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Suresh Chand Rai

Food and Livelihood Securities in Changing Climate of the Himalaya

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Preface

Climate variability/change is apparent from the observations of an upsurge in extreme weather events, average global temperature, melting of ice and snow, coastal flooding, and storm surge. It is a worldwide problem, and the Himalaya is subjected to it, due to its exceptional geophysical and hydro-climatic conditions. Climate change is expected to alter the existing vulnerability profile of the Himalaya. The Eastern Himalayan region of India is harboring the largest number of endemic and endangered species and is one of the significant biodiversity "hotspots" of the Indian subcontinent.

Livelihood in the villages of the Himalayan region mainly depends on subsistence farming. "These farming systems have developed over the centuries as a comparative advantage to other livelihood options in the mountain areas." Therefore, in the Sikkim Himalaya, upland farming is a traditional integrated land-use system comprising forest, agriculture, horticulture, agroforestry, bee farming, sericulture, poultry farming, and animal husbandry which will not only add to agricultural production but also improve the quality of food. Since there have been a lot of spatio-temporal variations in agriculture, there is a necessity for in-depth research in this direction. Therefore, the Sikkim Himalaya has been selected for the present study due to its heterogeneous geographical locations.

This study is constructed on both primary and secondary databases. The secondary information was attained from published and unpublished records of the government and semi-government organizations and NGOs. The primary data was collected from the household surveys along an altitudinal gradient. The data have been processed and analyzed using appropriate statistical techniques and presented in tabular, diagrammatic, and map forms using GIS software. The whole study has been organized into eight chapters. Chapter 1 describes the context, statement of the problem, review of literature, objectives, hypothesis, methods of data collection and significance of the study, etc. Chapter 2 deals with the biophysical and socio-economic characteristics of the area. Chapter 3 deals with climate variability and farmers' perception. Chapter 4 is about spatio-temporal change delineation and forecasting of snow/ice-covered areas. Agricultural systems and agrobiodiversity have been described in Chap. 5. Chapter 6 is about the analysis of food availability. Chapter 7 describes an analysis of livelihood security. Conservation of agricultural and sustainable livelihood has been discussed in Chap. 8. Based on the critical analysis of the facts and figures in the previous chapters, a summary and suggestions were given in the last.

I express my sincere thanks to the Director, G. B. Pant National Institute of Himalayan Environment and Sustainable Development (An Autonomous Institute under the Ministry of Environment, Forest and Climate Change, Government of India) who has generously sanctioned this major project for me. I am thankful to Dr. R. C. Sundriyal, and Dr. G. C. S. Negi, the Scientists In-charge, of the ERP Project for their continuous support during the project period. I also express my thanks to the Head, Department of Geography, Delhi School of Economics, University of Delhi for providing facilities. Special thanks are due to Dr. Prabuddh Kumar Mishra, Assistant professor, Department of Geography, Shivaji College, University of Delhi for his continuous help and support.

The entire fieldwork and collection of primary and secondary data have been done by project fellows, especially Miss Nikita Roy Mukherjee and Mr. Aman Rai. I place on record my thanks and appreciation for their painstaking study villages where they stayed for a considerable period and collected primary and secondary data. I am also thankful for my Ph.D. Scholars Dr. Pawan Kumar and Mr. Aakash Upadhyay for their continuous support to finish this task. A special thanks to all the farmers who supported us during fieldwork.

Delhi, India Prof. Suresh Chand Rai

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Chapter 1
Introduction

1.1 The Context

Climate change threatens people with "food and water scarcity, increased flooding, extreme heat, more disease, and economic loss." The World Health Organization (WHO) calls climate change the utmost threat to global health in the twenty-first century. Climate change is likely to deteriorate the condition in the major parts of the world which have already faced the serious problem of food insecurity. Higher rainfall variability has substantial consequences for food safety, the livelihoods of millions of people, and the migration of decisions of vulnerable households. Climate variability/change, directly and indirectly, influences several facets of food security, primarily in the livestock and farming sectors. The farming sector is the key source of income and engagement for about 70% of the world's poor in the countryside. Though, the livestock sector also contributes substantially to climate change, accounting for 18% of greenhouse gases, while also being a prime source of soil and water pollution (https://datos.bancompundial.org). Though the connection between climate change and food security is complex, most studies gave emphasis only on food availability. Its practical impacts also were reported on agrobiodiversity, ecology, hydrology, and agriculture in numerous studies (Chakrabarty 2016; Salinger et al. 1997; Salinger 1994). An overall increase in global temperature during the twentieth century has been reported in various studies (IPCC 2013). Interannual climate changeability has also been noticed in several parts of the globe. In the twentieth century, the overall worldwide terrestrial precipitation has augmented by about 2% (Hulme et al. 1998), but this is not constant temporally or spatially. Changes in rainfall and temperature pattern can simply change the hydrological cycle and environmental processes (Feng et al. 2016). According to IPCC (2012) report the timing, intensity,

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and frequency of extreme climatic conditions and weather variability are the results of changing climate. The occurrence and intensity of drought, flooding events, and heat stress are projected to increase, and these changes will create environmental, agricultural, and economical challenges for local communities all over the world. Apart from the environmental impacts of climate variability, its economic cost is also a foremost task. The average yearly damage caused by climate variability and extreme events has increased about 8 times between the 1960s and 1990s, globally the cost of extreme events between 1980 and 2004 was approximately 1.4 trillion US dollars (Mills 2005). Cost varies from region to region based on the climate, biophysical status, development level, vulnerability level, etc. However, the burden is more on developing and less economically developed countries as they are more susceptible to the paraphernalia of climate variation (IPCC 2014).

