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A Study of Climate Change in Himachal Pradesh

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ABSTRACT

The natural ecosystem in the north western Himalayas has experienced dramatic changes over the past fifty years. It has been observed that each degree rise in temperature would displace many land species tolerance limits to nearly 125 km toward poles. The drier and warmer weather will ultimately result in shorter growing season and lesser crop yields which will adversely influence the livelihood of millions of people.
Keywords: Climate Change, Himachal, Daily Life, Citizens

I. INTRODUCTION

The climate change is one of the eighth missions of National Action Plan of climate change towards green. The climate has always been changing and species and ecosystem have responded to these changes and adapted at rapid rate to the changed climate. The trend has been of concern to the global community. Developing countries are most affected from the negative consequences of global warming although they have contributed relatively little to the cause of global warming. The climate change is seriously affecting and altering the distribution, quality of natural resources and the associated livelihoods of the people. The demand for drinking water and for irrigation is increasing due to this change in climate increasing competition and conflict between the rural, urban and the industrial users.

This may lead to sustainability crises for requirement of food, fodder and fuel wood. Change in temperature and rainfall pattern may alter the distribution of disease vectors carrying malaria, dengue, diarrhea, bird flu etc as well as rodents and other pest problems. Bio-indicators Bio-indicators evidenced change in climate in the Himalayan region as it is warming at a higher rate than the global average rate. As a consequence many important forest species are likely to fail to regenerate if the synchrony between their seed ripening and commencement of monsoon rains is broken due to climate change. Although earlier studies conducted indicate changes in plant phenology over the advancement of flowering in Rhododendron arboreum and movement of species (like Tagetis minuta, Lantana camara and Eupatorium sp) to higher ridges may be the earliest response to moderate climate change (Moza and Bhatnagar 2005, Maikhuri et al 2003, Joshi 2011). The climate change adaptation and mitigation are meant to enhance ecosystem services like carbon sequestration and storage (in forest and other ecosystem), hydrological services and biodiversity along with provisional services like fuel, small timber and NFTPs. There is also need to put in efforts to develop new strains/varieties of food crops which could counteract the adverse effects of heat, drought, growing period, erratic rainfall pattern etc programmes for efficient utilization of water and soil resources in addition to minimize green house gas emission. Thus keeping in view the aforesaid effects of climate studies have been undertaken with the key innovations designed for climate change from Shivalik hills to alpine desert in Himachal Pradesh with the aim to observe adapted domestic biodiverse species and hydrological remedial services in different zones based on the focus of past experience of the inhabitants.

II. EFFECT OF CLIMATE CHANGE

India has been and will continue to be severely impacted by climate variability precisely at a time when it is confronted with huge development imperatives. The focus of climate change action cannot just be on emissions but must equally address the important issue of adaptation. India is already subject to a high degree of climate variability that is manifest in droughts, floods,

and other extreme weather events. The government's 11th Five Year Plan (FYP; 2007-2012) clearly articulates the impact and implications of climate change noted in the IPCC Assessment Reports.

Based on the recommendations of the NAPCC, eight National Missions have been established; each of the Missions will be managed by the respective Ministries and line agencies through inter-sectoral groups including related Ministries, Ministry of Finance, Planning Commission, and experts from industry, academia, and civil society.5 Each Mission is preparing detailed implementation plans under the 11th FYP and 12th FYP (2012-2017). In this context, measures for the conservation of mountains have been specifically envisaged. Of the eight National Missions, the National Missions for Himalayan Ecosystems under the Ministry of Science and Technology, the National Water Mission under the Ministry of Water Resources, and the National Mission for Agriculture under the Ministry of Agriculture are of special relevance to the study

2.1 Water

The impact of climate change on monsoon, a big source of fresh water as natural resource was declining as the analysis of the respondents revealed that climate change had been causing lesser rainy days during monsoon months even though overall precipitation levels were constant. The main uncertainty regarding climatic change was the sensitivity of monsoon regime against the changes in global climate. The biggest demand generator of water would be agricultural sector as it is reeling under global warming.

2.2 Land use and crop productivity

The demographic profile of Himachal Pradesh is changing at a rapid pace and more population is expected to live in urban areas due to industrialization. The viable land use pattern and crop productivity in the changing scenario of different agroclimatic zones of the state were enumerated like untimely rainfall and less moisture in soil would shift the sowing and harvesting time of crops as observed in all the zones.

