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Status of Water Sources and Its Impact on Livelihood Practices in Sardhukhola Watershed of Eastern Nepal (Sunsari)

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ABSTRACT

Watershed resources are the foundation of ecosystem integrity and livelihoods of mountain people. In this regard, this study entitled "status of water sources and its impact on livelihood practices in the Sardhukhola watershed of Eastern Nepal" was carried out to understand the status of water resources and its impact on rural livelihood practices. This study was conducted in Sardhukhola Watershed of Sunsari district. This research was conducted to know the present status of the water source around Sardhu River, including its trend of availability, human interventions and it's overall. This study analyses the change in cropping pattern within watershed. Both field observation and social survey were carried out during research work. Finding of this study shows that sources of water have been decreasing such as rivers, wells and water springs are being degraded. Frequent occurrence of landslide, sedimentation and seepage of water in both upstream and downstream as well as household garbage and improper infrastructure development are seen to be the major reasons behind the degradation. There is an increasing gap between demand and supply of water resources and people are expected to face severe scarcity of drinking water in the near future. After earthquake of 2015, water availability within the watershed is also found to be decreasing. Moreover, there is a weak co-ordination between upstream and downstream people to solve the major issue of watershed. Nevertheless people are interested to be involved in payment for ecosystem services mechanism, especially for proper water supply.

1. Introduction

Watershed can be defined as "spatially explicit landscape units that contain a range of interacting physical, ecological and social attributes" (Flotemersch et al., 2016). Soil and water resources are considered to be the principle natural resources of Nepal. Deforestation, forest degradation and natural hazards like flood and landslides are causing decline in water resources in both quality and quantity (DSCWM, 2005). Researches on watersheds were established by the U.S. Forest service near Wagon Wheel Gap, Colorado, in 1910 (Bates and Henry, 1928). Water resources continue to be degraded and lost by facing tremendous pressure from the anthropogenic actions like unplanned growth, siltation, encroachment, dredging, waste disposal, overexploitation and eutrophication. In developing countries, inadequate water supply and sanitation have led to 800 million patient of diarrhoea and 45 million deaths per annum (Bialey and Archer, 2000).

Misconceptions about the causes of environmental degradation and food insecurity have often led to watershed management initiatives failing to deliver. In the present context, fresh water scarcity remains a major challenge in many parts of the world where large scale water supply and sanitation infrastructure are both costly to develop and maintain. This is particularly true in the Himalayas, where remote rural communities are mainly dependent on local water flows (Gurung and Sherpa, 2014). The watershed of the Siwalik and Chure regions are more geologically fragile, erodible and are deteriorating day by day (DSCWM, 2005). Often un-supported by modern water and sanitation infrastructure and management, water utilization is influenced by the actions of upstream communities and by the natural vagaries of monsoons, avalanches and floods (Thapa and Paudel, 2002). Food security and environmental degradation are two of the main challenges people are facing in the 21st century (Lal, 2000). Protecting and strengthening watershed ecosystems is one of the main strategies to address these two issues. Water quantity and quality requires urgent development and health concerns (Pokhrel and Viraraghavan, 2004). Currently, more than 50% of Nepal's population does not have access to piped tap water within the home. Around 16,000 people die every year from waterborne diseases and other causes related to water quality. (Central Bureau of Statistics, 2012)

In this context, watershed is not just a source of drinking water but it also provides various services like food, fodder, fresh water and energy to upstream and downstream areas. Nutrient cycling, soil formation, primary production, climate regulation, flood regulation, diseases regulation, water purification, aesthetic, spiritual, educational, recreational service are the major ecosystem services provided from this watersheds.

Nepalese mountains, especially in the Eastern region, have often been reported to have water scarcity. Accordingly, in the recent year Dharan city is facing crises of water. The residents of Dharan Municipality have been facing water shortage and the people residing within the watershed have also been facing insufficiency of environmental services, particularly in food production, fodder, potable and irrigation water supply (IUCN, 2011). People living within the watershed are blaming each other; mostly people between upstream and downstream for the depletion of watershed and water source. So, it is useful to find out the status of the water sources that could help in the water resource management.

2. Materials and Methods

2.1 Study Area

This study was conducted in Sardhukhola watershed. Sardukhola Watershed is located between 26^0 45' 57.7" to 26^0 52" 30.95"N and 87^0 12' 20.43" to 87^0 19' 20.20"E in Sunsari district of province no. 1 of Nepal, which covers a geographic area of 39.35 km^2 (IUCN Nepal, 2011). It is part of the Siwaliks Hills. The watershed is populated by almost 12,383 households, with less than 10% of the population being upstream residents (Central Bureau of Statistics, 2013). The rest of the population lives in downstream areas that are part of Dharan sub metropolitan city. The Sardhukhola river, its tributaries and aquifers are the main water source for Dharan, a city of approx. 1,37,705 population (population census, 2011).