Climate change and intense events also influence agricultural yield, quality, and quantity. Response of protein content in crops to vagaries in the mean annual changeability of temperature and rainfall has been observed (Porter and Semenov 2005; Hurkman et al. 2009). Climate change-induced climate variability will certainly increase extreme weather conditions and severely impact agricultural production. Agrobiodiversity is an outcome of both natural selection and human interventions over millennia. It has been developed with the interactions between the environments and genetic resources, and by management systems and practices used by farmers (GIZ 2015). Various research has shown the effects of climate variability on agrobiodiversity, quality, and quantity of agricultural production. The impact of climate variability has been observed in agriculture in India too, it is estimated that surface warming and change in precipitation may drop agricultural yield by 30% by 2050 (Kapur et al. 2009). Shift and crop reduction have already been observed in different parts of the country (Ramulu 1996; Boopen and Vinesh 2011).

Climate variability is a foremost apprehension in the Himalayan region owing to its possible effects on the ecology, environment, and economy of the area. Glaciers in the Himalayan region cover about 17% of the global mountain area. The entire area of the Himalayan glaciers is 35,110 km^2. The overall ice preserve of these glaciers is 3735 km^3, which is equivalent to 3250 km^3 of clean water. Himalaya is the source of the major nine rivers of Asia, i.e., Brahmaputra, Ganges, Mekong, Irrawaddy, Yangtze, Trim, and Yellow, and is the lifeline for 500 million peoples of the region, or around 10% of the total regional population (IPCC 2007). The glaciers in the Himalayan area are said to be melting faster than in any other portion of the planet. For example, the Gangotri glacier has retreated at a rate more than three times faster in recent years than it did in the previous 200 years. On the Tibetan Plateau, the glacier area has shrunk by 4.5% in the last 20 years and by 7% in the last 40 years (CNCCC 2007). In the Himalayan area, increased glacier retreat has resulted in a broader range of glacial dangers known as glacial lake outburst floods (GLOFs). Nearly 200 possibly dangerous glacial lakes in the region might create devastating floods that could wipe out all means of subsistence in one fell swoop (Bajracharya et al. 2007; Aggarwal et al. 2017).

The effect of climate variation has become very apparent in the Himalayan region. Sikkim Himalaya is not an exception where climate change is badly disturbing agriculture and related ecosystems. Environmental degradation in the Himalayan region because of overuse and misuse of various natural resources is well recognized. The mountains of the Himalayas which make vital contributions to the ecological sustainability of the region are threatened by increasing population, open grazing, deforestation and loss of biomass cover, and overall biodiversity. Farm-based activities are important livelihood options for people worldwide, largely depending on weather and climate. Agriculture is very sensitive to variations in precipitation and temperature, and the destiny of the local communities of the region is closely tied to climate. It is self-evident that climate change will have significant consequences for agriculture and thereby food security. Tiwari and Joshi (2012) reported that the farmers have already experienced decreasing water supply in many parts of the Himalayas. It is also experiential that the carbon on the earth's surface and in the atmosphere due to its mobility contributes to climate change (Scherr and Sthapit 2009). Global warming is responsible for the increase of the world's average annual temperature because of greenhouse gasses (GHGs), which further lead to climate change. A dynamic interaction exists between various biotic (microbes, flora, and fauna) and abiotic (soil, water, air) elements in farming operations, and any disturbance in the natural balance may impact crop productivity through damage to the environment (Rathore and Jasari 2012). Seasons and weather are becoming increasingly variable and extreme, making it difficult for the farmer to decide on and cultivate a specific crop. The whole agricultural system would be collapsed if climate change continues (Harbinson 2001; Lal 2001). These changes are not only a potential threat to food security but also largely determine the socio-economic status of a large population dependent on their agricultural livelihood. The accessibility of accurate climatic data and continuous monitoring has improved our understanding of the climate arrangement and the features affecting climate change. However, there is still a knowledge and data gap in our understanding of the effects of climate variability on agrobiodiversity.

Mountain farming is unsustainable but some areas, such as Ningnan County in China, Ilam district in Nepal, and H.P. in India, have experienced a speedy change because of the adoption and implementation of environmentally caring and mountain-specific development strategies. The mountain-specific Research and Development, harnessing the comparative advantages of high-value cash crops, the promotion of agro-based industries, and off-farm employment are the focus of development strategies being followed in these parts (Sharma and Sharma 1996). The ancient cultivation of the large cardamom (*Amomum subulatum*) in Sikkim, on the other hand, is one example of connecting the native mountain niche. Large cardamom is a perennial high-value, low-volume, non-perishable cash crop growing beneath the forest cover on marginal and barren soils and is a hereditary plant of the Sikkim Himalaya. It is an exceptional example of the ecological and economic viability of a traditional farming system based on indigenously evolved agroforestry practices. In this case,