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Environmental Flow and River Ecology: A Case Study from Tamakoshi River Basin of Central Nepal

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Abstract

Does environmental flow (E-flow) work for maintaining the hydro-ecological regime in Tamakoshi River Basins of Nepal? The flow regime of 15 spatial and temporal locations of main and 17 tributaries was examined through the area velocity methods and Pigmy flow meter in the year 2014 and 2015. Moreover, observations and socio-economic survey of 412 household with buffer zone of 1000 meter in the either side was carried out to understand the flow characteristics along the settlements of 1000 meter (each side) of the basin. However, the Basin is in pressure due to fifteen different types of major and minor hydropower projects. Therefore, desired environmental flows need to be maintained to understand existing geo-hydro- ecological relationship associated with river side settlements. The present policy and practice of allocating 10%—flow is not feasible for the existing ecological balance and local stakeholders. There is an urgent need to develop holistic basin wise approach, and frameworks for environmental flows in the Tamakoshi River Basin.The main objective of this paper is to assess implication of ecological flow maintaining river ecology and perception of basin people. The present paper is based on the field survey of the basin 2014 and 2015, Key Informant Interviews, Stakeholder consultation.

Key words: Ecological flow, Hydropower policy, Local community, River ecology, Tamakoshi River basin.

Introduction

Environmental flows play a key role to maintain river health, economic development and poverty alleviation. They ensure the continued availability of the many benefits that healthy river and groundwater systems bring to society (IUCN, 2003). The Brisbane Declaration (2007) has defined environmental flow as quantity timing and

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quality of water flows required to sustain freshwater and estuarine ecosystems and human livelihoods and well-being that depend on these ecosystems. “Every river system has an individual or "signature" flow regime with particular characteristics relating to flow quantity and temporal tributaries such as seasonal pattern of flows. (Richeter, et al. 1996; Poffet et al.. 1997; Olden and Poff 2002). Is the environmental flow in Nepal well maintained as per government rules and regulations? What is the view of local stakeholders and strategic view on the flow regime? The research conducted byAryal (2017), Tamacho, Bhattarai (2017), Thapa (1989), Mishra Tripathi, and Bhattarai(2014), Sada (2017) Shrestha(2017) have raised issues on the E- flow and its impact on the overall river ecology . They found that the flow of the river has changed the existing system of river hydrology, affecting aquatic system and livelihood of riparian settlements. In this context, proper maintaining the flow regime of major river and augmentation flow of tributaries are major concern of the hydrological regimes of the river basins. Government electricity authority, other foreign investment companies and domestic investors have started to receive license for hydropower production for major and tributaries Rivers of the Tamakoshi River Basin.

Objectives

The aim of this paper is assess the implication of environmental flow (e-flow), in the river ecology of Tamakoshi River Basin.

Rationale of the study

The concept of ecological flow for requirement of river health and downstream riparian settlements started since 1996 with the Integrated Treaty on the Mahakali River with India. It had a provision for releasing 10 m^3/s flow for ecosystem needs. (SWECO, 2010).According to the Hydropower Development Policy in Nepal (1992) and first amended 2001 Act 6.1.1, ‘provision shall be made to release such quantum of water which is higher or either at least ten per cent of the minimum monthly average discharge of the river/stream (MOWR, 2001)

As per government rules, the Upper Tamakoshi Hydroelectric Project (UTHP) with capacity of 456 MW has adopted policy of compliance release of 1.3 m^3/s is enough for the maintenance of adequate wetness conditions to support the ecosystems. The stretch of the e-flow is about 11 km between Lamabagar to Gonger. Moreover, the additional 2 km of dewatering stretch in Rowling valley is proposed.Thus there will be 13 km of de-watering zone in Upper Tamakokoshi Project site. The Tamakoshi 3 HEP (600MW)is proposed in the middle part of theTamakoshi River Basin. The e-flow of the project is fixed at 15.25 cm^3/s, which will make dewatering zone of 20 km stretch. (SWECO, 2010). Similarly The KhimtiKhola Hydropower (60MW) which has been regulated since 2000 minimum release or E-flow is maintained at 500l/s throughout the dry season(HPL, 2002).The total stretch of dewater zone is 11.90 km. The number of fishes and its habitat has decreased inversely with its altitude after adoption of E—flow. In this way, the area of de-watering stretch is increasing in river basin with increasing number of hydropower projects (See fig.3). This is the main issue of discussion where more than 60% riparian settlements like Majhi, Bote, Newar, and other groups is getting ecological services from the flow of the water. However, there are limited research on the issues, so the researcher has carried out the study on the E-flow and its implication in the river ecology.