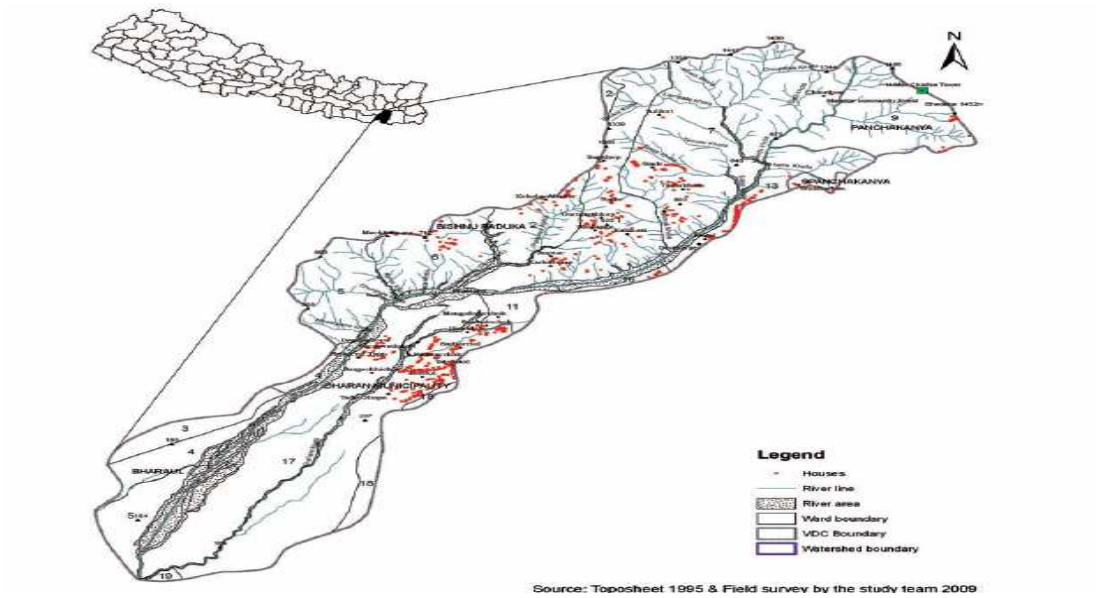

Figure 1. Study area of Sardhukhola watershed (Source: IUCN Nepal, 2011)

Figure 2. Google Earth view of study area.

2.2 Data Collection Method

A. Primary data collection

Primary data was collected from direct observation, which focused not only for checking and updating existing data but also for gathering basic ground information regarding the condition of the water sources i.e. poor, fair, good. Basic parametric like sediment deposition, pollution, drainage, waste disposal were used to study the condition of water sources. Past and present pattern of settlement, along with major reason behind shifting settlement linked with water resources were studied. Impact assessment was carried out in both the aspects. Such as impacts towards the livelihood due to the degradation of the water sources and impacts on the water sources of the particular watershed due to population pressure and human activities. Past and present water availability, change in cropping pattern and area of cultivation was observed and studied. This study also established linkage of upstream and downstream in term of water pollution and waste disposal and their impacts on downstream people.

Questionnaire survey was carried out in and around the watershed. Surrounding people were refered to all classes local people in and around of watershed. The sample size was computed by using formula developed by Pagose et al (1978) and adopted by Thapa (1990) in Nepal i.e.

$$\mathbf{n=N/(1+Ne^2),}$$

Where, n=sample size, N=population size and e=desired margins of error.

- Total number of household in upstream=230
- Total number of sample household in upstream=33
- Total number of household in downstream=358
- Total number of sample household in downstream=50
- Desired margins of error=10%

Various group discussions within the watershed dependent population and stakeholder were conducted. The evidences obtained from the survey of Sardhukhola watershed was recorded using handheld GPS.

B. Secondary data collection

The secondary data was collected from various research reports, literatures, books, published and unpublished documents, magazines and news papers. Likewise, internet surfing was carried out to acquire relevant information concerning the particular watershed.

C. Data Analysis and generalization

Data analysis consists of both descriptive as well as inferential statistics. To map the water sources area the GPS point of each source was taken and was feed on the GIS. Social data of quantitative origin was analyzed using descriptive statistics which includes mean, percentage and frequency. The findings of the study are presented in charts, tables and bar diagram.

3. Result

3.1 Present status of water source

There are many tributaries within Sardhukhola watershed. Along with Sardhu and Khardhu khola, there are many other tributaries like *Nisanekhola, Pakuwakhola, kalimatikhola, chumpolekhola* from where community based water supply corporation supply water to limited household. These tributaries are the main source of water supply in the Dharan sub-mteropolitan city. Major portion of the population of the Dharan city are depending on these tributaries for water supply.

Figure 3. Present condition of public tap

Pollution, population pressure and infrastructure development has caused decline in the water source condition. Nepal Water Supply Corporation and many other community based water supply board depend on these ground water source for water supply. From upstream NWSC (Nepal water supply corporation) collect water from Sardhukhola and Khardukhola to supply water to 19,000 private tap and 304 public tap.

