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Socio-economic Impact and Adapting Strategies of Inter Basin Transfer by Kulekhani Hydro-electricity Project Nepal

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Abstract

Kulekhani hydropower is the first hydropower project in Nepal in which river water has been transferred from the Kulekhani to the Rapti basins since 1982 to produce electricity. At Markhu, a 4.4 million m3 dam with a height of 114 meters was constructed for reserve wire. This study's major goal is to assess the socioeconomic effects of water transfer between basins. To identify changes in many areas of the socioeconomic environments, such as the people's choices for subsistence in the dewatering zone and the effects of water consumption (drinking, irrigation, sanitation, and other uses) on different components of subsistence. The research region is the dewatering area between Kulekhani Dam and Bagmati Confluence, which is located in Kulekhani and Sisnery. Study area is divided into two reaches, the upper reach and the lower reach. For the analysis of this research, both qualitative and quantitative data were used. Various techniques were used, including field observation, household surveys, focus groups, and key informant surveys. The study area has decline the productivity because of decline in irrigation particularly during winter season, then livelihood options are affected. Downstream people are depending for water on different resources such as natural springs; tap etc. Traditional water mills are either non-functioning or its efficiency is declined due to decline in water availability. Out of 16, 9 water mills have been closed, remaining are hardly conducting. Almost 90% fishes have decreased and some species of fishes have disappeared from the river therefore, Fishermen who were economically dependent on fishing activities have forced to replace their traditional fishing occupation. People have felt new experiences such as temperature increased and appearance of mosquitoes. Upper reach has almost completely dried but lower reach has little water available in the river because of its tributaries thus upper reach is more effected than lower reach. The risk of artificial uncertain flood due to high dam may burst by natural or unnatural forces and during the period of opening dam gates due to overflow, as there are no enough early warning systems developed particularly at the time of opening the dam gates, the unexpected risk has increased in downstream area.

Keywords: inter basin transfer, livelihood, socio economic Impact, adapting strategies, Kulekhani hydro-electricity

Introduction

Inter-basin transfer or transfer (IBT) diversion terms are used to describe man-made conveyance schemes which move water from one basin where it is available, to another basin where water is less available. In simple terms, inter-basin water transfer is defined as "the artificial withdrawal of water by ditch, canal or pipeline from its source in one basin (or catchment) for use in another".

Biswas (1983) defines the term as "a large-scale artificial mass transfer of water from a water-surplus to a water-deficient reach in order to further the economic development of the latter, mainly through agricultural and industrial development". Similarly, Micklin (1985) defines inter-basin water transfer as "the purposeful arrangement of natural hydrologic patterns via engineering works (dams, reservoirs, tunnels and pumping stations) to move water across drainage divides to satisfy human and other needs".

There are dozens of large inter-basin transfer around the world, most of them concentrated in Australia, Canada, China, India and the United States. Inter-basin transfer of river flow for different purposes such as drinking water, irrigation, hydroelectricity and flood control has been increasing in recent years. Such inter-basin transfer of water from Kulekhani river to Rapti river for hydroelectricity development was started in 1982. Work for inter-basin transfer of water from Melamchi river to Bagmati river for drinking water supply in Kathmandu valley is being carried out and schemes for the transfer of water from Sunkosi, Gandaki and Karnali for irrigation in the Tarai have been developed and proposed.

This research work aims to identify the socio-economic consequences and adaptation strategy to cope the adverse impact of such change in different aspects described above due to inter-basin transfer of water from Kulekhani to Rapti river. The main objective of this study is to identify the consequences and process of change and its pace and quantify the biophysical and socio-economic impacts due to inter-basin transfer of water and sediment. The specific objectives are: to identify the changes brought in the socio-economic condition or livelihood options of the people living in dewatering zone; to describe the impacts of water uses in various aspects of livelihood; discuss the processes of coping / adaptation strategies to such changes.

Methodology

Study Area

Study area lies in Makwanpur district. Makawarpur district is located between the latitudes $27^0 10'$N to $27^0 40'$N and 84^0 $41'$ to $85^0 31'$E longitude. Total area of this district is 2428sq.km and elevation ranges from 166m-2584m (District Profiles, 2066/2067). This area is surrounded by Kathmandu, Lalitpur, Kavre and Sindhuli in the east Chitwan in the west, Dhading and Kathmandu in the north and Bara, Parsa, and Rautahat in the south respectively (Figure1). This river in the study area covers two physiographic zones: the Mahabharat Lekh and inner Tarai.

Kulekhani watershed with a total area of 208.28 sqkm is located about 50 km southwest of Kathmandu in the middle hills of Nepal. Study area has divided into two reaches i) upper reach with a total area 34.84 sq.km (16.73%) and ii) lower reach with a total area 22.67 sq.km (10.88%). The altitude of the watershed ranges from 1100 m in the southeast to 2600 m in the northwest. A 103-m high hydro-electricity dam was constructed near Markhu village in 1982. The flow of water and sediment from headwater with basin area of 126 sq. km has been dammed in about 2.2 sq. km area and the flow has been diverted into Kulekhani basin through a tunnel and penstock pipe constructing lake knows as Indrasarobar Lekh where sediments are trapped into. Diverted water from Kulekhani is added into Rapti river.