Methods and Materials

The water flow study was collected for two successive year during pre-monsoon, monsoon and post- monsoon period of 2014 and 2015 using area flow method. The minimum flow of the sample tributary was collected using pigmy meter(Digital counter revolution and time pre-set), model RCT 003T, current meter no 1142 and spin time was 55 seconds. The observation was made from Lapchi (3109amsl) to Tribeni (390 amsl), confluence of Tamakoshi and Sunkoshiriver.For socio-economic view, a total of 412 sample households were selected from 58 sample riparian settlements accounting for 20% (at 95% with 4% error) of the total households of 2,102 all along the river covering its I^{st} sector, II^{nd} sector, III^{rd} and IV^{th}sectors. The households by settlements were based on the 2011 population census (CBS 2012).

Methods of measuring flow of river

- Depth and velocity: The depth of the river was measured at every station by immersing a straight rod in the river. The time'‘t' required for a float to travel a known distance 'd' was observed and the average velocity was obtained by using the following equation (Punima and Lal, 2009).

$$v = \frac{d}{1.2t}$$

- Discharge: The total discharge (Q) is calculated by the method of mind-sections as follows (Subramanya, 1998):

$$Q = \sum_{t=1}^{N-1} \Delta Q\, i$$

Where,

ΔQi = discharge in the i^{th} segment.

The Figure 1 shown below is considered where the cross-section of a river is divided into N segments by N-1 vertical. The velocity averaged over the vertical at each section is known. Then,

$Q=\sum \Delta Q_j+\Delta Q_1+\Delta Q_{N-1}$ Where,

$\Delta Q1=\bar{v}\ 1\ .\Delta A_1;\Delta Q_{N-1} = \bar{v}A_{N-1}$ and j = 2 to (N-2)

Discharge except for 1^{st} and last segment;

$\Delta Q1 \quad = \Delta A_j \times V_j$

= (depth at the j^{th} segment) × $\frac{1}{2}$ *width to the left* + $\frac{1}{2}$*width to right*) × (*average velocity at jth vertical*)

$yj \times (\frac{Wj}{2} + \frac{Wj+1}{2}) \times Vj$

For, j = 2 to (N – 2)

