Sustainable development and management of water resource in mountain ecosystem: Some examples from Sikkim Himalaya

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Abstract

Water is vital for increasing the agricultural production. It is also in great demand for domestic and industrial use. Further it is an important medium for generating cheap hydroelectric power. Water is thus regarded as a resource among resources as all other resource bases have no meaning without this resource and life is not possible in its absence. The supply of drinking water to rural and urban population is another important aspect of utilization of water resource.

Introduction

The State of Sikkim is a small geographical entity located in the Eastern Indian Himalayan Mountain System. Completely landlocked and criss-crossed by green valleys, high peaks and rippling rivers the region is bounded on the north by China (Tibetan Plateau), Bhutan and Tibetan Plateau on the east, Nepal on the west and the Darjeeling Hills of West Bengal on the south. The entire Sikkim Himalaya is a part of the youngest and loftiest mountain system of the world 'the Himalaya" and hence is characterized with highly folded and faulted rock strata at many places. Covering just 0.2 percent of the country the state is characterized with formidable physical features.

General View of the middle hills in Sikkim Himalaya (photo-vimal khawas, June,)

It presents a compound landscape because the complexity of geomorphic evolution has played an important role in the development of the existing topography. Starting at the foot with a meager elevation of less than 300 meters it stretches up to as high as 8550 meters above the mean sea level. The hills rise abruptly from the plains and the elevation increases northward and northwestward. The third highest mountain ridge Mt. Kanchenjunga (8598 m) and other high elevations are located in the northwestern part of the system.

Water Resource and Development Paradigm

The last one-decade has invoked tremendous discourses with reference to misuse of water resource, over exploitation of water resource and possible threat to our future generations in this regard if this resource is not utilized in scientific and sustainable way. Truly, civilizations have been supported, controlled and directed by water resource if we glance through historical documents. The development paradigms of earlier human settlements followed the drainage patterns and surrounding watershed region. Great rivers like Ganges, Indus and Brahmaputra with their associates not only sustained the Himalayan orogeny across the geological times but also guided several civilizations right from their sources to their confluence with the ocean. The whole of the Himalayan mountain ecosystem has been sustained by these three great water systems forming their own drainage basins. Numerous small but antecedent and perennial Himalayan and trans-Himalayan rivers join these basins. These small rivers again have formed their own smaller basins where smaller streams or what we also locally called "*jhoras*" often perennial flow and ultimately join them. Thus, there is an intimate relationship and ecological linkages across various drainage channels both horizontally and vertically. We need to understand these relationships and the impact if we intervene such linkages as we proceed with our development paradigm. Sikkim Himalaya forms a part of the Brahmaputra river water ecosystem or Brahmaputra basin. The most important river of Sikkim - River Teesta along with its major tributary River Rangeet ultimately flows through the basin and join the great Brahmaputra. Teesta and Rangeet have their own basins with distinct watersheds and sub-watersheds. These rivers are not only fed by the glaciers but they also benefit from various *jhoras* that flow across their basins. Therefore, conserving and maintaining small *jhoras* becomes critical in order to maintain the volume of big rivers and the ecological linkages there in. Their conservation and optimal utilization is also crucial as they are the only source of domestic and drinking water across the villages of Sikkim and other parts of the Himalayas.

Water Resource in Sikkim: Its Importance and Environmental Concerns

Sikkim Himalaya has been bestowed with some of the outstanding natural features. Availability of water resource in the form glaciers, lakes, rivers and streams, and natural springs is one such example in this respect. Sustainable utilization of this natural endowment becomes critical in a Himalayan State like Sikkim.

River Teesta traversing down its valley in its upper reaches, North Sikkim
(photo-vimal khawas, June,04)

Glaciers and their Retreat:

Some of the prominent glaciers and the associated features of the Eastern Indian Himalayan System flank the region that makes it one of the unique regions across the Himalaya. Some eight important glaciers features the region as highlighted in the table below-

Table 1 Important Glaciers of Sikkim Himalaya

Sl. No.	Name of Glacier	District
1	Zemu Glacier	North
2	Rathong Glacier	West
3	Lonak Glacier	North
4	Hidden Glacier	North
5	Talung Glacier	North
6	North Lonak Glacier	North
7	South Lonak Glacier	North
8	Tista Khangse Glacier	North

Source: Sikkim: A Statistical Profile: 2002, 2003, Govt. of Sikkim

Almost all the important glaciers of Sikkim Himalaya are located in North district. Geographically they are located in Northern and Northwestern part of the Sikkim Himalaya. Apart from providing scenic beauty they are the water tower in the region and the controller of the whole of the hydrology and geo-hydrology and hence water ecosystem in the region. They are the sources of all the perennial rivers and streams. The peaks that support these glaciers are revered by the Sikkimese and hence regard them as the abodes of God.

Observations, by the geo-scientists, of the Himalaya have led to the detection of various rates of glacial retreat in different parts of the Himalaya. In this connection it is observed that the Zemu Glacier of North Sikkim has been retreating 8 meters per year while the Kangchenjhau Glacier in North Sikkim is behaving differently from those of the adjoining areas in recent times.