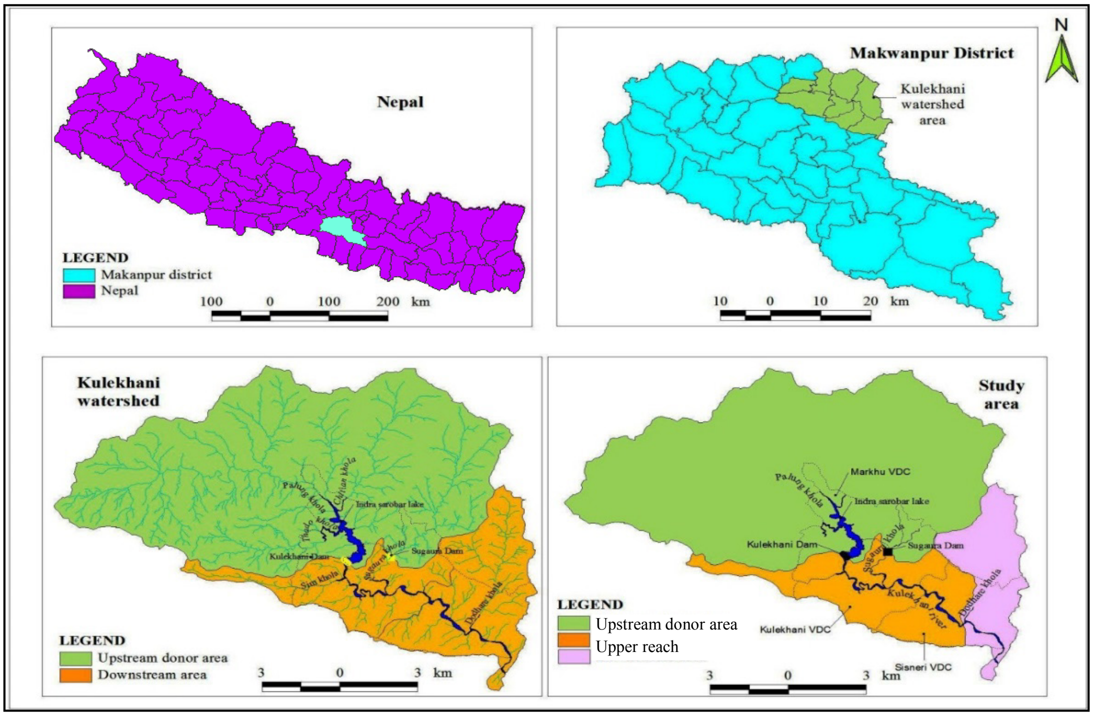


Figure 1: Location of study area

Method of Data Collection

Water has been diverted from Kulekhani basin to Rapti basin for generating hydroelectricity, which is the first example of inter-basin transfer of river water in Nepal since 1982. A 114-m high dam with a volume of 4.4 million m3wasmade at Markhu village for reservoirs. The main objective of this study is to find out the socio-economic consequences due to inter-basin transfer of water. To extract changes in different aspects of socio-economic and aquatic environment such as livelihood options of the people living in dewatering zone, impacts of water (drinking, sanitation, irrigation and others) uses in various aspects of livelihood.

Dewatering area from Kulekhani dam to Bagmati confluence is the study area, which lies in Kulekhani and Sisnery. Study area is divided into two reaches, i) Upper and ii) Lower reach. Both Qualitative and quantitative data have used for the analysis of this study using various techniques such as Field Observation, Household survey, Focus Group Discussion and Key Informant Survey.

The Figure 2 shows the conceptual framework of the study on the impacts due to inter-basin transfer of water and its consequences and adaptation strategies on socio-economic condition.

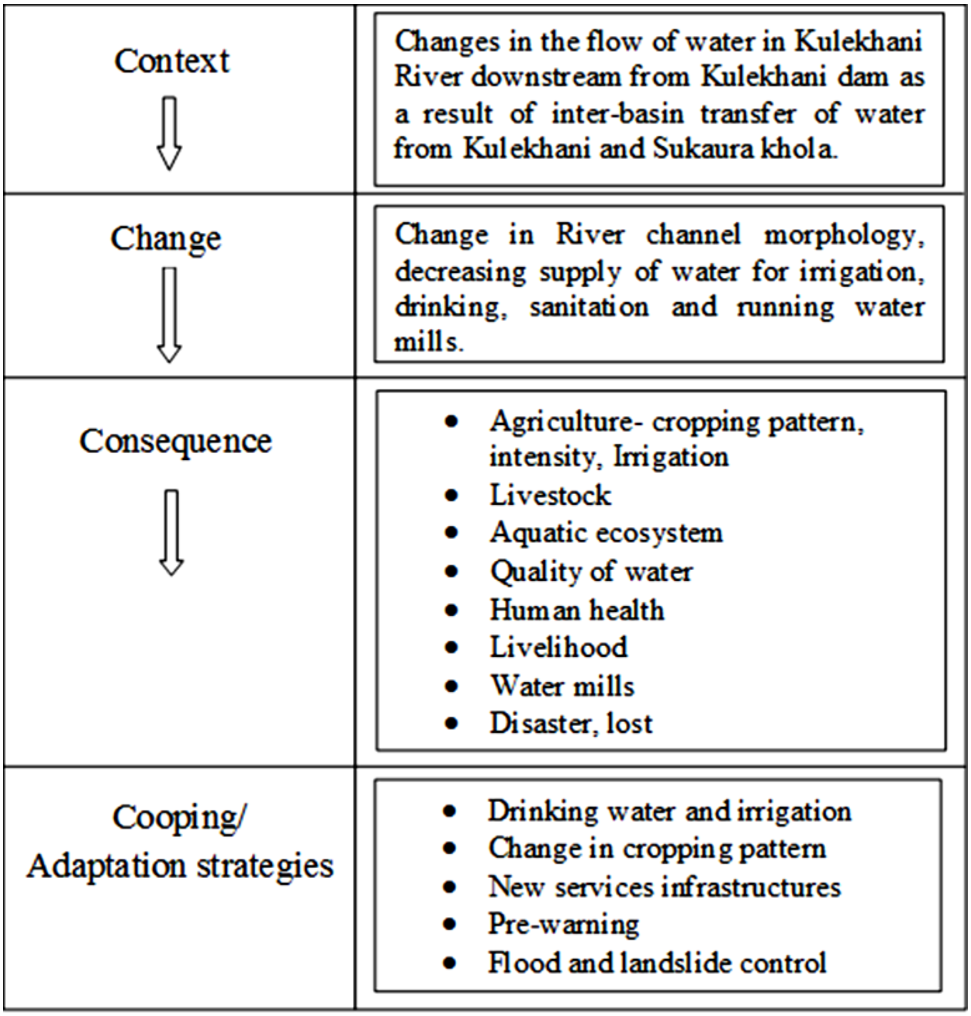


Figure 2: Conceptual framework of study on the consequences of inter-basin transfer of river water

This study is based on primary information collected during fieldwork in the study area. The study area has divided into two parts 1) upper donor, which covers all upper parts of river networks from Kulekhani and Sugaura dam and 2) downstream area, which covers the lower parts from Kulekhani and Sugaura dam. Downstream area also divided into two sub-divisions i) upper reach and ii) lower reach.

During the research, more emphasis was given to collect accurate information and an effort was made to get the reality of the people. Both qualitative and quantitative data were collected for fulfilling the objectives of this study using various techniques such as household survey, field observation, key informant survey and focus group discussion.

Information on the flow of water and sediment in Kulekhani River and its changes after the additional water were collected by reviewing project documents and consulting with project staffs. The changes in land use along the river channel were detected after comparison of Topographic maps of different period. In addition to this, 30 households in upper and 30households in lower reaches were surveyed along the Kulekhani river within the 500m buffer zone from the Kulekhani river. Four focus group discussions, two in upper and two in lower reaches and three key informant surveys were organized.