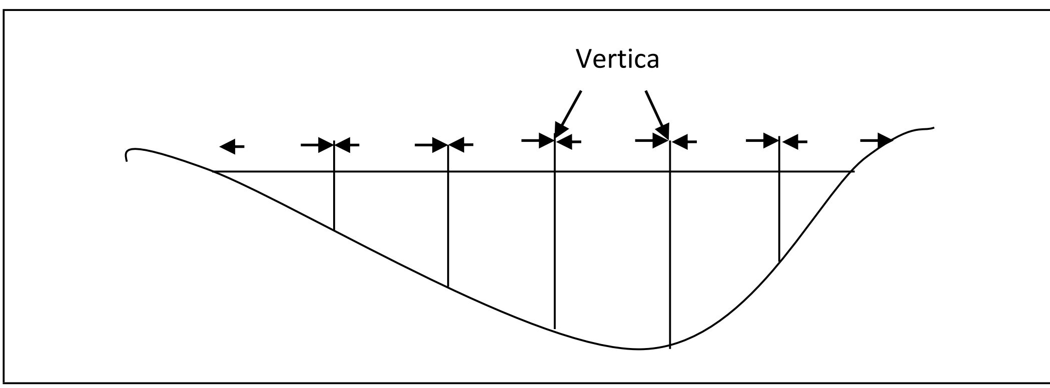
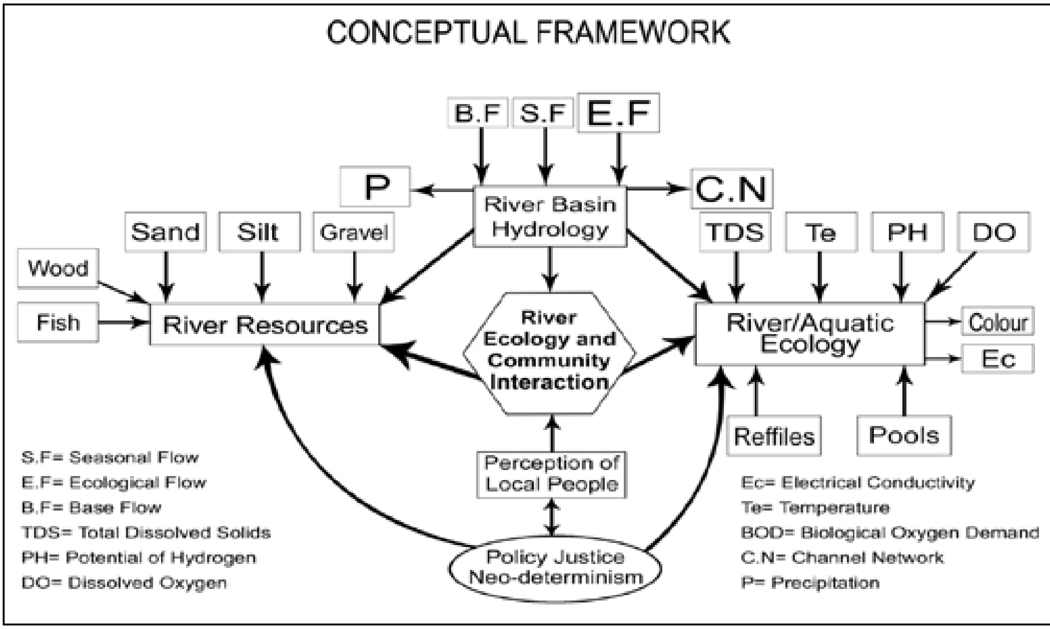


Figure 1: Stream section for area – velocity method for discharge calculation

Similarly, sedimentation was measured through direct observation and distance, width, slopes, sinuosity, power were measured through topographical sheets. The flow, width, slopes, sinuosities were independent variables where as the river power, and sedimentation was dependent variables.

The analysis of the flow data results related to the river hydrology and E- flow ecological has been performed in graphs, SPSS with reference to the relevant studies. The analysis of all data and information has been based on the four sectors: I^{st} ,II^{nd}, III^{rd} and IV^{th} of the study area.



The Study Area

Located in the central mountain region of Nepal (Figure 2.), the Tamakoshi River Basin consists of two types of relief features in terms of elevation, namely high Himalayas and lesser Himalayas, according to the physiographic divisions of Nepal (Burathoky&Malla, 1968). The elevation of the terrain rises from 380 meters at the confluence points of the Sunkoshi River and the Tamakoshi River in the south to as high as 7,117 m (Mt. Gaurishankar) to the north. The basin has been extending from the Tibetan (China) border in the north to the confluence, locally known as 'Tribenighat' in the south. The Tamakoshi is the main river and 72 feeder streams join it in the basin.The basin has a total area of 2700 km^2 out of which 50 percent lie in the Tibetan Autonomous Region of China (DHM, 2011).

For the study, a buffer zone of 1000 meters on either side (east & west) of the Tama koshi river has been defined. The study area comprised 30 local administrative units, including 28 village development committees or village areas and two municipalities of two districts–Dolakha and Ramechhāp (Figure 2). The estimated number of households of the basin were 34,812 (with a mean household size of 5.5 persons), consisting of various castes and ethnic groups, such as Janajatis (ethnic), Bahun-Chhetri, and Dalits. The Lamosangu-Jiri Road passing through the basin is the main thoroughfare, which connects with the Aranikohighway at Khadichaur linking Kathmandu Valley with Tibet. The Araniko or Kodari highway was built in 1966 and is the country's second oldest highway.

