IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

URBAN GROWTH AND ITS ENVIRONMENTAL RISKS IN HIMALAYA UNDER CLIMATE CHANGE: AN ILLUSTRATION OF THE MOUNTAINOUS REGION OF DISTRICT NAINITAL, UTTARAKHAND

Manika Kweera*, Prakash C. Tiwari, Kevla Nand, Dheeraj Pant and Rahul Kumar
Department of Geography, D.S.B. Campus, Kumaun University Nainital, Uttarakhand, 263001, INDIA
*manikakweera@gmail.com

Abstract:

The Himalaya is the most densely populated and rapidly urbanizing mountain on the planet. In recent years, it has experienced rapid urban growth, which is mostly unplanned and unsystematic manner. The study aims to interpret and analyze the emerging risks of unplanned urban growth under climate change with a case illustration of the mountainous region of district Nainital, Uttarakhand Himalaya. Besides interpreting secondary data, the study employed comprehensive socio-economic surveys and empirical field observation methods. More recently, rural areas located far away from fast-growing urban centres have also come under the process of rapid urbanization, mainly owing to the growth of tourism. Consequently, the size, area, number, and complexity of urban settlements in the Himalaya have increased dramatically, resulting in the expansion of urban processes as well as an increase in the intensity of urban land use within towns. Moreover, due to an increase in the frequency, severity, and intensity of extreme weather events, climate change has stressed urban ecosystems. These changes are making urban ecosystems and their peri-urban zones highly vulnerable to a variety of climate change induced natural hazards, such as flash floods, slope failures, landslides and livelihood insecurity affecting mainly poor and marginalized sections of the community. These changes have increased the vulnerability of nearly 55% of the urban population to flash-flood, slope failure and landslides in Himalaya under climate change. It is therefore, highly inevitable to evolve effective land use policies and integrate socio-economic equality and environmental justice into urban development policies particularly in view of the emerging threats of climate change.

Keywords: Unplanned Urbanization, Growth of Tourism, Flash Floods and Landslides, Natural Disasters, Community Perception, Climate Change

1. Introduction

Mountains are extremely critical from the marginality, ecosystem sensitivity, inaccessibility, terrain complexity, and climate change viewpoint (Meybeck et al., 2001 and Tiwari et al., 2018). However, it forms the home of nearly 12% of the global population (Huddleston et al., 2003). Mountains are the source of several ecosystem services, such as freshwater, biodiversity, and soils that sustain the livelihood and economy of the large community of the mountains and the nearby lowlands (Tiwari et al., 2018). On the other hand, they have long been overlooked in terms of the sustainable development of their resources and inhabitants (Tiwari and Joshi, 2020). Currently, the ongoing process of global environmental change is particularly threatening the mountain environment and community (Borsdorf et al., 2010). Over the past few decades, particularly in developing and underdeveloped nations, the practices of traditional resource utilization pattern in the high mountain regions have changed dramatically (Tiwari and Joshi, 2020). As a result, globally, mountains have been passing through a rapid environmental, socio-economic, and cultural transformation process and degradation of natural resources making environmental and socio-economic unsustainability both in upland and lowland regions (Haigh, 2002). Rapid urbanization has emerged as one of the major drivers of environmental change, transforming the Himalayan mountains (Walker, 2011). Undoubtedly, the urbanization in the Himalaya has improved infrastructure, offered a range of socio-economic services and generated employment opportunities (Tiwari and Joshi, 2016). The rising population, improved road connectivity, tourism industry, and economic globalization are the key factors of rapid urban growth in the Himalaya; therefore, more recently, comparatively less accessible areas have also unlocked under the process of rapid urbanization. However, the process of urbanization has been mostly unplanned and unsystematic manner. As a result, urban sprawl is bringing ecologically critical and environmentally unsafe areas under unplanned urban growth, disrupted critical ecological services, depleted natural resources and increasing environmental and socio-economic inequalities (Kweera and Tiwari, 2023). The hydrological system of the fragile mountain has been disrupted and depleted by the urban sprawling and the associated land use intensifications, which has increased the vulnerability of the Himalayan communities to frequent slope failures, landslides and flash floods (Anbalagan, 1993). The water demand of the rising population has increased significantly, especially during the summers and high tourist influx, due to the encroachment or depletion of natural water bodies and traditional water sources. Furthermore, the highly populated Himalayan Mountain region has already seen the impact of climate change on urban ecosystems through increasing mean annual temperatures, altered precipitation patterns, and increase in the frequency, severity, and intensity of extreme weather events (Balk et al., 2009; ICIMOD, 2010; Durga Rao et al., 2014). Therefore, the natural risks of unplanned urbanization are now clearly discernible in most of the densely populated Lesser Himalayan urban centres and their peri-urban zones (Tiwari, 2007, 2008). The study attempts to analyze the emerging risks of unplanned urban growth under climate change with a case illustration of mountainous region of district Nainital located in Uttarakhand Himalaya. The major objective of the study is to analyze the changing climatic conditions particularly temperature trends and rainfall variability and to access the community perceptions about climate change and visualization of its

impacts on urban ecosystem. The study would also recommend a framework for sustainable and climate resilient urban development.

