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RESEARCH ARTICLE

CLIMATE CHANGE IMPACT ON WATER RESOURCES AND SUSTAINABLE ADAPTATION STRATEGIES IN SOUTH SIKKIM: *A STUDY OF RAVANGLA-TINKITAM RURAL AREAS*

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ABSTRACT

Climate change is a serious environmental concern not only at global level but regional and local level too. It is primarily caused by the increasing up of Greenhouse Gases (GHGs) in the atmosphere due to increase negative human interference to the environment which cause impact on the changes in temperature, precipitation, increase the rate of melting glaciers, increase in sea level is an emerging issue. Water is an essential resource to maintain ecological balance, sustain livelihood and economy. It serves as the fundamental link between the climate system, human society and the environment. Depleting prime recourses, frequently drying up natural spring, lakes and ponds are the serious concern of local communities. Climate change has substantial impact on both water resources demand and availability. Adaptation is an adjustment in human and natural systems in response to actual or expected climate stimuli or their impacts that moderate harm or exploit beneficial opportunities (IPCC 2007). Sustainable Adaptation techniques are the only weapons to cope up potential impact of dynamic behavioural challenges caused by the climatic elements.

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INTRODUCTION

South district of Sikkim is located at the latitude 27° 10' N and longitude 88° 22' E. The total geographical area of the district is 750 Sq. km. It is sandwiched between East, West and North district in respective directions and West Bengal in the Southern direction. It has high range of altitude gradient as it offers very diverse climatic variation from tropical to alpine climate and thus has a wide range of ecological conditions. The district is a central part of the catchment areas of major rivers of Sikkim which forms right and left bank tributaries of river Tista and Rangit respectively. The rivers are perennial in nature which is fed by both snowmelt water and rain water. Only 11 per cent of the total geographical area is at an altitude of a little less than 2,000 metres and is available for cultivation. The total population of south district is 146850 wherein male 76670 and the female 70180, the total number of rural and urban population is 125651 and 21199 respectively. The density of population is 19.8 persons/ km which are slightly higher than to state's density of population (DESME, 2013). Over 60 per cent of the rural population is directly or indirectly dependent on agriculture and allied sectors while the rest depends on the manufacturing and service sectors for a living.

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Rice, maize and buckwheat, are the main agricultural crops grown through terrace cultivation and channel irrigation. The average productivity is much below the national average due to the lack of modern techniques, constraints of the mountainous terrain and poor infrastructure related to irrigation, input supply and market support (Sikkim HD report 2014).

Climate Change Impact and Water resources in South Sikkim

Climate change is one of the main driving forces of change for water resources. Dynamic behaviour of natural resources such as water flora and fauna stands as priority evidence to changing pattern of climatic condition. District wise projected increase in temperature for the period 2021-2050 for Sikkim shows that the temperature will rise by greater then 2˚C in South Sikkim district (Data from the HadCM3 GCM, downscaled by PRECIS model). The potential unprecedented dynamic behaviour of surface temperature will more impact to sustain rural livelihood economy. The water resources totally based on the monsoonal summer and winter rainfall, the areas is absence of high mountainous range and hence does not have any permanent glaciers. Tendong and Mainamla hill are the top two hills wherein winter (Jan-Feb) seasonal precipitation were in the form of snow flakes, the pattern of this precipitation has been changing since from (10-20 yrs) as based on personal and local communities observation.

Therefore, perennial sources of water resources are no more sustaining in this region. The region has experienced change in the monsoonal pattern of rainfall, which is the only source for sustain our diversity and economy. The season-wise rainfall data of past 30 years shows that decrease in both number of rainy days and quantity of rainfall during winter was comparatively higher than during monsoon season. The number of rainy days has decreased at the rate of 4.50 days/30 years (0.15 days/year) during winter, whereas the decrease was higher during monsoon period i,e 8.10 days/30 years (0.27 day/year). The average seasonal rainfall has decrease at the rate of 53.43mm/30years (1.78mm/year) during winter, whereas the decrease the decrease was higher during monsoon period i.e. 139.01 mm/ 30 years (4.63mm/year). Although the decrease of rainy days and rainfall was much higher during monsoon period than winter, due to continuous rain the decrease was not felt and vice versa in winter. Nonetheless, the region has experiences changes in rainfall pattern, heavy shower of rainfall for short duration leads to high surface rainfall and low infiltration and percolation. Therefore, minimum underground recharge of aquifers leads to frequently drying up natural spring, lakes and ponds in the district. Increase phenomena of drought, extreme events, failure of crops, growth of population, acute shortage of drinking water, etc are the serious concern of mankind in the areas.