During filed visit, it has been seen that in the upstream there is problem of landslide, soil erosion and sewage from uphill settlement. Whereas in the case of downstream; pollution, seepage of water, sedimentation and infrastructure development are affecting water source. Impact assessment has been conducted in the major tributaries of Sardhukhola watershed keeping the parameter like landslide, seepage, pollution, human settlement, infrastructure development and sedimentation. According to an observation, the tributaries that have not been affected by any of the above mentioned parameter have been ranked the condition as good. Similarly tributaries that are affected by only one parameter has been ranked as fair, affected by more than one parameter are considered as bad. Result obtained from field observation about the present status of major tributaries of Sardhukhola watershed is shown in table below:-

Table 1. Present status of major tributaries of Sardhukhola watershed

S.N.	*Water source/ river*	*Affected by*					*Condition of water source or river*
		Landslide	*Pollution (Sewage & waste)*	*Infrastructure & human settlement*	*Seepage*	*Sedimentation*	
1.	Lampate khola	√	-	-	√	√	Bad
2.	Sardhu khola	-	-	-	-	-	Good
3.	Cheuribas Khola	√	-	-	√	-	Fair
4.	Badare khola	√	-	-	-	-	Fair
5.	Jod dhara khola	-	√	√	-	-	Fair
6.	Gully from devi gau	-	√	√	-	-	Poor
7.	Nisane Khola	√	√	√	√	-	Bad
8.	Pakuwa khola	√	√	√	-	-	Poor
9.	Tamakham khola	-	-	√	-	-	Fair
10.	Chunpole khola	√	-	-	-	-	Fair
11.	Kalimati khola	-	√	√	-	√	Poor
12.	Machhamara khola	-	√	√	-	-	Fair
13.	Simle khola	-	√	–	-	-	Fair

It shows that water sources are greatly affected by landslide and infrastructure development in the upstream. Whereas; pollution, seepage and human settlement are the major impacts on water source in the downstream upstream.

3.2 Dependency of Households on single source

Out of total 83 sampled household within the watershed, 33 were in the upstream and 50 in the downstream. It is found that about 19 household can fully depend on single water source for whole year in upstream. These household have faced certain problem during rainy and winter season but they have managed to store water in reservoir at house. Whereas; 14 out of 33 household cannot depend on single source of water (Fig. 4).

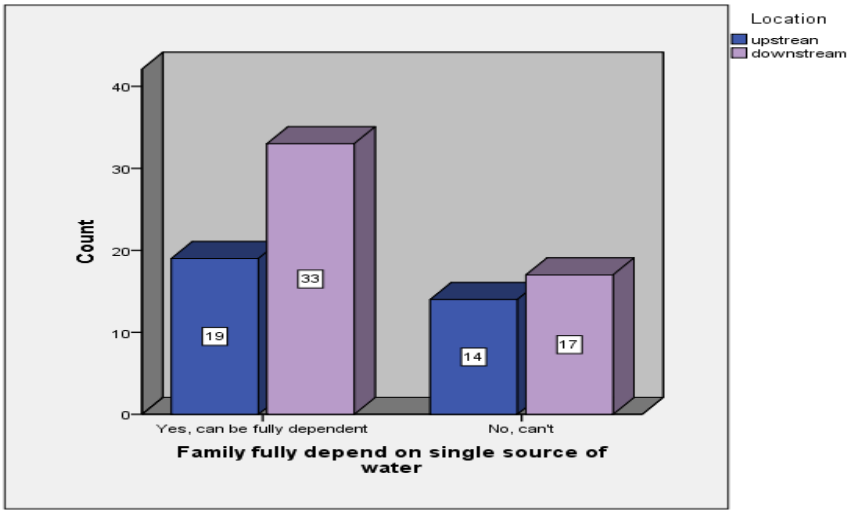

Figure 4. Family dependency on single source of water

During dry season there is scarcity of water and time table for tap water supply also decreases hence they have to depend on alternative source to fulfill their requirement. It was also found that some household have less storage capacity within house which makes them to depend on alternative source. During rainy season, waste, sewage, dirt, pollution affects the water source as waste and sewage are washed away by rain water from uphill which creates pollution in water sources. In many case, it has been found that during rainy season landslide damage source of water and affect the purity of water which creates shortage of drinking water. In shortage of tap water supply people have to travel average 10-15 min to fetch water from nearby well, spring and river. Whereas 17 HHs (about 34%) in the downstream cannot depend on single source. These populations have less water storage capacity, so during dry season, it becomes difficult to fulfill water requirement. It has also been found that some households have hotel and other business which require more amount of water which has been fulfilled from tank and jar water.

3.3. Water demand and supply

Its seems that water demand within Dharan sub-metropolitan city is increasing rapidly as population from the village area and other different district like *Dhankuta*, *Bhojpur*, *Tehrathum* are being migrated to Dharan. NWSC is the major body to supply water in Dharan sub-metropolitan city. In present context, NWSC is supplying water through 19,000 private tap and 304 public tap. They have two major reservoirs to collect water of sardhukhola and khardukhola having capacity of 6 MLD (Million Liter per Day) each. According to head of NWSC MR. *Ram Kumar Shrestha* daily requirement of water for dharan sub-metropolitan city is 30-35 MLD (Million Liter per Day) but NWSC is only able to supply 12 MLD(Million Liter per Day) during dry season and 30 MLD (Million Liter per Day) during rainy season.

