table 3).

TABLE 3 Status of water resource of the study areas (Credit: Socio-economic and Biodiversity survey reports of the Wamrong-Kangpara CBNRM Programme Areas of RSPN by Dorji, T. 2008).

Year	Status of Water	Causes
.... 1990	Abundant (70%-90%)	a) More water source due to abundant forest coverage. b) Less population depending on water resources.
1990-2003	Moderate (40%-70%)	a) Shifting cultivation reduced the forest cover in watersheds. b) Heavy dependence on water by the increasing population.
2003-2008	Scarce/Limited (<40%)	a) Degradation of water sources and watersheds by landslides. b) Lack of backup services: poor management of water source and maintenance of water supply schemes.

The study observed that the causes of decreased in safe drinking water and its sources are: deforestation in the water sources due to extensive shifting cultivation and exploitation of forest and non-wood forest products by the increasing population of Tshogonpa and Khaimanma and as well as from the nearby

villages. The other causes are landslides and erosion due to degradation of forest in the slopes, inconsistent rainfall and poor management of rural water supply systems. The poor management of water and outdated rural water supply system also contributed the causes to threat of water sources (Table 4).

TABLE 4 Threats to water sources of the study areas.

Threats	Causes
Deforestation in the source	Shifting cultivation and forest and NWFP resource exploited by increasing population.
Landslides and erosion in the source	Degradation of forest in the slopes, inconsistent rainfall, poor management of RWSS.
Poor water management	Old drinking water supply system (RWSS) and inconsistent rainfall.
Outdated RWSS	Leakage of run of water from reserve tanks, pipelines and tap-stands.

Deforestation and poor water management

The study concluded that in Tshogonpa and Kaimanma areas, natural forest has been cleared for shifting cultivation for growing food crops and used for supply of firewood and timber. Today, forests have receded towards the top of the hill and except some trees around

one of the lakes (depression), and most of the area is covered with shrubs and the noxious weed *Eupatorium adenophorum*. This plant dominates the deforested areas and grazing land, where it has replaced most of the native plants (Figure 4).



FIGURE 4 Flowering of *Eupatorium* plants in the degraded area

The study has evident that a direct consequence of deforestation is acute shortage of firewood. It was observed that everyday old women and young girls go out to get firewood in the morning. But in the evening they return with fresh twigs and branches from the nearby forest, which does not allow nearby trees to grow up, thus leading to more forest degradations.

Drinking water was supplied in the 1980s by means of water pipes as per the report – ‘The landslides and depressions of Tshogonpa Report by Wangchuk, T. 2003’. The study has observed that due to poor management, lot of unused water flows down the slopes from leaks through defect tap-stands. It was also noticed that in some places there are no taps installed at all. In addition, it was observed that

during monsoon, rainwater adds to unused flowing water from defected tap-stands and small rivulets are created which starts to form channels, and these channels has developed into gullies and then into ravines.

Recommendations

The recommendations of this study may not put into government policy, but it is to be used as guidelines by concerned agencies and NGOs while initiating community-based natural resource management (CBNRM) programmes in Tshogonpa and Khaimanma areas. Therefore, the study has identified numbers of mitigation measures, which can help to stabilize the existing ravine in Tshogonpa and Khimanma areas and to prevent water source degradations and formations of new landslides. The

mitigation measures must be implemented in a participatory manner; they must be acceptable to the farmers and they should be able to put them into practice. It is strongly recommended that support to plan has to be provided by the regional institutions such as concerned district, sub-district, Renewable Natural Resources Research Center (RNRRC) and Sustainable Land Management Program (SLMP) and Royal Society for Protection of Nature (RSPN).

Management of drinking water

The study has observed that proper management and utilization of the drinking water is a must to prevent further creation of gullies and overcome the water shortage. Thus, there is a need to construct either bigger or additional tanks and introduce more water taps, which can be closed. The unused water from defected water taps have been flowing down the slopes causing landslides and erosion annually; thus, it is strongly recommended to construct channels to dispose the excess water safely into a natural drainage to prevent havoc sooner or later. This activity can be coordinated by village Chairperson or Tshogpa.

Management of footpaths

Through the study, it was observed that the footpaths become channels for runoff water during monsoon, which resulted to formation of gullies and further turned into ravines. Therefore, development of steps along the footpaths with wooden sticks at 2m spacing will not only improve the footpaths but also reduce the velocity of the runoff and thus, prevent the formation of gullies and ravines. This activity can be coordinated by village Chairperson or Tshogpa.

Plant native and fast growing tree species inside landslides and around water sources

It was observed that due to over exploitation of forest resources by increasing population and uncontrolled overgrazing by livestock, the

entire area has been now reduced to almost a bald condition left only with secondary growth and shrubs. Thus, native and fast growing tree species such as *Alnus nepalensis*, which can thrive in degraded soil, should be planted inside the ravine and landslide area and around the degraded water sources. The plantation of recommended species will not only promote the quick undergrowth of the degraded areas but also can prevent from landslides and erosion, gullies and ravine formations. This activity could be coordinated by Extension Forest Officer with assistance from District Forest Officer, Forestry Sector of RNRRC, SLMP and RSPN.

Promote soil conservation measure

The gradient of the entire study area and arable lands are very shallow and steep with poor soil fertility. Therefore, there is a need to improve soil conservation measures through construction of stonewall on the counters and counter hedgerows with suitable species. Undertaking of these activities will not only promote the improvement in soil fertility but also will prevent from runoff and topsoil erosion, and protect from landslides. This activity can be coordinated by Extension Agriculture Officer with assistance from District Agriculture Officer, Land Officer of RNRRC and Experts from SLMP.

Conclusion

The main cause of landslides and water source degradations in Tshogonpa and Khaimanma is the natural geological situation: the geology, steepness of slope and orientation of the rocks. This unfortunate combination is aggravated by human activity through deforestation and poor water management. The increase in population had lead to increased pressure on forest and land for more firewood, timber and shifting cultivation to grow food crops. Forest degradation has lead to upsets in the water balance, which contributed to the acceleration of the landslides and ravines.

Plantation of preferred types of trees across the slope will help to mitigate the problem. This can be achieved through establishing community and private forests as well as the promotion of fodder and fruit trees. Other measures such as trimming the edges of the landslides, management of drinking water, footpaths and gullies will be effective in stabilizing the landslides and sustainable management of water sources.

Therefore, *'true development lies not in building concrete structures in the cities but in bringing a change in the lives of the rural community where most of the Bhutanese live.'* Thus, the idea of sustainable management and conservation should be used as guidelines.

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