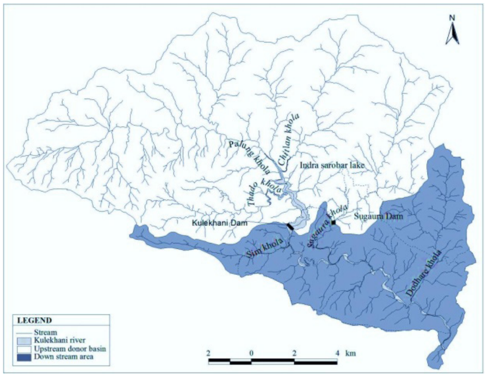


Figure 3: Kulekhani watershed area divided into two divisions i) Upper donor area and ii) Downstream dewater area

Source: Field Survey, 2012

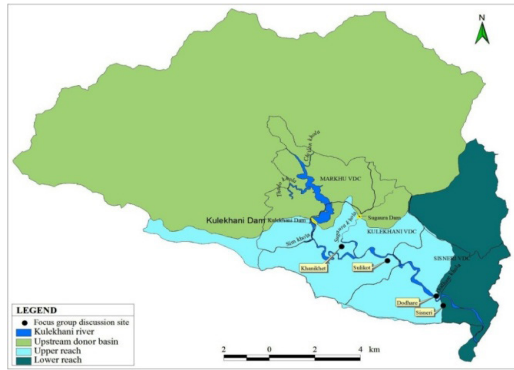


Figure 4: Downstream dewater area divided into two sub-divisions i) Upper reach and ii) Lower reach

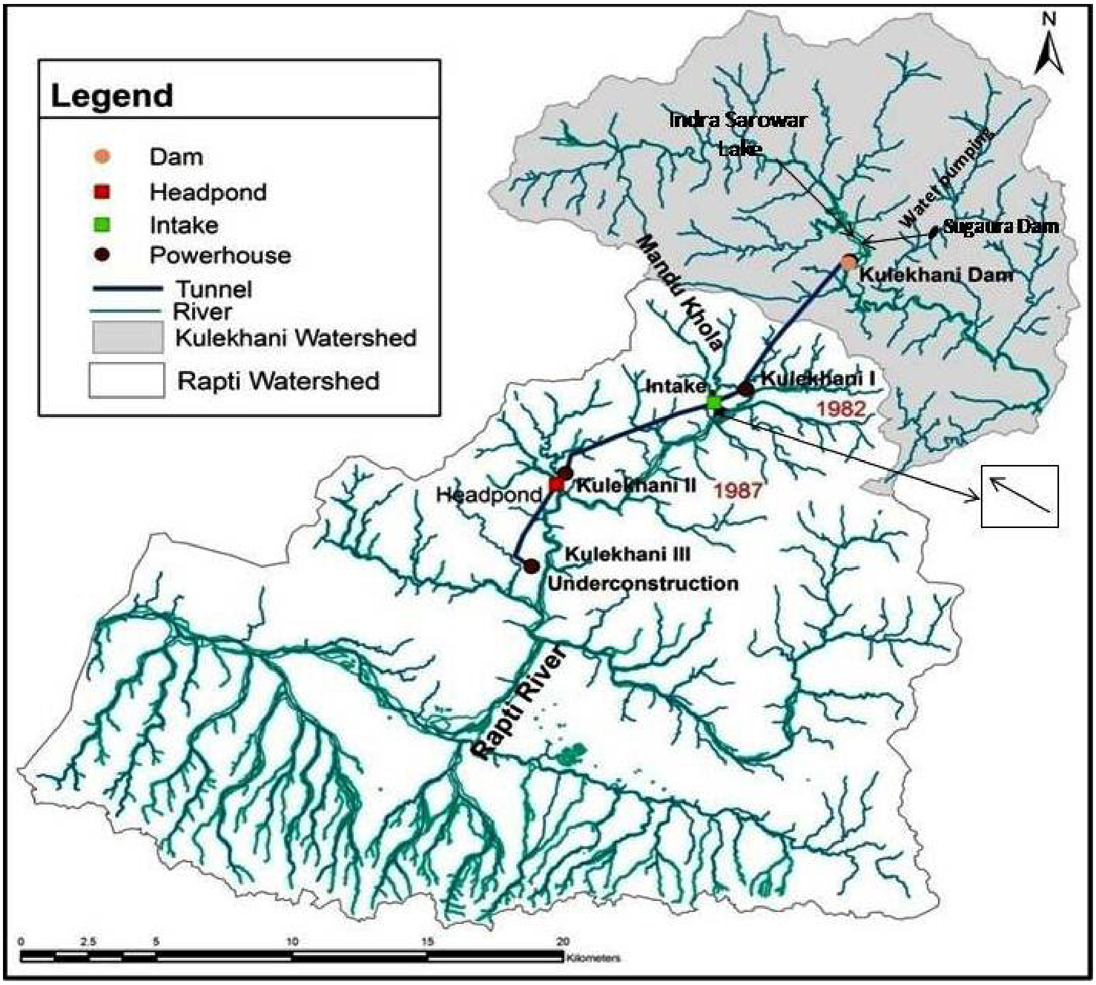
Source: Field Survey, 2012

Results and Discussions

Kulekhani Hydropower Project

A 114-m high hydro-electricity dam with a volume of 4.4 million m3 was made at Markhu village in 1982. Kulekhani dam is zoned rock fill dam, consisting of an inclined core zone, filter core zone, quarry rock zones and a random rock zone. Its crest is 397 m long and 10 m wide. The flow of water and sediment from headwater with basin area of 126 sq. km has been

dammed in about 2.2 sq. km area and the flow has been diverted into Rapti basin through a tunnel and penstock pipe constructing lake known as Indrasarobar where sediments are trapped into (Figure 3, 4, 6). At present two stations Kulekhani- I and Kulekhani-II are generating hydroelectricity with installed capacity of 60 and 32 MW respectively having two units each of 30 and 16 MW (Table 1) and Kulekhani- III is under construction. Kulekhani- I has 13.1 m^3/sec designed discharge; 550m rated net head, with 6233m long and 2.3 diameter headrace tunnel, 1324m long and 2.1-1.5 diameter steel pipe.