The solution of such problems is not so easy. Local steps like checking deforestation and overgrazing in the high altitude areas may not be sufficient enough to check glacial melting. This is a global problem and needs a global action. We, however, need to act in our own way to check global warming and at the same time keep in touch with other counterparts and see how they react to the problem. It is also that, all scientists associated with the geo-science should come together and work in close cooperation in the interdisciplinary problem of glacier variation with the aim of saving humanity from approaching disaster.

Glacial Retreat and Advance

Glaciers originate in the high mountains where the snow budget is positive i.e. where the winter accumulation exceeds summer ablation. In such areas snow continues to grow year after year, and when the net accumulation in an area exceeds about 50 meters in thickness, the snow gradually changes into firn and then into ice through various processes of metamorphism, crystallization, melting and refreezing etc. The snow and ice ultimately fill up the snowfield and over flow down the preexisting stream valleys as mountain/valley glaciers. The snout of the glacier invariably descends well below the snow line, the lowest limit of perpetual snow, as a contrary to some prevalent conceptions and modifies topography initially produced mainly by fluvial action. This is the process by which the glaciations in the Himalaya and other high mountains of the world took place in the past. If the summer ablation in an area exceeds the winter accumulation of snow for several years or decades in succession, then the glacier and the snowfield start shrinking. Accumulation and ablation of snow in an area depends primarily on temperature and humidity of the atmosphere. Advance and retreat of the glaciers thus results from global and/or local changes of weather and climate. Such variations therefore, may be regarded as a reflection of changes in the atmospheric conditions of the earth as well as the area where it is taking place. (Bandhyopadhyay, 1998, Geographical Review of India)

Lakes and their Pollution

Lakes are the major environmental asset of Sikkim and important geographical component of Sikkim Himalaya. They are not only part and parcel of natural resource endowment but also valuable aesthetic spots and important revenue generators to the state.

Table 2. Important Lakes in Sikkim Himalaya

	Name of lakes	District
1	Khe-Cheod-Palri (Khecheoperi)	West
2	Gurudungmar	North
3	Lam Pokhari	West
4	Changu (Tsomgo)	East
5	Laxmi Pokhari	West
6	Cholamu	North
7	Bidang Cho	East
8	Menmecho	East
9	Majur Pokhari	West
10	Sima Choka	North
11	Dud Pokhari	West
12	Samiti Lake	West
13	Ram-Laxman (twin lake)	West

Source: Sikkim: A Statistical Profile: 2002; 2003, Govt. of Sikkim

More than 10 natural lakes feature Sikkim Himalaya. They are the major storehouse of water and significantly contribute to the stability of water ecology in the region. Further, they are open to the natural tourists, and thus also contribute to the revenue generation of the state.

This valuable resource zone has been degrading with time. Unsustainable utilization of this natural entity through tourism, human habitation and livestock grazing in and around Lake Ecosystem has led to pollution impacting the quality of lakes. Plastic bags, biscuit covers, excessive human and livestock refusals etc are the major cause of concern that need urgent attention. In this connection mention should be made of the Changu Lake just six kilometers below the Nathula Pass and attractor of a major chunk of tourist population. This lake and its surrounding is observed to be sustaining tourism traffic more than its carrying capacity. As a result, the lake is heavily polluted with the plastic glasses, biscuit covers, polethene bags, human and animal excreta and other refuses.

River Ecology and Associated Features

Sikkim Himalaya is characterized by two important river systems namely, Teesta and Rangeet River Systems. These great Himalayan Rivers have over the period of time created their own watersheds and sub watersheds. Numerous small streams, channels and rivulets flow along their basins and join them at lower reaches. Such network of the river systems in Sikkim Himalaya has played their own role in maintaining the over all ecology in the region and have crucially influenced the economy of the Sikkimese since historic past.

Table 3. Major River Systems in Sikkim

	River System	Major Tributary
1	Rangit	Rangbhang, Relli, Rathong and Lalej
2	Tista	Dikchu, Rangyong, Bakchachu, Rongpochu, Zemu Chu, Lachung Chu

Retreat of the glacial stock due to unnatural melting negatively impacts Himalayan River Ecosystem as the volume of the snow fed rivers gets affected in the long run. In the short run it invokes numerous natural hazards like Glacial Lake Outburst Floods, Soil Erosion, River Floods and Landslides. Such process has started getting noticed in the river ecology of Sikkim Himalaya. Further, small streams that feed the large rivers are drying up more recently due to excessive deforestation in and around the major watersheds of the region. This has not only affected the volume of the major rivers but also impacted the delicate relationship of flora & fauna and human habitation mainly the livelihood of the poor rural hill folks, in the area.