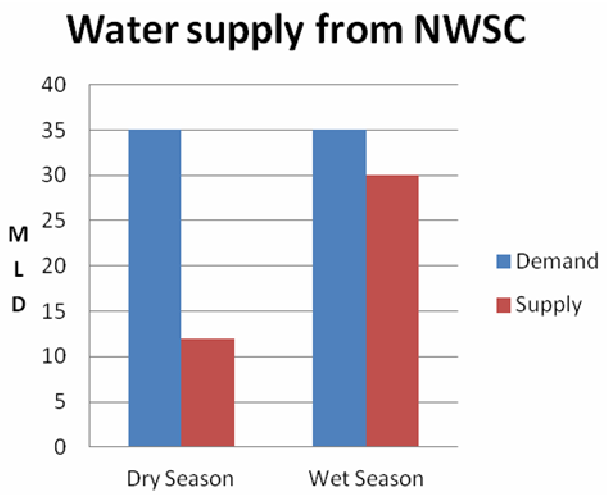

Figure 5. water demand and supply by NWSC

Hence, there is found to be a large gap between demand and supply of water. This gap is increasing as number of consumer is increasing day by day. In dry season, NWSC supply water 2 to 3 hrs in alternative day whereas during rainy season they supply water about 2 to 3 hrs in morning and 2 to 3 hrs during evening.

There are many tributaries in Sardhukhola watershed, among them major tributaries that supply water to people and their capacity in dry and wet season are given below:

Table 2. Water availability in Sardhukhola watershed (IUCN, 2011)

Major tributaries	***Dry Season***		***Wet Season***	
	Lit/sec	***MLD****(Million Liter per Day)*	***Lit/sec***	***MLD*** *(Million Liter per Day)*
Sardhu & khardu river	280	24.0000	860	74
Pakuwa Khola	0.63	0.054432	7.2	0.6221
Nisane Khola	195	16.8480	278	24.0192
Kalimati Khola	0.61	0.0527	1.02	0.088128

According to present population of Dharan sub-metropolitan city and growth rate of 1.79%, it shows that this population will be doubled in 39 years. With the increase in population, demand for water also increases but the sources of water are limited or constant.