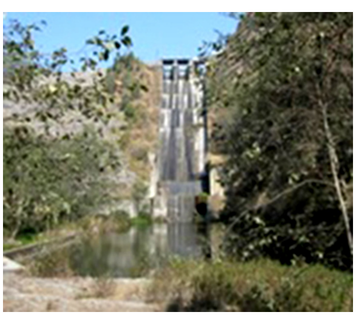


Figure 5: Kulekhani dam

Figure 6: Kulekhani Reservoir

Figure 7: Steel Pipe of Kulekhani I at Jurikhet

Table 1: Salient Features of Kulekhani I and II

Features	Kulekhani-I	Kulekhani-II
Rated net head	550 meter	284.1 meter
Design discharge	12.1 m 3/s	6.65 m 3/s per turbine
Head race tunnel	6233 m, 2.3 m diameter	5748.7 m, 2.5 m diameter
Penstock pipe	1324 m long, 2.1 – 1.5m diameter steel pipe	843 m long, 2.1-1.5 m dia., steel pipe
Installed capacity	60 MW	32 MW
Turbine Generator Set	2 sets	2 Sets
Type of Turbine	Pelton	Francis
Rated Speed	600 rpm	750 rpm
Type of Generator	Vertical shaft, Synchronous	Vertical Shaft, Synchronous
Capacity	35 MVA	18.8 MVA
Rated Voltage	11 KV	6.6 KV
Power Transformer	11/66KV, 3 phase, 35 MVA, 2 Nos	6.6/132 KV, Single Phase, 12.6 MVA, 3 Nos
Transmission Line		42 km long, 132 KV single circuit
Average Annual Generation	211 GWh (Primary energy 165 GWH and secondary energy 46 GWH)	104.6 GWh
Catchments Area	126 sq. km.	126 sq. km.
Commissioning Date	1977 A.D. -14th May, 1982	November, 1886
Construction Cost	117.84 million USD	NRs. 1240 million
Financed by	World Bank, Kuwait Fund, UNDP, OECF and OPEC Fund	Government of Nepal, OECF of Japan

Source: Environment resource Group P Ltd

NEPECON, 2011 has studied the potential environmental impacts entitled "Environmental Impact Assessment Report of Kulekhani III Hydro Electric Project". The construction and operation of the Kulekhani III HEP will affect land use pattern in 21 ha of the project area. *Khet, Bari*, forest and bushes, and *Kharbari* are the other land use affected by the project.

Table 2: Land Use Affected by the project

S.No.	Land Use Type	Affected Area (ha)	Percentage
1	Khet	4.22	20.39
2	Bari	5.78	27.85
3	Forest and Bushes	1.66	7.99
4	Kharbari and Parti land	2.83	13.68
5	Bari and Pakho	5.98	28.78
6	Kulo	0.22	1.07
Total		20.79	100

Source: NEPECON, 2011

Physical Characteristics of Study Area

Physiography, geology and soil

Physiography of the study are lies on Mahabharat Lekh and inner Tarai and elevation ranges from 166m-2584m (District Profiles, 2066/2067). This region is composed of phylliticshicsts, limestone, sandstones and slates. Most slopes are under 25° and weathering horizons are deeper than in Mahabharata range. The soils in the lowlands of midland region are deep, rich alluvial or in situ soils and very suitable for cultivation. Northward, on the ridge slopes are thinner and erodible. The mountain soils are derived from the parent rock consisting mostly of phyllite, granite and quartzite. Soils are poorly developed in the Mahabharata range, with forest pod sols of relatively low fertility and high readability. In most places, phyllite being susceptible to weathering gives rise to ferruginous soil. In quartzite zone, there is very little development of soil. In places where granite rocks are exposed the feldspar is highly weathered and gives kaolin-bearing soil. The climate also works differently in the soil formation in the mountainous part.

Temperature

Altitude and physiography are the major determinant factors of the temperature in Nepal. Recorded temperaturedataof Daman station gives overall temperature condition and trend of Kulekhani and Kulekhani river basin. The average temperature in warm temperate humid zone is 15 to 20 degree Celsius and 10 to 15 degree Celsius in cool temperate humid zone (Ghimire, 2004). The minimum and maximum yearly temperature data recorded at Daman for the last 40 years from 1971 to 2010 gives overall temperature condition and trend of Kulekhani river basin (Table 3.). In the year of 1971 minimum temperature at Daman station was 6.8^{0}C and maximum temperature was 14.90^{0}C. Temperature has been gradually increasing since the year of 1971 to 2010. Minimum and maximum temperature of 2010 was 9.06^{0}C and 20.4^{0}C respectively (Figure 9).The overall trend of temperature of Daman stations is gradually increasing but from the year of 1978 to until 1982, the minimum temperature has decreased.

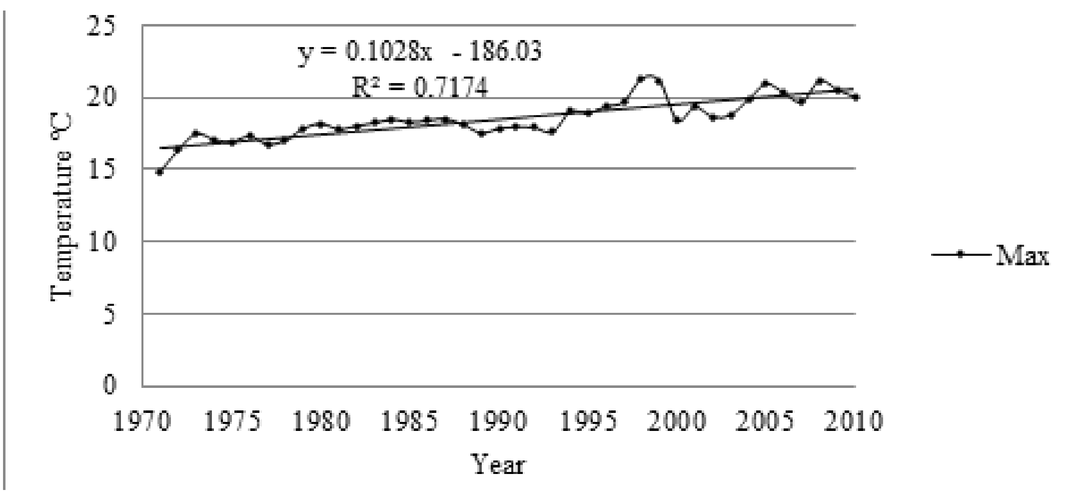
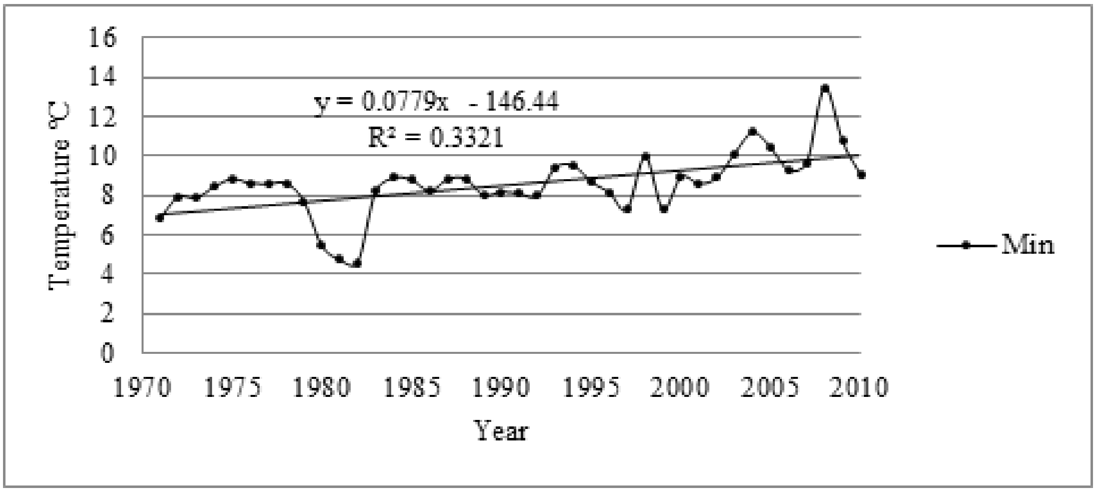