Small streams are drying up with time and many have already dried up

(photo- vimal Khawas, June, 04)

Table 4 Places threatened by River Erosion

North District	East District	West District	South District
Mangan	Ranipool	Legship	Melli
Lachung	Singtam	Dentam	Jorethang
Chungthang	Sirwani	Reshi	Majhitar
Dikchu	Rangpo	Rimbi	
	Rorathang		
	Rongli		
	Saramsa		

Source: Irrigation and Flood Control Dept., Govt. of Sikkim

Vanishing Springs

Springs are the most obvious attributes of Himalayan geo-hydrology and the source of domestic and drinking water to the hill folks. Further springs have been the important indicators of the status of underground water and water table across the elevated land systems. Thus the number of springs increases during the monsoon season and decreases during the drier period. Sikkim has always been known for its thermal springs, which are found all over the state. These waters have great therapeutic value because of the presence fluorine and sulphur. Several seasonal springs surface during the peak rainy season. Locally known as "*mulphutnu*" they have always been a major source of domestic and drinking water in both rural and urban areas. A simple geomorphic explanation of *mulphutnu* is the gradual rise of the water table due to the seepage of rainwater underground for many days together. As the water table rises, it finally hits the rock surface or other outlets and oozes out through a fractured area, weak surface points or any form of outlets serving as a good and potable source of water for three to six months. However, there may be perennial springs that serve as the source of drinking water for the whole year.

Such phenomenon has now been rare. This traditional and renewable source of water particularly in the dry period of September to April is fast vanishing, especially in the urban areas. Their extinction is largely attributed to deforestation and the destruction of other ground vegetation, which in turn has resulted in soil erosion, poor seepage of rainwater and recharging of the groundwater.

Natural springs have been the traditional source of drinking and domestic water. They are vanishing with time

(photo-vimal khawas, June, 04)

Conservation and management of Water Resource

The above discussions lead us to the importance of planning environmental strategies at a regional level in order to prevent the further degradation and sustainably develop our water resources. Further, there is a pressing need for conservation of water resources as it is the most important element in the biosphere since it sustains all sorts of life on the earth.

As the first step towards this end following measures may be taken by the state-

- Educate the masses about the causes of degradation, depletion, pollution of water resource and resultant future threat along with the methods of preventing such catastrophe
- Individuals (including tourists) and communities must be restrained from throwing human and animal excreta and refuse into the water bodies
- The urban areas must arrange for proper sewage treatment plants and reduce water pollution
- Strict laws should be passed to punish those who indulge in water pollution
- Promote conjunctive use of water resource
- Increase infiltration with the help of plantation- it will help check soil erosion and desertification of soil as well
- Do not encourage the spread of human habitation/urbanization in the sensitive catchments of the rivers.
- Revive and maintain the positive points of traditional water harvesting practices

Traditional Water Harvesting in Sikkim Himalaya

The local people of Darjeeling and Sikkim himalaya have over the years evolved efficient water harvesting systems together with their traditional land management systems. Construction of water channels, regulation of water flow and drawing of drinking water were traditionally organized as community enterprises. Common traditional sources of drinking water are natural springs (locally called dhara, pandhera etc), and streams locally called jhoras or kholas. The locals have traditionally evolved an ingenious method of transporting water from these sources to their houses by using bamboo poles. However, in recent years, rubber pipes have replaced most of these bamboo channels.

Irrigation is mainly confined to rice fields (locally called Khet) and cardamom plantations. In rice fields irrigation is done on man made bench terraces located near the streams or natural springs from where the water is diverted with the help of small artificial channels locally called Kulo or in some case with the help of bamboo pipes. In the case of cardamom irrigation water is allowed to flow without proper distribution channels. Cultivation of wet rice in Sikkim is based almost entirely on artificial irrigation. The irrigation cum drainage channels run across the terraces and often serves as field boundaries.

Due to very high rainfall surface run off is abundant. But due to a very steep gradient it is difficult to store the water. Moreover, the physiography of the region is such that the major perennial streams flow through deep gorges, which makes the damming of these streams very difficult. Farmers tap only those streams, which have high heads by drawing channels from a high point. (CSE, 1995, The Dying Wisdom, with additional inputs)

Further, in view of the ecological and other associated constraints attention be paid to meet the challenges of water shortage resulting from environmental degradation in the state. It is essential to think globally and act locally. The management of water resources need to be taken with reference to the over all-regional development of the state and not by project basis. For this purpose, the management and development has to be planned in terms of viable planning regions such as river basins or watersheds and should be linked to a national plan over time and space. Further, the water resource planning has to be linked with the total socio-economic planning. For instance, it is impossible to develop urban or rural water supply unless it is integrated with total urban-rural development. For socio-economic development of the area more attention should be paid towards those areas where resources have been rapidly depleted.

It is essential to inspire the society about the importance of resources, its preservation, restoration and rational use. It is also necessary to give knowledge about interaction and effect of natural resources on mankind. It is essential that geomorphologic mapping and hydrological system analysis of the state be started on systematic and scientific basis. A planned and integrated

development of this vital element of the state will help to solving the problem of drinking water in future without environmental degradation.

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Notes to readers

This paper is an outcome of the author's one-month field visit in the state of Sikkim and its villages during the month of April 2004 in regard to the State Development Report-Sikkim.

The author is a young development consultant and researcher who has been associated with many development projects in Darjeeling and Sikkim Himalaya including the report above and a study pertaining to the revival of Indo-Chinese Trade Linkages.