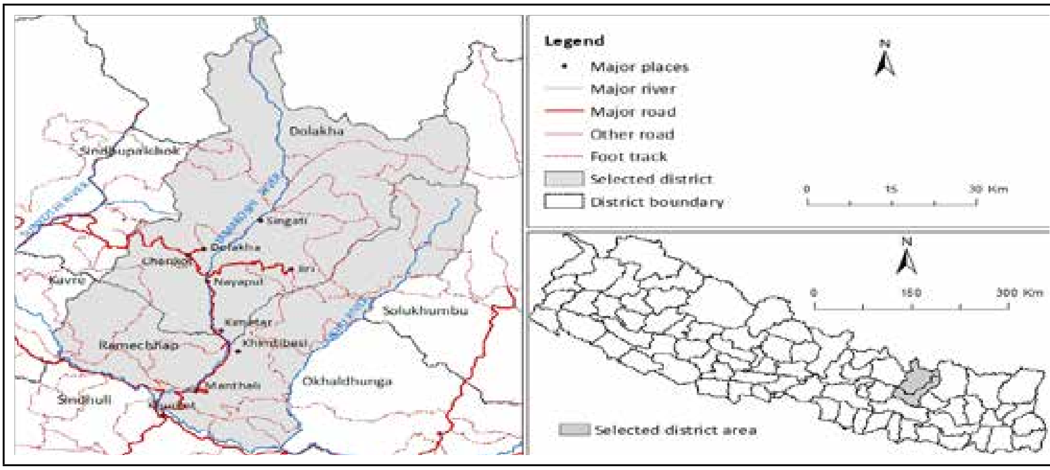


Figure 2: Location of the Tamakoshi River Basin, central mountain region of Nepal

Geographically, the study area extends from 27° 19' 00"North to 28° 10' 00" North latitude and 85° 30' 00"East to 86° 30' 00"East longitude. It's surrounded by the Tibetan Autonomous region of the People's Republic of China in the North, Sindhuli district in the South, Okhaldhungadistrictinthe East, and Sindhupalanchowk district in the West.

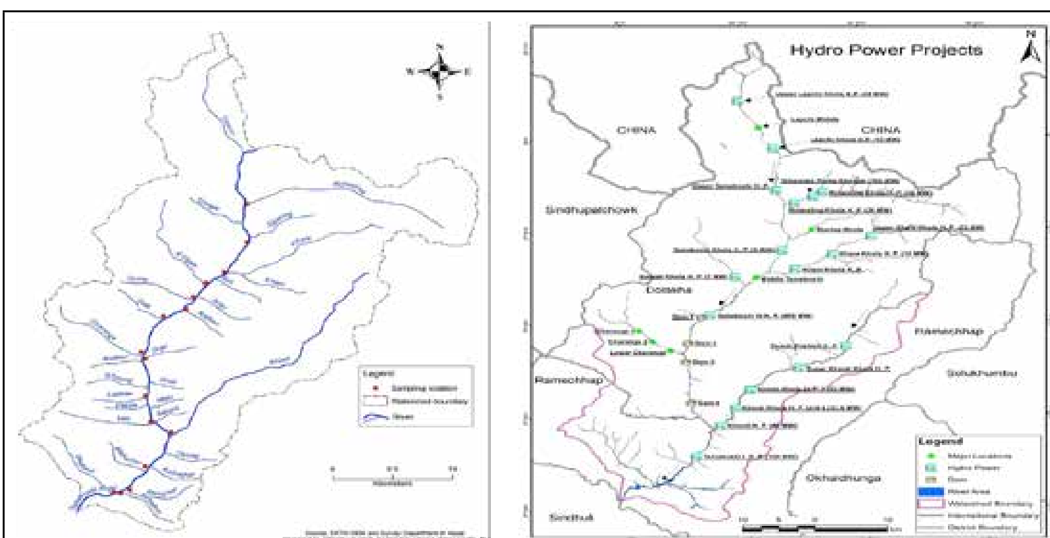


Figure 3: Tamakoshi drainage with proposed hydropower Projects

Results and Discussions

The measurement of mean discharge of the fifteen locations of 2014 and 2015 is presented in Table 1.