Figure 9 Average Annual Temperature of Daman, 1971 -2010



Source: Department of Hydrology and Meteorology

Station Daman: Station no. 0905, Latitude: $27^0 36'$, Longitude: $85^0 5'$, Elevation: 2314m.

Table 3: Average Annual Temperature of Daman, 1971 -2010

Year	Max	Min	Year	Max	Min	Year	Max	Min
1971	14.9	6.87	1985	18.28	8.8	1999	21.18	7.31
1972	16.38	7.93	1986	18.41	8.23	2000	18.41	8.96
1973	17.49	7.88	1987	18.53	8.83	2001	19.33	8.61
1974	17.08	8.44	1988	18.13	8.86	2002	18.65	8.9
1975	16.94	8.84	1989	17.54	8.03	2003	18.79	10.15
1976	17.31	8.63	1990	17.86	8.19	2004	19.88	11.2
1977	16.74	8.59	1991	18	8.08	2005	20.94	10.43
1978	17.02	8.63	1992	17.92	7.97	2006	20.3	9.27
1979	17.84	7.71	1993	17.62	9.42	2007	19.69	9.66
1980	18.2	5.44	1994	19.03	9.51	2008	21.18	13.49
1981	17.81	4.74	1995	18.92	8.7	2009	20.53	10.74
1982	18.05	4.61	1996	19.38	8.16	2010	20.04	9.06
1983	18.23	8.22	1997	19.7	7.28			
1984	18.49	8.89	1998	21.32	9.99			

Source: Department of Hydrology and Meteorology

Precipitation

After the condensation of water vapor, the release of moisture is known as precipitation.

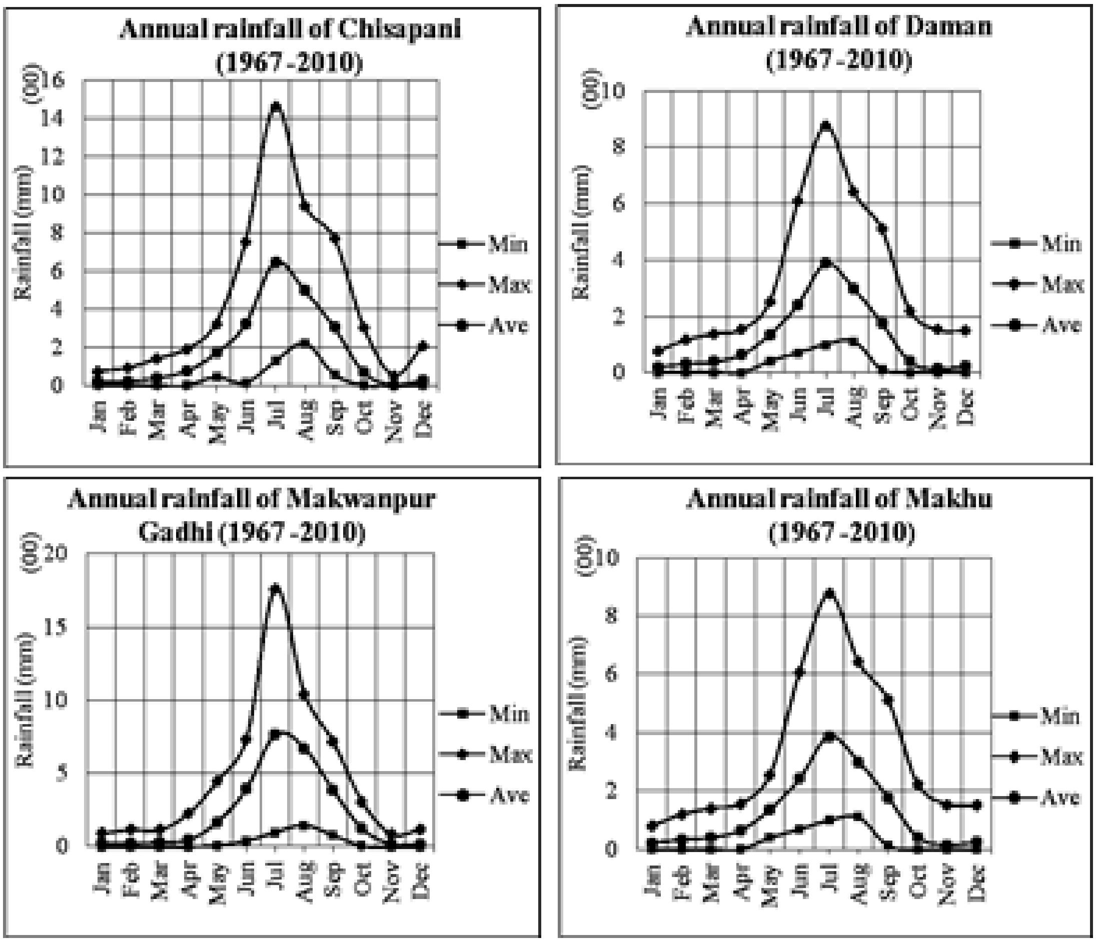


Figure 10 Annual rainfalls of Chisapani Daman, Makwanpur, and Markhu
Source: Department of Hydrology and Meteorology

Following figures show the annual average precipitation at different station within Kulekhani and Rapti river basin. There is clear seasonal variation in precipitation at all stations. June to august is known as rainy season comprise the huge amount of precipitation. July has the highest amount of precipitation of rainfall. Fluctuated nature of precipitation directly effect on seasonal variation and magnitude of water and sediment discharge. The month November to February comprises few amount of precipitation. It indicates that there is very dry winter and rainy summer. That is the main feature of monsoon climate.