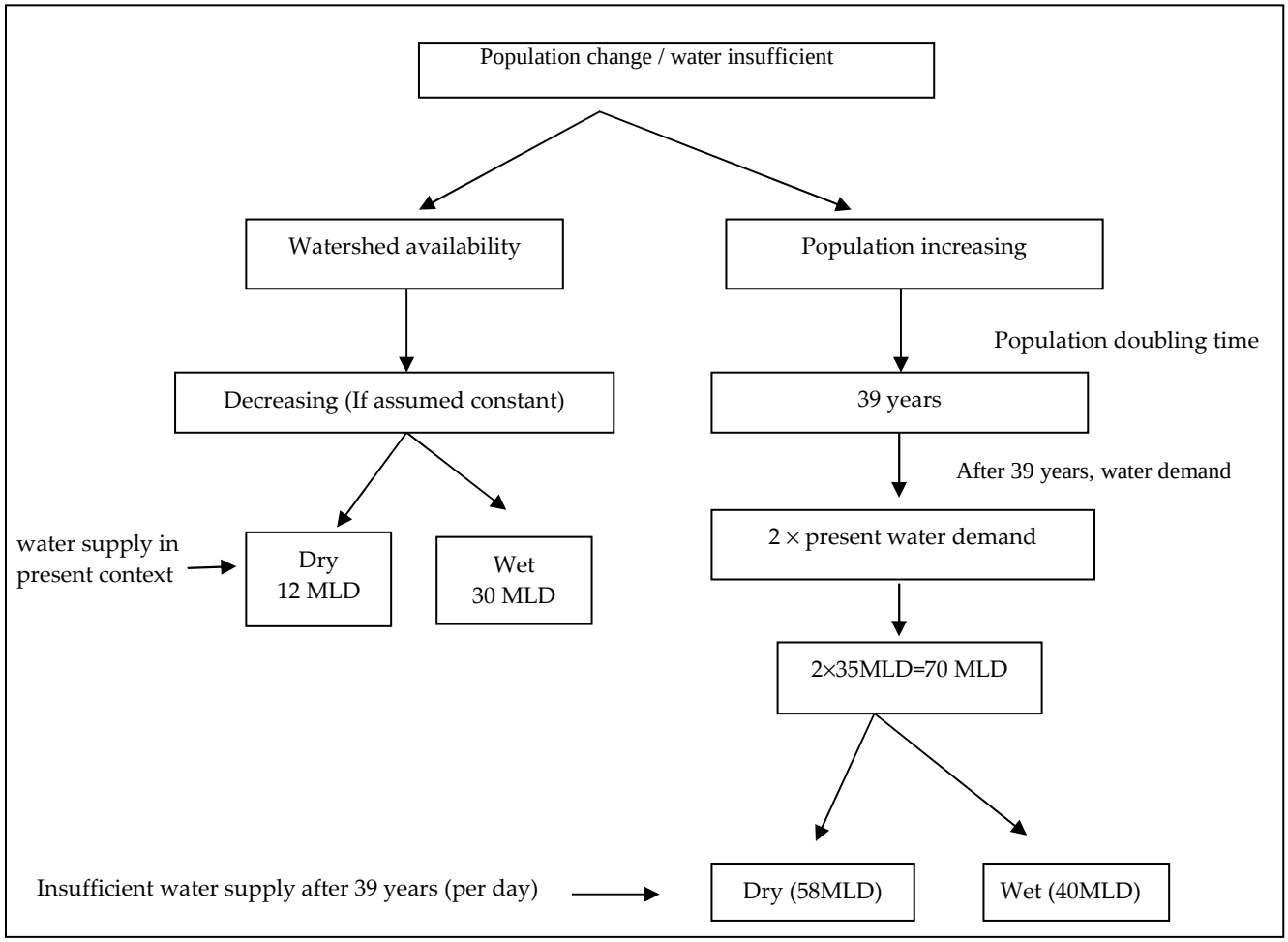

Figure 6. Future projection of water demand and supply

3.4 Earthquake as one of the reason behind change in water source availability

This study also outlines the major reasons behind change in water availability were listed out and among them people view were collected. Results obtained from people perception are given below in bar graphs.

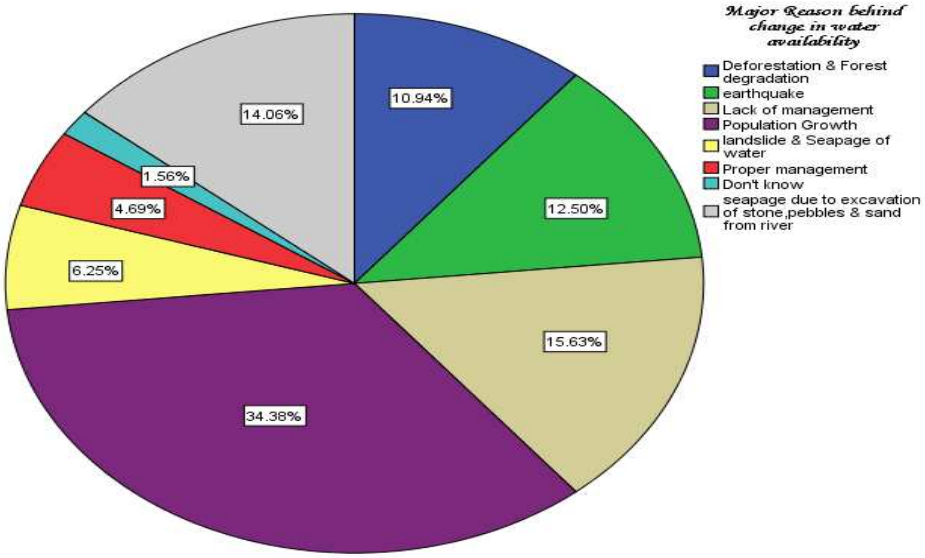

Figure 7. Major reason behind change in water availability

According to local people in the watershed, about 10.94% of people said that deforestation and forest degradation the major causes in change in water availability. Similarly, 12.50% of the people said that after earthquake 2015 they realized change in water availability. Mostly in upstream, source of water like spring and wells have been dried and water quantity has been decreased after earthquake. In *Bhedetar* (Upstream) they are planning for lifting water from underground to fulfill their water requirement as surface water had dried after earthquake. 15.63% people think that main reason behind water change availability is lack of management of water source and watershed. Likewise, 34.38% people have responded that population growth is a major reason behind change of water availability. Increasing population and settlement has causes increase in development works like road construction in up hills and other development works which can be consider as major reason in water availability according to people. In upstream, 6.25 % of people have reported that landslide and seepage of water is the major causes. Accordingly, 4.69% of people believe that water availability has increase and major reason is proper management. In the past they had to bear many problems to fetch water but after proper management of water supply through tap and other means from community level and government level water availability has been increased. About 14.06% of the people mostly downstream people believe that major reason in change in water availability is excavation of sand, pebbles and stone from river which has causes seepage of water in downstream. This study also noticed the seepage of water in Sardhu River. Water source was present in upper part of sardhukhola as water reaches downstream water flow decrease and disappears. After traveling 7-8 km water reappear in *Amaha* wetland.

3.5 Change in cropping pattern

In the period of 15-20 years, it has been found that many HH have changed their cropping pattern. This study shows that change in water availability is one of the major reasons in change in cropping pattern. It has also been found that about 84% of the total people adopting agriculture have change their cropping pattern in period of 15-20 years, and remaining 16% have the same traditional cropping pattern.

Major crops in agricultural in past and in present are given below:

Table 3. Past and Present Crops

Past Crops	***Present crops***
Rice	*Amliso*
Maize	Potato
Wheat	Tomato
Barley	Vegetable
Potato	Ginger
	Turmeric
	Cash crop