Table 1: Minimum flow with environmental flow in the TRB River Basin

Section	Location	Flow (m^3/s)	E – flow	Contribution by tributaries(m^3/s)
I	Lapchi	19.88	1.92	0.00068
	Lamabagar	49.10	4.9	0.00054
	Gongar	83.185	8.3	0.00003
II	Suri	120.14	12.0	0.00004
	Singati	158.59	15.8	0.0006
	Gumukhola	176.77	17.6	0.00002
III	Nagdaha	198.76	19.87	0.00002
	Nayapool	232.98	23.29	0.00015
	Malu	238.23	23.83	0.0003
	Milti	245.86	24.58	0.00002
	Khimti	258.34	25.83	0.00021
IV	Chisapani	261.33	26.13	0.00001
	Manthali	322.96	32.29	0.00001
	Masantari	320.16	32.01	0.00001
	Tribeni	258.76	25.87	0.0001

Source: Field Survey 2014, 2015

Table1 shows that the minimum flow of the Tamakoshi ranges from 19.88.m^3/s in Lapchito 258.76m^3/sin Tribeni within distance of 110 km. The corresponding flow rises from 19.88 m^3/s in Lapchi to 2558.766m^3/s in Tribeni(Table 1, Fig 2).The temporal variation of the flow during pre-monsoon, monsoon and post monsoon has been recorded 32.08m^3/s,360.04m^3/s and 67.76m^3/s respectively. The figure represents 6.9%, 78.43% and 14.71%in pre-monsoon, monsoon andpost monsoon respectively.

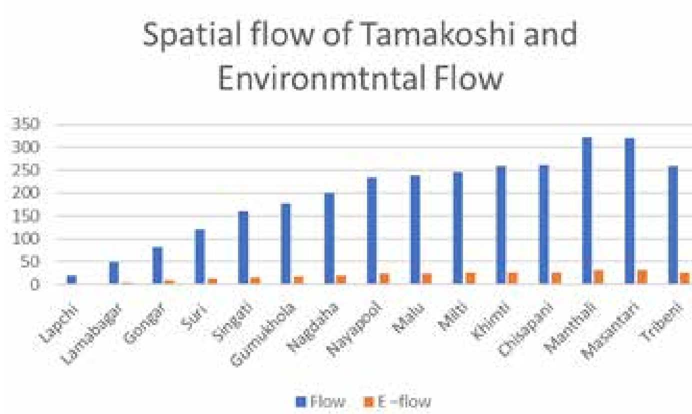


Figure 4: Spatial flow of Tamakoshi and Environmental flow

From the total tributaries, seventeen tributaries have been selected for discharge measurement in the lean flow period (April, 2014)with help of Pigmy meter. The data acquired from the measurement of the tributaries is presented in the Table 3. fig . 5.

Table 3:Discharges of Tributaries

Section I	**Name of River**	**Width(m)**	**Discharge (Q) m^3/s**	**Remarks**
1	Rolwaling	3.5	2.16	Nearbridge on way to Simigaon
2	Gongar	3.1	0.36	Upper part of Suspension bridge
3	Bhainse	2.1	0.11	Road side
4	Tinukhu	1.2	0.14	Road side
Section II				
5	Khare	11.7	2.12	200 meter from confluence
6	Singati	24.4	3.7461216	Near SingatiBazarnorth of bridge
7	GumuKhola	7.3	0.220929	Gumu Bazar
8	Dolti	4.3	0.388858	Near Nagdaha
Section III				
9	Andheri	1.5	0.0209346	Tamakoshi confluence
10	Charange	12.8	2.393952	Upper side of Charange