Table 4: Monthly Rainfalls of Chisapani, Daman, Makwanpur and Markhu, 1967 -2010

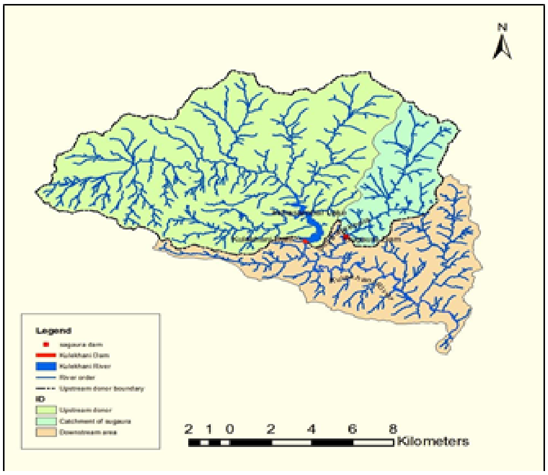
Chisapani				Daman			Makwanpur			Markhu		
Months	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Jan	0.00	75.00	19.77	0.00	78.40	21.44	0.00	90.00	22.72	0.00	78.40	21.44
Feb	0.00	91.40	22.94	0.00	118.00	31.65	0.00	118.00	22.18	0.00	118.00	31.65
Mar	0.00	139.50	41.94	0.00	139.80	39.02	0.00	113.90	27.86	0.00	139.80	39.02
Apr	0.00	189.80	77.83	0.00	155.60	63.91	0.00	230.00	47.09	0.00	155.60	63.91
May	43.90	325.30	171.40	40.50	254.60	135.53	8.80	449.50	167.28	40.50	254.60	135.53
Jun	15.20	756.90	324.48	69.30	609.60	241.08	39.50	737.00	394.87	69.30	609.60	241.08
Jul	127.50	1466.60	648.49	99.60	877.40	387.05	96.90	1764.60	765.62	99.60	877.40	387.05
Aug	224.30	945.60	499.51	110.30	642.20	298.73	142.40	1046.00	673.99	110.30	642.20	298.73
Sep	58.80	771.60	307.21	12.10	510.80	176.47	76.30	717.30	383.13	12.10	510.80	176.47
Oct	0.00	303.30	69.47	0.00	222.30	39.93	5.90	306.80	121.24	0.00	222.30	39.93
Nov	0.00	52.80	5.89	0.00	153.40	14.42	0.00	88.50	16.65	0.00	153.40	14.42
Dec	0.00	207.00	27.59	0.00	150.70	22.87	0.00	118.50	17.69	0.00	150.70	22.87

Source: Department of Hydrology and Meteorology

Drainage

Makawanpur district is drained by Bagmati in the east,Bakaiya in the Middle East, Kulekhani in the middle, Manahari and LotharKhola in the waste part respectively;all the rivers originate with in Mahabharat and Siwalik range.

Diversion of Kulekhaniriver to Rapti river basin is to produce hydroelectricity, which is known as Kulekhani Hydropower Project. Former one is sub-basin of Bagmati River system and latter is sub-basin of Narayani River system. Some major tributary of Kulekhaniriver are Ghsrti, Khaiti, Keteni, Andhari, Tistung and the Seramaidan khola etc. (see figure 11 & 12). Before approaching reservoirKulekhaniriver has number of small tributaries, these include Mandu, Rani, Yangrang, Kasadi, Samari, Karra, Manahari and Lotharkhola. Many small streams join these tributaries and demonstrate parallel, sub-parallel and dendritic drainage patterns. These Catchments distinctively influence by seasonal variation i.e. wet monsoon from June to September and dry season from October to May.



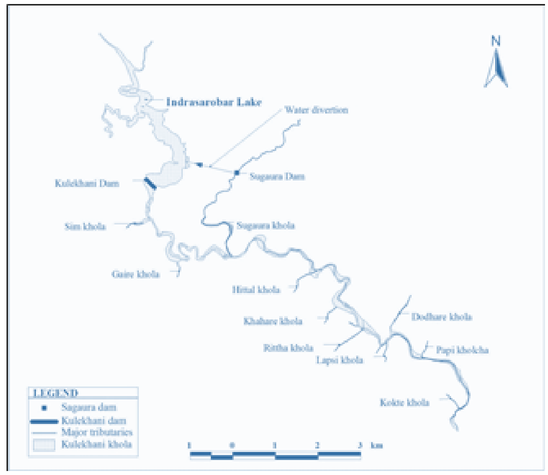


Figure 11: Kulekhani River Network
Source: Survey Department, 1995

Figure 12: Major Tributaries of Kulekhani

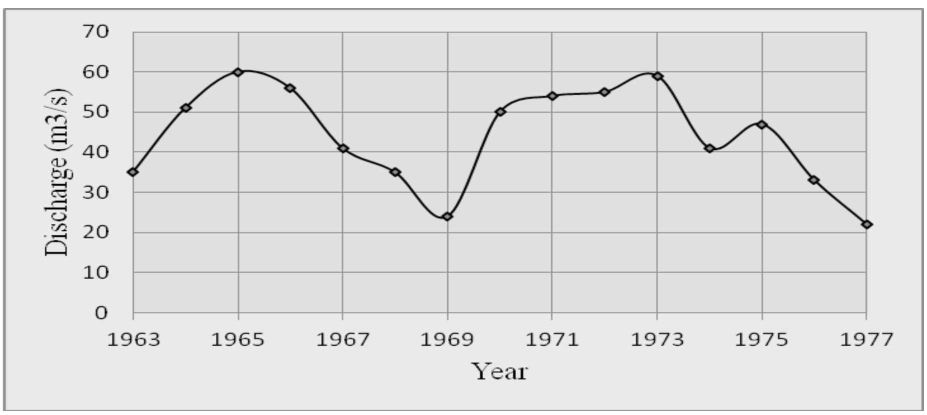


Figure 13: Annual Discharge of Kulekhani River
Source: Department of Hydrology and Meteorology