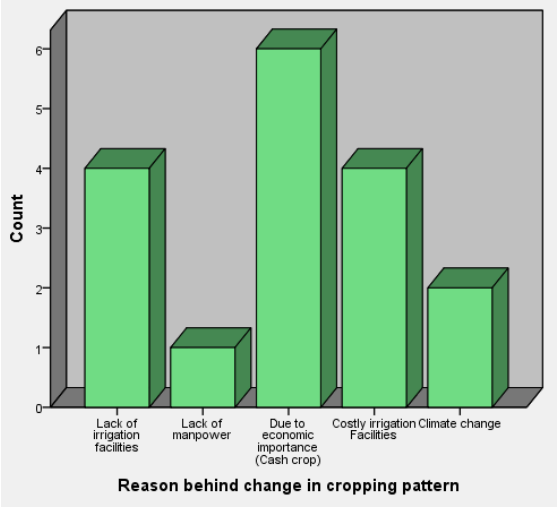

Figure 8.► Reason behind change in cropping pattern

Most of the HH have changed their cropping pattern due to market price of agriculture product. They said that traditional cropping pattern and crop hasn't good market price and hence they have changed their cropping pattern. Similarly in the past there was good water supply from river, spring and well so it become suitable for agriculture and irrigation facilities but in present context, with the drying of water source irrigation facilities have been reduced causing decrease in production and change in cropping pattern. In the past peoples used to plant rice, maize, wheat which required more water supply but which the decrease in water supply people shifted toward the crop and plant which required less water like *Amlis0*, Ginger, Turmeric.

In the past, they used to acquire water for irrigation from well and spring for which they have not to pay but in present context due to decrease in water quantity in well and springs they have to depend on tap water supply to irrigate kitchen garden which become costly as they have meter system of water supply.

3.6 People's perception on linkage between upstream and downstream and PES mechanism

During group discussion in upstream and downstream, it has been realized that there is no much co-ordination between people of upstream and downstream. It was found that upstream people think that they are conserving forest and other natural resource for the people of downstream as people of downstream depend on water supply from upstream area. Upstream people said that if there could be some financial help especially from PES mechanism they will conserve forest and other resource in better way than present condition. Whereas

downstream people think that upstream people are polluting their water source. There is no any co-ordination from the government bodies and from public sector to address the issue of upstream and downstream and to establish good relation between upstream and downstream.

It was found that most of the people have no knowledge about PES mechanism whereas when we tell them about PES mechanism and many people were interested to be part of PES mechanism.

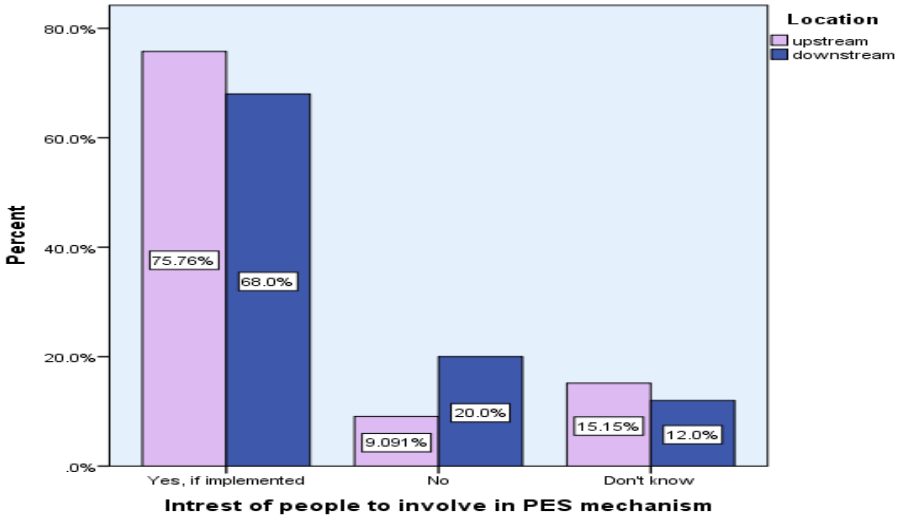

Figure 9. Interest of people to involve in PES mechanism

Comparatively less number of the people of downstream wants to be involve in PES mechanism comparison to upstream people. Downstream people thinks that money they pay for the PES mechanism will be in wrong hand and will not be use for the conservation of forest and other resource in the upstream. Similarly, more number of people wants to be part of PES mechanism in the upstream as they receive money for conservation.