2. Material and Methods

The Study Area: The study area encompasses of Betalghat, Ramgarh, Okhalkanda, Dhari and Bhimtal developmental blocks, as shown in Figure 1. The study area located between the 29º12'0" N to 29º36'0" N latitudes and 79º20'0" E to 79º51'0" E, longitudes in the Siwalik and the Lesser Himalayan ranges of Uttarakhand's Kumaon Division. It comprises a geographical area of 1624.85 km², and has elevations ranging from 390 and 2629 meters above the mean sea level (MSL). The study area has a range of climatic conditions with an annual mean minimum and maximum temperature of 1.8ºC and 23.8ºC respectively, extending from sub-tropical to cool temperate transects. Because of the abundance of natural lakes in the region, a significant proportion of the mountainous region of district Nainital is often referred to as the "Lake Region." The important lakes situated in the study area include Naini Tal, Bhim Tal, Naukuchia Tal, Sat Tal, Khurpa Tal, and Nal-Damyanti Tal. With rapidly expanding notified urban centers—Nainital (Municipal Council), Bhowali (Nagar Palika), and Bhimtal (Nagar Panchayat)—as well as several developing urban areas—Jeolikote, Mukteshwar, and Garampani—the study region demonstrates the most densely populated and swiftly urbanizing regions of Uttarakhand. Because tourism is one of the most important sectors of the Himalayan state of Uttarakhand's economy, the fast-booming tourist industry has emerged as one of the principal drivers of urban growth in the study region.

Data Source and Methodology: The data and information required for the study have been generated and collected from diverse primary and secondary sources. The preliminary data required for the interpretation of citizen's perception and responses to climate variability and its impacts on unplanned urban growth have been generated by conducting socio-economic surveys using specifically framed schedules and questionnaires, field observations and mapping and focused group discussions and interviews of selected key respondents. The secondary data and information used in the present work has been derived from various sources including, Census of India, statistical records of the Government of Uttarakhand, Nagar Palika of Nainital, many district level offices, handbooks and reports from departments and organizations of both the Central and State Governments, as well as published and unpublished literature. The topographical sheets of the survey of India [SOI] at scale 1:50,000, cadastral maps and forest maps were used to produce the base maps for the study area. Based on the daily temperature and rainfall data generated by the automated weather station (AWS) of the India Meteorological Department, situated in Mukteshwar, district Nainital, a comprehensive analysis has been carried to understand the emerging trends in temperature and precipitation. Temperature and rainfall data for 1973-2022 were collected from the India Meteorological Department's Automated Weather Station in Mukteshwar. The annual and seasonal changes in rainfall and temperature have been determined using standard statistical techniques (arithmetic mean, standard deviation, and regression analysis). To obtain the maximum and minimum temperature values, the daily mean of the maximum and minimum temperature was calculated. Similarly, the seasonal mean temperature was

calculated by averaging the season's daily minimum and maximum temperatures. The arithmetic average has also been used to obtain monthly mean rainfall data and to analyze the daily rainfall pattern.