Table 5 Total Annual Discharge of Kulekhani River

Year	Total annual Discharge (m3/s)
1963	35
1964	51
1965	60
1966	56
1967	41

1968	35
1969	24
1970	50
1971	54
1972	55
1973	59
1974	41
1975	47
1976	33
1977	22

Source: Department of Hydrology and Meteorology

Discharge station of Kulekhaniriver was collapsed during the phase of Kulekhani dam construction in 1977. Overall discharge trend of Kulekhaniriver is decreasing from 1963 to 1977. In the year of 1996, discharge has decreased which was 24-m3 sec^{-1}. From 1970 discharge is has increased until 1973 (Figure 13) but from 1974 it has been decreasing until 1977.

The discharge of downstream Kulekhani river at 30 surveyed (2012) sites ranges from 0.02 m^3 s^{-1} to 0.95 m^3 s^{-1} with an average discharge is 0.45 m^3 s^{-1}. Before the dam construction the average discharge of same river between 1963 to 1977 was 1.14 m^3 s^{-1} therefore it can concluded that the value of 0.69 m^3 s^{-1} has decreased in an average discharge of downstream Kulekhani river after the Kulekhani dam construction.

Land use and Land Cover

According to the Department of Soil Conservation (DoSC), forest occupies about 44% of the entire Kulekhani watershed and the sloping agricultural land occupies about 34% of the total area. The remaining 22% of watershed area consist of grazing lands, rock fields, landslides, reservoirs and others. Kulekhani watershed has a diverse type of topography from river valley, alluvial fan, flood fans, and flat terraces to steep and high hills and mountains. The steep rocky cliffs and moderate soil terrace indicate the surface relief is strongly controlled by the litho logical variation and its' Structure.

The land use pattern of the area is diverse. According to the data of survey department (1998), the forestland comprises 62.46 percent getting first position followed by 26.83 percent cultivable land in second. Similarly, other main types of land use/land cover are bush/shrub land, water bodies and grass land. It is shown in table 6.

The main cereal crops are produced in study area are paddy, maize millet wheat and barley as well as other cash crops grow are pulses, oilseed, potato, etc.

Table 6: Land use of Kulekhani Watershed

Class	Upstream Donor area		Downstream area				Total
			Upper reach		Lower reach		
	Area sq. km	%	Area sq. km	%	Area sq. km	%	
Bush/Shrub Land	16.95	11.24	2.28	6.54	5.38	23.75	24.61
Cultivated Land	69.19	45.89	9.03	25.9	6.89	30.42	85.11
Forest	62.33	41.34	21.94	62.94	10.13	44.72	94.4
Grass Land	0.12	0.08	0.59	1.69	-	0	0.71
Land Slide	0.07	0.05	-	-	-	-	0.07
Orchard Nursery	0.24	0.16	-	-	-	-	0.24
Sandy Area	0.59	0.39	0.67	1.92	0.15	0.66	1.41
Water Bodies	1.28	0.85	0.35	1	0.1	0.44	1.73
Total	**150.77**	**100**	**34.86**	**100**	**22.65**	**100**	**208.28**

Source: Survey Department, 1995

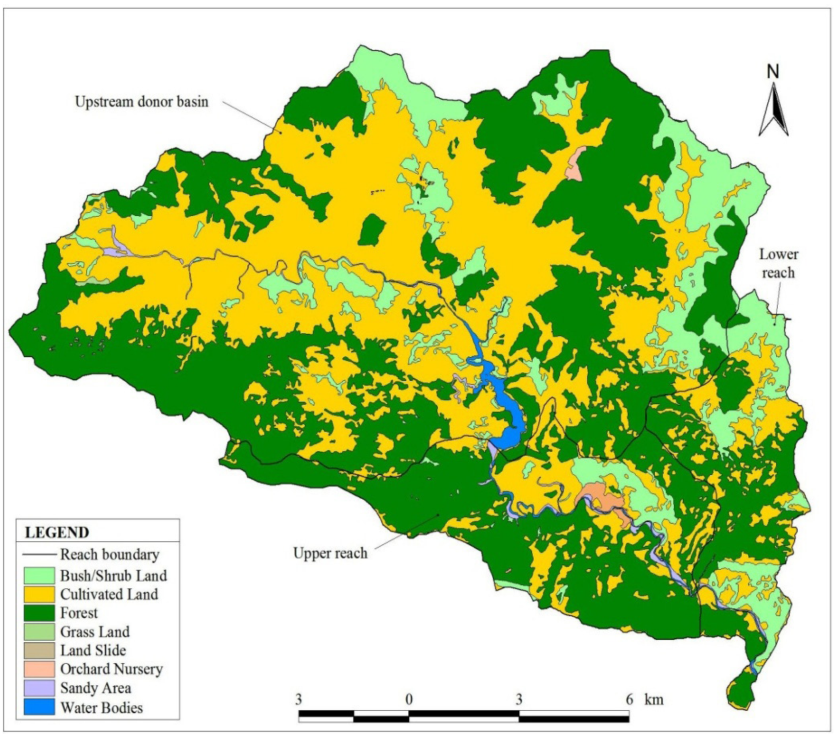


Figure 14 Land use Map of Kulekhani Watershed
Source: Survey Department, 1995

Socio-economic Impact and Adapting Strategies of Inter Basin Transfer

Kulekhani watershed with a total area of 208.28 sq. km is located in the middle hills of Nepal. Terrains elevation varies from 1534 m at dam site to 1053 m at Bagmati confluence. The geology of the Kulekhani area consists of Precambrian to Cambrian metamorphic rocks. The soils in the lowlands of midland reach are deep, rich alluvial or in situ soils. In most places, phyllite being susceptible to weathering gives rise to ferruginous soil.

Due to the variation in topography, the climate of Kulekhani watershed varies from subtropical at low lands to temperate at higher elevations.Average minimum temperature of high MahabharatLekh is 7.65^0c, and maximum average temperature 17.67^0c and annual mean minimum and maximum temperature in the inner Tarai and Siwalik range is 15.96^0c and 18.59^0c respectively.