2.3 Snow and Glaciers

Various studies and estimates of the state of the glaciers have been prepared. One of the most recent studies for Himachal Pradesh in 2004 has documented that there are 2,554 glaciers in the state.11 Covering an area of 4160 km^2 , these high frozen reservoirs release their water at the top of the watersheds. The glaciers plus the seasonal snow cover serve as the perennial sources of rivers that wind their way through grazing, agricultural, and forest lands, and are used as renewable sources of irrigation, drinking water, energy, and industry for Himachal Pradesh as well as the downstream plain states of Punjab, Haryana, and Uttar Pradesh.

2.4 Rainfall

The study demonstrates that the glaciers are retreating in the face of accelerated global warming. While it may be difficult to ascertain the precise pace of glacier recession, there is robust scientific evidence that glaciers are being affected by global warming. The glaciers are particularly vulnerable to climate change and the resultant long-term loss of natural fresh water storage will have as yet uncalculated effects on communities downstream. More immediately, as glaciers retreat, glacial lakes form behind some of the now exposed terminal moraines. Rapid accumulation of water in glacial lakes, particularly in those adjacent to receding glaciers, can lead to a sudden breaching of the unstable dam behind which they have formed. The resultant discharges of very large amounts of water and debris - a glacial lake outburst flood or GLOF - often have catastrophic effects downstream.

2.5 Surface Water Resources

The state is drained by nine river systems.

The Satluj: The largest river system in the state with a total catchment area of 20,398 km^2, spread over the districts of Lahaul and Spiti, Kinnaur, Shimla, Solan, and Bilaspur before entering Punjab, it enters the large Bhakra dam.

The Beas: Originally known as the 'Vipasa', this is the second most important river with a catchment area of 13,663 km^2 . It originates at Beas Kund near the Rohtang pass. It flows from North to South west over a distance of 286 km before entering the Pong Reservoir and into Punjab.

Table 1 *Summary of Glaciers in Himachal Pradesh*

Bara Shigri the largest glacier in Himachal Pradesh. It is located in the Chandra valley of Lahaul and it feeds the river Chenab. Bada Shigri glacier is more than 25 km. long and about 3 km. wide. It lies on the middle slopes of the main Himalayan range. It is fed by many small tributary glaciers. It is said that this glacier formed Chandertal lake which caused major havoc in Chandra valley in 1936. There are a number of prominent glaciers in Chandra valley in Lahaul. Some of them are Chhota Shigri (means Small Glacier), Kulti, Shpting, Pacha, Ding Karmo, Tapn, Gyephang, Bolunag, Shili and Shamundri. Gyephang is the chief deity of Lahaul valley and the Gyephang glacier is named after him. It is full of snow all the year. It is considered as the Manimahesh of Lahaul.
Chandra Glacier falls in the Lahaul - Spiti district. It is located on the slopes of the main Himalaya. It has been separated from Bara Shigri glacier. This glacier is behind the formation of Chandertal lake, which is surrounded by snow and acres of scree. This deep blue-water lake has a circumference of 2.5 km. It is also called the 'Lake of the moon'. It remains completely frozen during winter. Chandertal lake is the source of the river Chandra.
Chandra Nahan Glacier located on the South-Eastern slopes of the main Himalaya in the area to the North-West of Rohru in Himachal Pradesh. Chandra Nahan Glacier is also aided by various small tributary glaciers. The famous Chandra Nahan lake lies in it and it feeds the river Pabbar. The elevation of Chandra Nahan glacier is more than 6,000 meters.
Bhadal Glacier is located on the South-Western slopes of the Pir Panjal range in the Bara Banghal area of Kangra district. It feeds the river Bhadal, which rises from the snowy range of the area lying between the Pir Panjal and Dhauladhar ranges. Bhadal river's catchment is made up of U-shaped valleys, waterfalls, moraines, cirques, and towering peaks. This river is one of the main tributaries of the river Ravi.
Bhaga Glacier is located on the slopes of the main Himalayan range in Lahaul area. This glacier feeds the river Bhaga. U-shaped valleys, waterfalls, glaciers and moraines characterise the upper catchment of the Bhaga river. The discharge of this river increases during the summer months when the snow on the high mountains start melting. Bhaga glacier is 25 km. long. The other important glaciers of Bhaga valley are Lady of Keylong, Mukkila, Milang, and Gangstang.
The Lady of Keylong is situated at an altitude of about 6,061 meters and can be seen clearly from Keylong. It remains covered with snow throughout the year. In the middle, there appears to be a dark bare patch that looks like the figure of a woman, walking with a load on her back. It is therefore, named 'Lady of Keylong' by the geological survey team of India.
Mukkila Glacier: It is situated at a height of about 6,478 meters. **Sonapani:** About 6 km. from the confluence of Kulti Nala. **Gora Glacier:** It has receded in the recent past due to an unstable mass balance. It lies in the South, facing the main Himalayan range. **Perad Glacier:** Small and easily accessible, this glacier is near Putiruni. **Parbati and Dudhon:** These glaciers are located in district Kullu. Both glaciers are 15 km long. They feed the Parbati river. **Beas Kund:** It feeds the river Beas and is located on the south facing slopes of the towering Pir Panjal near the Rohtang Pass.