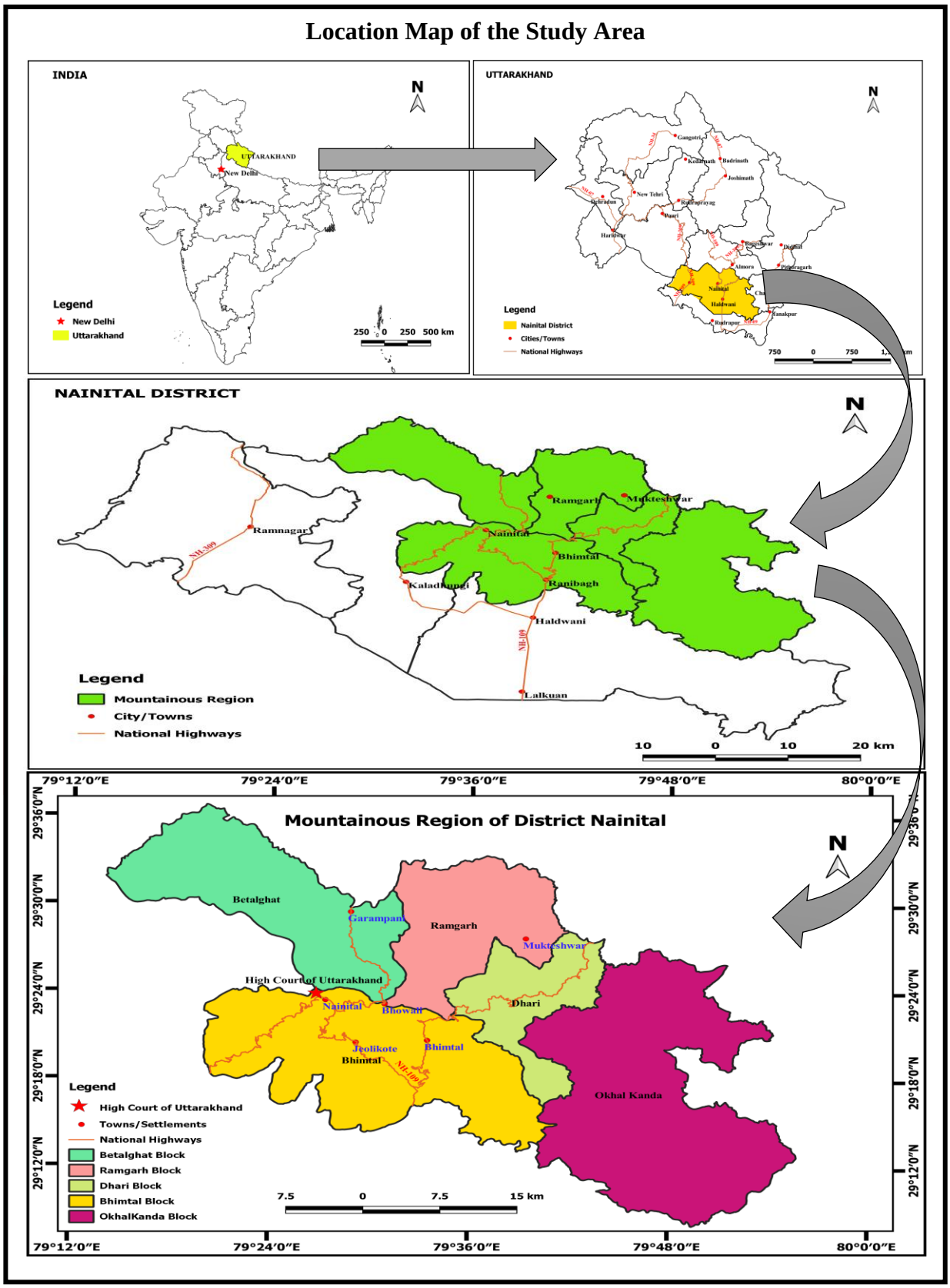

Fig. 1: Location Map of the Study Area

3. Results and Discussion

Observed Changes in Climatic Conditions: The fluctuations in temperature and rainfall at the automated weather station of the India Meteorological Department, Mukteshwar, have been analyzed for the 50 years from 1973-2022 [Fig. 2, 3, 4, and 5]. The mean value of the average annual maximum temperature (T_{max}) and the average annual minimum temperature (T_{min}) in the study area are 18.94ºC ± 0.69ºC and 8.87ºC ± 1.49ºC, respectively, which demonstrate significant change in the annual average temperature. Figure 2 shows that the T_{max} and T_{min} reveal an increasing trend of 0.02ºC/year, and 0.06ºC/year, respectively. Moreover, the seasonal temperature pattern for T_{max} exhibit a rising trend in all the seasons, viz., 0.03ºC/year (summer season), 0.02ºC/year (monsoon and winter season), and 0.01ºC/year (post-monsoon season) (Fig. 3). Furhermore, the T_{min} is also increasing at the same rate of 0.06ºC/year for all the seasons (summer, monsoon, post-monsoon, and winter). Figure 4 indicates that over the past fifty years, the average annual rainfall in the study area has been steadily increasing at a rate of 1.2 mm/year. After a comprehensive analysis of seasonal rainfall data, it was observed that the monsoon season has recorded the highest and the post-monsoon season has received minimum rainfall amount of 47589 mm and 2128.1 mm, respectively. However, Figure 5 shows that the seasonal rainfall of the study area illustrates a slightly increasing trend in all the seasons; respectively, 1.4 mm/year (summer season), 11.9 mm/year (monsoon season), 0.65 mm/year (post-monsoon), and 0.44 mm/year (winter season).