Total population of the surveyed households was 367.Proportion of male population was higher in lower reach while proportion of female waslower in upper reach. Buddhist and Hindu are the dominated religious group in both reaches. Almost of the households participated in agriculture. Average family member of the study area is 5 at lower reach and 7 in upper reaches. Unmarried population was higher (50.52%) in lower reach. Tamangwas the dominant ethnic group and Dalit was lest dominant group in bothreaches. Majority respondents are illiterate in both reaches. More than 50% people were engaged in agriculture as the main occupation in both the reaches.

Major source of energy are electricity and kerosene for lightning and firewood for cooking. Firewood is major energy source for cooking and heating. Government forest and community forest are the main source for firewood. They extract timber wood to build houses and shed as well as fodder, Leaf / litter, cut grass for animal and sometimes they used wild edible food like *Kafal, Amala, Tarul, Blackberries and Lapsi* in season from the forest. Study area was not affected by severe disease. Most of them had faced common disease like fever, cold and cough for two or three times in a year.

Drinking water is essential so almost houses have drinking water facilitated by tap using natural spring water through pipeline. The flow of river water has decreased from 85 % to 95 %, in downstream area and water quality of the river also decreased. Almost households have toilet facility. Some houses still uses *Dhiki*, others uses water mill and electric mill for grinding grains. Disposal pit, *Jatno*, telephone, radio/TV, and *Okhal* are also used in both reaches. Livestock farming is one of the most important sources of income so almost houses have some kinds of animals. Chickens is the higher number as a pet. Goat, cow/oxen, and buffalos are kept as a pet for milk, meat and manure. Milk and Khuwa are major livestock products of the both reaches. Lower reach produce more Khuwa than upper reach. Lower reach produce 13.33% *Khuwa* (pond) and upper reach produce 6.67%. Agriculture is the major source of income. Most of the people holding 1-10 ropanies land for agriculture and other prospects. Only few households occupied more than 50 ropanies of land. In the case of cultivated land, some of them were said production had decreased due to low productivity and quality of soil. Majority of people said no change on their agriculture land. One house said abandoned land in the lower reach.

Maize has the major consumption food and rice occurs in second places in both reaches. In lower reach 56% households consumed Maize and 48% consumed by upper reach. Wheat, potato, finger millets and pulses are the common consumed grains in both reaches. The production of paddy is higher in lower reach than upper reach due to availability of little water by its Tributaries river in lower reach with the comparison of upper reach. Wheat, summer maize, winter maize and millet are the crops produce by both reaches. Out of 60 households 33.33%, households in lower reach and 46.67% households in upper reach were only self-sufficient for 12 months. Irrigation plays vital role for productivity. In upper reach, 6.67% households said the problem in irrigation, 3.33% said conflict in irrigation, and 3.33% households said scarce. In lower reach 10% households said that the problem in irrigation. If there were adequate water in river and well managed of irrigation, productivity and economic status of the people could be raised. Productivity of the crop is declined due to adequate irrigation but some of them increased by using hybrid seeds and chemical fertilizer. People are participated in different kinds of income sources such as cottage industry, trade, wages, services, remittance, pension, sand sale, driving, water mill and alcohol sale are the source of income.Watermills playsvital role in the life supporting system of the local people. Efficiency of water mills has declined due to decline in water availability in the river. Out of 16 water mills, 9 mills have closed. It has difficult to operate water mills in winter season. Some of them have to close their mills for 4 months in a year because of low velocity of water. Some new experiences like temperature raised, appearance of mosquitoes have felt in the study area by local people. After construction Kulekhani high dam downstream people always felt that they are in vulnerable. In rainy season, there is always danger of sudden flood in downstream river by the over flood of dam. It has no effective early warning system at the period of opening dam gates thus the chances of the loses has raised. In the flood of 1993, one human body has lost in Kunyutar and one house had washed-out in the lower reach (Kalleri). At the time five ropanies in lower and seven ropanies-cultivated lands in upper reach has washed-out by the flood.

Aquatic life has most affected in downstream-dewatered area. Up to 90% of aquatic life has decreased inthe river. Especially species of fishes has decreased in large scale as well as some of them have disappeared from Kulekhani river i.e. *asala, katle, bam, hile, budhuna* etc. Now-a-days fishes are hardly found in the downstream river. Fishermen who are depended on fishes are obligated to change their traditional occupation due to decreased of fishes in the river. People who are living in downstream area they are most affected and expressed some ideas for adaptation strategies that reduce loses cause by flood and landslide in future. Early warning system should make effective during the period of opening dam gates. Plantation, embankment and galving wall making etc. could control such flood and landslide. People are always ready to help to control such a problem by contributing giving money and participating as a worker as can as possible.

Conclusion

River water has diverted from Kulekhani river to Rapti basin to generate hydroelectricity in Nepal since 1982. Such type of inter-basin transfer of water has creates several socio-economic and biological consequences both in donor and recipient basin.In the case of downstream area of Kulekhani dam both positive as well as negative effects have been seen in various aspects onsocio-economic condition after river water diversion. The livelihood options of the people are adversely affected due to decline in productivity because of decline in irrigation particularly during winter season. On the other traditional water mills are either non-functioning or its efficiency is declined due to decline in water availability in the river. Before dam construction, 16 water mills were conducting but after dam construction, altogether 9 water mills have closed and remains are hardly conducting. Moreover, water mills are closed for 3-4 moths particularly during winter season in a year due to lack of running water. Downstream people are depending for water in different resources such as natural springs; tap etc. Now-a-days in some places, electric mills are being used for grinding prospect as an alternative way of water mill.

Aquatic ecosystem has also more affected after water diversion. Respondent have experienced that almost 90% fishes have decreased and some species of fishes have disappeared from the river due to lack of running water and proper breeding ground. Therefore, people have forced to change their traditional occupations who were involved in fishing activities and conductingwater mills along the Kulekhaniriver. Mosquitoes have appeared and temperature increased due to enough running water in the river.Upper reach is more affected than lower reach.Several researches have also proved that such type ofnegative impacts on socio-economic and biological conditions due to inter-basin transfer of water in other places as well.

Most of the respondents have one voice that to control or reduce loses from flood disaster some major precautions like embankment, making bridges, and plantation should take and early warning system should make effective during the period of opening the dam gates. The risk of yearly river flood has decreased because of high dam construction. On the other hand the risk of artificial uncertain flood due to high dam burst by natural or unnatural forces i.e. earthquake and during the period of opening dam gates due to overflow, as there are no enough early warning systems developed particularly at the time of opening of dam gates, the unexpected risk has increased in downstream area.

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