MATERIALS AND METHDOS

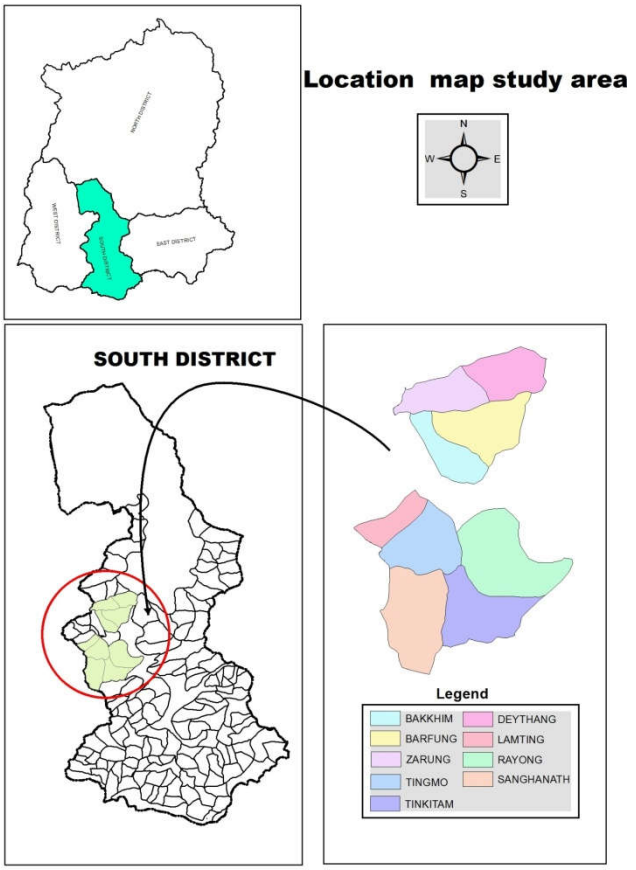
The present research work will be based on both primary and secondary data. Primary data will be acquired through a detail field survey in the Ravangla - Tinkitam rural areas (Questioners method). Selection of villages is according to altitude and drought prone areas of South Sikkim mapped by SSAPCC, 2011. Secondary data generated through published books, journals, and reports.

Objectives

- The main objective of the survey is to understand the impact of climate on water resources and potential impact of climate change and to frame out sustainable adaptation strategies.
- It is also aimed to understand the adaptive capacity and traditional knowledge practices of local communities towards the ongoing climate change to sustain their water resources.

Study Areas

Ravangla-Tinkitam Rural AreasRavangla-Tinkitam is located in south district of Sikkim. Geomorphologically, it consists of steep to gentle slope in the higher and lower altitude villages respectively. Altitude ranges from 500 - 2000 mtrs above from the mean sea level. The vegetation cover extends from Minimum Vegetation in the lower villages viz. Jarong, Ranek, Lower Tingmoo, Lamateen, Lower Lingyong to Dense Vegetation in some pocket of viz. Mainnam, Barfung, Dethang, Tarname, Rayong. Well define dendritic pattern of drainage system is formed by the perennial and ephemeral streams and rivers. Climatically it ranges from Tropical to Alpine according to its height and vegetation cover. Demographic it is consists of Bhutia, Lepcha, Chettri, Bhaun, Rai, Manger, Limbo, Sherpa, etc. Most of the inhabitants are dominated by the primary activities like horticulture, agriculture dairy farming, etc.



Around 12-15 percent of the population are engaged in secondary and tertiary activities like business, private and government services etc. The region is blessed with high density of cultural and physical features.

Climate Change Impact

Most of the inhabitants are dominated by the primary activities like horticulture, agriculture dairy farming, etc. Around 12-15 percent of the population are engaged in secondary and tertiary activities. Agriculture is mostly dependent on the monsoonal source of water, frequently drying up natural spring, lakes and ponds (*Dhara, Kuaha, Padehro, Kholsa, Mauhan) were the serious impact to their economic activities. Increase in surface temperature, extreme events, change in rainfall pattern, etc. are some of the emerging problems felt in the households in the surveyed villages.

Locally called natural springs

Depleting water resources and influencing climatic impact moreover got enough evidence from the above mentioned table. The main cash crops of the surveyed areas are ginger, maize, vegetable, large cardamom, orange, pulses, etc. The production levels were also directly depends upon the climatic condition of the areas. In fact, the production of crops has been fell down especially ginger in the surveyed village, ginger is replaced by the large cardamom but the acute shortage of water is an emerging an important problems to sustain their livelihood economy.