Geo-Environmental Risks of Unplanned Urbanization: In recent years, urbanisation has emerged as one of the key drivers of global environmental change, changing the natural ecosystem, particularly in high mountains of developing nations where urban growth is mainly unplanned and unorganized. The haphazard urban growth in the Himalaya, particularly in geologically dynamic and environmentally vulnerable Lesser Himalayan ranges, has resulted in the depletion and degradation of natural ecosystems, as well as an increase in the occurrence and severity of urban environmental hazards, such as flash floods, slope failures, disruption of natural drainage, depletion of forests and biodiversity within the urban ecosystems as well as in their adjoining areas. Moreover, the rapid urbanization and population expansion enabled the creation and rise of a huge number of slums, mainly along the fragile slopes, drainage channels, and other environmentally insecure zones in urban settlements. The rampant urbanisation and the resulting increased scale of anthropogenic actions for infrastructure development are exacerbating slope instability through disturbance of natural drainage, encroachment of drains, and inadequate slope protection measures. According to the studies, the primary causes of slope instability in all of the municipalities and emerging towns are a lack of effective surface drainage and unplanned anthropogenic intervention. Furthermore, the observed uncertainty in rainfall patterns and increased occurrences of high-intensity rainfall are anticipated to rise the region's vulnerability to a number of hydro-geological hazards, including flash floods, creeping, subsidence and landslides. More recently, comparatively less accessible regions of the study area have also been prone to increased urbanization, primarily because of the growth of horticulture, the expansion of the road network, and the ongoing shift from primary resource development practises to secondary and tertiary domains, and the expansion of domestic tourism through the advertising and marketing of