11	Gopi	5.25	0.58816395	Gopitaar
12	Milti	3.4	0.092676	About 150 meterabove the confluence
13	Khimti	2.5	2.13	200 metr above bridge
Section IV				
14	Mahadev	-	-	Dry
15	Bhatauli	1.4	0.03192	200 meter above the confluence of Bhatauli withTamakoshi
16	Ranajhor	2.5	0.68	100 metre above bridge
17	Sukajhor	-	-	Dry

Source: Field Survey 2014, 2015

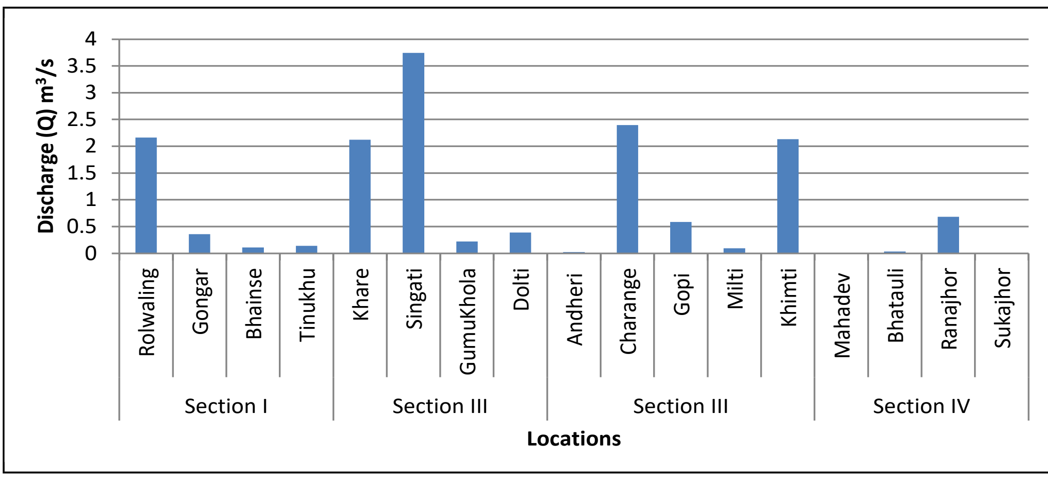


Figure 5: Discharges of Tributaries at different locations.

From the Table 3and fig 5 , it reveals that the Singati River (Sector II) has the highest discharge of 3.746m^3/s., followed by the Charange River(Sector II) with 1.393 m^3/s. Among the tributaries, the Bhatauli River has the lowest discharge which accounts for 0.03192m^3/s (Table 3, figure 4.).

The contribution of the watershed greater than one hundred square kilometer to main river basin is limited. The Rolwaling (173.5 km^2) SingatiKhola (187.4 km^2), Khimtiwatershed(302km^2), Charange Khola (212.2km2) are the bigger watersheds which contribute more than one cubic meter of water flow during dry period from the first to third sector andBhatauli (100Km^2) in the fourth section.The relationship between lean flow with its watershed has been examined through watershed coefficient floe value. The coefficient of flow (Qm^3/A) of RolwalingKhola ($0.61m^3/s$), Singati Khola ($0.15m^3/s$), Charange Khola ($0.49m^3/s$), Khamti ($0.53m^3/s$) and Bhatauli ($0.039m^3/s$) Show that the flow during the lean flow is less than the desired flow of 10 per cent. The mean distance of e-flow from one point to other point is 5 km. the main flow and its distance with respect to augmented flow has been measured with Beta Coefficient and the value of flow is only .060 only. The problem is serious in the sector IV^{th}(0.06).

The relationship between current rivers flow and cumulative distance with reference point in the river system is examined with the correlation scatter diagram techniques (fig. 4).