3.7. Land use and land cover changes

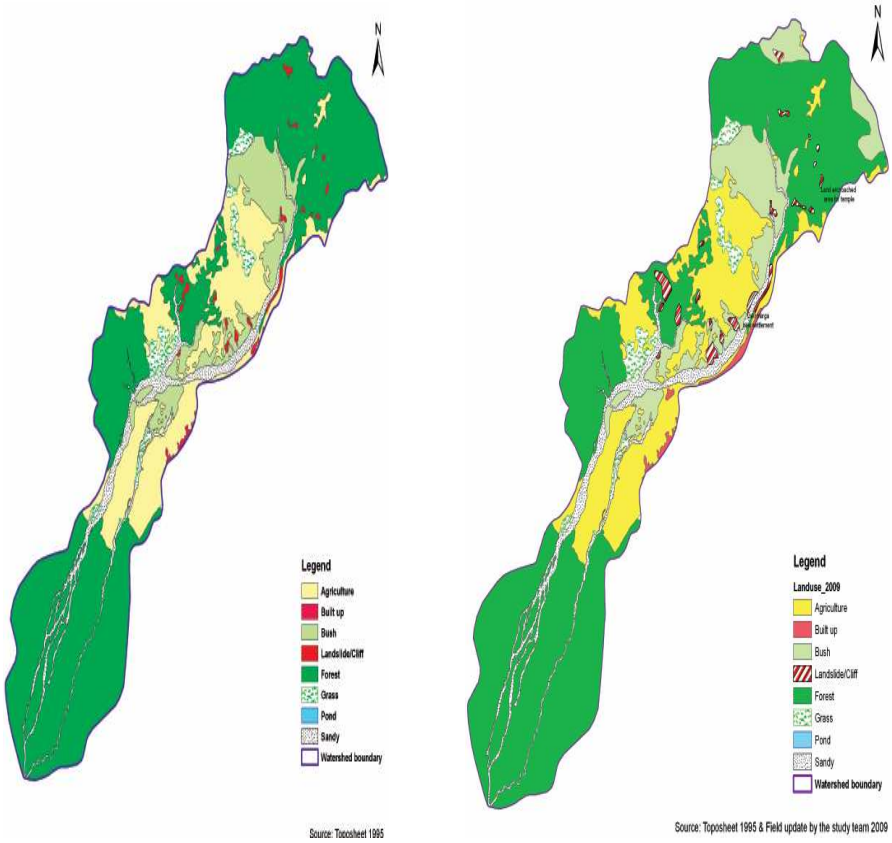

Figure 10. Land use and land cover changes in 1996 and 2009 (Source: IUCN Nepal, 2011)

Land use and land cover changes in the period of 13 years are shown in the Figure 10 in various aspects like agriculture, built up, bush, landslide, forest, grass, pond and sandy. Change in land area in the period of 13 years in shown below:

Table 4. Land use and land cover change in 13 years time period (Source: IUCN Nepal, 2011)

Types	***Land use in 1996***		***Land use in 2009***	
	Area in Ha	***Percent***	***Area in Ha***	***Percent***
Agriculture	804.60	20.45	733.02	18.63
Biult up	11.43	0.29	101.46	2.58
Bush	371.57	9.44	595.25	15.13
Forest	2347.87	59.67	2079.44	52.84
Grass	105.63	2.68	101.18	2.57
Landslide	32.27	0.82	61.67	1.57
Sandy	261.53	6.65	262.87	6.68
Total	3934.89	100	3934.89	100

Table 5. Land use and land cover Change in percent

Types	***Change in Percent***
Agriculture	-1.82
Built up	+2.29
Bush	+5.69
Forest	-6.83
Grass	-0.11
Landslide	+0.75
Sandy	+0.03

In the period of 13 years (1996-2009) 1.82% of the agriculture land has been decreased within the watershed whereas settlement area has been increased by 2.29% and in the 2009 total area occupied by settlement is 101.46 ha. Similarly, bush land has been increase by 5.69% in this period. In 1996 forest area had cover 2347.87 has (59.67%) but in 2009 forest area has decreased to 2079.44(52.84%) this shows that forest area had decreased about 6.83% in this period. Landslide in the period of 13 years is also found increasing from 32.27 ha to 61.67 which is 0.75% increment.

4. Discussion

The result obtained from the extensive field observation and social survey shows those watershed and water sources are degrading. The results of this study provide further evidence on the degrading condition of sardhukhola watershed. Both human caused and natural factors are seen reason behind decrease in watershed quality.

Impacts on water sources had cause impacts on livelihood of people. In future, people of this watershed are likely to face more scarcity of water. Natural disaster like flood, landslide can causes more impacts on water source as forest cover and area had decreases. Poor waste management system and lack of awareness among people can causes more impacts on water source in near future. In previous studies, major impacts on water source were analyzed (IUCN Nepal, 2011; Achet, 1999; Guragain et.al, 2002; Lal, 2000; Rai et.al, 2016). All these studies reported that water source of many watershed is being polluted. Population growth, over dependency on the forest, landslide in upstream and pattern of agriculture practice are the major reason. IUCN, Nepal have also mention that excessive human interventions like terrace buildings, framings on slope lands, clearance of forest, encroachment of river course, free and overgrazing and un-planned excavation for construction materials had cause Sardhukhola watershed deterioration (IUCN, 2011). *Chure* region are fragile to flood and landslide. Sloppy terrain in *chure* region had caused soil erosion causing impacts on water source and pollution. The areas within the watershed, around the left bank of Sardukhola River and upstream of watershed are at high risk to floods and landslide during the monsoon seasons (Wenger et al. 2004; IUCN Nepal, 2011).

This study analyzed the change in water availability in period of 15-20 years. The result of decrease in water availability within watershed is aligned with the results that have been reported in some of the previous studies (Richter et.al, 2018; IUCN Nepal, 2011). Decrease in forest area can also be the reason behind decrease in water availability and increase in landslide. But due to proper water supply through tap, distance to fetch the water has been decreased. This result is supported by NWSC, as in the period of 9 years more than 8,000 private tap have been added and many other community level water supply board had been established which supply the water to local resident. Result of earthquake as one of the reason behind change in water availability is also supported by previous report.(king et.al, 1999). According to king et.al. (1999) after earthquake level of ground water have

been changed and mostly in uphill appearance of spring water have also been shifted downwards. On a national level analysis, road construction in the chure regions have causes decline in water availability. Increase in runoff due to compactness of road seen to be causes of change in water availability (Gautam et al, 2012). The topography of many uphill areas is not suitable for the construction of roads by using heavy machinery equipments. But, rural earthen road are being constructed haphazardly without undertaking any precautions to control erosion and landslides at sardhukhola watershed (IUCN, 2011). Result of this study also shows that road construction on uphill is increasing without any EIA (Environment Impact Assessment) and IEE(Initial Environmental Examination) studies and these development activities can greatly affect the water availability in near future.