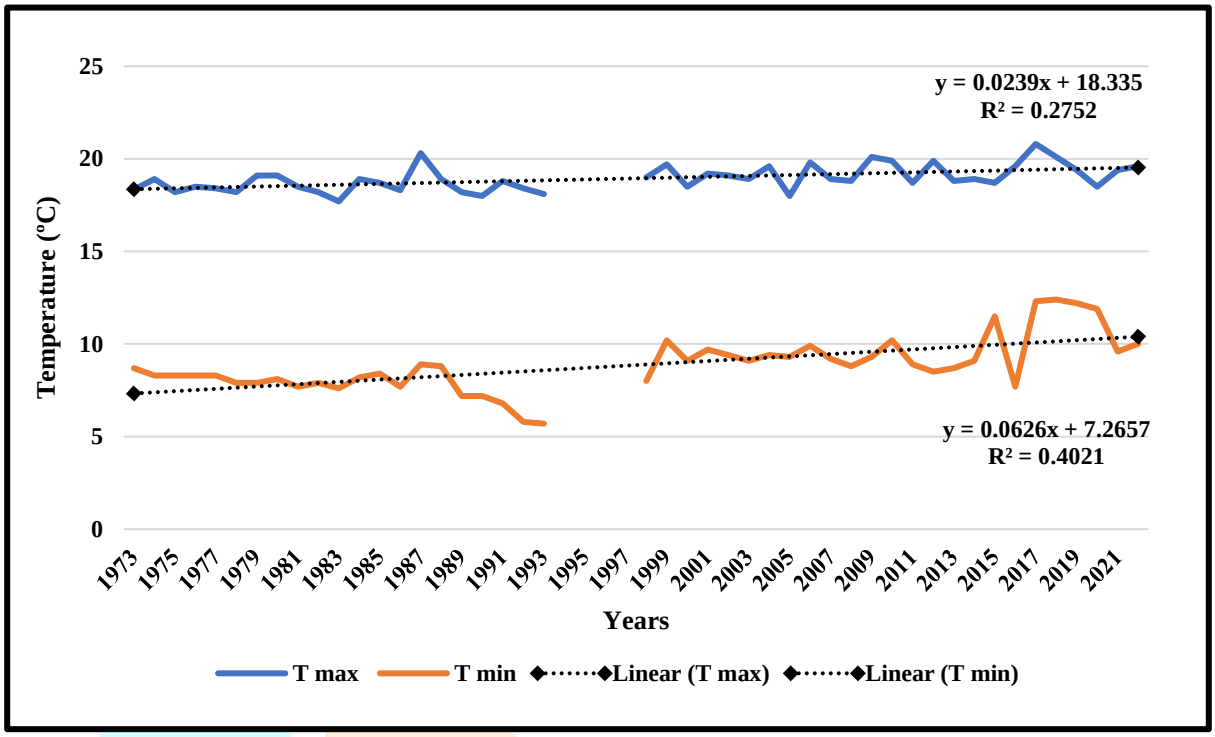

Fig. 2: Annual Mean Temperature Trends Between 1973-2022

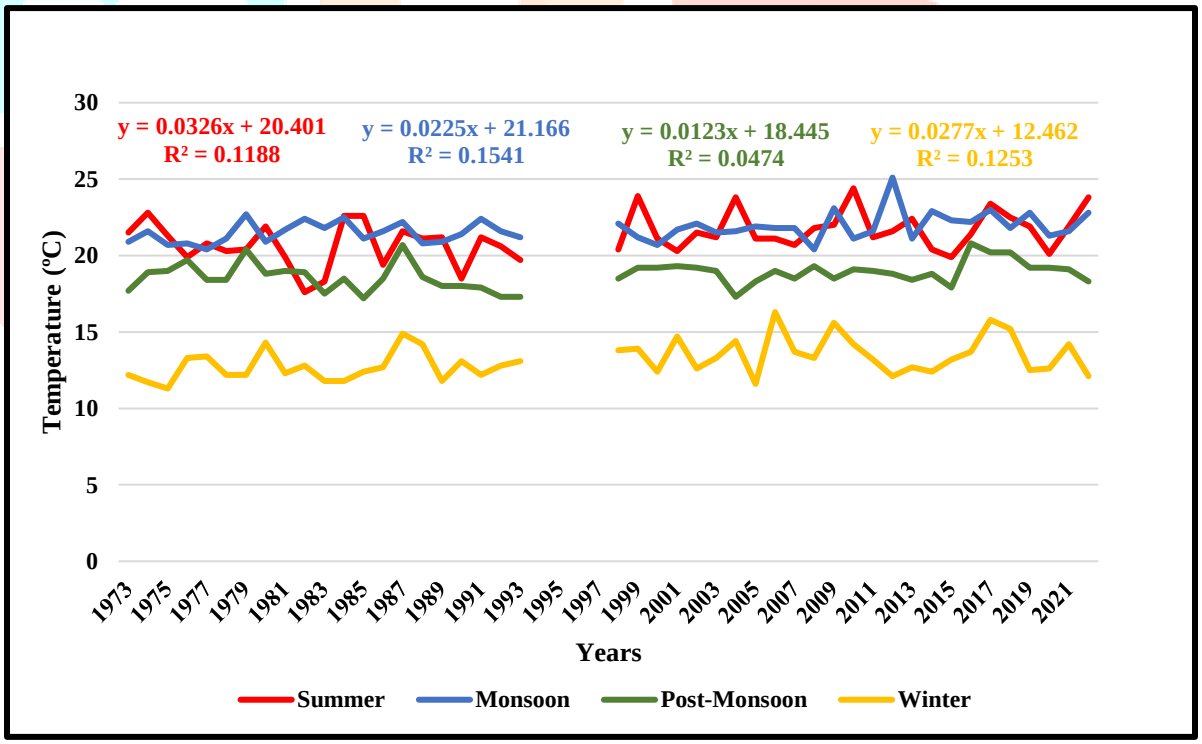

Fig. 3: Seasonal Temperature Trends Between 1973-2022

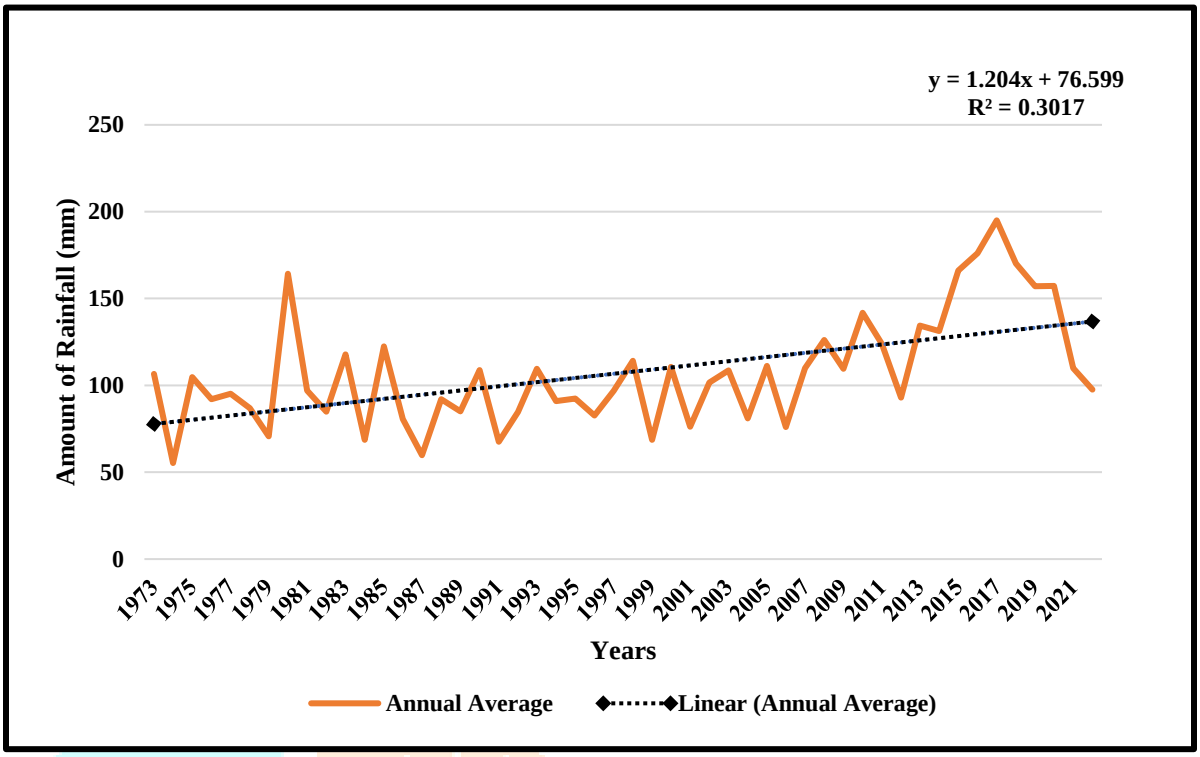

Fig. 4: Annual Average Rainfall Trends Between 1973-2022

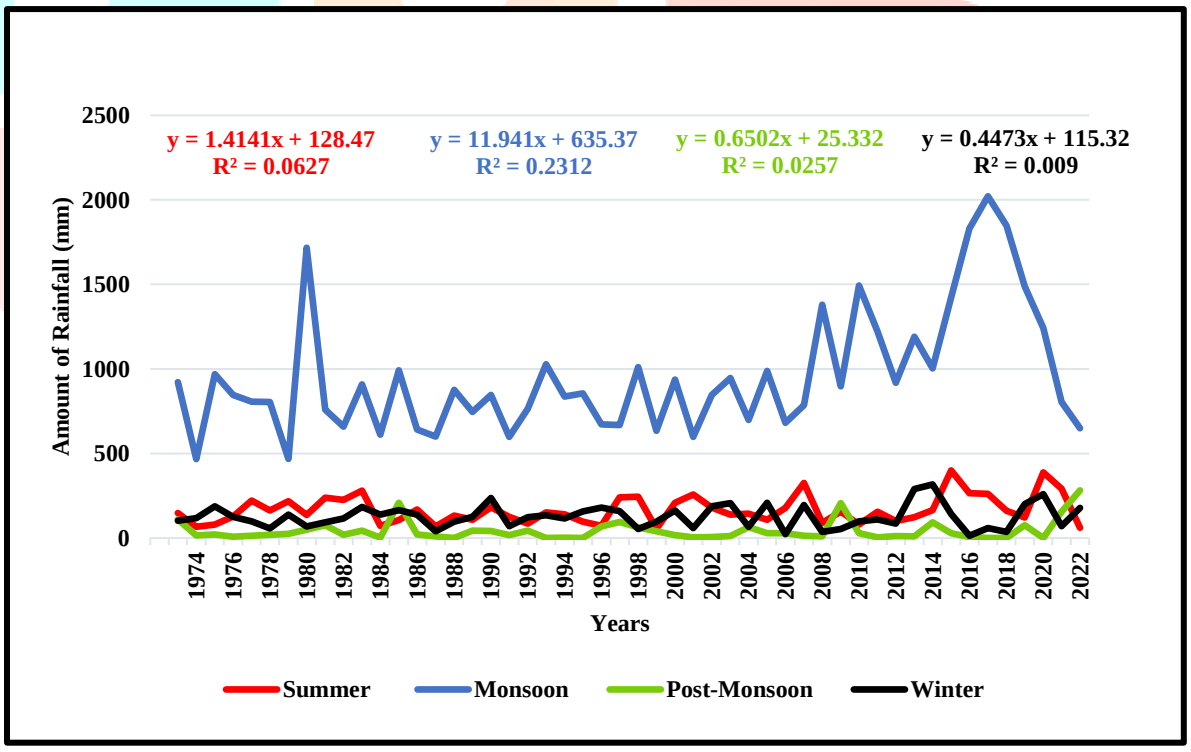

Fig. 5: Seasonal Trends of Rainfall Variability Between 1973-2022

new tourist destinations. The geo-environmental risks of this unplanned urban growth are now clearly visible in most of the urban centres and their outskirts, particularly in the densely inhabited Lesser Himalayan ranges of the newly formed mountain state of Uttaranchal, such as Joshimath, Nainital, Mussoorie, Pauri and Almora. Rising temperatures and weather extremes, particularly drought and high-intensity rainfall events, undermining the

groundwater recharge and the capacity of the region's springs and streams to generate water. Resultant, springs and streams are drying up and their water discharge is also reducing, resulting in less water available in water sources, including the lakes in of the study area. Furthermore, during the period 1985-2015, 45% of natural springs dried out, 21% became seasonal, and stream discharge decreased by 11% in the heavily urbanized mountainous region of district Nainital (Tiwari et al., 2018). More frequent and intense rainfall events are currently causing floods and landslides, mud and debris flow, and mass movement. These processes are causing the lakes in the region to silt up, in addition to destroying life, property, and critical infrastructure. In addition, there are more forest fires occurring in and around the townships in the area due to a dramatic increase in temperature and an increased frequency of droughts. The water, food, livelihood, and health security of urban communities—especially the impoverished and other marginalised groups—are being jeopardised by these climate change-related phenomena. Additionally, the towns and their surrounding region are experiencing an upsurge in environmental and socioeconomic disparities.