Modern Adaption Strategies in the Surveyed Village

Adaptation techniques more or less help in enhancing their ability to cope up with the climate change impact. Some of the modern mitigation and adaptation strategies measures taken by the local communities supported by the local government and non-governmental organisation are as follows:

Table 1. Showing Decade-wise and season-wise changes in rainfall pattern at Sikkim

Season/Rainfall Details	Pre-monsoon (March-June)	Monsoon(July-October)	Winter (November-Feb)
Rainy days			
Mean 1981-1990	64.60	77.30	11.60
Mean 1991-2000	66.50	83.50	12.20
Mean 2001-2010	71.90	75.40	7.70
Decade-wise increase/decrease in rainy days			
1981-1990 to 1991-2000	1.90	6.20	0.60
1991-2000 to 2001-2010	7.30	-1.90	-3.90
1981-1990 to 2001-2010	5.40	-8.10	-4.50
Rainfall (mm)			
Mean 1981-1990	1344.93	1491.80	118.91
Mean 1991-2000	1411.97	1680.09	165.64
Mean 2001-2010	1426.73	1541.07	112.21
Decade-wise increase/decrease in rainfall (mm) days			
1981-1990 to 1991-2000	67.40	188.29	46.73
1991-2000 to 2001-2010	81.81	49.27	-6.70
1981-1990 to 2001-2010	14.76	-139.01	-53.43

Source: Climate Change in Sikkim, IPR, Govt. of Sikkim

Table 2. Showing the Responses of Climatic Elements in Percentagewise in the Surveyed Household

Rainfall	More	Less	Winter less	Summer more
	40	60	80	60
	More frequent	Less frequent	Winter more	Summer less
Forest fire	80	20	80	20
	More frequent	Less frequent	Winter more	Summer more
Landslide	80	20	05	95
	Increase	No change	Winter more	Summer more
Surface temp.	90	10	10	90
Rainfall	More change	No change		
Pattern	80	20		
	More frequent	Less frequent	Winter more	Summer more
Drought	100	00	90	10
	Drying up	No changes	Winter drying up	Summer drying up
Water sources	100	00	100	00

Source: Field Survey

- Ground water development and management strategy.
- Construction of reservoirs, irrigational canals, tank, water supply through pipe lines and judiciously use of water resources.
- Planning and applying new investment in 'Dhara Vikash Yojana' Spring Rejuvenation Programme in *Dethang, under Jarrong-Bering, Gram Pnchayat Unit.
- Rain water harvesting can be adopted by the villagers.
- Plantation in catchment areas.
- Awareness programme through media and institutions.

Name of the village

Indigenous Sustainable Adaptation Strategies in the Surveyed Village

Native technique to cope up with ongoing climate change impacts on their livelihood are as follows:

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- Protection and conservation of water and forest resources are organized through practising native cultural and traditional beliefs such as *Devithan Puja, *Sansari Puja, *Naag Sthan, etc.
- Construction of irrigational canals locally known as 'Kullas' by using local materials such as bamboo, bark of banana plant.
- Plantation of locally called '*Pani Sajj,* Dhodray,* Karah' in the catchment areas to sustain water source.
- Changes in the livelihood activities, such as agricultural to allied activities.

Migration

- local beliefs & practices.
- Names of local vegetation.

Conclusion

Himalaya is a source of countless perennial rivers, the mountain people who depend mostly on spring water. The Main challenge in ensuring rural water security in mountainous areas is to revive the spring which are drying up and also becoming seasonal. The impact of the changing climate is probably the greatest challenge that humanity faces in the 21st century. It has resulted in the changes in the weather pattern over the last few years in the State. Some of the changes which have been observed include: unreliable weather pattern-the autumn season has extended and winter have become dry; extreme climate events have become more frequent, rainfall pattern have become erratic, monsoons are usually late and in general torrential rainfall has replaced the monsoon drizzle. This has increased the surface runoff and dry period during winters, resulting in a higher incidence of forest fires and drying up of springs and many of them have started becoming seasonal. (IPR, Govt of Sikkim, 2013). Community Based Adaptation is an integrated approach to improve the capacity of local communities to adapt to climate change that combines traditional knowledge with innovative strategies that not only address current vulnerabilities, but also build the resilience of people to face new and dynamic challenges to protect and sustain the ecosystems that people depend on for their livelihoods.

Many governmental and non-governmental organizations, scientists, researchers, policies maker, etc. at various level has been dedicating for the adaptation of climate change. Local traditional adaptation technique should be encourage and provide favourable condition to flourish their technique to sustain their economy. Until and unless if an individual does not treat it as a' priority issue' will not be able to protect our mother earth and should treat it as a 'common concern of mankind' then only it will be possible to protect our mother.

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