Water availability in smaller watersheds and micro watershed is prone to be impacted by changes in land use and land management (Blöschl et al, 2007). In some cases, anthropogenic activities like irrigated agriculture, development work and population growth have significantly affected the runoff in the streams (Hao et al, 2008) as water is drawn from the river for anthropogenic usage. In the *chure* area of Nepal, reforestation in the hillsides is reported to cause a considerable amount of water loss through evapotranspiration, contributing to the observed decline in seasonal stream flow (Ghimire et al, 2012). However, This research study does not make a final claim between forest condition and stream flow, as there is a range of other factors, such as stone quarrying, agricultural intensification, more demand of water than supply, infrastructure development. This study shows that one of the reasons behind change in water availability is seepage in downstream. According to people perception; over excavation of stone, pebbles and sand causes the seepage of water in the *chure* regions. If same condition goes on runoff in the river of downstream will decrease rapidly in both the season due to seepage of water and people of downstream can faced scarcity of water. However this research study does not fully claim seepage is only reason behind change in water availability in downstream as there can be other factors like population growth, decrease in forest cover in uphill and decrease in infiltration rate.

Result of the land use and land cover analysis had show the decreases in forest cover which could be the reason behind decrease in water availability and increase in landslide area. This seems people will face scarcity of water and more pressure on forest in near future. Previous reports had also mention that change in Water quality and quantity on sardhukhola watershed are dependent on flood, forest cover, land use practices and human interventions and behaviors and people's understanding about the watershed (IUCN,2011). Runoff of Pakuwa river (one of the tributaries of sardhu river) was measure in dry season at different location and found to be 0.57lit/sec which is found to be less than measurement of IUCN, 2011 i.e. 0.63lit/sec. which shows that water quantity is decreasing. However, this result can also be diverse due to different time and season of measurement. This study shows that water of sardhukhola watershed is being polluted. If same condition goes on people of this area is likely to face various health related issues in near future. Improper management of sewage from house and animal waste in the upstream can causes various water related disease for the people of downstream. However pollution in the downstream can also be due to infrastructure development in the upstream. But a study conducted by IUCN in 2009 at sardhu river shows that raw waters of Sardukhola and Khardu Khola were potable only with respect to the physical and chemical characteristics but not with respect to bacteriological aspect. They also have mention that standard plate count of CFU (Colony Forming Unit)/ml in Sardu and Khardu were of 2200 and 2600 respectively and were found to be unsatisfactory in terms of bacterial purity. Similarly, the total coliform count of Sardukhola and Khardukhola were of 1100 and 150 MPN (Most Probable Number)/100ml respectively that showed the Khola's water was highly polluted and the quantities were higher than WHO standards (the total Coli-form per 100ml is close to zero) (IUCN,2011).

5. Conclusion and Recommendations

This study show that present status of water source is rapidly degrading. It has been found that human activities within the watershed are major causes behind declining in water quality and quantity. Waste and garbage from the upstream are polluting source of water for downstream people. Landslide is seen as major reason behind pollution in water source. Road construction and increase in settlement near water source have also greatly affected the water source. Most of the tributaries of Sardhukhola watershed are found to be polluted from human activities. Most of the people within watershed are interested to be part of PES mechanism. About 12.5% of the total sample populations suggest that there should be integrated settlement in upstream for the conservation of watershed. As in present context, the settlement pattern of upstream is scattered which shows that there is more exploitation of natural resource and have causes impact of environment. Waste disposal on both up and downstream is the major reason behind pollution on river and water source. The study showed that there is weak proper co-ordination among people of upstream and downstream in the common issue of watershed management.

People are found to be changing their cropping pattern in the period of 15-20 years. They are found to be shifting from the crop which required more water to the crop which required less water. Among many reasons behind change in cropping pattern lack of irrigation and costly water supply are related to watershed and water

supply. Water source is in decreasing trend, from the past to present. But due to management of water supply most of the people are being benefited as distance to fetch the water has been decreased. Most of the HHs within the watershed have access to tap water supply through different sources which save their time to fetch water from long distance.

So for the proper management of watershed following point are recommended:

- For the proper management and conservation of watershed it has been observed that there should be proper control of natural disaster like landslide and soil erosion. Proper control of landslide in upstream can increase the water availability in the downstream and can fulfill the water demand in near future.
- Awareness among the people should be increased about the benefits of conservation of watershed.
- People's dependency on forest resource is found to be decreasing. This dependency on the forest can be even decreased more by introducing alternative source of energy. HHs with livestock husbandry should be encouraged to adopt agro forestry which decreases dependency on forests for fodder.
- PES mechanism can be the milestone to solve the issue of upstream and downstream; for the conservation of watershed and to balance the drinking water demand and supply within the people of watershed.
- Local Government should bring some rules related to settlement in upstream which can reduce impacts on environment.
- Municipality as well as other government and non government sectors should take an initiation for the conservation of water source and watershed.
- For the management of waste, municipality should bring awareness programs and should restrict to throw the waste in river or near water source.

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