Perception of the Local Community on Climate Change: The community perception is defined as a cumulative body of information, know-how, and practises developed by peoples with a long history of contact with the natural environment. These complicated understandings, explanations, and meanings are a component of a cultural complex that also includes methods of resource utilization, language, naming and classification frameworks, rituals, spirituality, and worldviews (United Nations, 2005). However, a number of socioeconomic characteristics, including people's participation in decision-making processes, access to knowledge and information, awareness, education level, division of labour, and ownership and rights over natural resources, shape and structure the community perception in a given geographic area. (Agrawal, 1995). In this research, an effort has been made to examine and understand the citizen's perception of climate change and its impacts on the urban environment in the notified towns of Nainital, Bhowali and Bhimtal and all the emerging urban areas of the study region. As a result, the local community has developed creative adaptation strategies to deal with the changing environment and acquired deep insight into how climate change affects their habitat and urban system.

Table 1: Community Perception (Household People) of Climate Change in the Study Area

S. No.	Community Perception on Climate Change	Community Responses (%)		
		Yes	No	Do not know
1.	Rise in Temperature	98	1	1
2.	Erratic and Reduced Rainfall Amount	98	1	1
3.	Decrease in Snowfall Incidents	95	2	3
4.	Increase in Hailstorm Incidents	91	5	4
5.	Change in Timing of Seasons	97	1	2
6.	More Precipitation in the Form of Rain Instead of Snow	94	2	4
7.	Fluctuation in Water Availability	98	1	1
8.	Increased Drought Conditions	89	6	5
9.	Increased in High Intensity Rainfall Events (Cloudburst)	92	4	4
10.	Increased in the Frequency of Flash Floods	84	12	4

Source: Fieldwork

Table 1 shows that among the 195 households surveyed and interviewed in the townships, respondents have a clear understanding of climate change and climatic extremes ranging from 84% to 98%. The Table shows that the citizens of the towns of Bhowali, Bhimtal, and Nainital have developed an analytical, comprehensive, and in-depth knowledge and understanding of extreme weather events and climate change. Similarly, the exercise presented in Table 2 shows that the people of all the notified and emerging towns and their surrounding settlements have a very good understanding and knowledge of climate change and its impacts on the urban ecosystem and the surrounding rural environment. Table 2 demonstrates that out of 195 respondent households, from a minimum 85% to a maximum of 98% have the clear awareness of the vulnerability of the urban ecosystem services to climate change induced natural hazards and risks in the region.

Table 2: Community Perception About the Impacts of Climate Change on Unplanned Urban Growth

S. No.	Community Perception about Climate Change Impacts on Unplanned Urban Growth	Community Responses (%)		
		Yes	No	Do not know
1.	Increased the Susceptibility of Inhabited Fragile Slopes	85	10	5
2.	Increased the Vulnerability of Urban System to Climate Induced Natural Hazards (Flash Floods, Slope Failures and Landslides)	91	6	3
3.	Disrupting Urban Ecosystem Services (Freshwater Supply)	94	3	3
4.	Depleting Natural Resources (Land Resources)	98	1	1
5.	Affected Traditional Water Resources (Naula/Dhara)	97	2	1
6.	Increased Socio-Economic Inequality	88	10	2
7.	Decreased Agricultural Production and Increased Food Insecurity	90	6	4

Source: Fieldwork

4. Conclusion

The Lesser Himalaya is not only the most densely populated mountain range but it is also most rapidly urbanizing. As in other regions of the world, urban growth in the Himalaya cannot be stopped, but it can be steered more sustainably through integrated urban-rural land use planning. According to the findings of the study, unplanned urbanization has increased the vulnerability of intensively altered and densely populated unstable slopes to active processes of mass movement and landslides in the mountainous district of Nainital. Moreover, climate change-induced hydrological extremes, pose serious concerns to the sustainability of fast-growing urban ecosystems by increasing the magnitude, frequency, and intensity of geo-hydrological hazards in the town and its surrounding regions. Thus, climate change is anticipated to cause slope instability and disturb the hydrological regime of headwater and watershed ecosystems that are already stressed due to increasing urbanization. Consequently, the notified towns of Nainital, Bhowali, and Bhimtal, as well as the emerging towns in the area, are now more susceptible to climate change-related geo-environmental risks due to recent observations of temperature and rainfall patterns. Given this, all the urban centers of the study region including the emerging townships are becoming increasingly susceptible to climate change induced natural risks. There is an urgent need to develop

and adopt a sustainable urban development policy for the entire Himalayan region. This aims to clarify the local geo-tectonic and geomorphological conditions before extending urbanisation in fragile Himalayan terrain. Furthermore, a detailed climate change vulnerability assessment and large-scale risk zonation mapping should be carried out to analyze all the critical parameters of exposure, sensitivity, and adaptive capacity of urban environment.