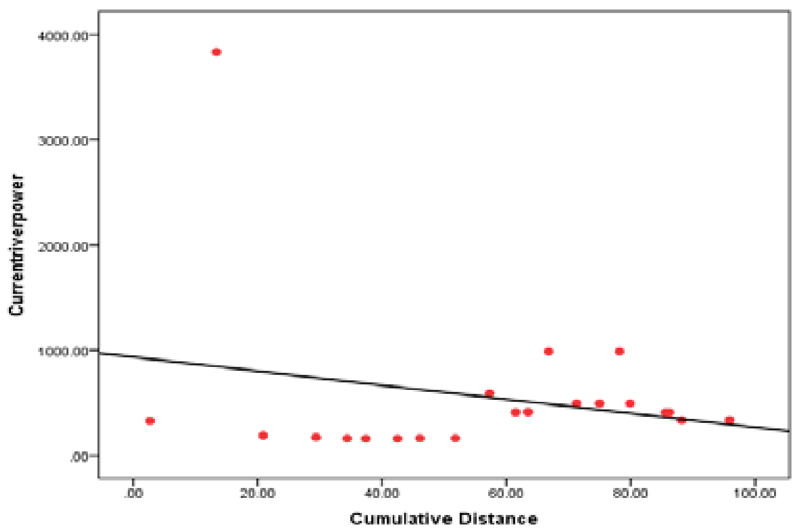


Figure 6: Scatter plot of current power against cumulative distance

For sampling data person's correlation is -.224 along with P value of test statistics t 0.329. Since, thus p value is (>0. 5) is not significant, there is no significant relationship between current river and cumulative distance.

Similarly, the significance of river discharge is measured with distance, depth and width. The significant value of depth is 0.03 (<0.5) value. So, the water depth played a significant role in the flow regime of the Tamakoshi River.

Putting all variables together in order see the effect of the variables for sedimentation, the p value of sinuosity is less than 0.5value.The sinuosity ratio has a high effect for sedimentations than other variables.

The data collected from 412 household survey. It shows that 47 percent of them are unaware about e- flow and 34% have negative impact whereas only 19 per cent of them are positive on the e-flow.

Environmental Impact Assessment is legally mandatory with amendment of Hydro power policy Act 1992, (first amended in 2001), and latest Environmental Act (2019) and Environmental Protection Rules (2020). There are more than 24 hydropower projects that are going to be built near future. The e-flow of these projects will directly or indirectly make hamper in overall hydro-ecological balance of the river basin. The above results are also supported by different studies of Nepal and abroad (Covich, 1993, Loucks and van Beek 2005, Poff et al. 1997).

Covich (1993) has shown that stream flow regimes have a major influence on the biotic and abiotic processes that determine the structure and dynamics of stream ecosystems. High flows are important not only in terms of sediment transport, but also in terms of reconnecting floodplain wetlands to the channel. Adaptation to this environment allows riverside species to persist during periods of droughts and floods (Loucks and Beek 2005, Poff et al., 1997). The system of 10 per cent has raised many controversial problems in river ecology. The changes in flow regime brings major changes in its hydro- geomorological system, river channel and many aquatic system come into problem by this. This would ultimately affect people living in the riparian zone(Personal communication with Dr. Suman Shakya, Water Ecologist, August 28, 2017, Kathmandu). The augmentation flow by tributaries is not enough to sustain the aquatic life in the downstream as most of the soil easily socks such flow easily during dry period(Personnel communication with Prof. Dr. Tej K. Shrestha, Biologist, June 25, 2017, Kathmandu).

In the international arena, it appears that rivers and associated species behave differently and there is no common standard for minimum flow needs, and thus a case specific decision has to be made (Bain 2007). The 10% minimum flow thus appears to overall have a stabilizing effect in that, with densities tending to decrease but populations are maintained. This observation supports some of the findings from international studies.This study is also similar with the study inKhimtiKhola, (Kaasa et al., 2008,Modikhola and GWP).

Conclusion

The existing flow of water in the Tamakoshi River with distance is not significant. The e-flow must be examined through entire gamut of public view also. The major flow regime is related with distance, depth, sedimentation, river power etc. The study of water depth and sinuosity should be taken into consideration during implementation of E – flow in hydropower projects for maintaining livelihood (fishing community, ecology, sand gravel mining and religious purposes) of the local people.

So, government should revisit the existing law of water flow in Hydropower policy (2001) EPA (2019) and EPR (2020). More scientific studies on the ground is needed to cope with unavoidable circumstances which will come in the nearby future by use of ecological flow (10%) in cascading hydropower projects under existing policy.

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