The Chenab: Also known as the Chandrabhaga, it is the largest river in terms of water volume. Its catchment area is 7850 km^2 . The Chandra and Bhaga originate on opposite sides of the Baralacha at an elevation of 4891 m. It flows North West before entering Kashmir. The Yamuna: In the south eastern part of Himachal Pradesh, the Yamuna is fed by a number of tributaries before flowing into Uttar Pradesh.

The Ravi: This River originates from an amphitheatre type basin in the Dhauladhar Range, turning southwards cutting a deep gorge through the Dhauladur hills. The Ravi stretches 130 km before leaving the state into Punjab and Pakistan.

Table 2 *Summary of Glaciers in Himachal Pradesh*

	Basin	Number of Glaciers	Area (km^2)	Ice reserve (km^3)
1.	Beas	358	758	76.0
2.	Ravi	198	235	17.0
3.	Chenab	681	1704	187.0
4.	Satluj	945	1217	94.0
5.	Tsarap Chu	250	163	8.0
6.	Taklingla	55	32	1.4
7.	Bhagirathi	43	43	2.4
8.	Pabbar	24	6	0.2
	Total	**2554**	**4160**	**387.0**

Table 3 *Catchment Area of River Systems*

	Name of River System	Catchment Area (km²)	Percent
1.	Satluj	20,398	30.7
2.	Beas	13,663	24.5
3.	Chenab	7,850	14.2
4.	Yamuna	5,872	10.6
5.	Ravi	5,528	9.9
6.	Indus	1,450	2.6
7.	Markanda	360	0.6
8.	Ganga	290	0.5
9.	Ghaggar	262	0.5
	Total	**55,673**	**100.0**

2.6 Groundwater Resources

Most of the areas of Himachal Pradesh are hilly except for some intermountain valleys. These valleys consist of alluvium, fluvio, and fluvio-glacial deposits. There are five major valley areas covering a total of 120,000 ha. Apart from these, there are numerous valleys with areas so small that no quantitive assessments exist.16 In the five major valleys, groundwater occurs under unconfined to confined conditions; discharge varies but normally in the range 15-25 l/sec with transmissivity up to 2000 m2/day. Minor aquifers also exist in the rock sedimentary zones or fault zones in hard rock. Groundwater is sourced through either tubewells or springs. Springs exist in many areas where favourable conditions exist mainly along the structurally weak zones; springs are a major source of water supply in the state.

Overall groundwater development is estimated to be 31 per cent of the potential. In district Una, development is however, up to 62 per cent of potential. Estimates by the Central. Groundwater Board indicate that in all five valleys, groundwater extraction remain below the maximum sustainable levels. Under climate change conditions, the projection is that the annual rainfall will fall in more intensive storms resulting in increased runoff and lower levels of infiltration to support groundwater recharge. Groundwater in the valleys would however, get recharge from both the rivers and rainfall. Quantities of extraction and groundwater levels require to be monitored carefully. However, the Groundwater. Development Board estimates that some further limited expansion of groundwater would be sustainable. The Departments of Agriculture and Rural Development are constructing concrete check dams in some tributary creeks to improve groundwater recharge. Many of the creeks are in fairly impermeable geology which is good for storing water but limit the amount of groundwater recharge. It is understood that there are plans to construct a sub-surface dam in the Beas river in Hamirpur district which could increase the potential for extraction from shallow groundwater in the river bed gravels.

III. CONCLUSION

The shift in scenario of farming community in cultivating crops due to the direct impact on hydrological services in the experiences of the respondents outlining changes in climate in their immediate environment led to adaptation strategies of the species as a bio-indicator of climate change. This trend regularly needs to be monitored in the interest of the farming community in understanding the shift towards climate change based on hydrological services as well as land use and crop productivity pattern.

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