Acknowledgement

One of the authors Manika Kweera is grateful to the Indian Council of Social Science Research [ICSSR] for Providing financial assistance through a doctoral fellowship.

References:

1. Anbalagan R (1993) Environmental hazards of unplanned urbanization of mountainous terrains: a case study of a Himalayan town. Q J Eng Geol 26:179–184.
2. Meybeck, M., Green, P. and Vörösmarty, C. (2001). A new typology for mountains and other relief classes: an application to global continental water resources and population distribution. Mt Res Dev 21:34–45
3. Tiwari, P. C., Tiwari, A. and Joshi, B. (2018). Urban Growth in Himalaya: Understanding the Process and Options for Sustainable Development. Journal of Urban and Regional Studies on Contemporary India, 4(2), 15–27. http://home.hiroshima-u.ac.jp/hindas/index.html
4. Huddleston, B., Ataman, E. and d'Ostiani, L. (2003). Towards a GIS-based Analysis of Mountain Environments and Populations. Environment and Natural Resources Working Paper, No. 10. Food and Agriculture Organization of the United Nations, Rome.
5. Tiwari, P. C. and Joshi, B. (2020). Challenges of Urban Growth in Himalaya with Reference to Climate Change and Disaster Risk Mitigation: A Case of Nainital Town in Kumaon Middle Himalaya, India, in Dimri et al. (eds.) Himalayan Weather and Climate and their Impact on the Environment, Springer, Switzerland. doi.org/10.1007/978-3-030-29684-1
6. Borsdorf, A., Tappeiner, U., Tasser, E. (2010). Mapping the Alps. In: Borsdorf, A., Grabherr, G., Heinrich, K., Scott, B., and Stötter, J. (eds.) Challenges for mountain regions. Tackling complexity. Böhlau, Vienna, pp 186–191
7. Haigh, M. (2002). Headwater control: integrating land and livelihoods. paper presented at the international conference on sustainable development of headwater resources, United Nation's International University, Nairobi, Kenya, September.
8. Walker, B. (2011). Urban Peaks in the Himalayas. China Dialogue. https://www.chinadialogue.net/article/show/single/en/4306- Urban-peaks-in-the-Himalayas (accessed December 15, 2016)

9. Kweera, M. and Tiwari, P. C. (2023). Urban Land Use Dynamics and Assessment of Environmental Risks in Bhowali Urban Zone, Kumaon Lesser Himalaya, India using Remote Sensing and Geographic Information System. Disaster Advances, 16 (9), 38-48.
10. Tiwari, P.C. and Joshi, B. (2016). Rapid Urban Growth in Mountainous Regions: The Case of Nainital, India. Urbanization and Global Environment Change (UGEC) Viewpoints, Global Institute of Sustainability, Arizona State University, Tempe.
11. ICIMOD (2010) Mountains of the world – ecosystem services in a time of global and climate change: seizing opportunities – meeting challenges. Framework paper prepared for the Mountain Initiative of the Government of Nepal by ICIMOD and the Government of Nepal, Ministry of Environment.
12. Balk, D., Montgomery, M.R., McGranahan, G., Kim, D., Mara, V., Todd, M., Buettner, T., and Dorélien, A. (2009). Mapping Urban Settlements and the Risks of Climate Change in Africa, Asia and South. José Miguel Guzmán et al. (eds.): Population Dynamics and Climate Change. International Institute for Environment and Development (IIED), London, 80–103.
13. Durga Rao, K.H.V., Rao, V.V., Dadhwal, V.K. and Diwakar, P.G. (2014). Kedarnath Flash Floods: A Hydrological and Hydraulic Simulation Study. Current Science, 106(4), 598–603.
14. Tiwari, P. C. (2007). Urbanization and environmental changes in Himalaya: a study of the lake region of district Nainital in Kumaon Himalaya, India. International working paper series ISSN 1935-9160, Urbanization & Global Environmental Change (UGEC), International Human Dimension Programme (IHDP), Working Paper 07-05, pp 1–19.
15. Tiwari, P. C. (2008). Land use changes in Himalaya and their impacts on environment, society and economy: a study of the Lake Region in Kumaon Himalaya, India. Adv Atmos Sci 25(6):1029–1042.
16. Tiwari, P. C., Tiwari, A. and Joshi, B. (2018). Urban Growth in Himalaya: Understanding the Process and Options for Sustainable Development, Journal of Urban and Regional Studies on Contemporary India, 4(2), 15–27. http://home.hiroshima-u.ac.jp/hindas/index.html