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Urban Growth in Himalaya: Understanding the Process and Options for Sustainable Development

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Abstract During recent years, urbanization has emerged as one of the important drivers of global environmental change transforming mountain regions, particularly in developing countries where the process of urban-growth has been fast but mostly unsystematic, unplanned and unregulated. Himalaya representing tectonically alive, densely populated, and one of the most marginalized mountain regions of the world has experienced rapid urban growth during last three decades. More recently, comparatively less accessible areas have also come under the process of rapid urbanization mainly owing to improved road connectivity, publicity and marketing of new tourist sites and the resultant growth of domestic as well as international tourism; development of horticulture; economic globalization and gradual shift from primary resource development practices to secondary and tertiary sectors; and due to absence of urban land use policy. Consequently, there has been tremendous increase in size, area, number and complexity of urban settlements in the Himalaya resulting into the expansion of urban processes (i.e., expansion of urban land use in surrounding agricultural zone, forests and rural environments) as well as increase in the intensity of urban land use (i.e., increase in the density of covered area, density of building, and increase in the density of population) within the towns.

On the one hand, the growing urban areas in high mountain are now serving as the centres of growth by creating opportunities of employment, variety of socio-economic services and expansion of infrastructure; and contributing towards the development of their vast hinterland through trickledown effect; while on the other, the sprawling urban growth in fragile mountains has disrupted the critical ecosystem services. The speedy and unplanned urbanization has perturbed the hydrological regimes of Himalayan watersheds and reduced ground water recharge, and decreased the availability of water for drinking, sanitation and crop production; depleted forests and biodiversity; increased risks of natural hazards and disasters both in urban areas as well as in their peri-urban zones; and increased vulnerability of mountain inhabitants to water, food, livelihood and health insecurity. Moreover, climate change has stressed urban ecosystems by increasing the frequency, severity and intensity of extreme weather events. As in other parts of the world, urban growth cannot be stopped or reduced in Himalaya, but it can be steered in a more sustainable manner through an integrated urban-rural land use planning. Effective land use policies need to be evolved and implemented for the protection and conservation of forests, biodiversity, water resources and agricultural land.

Key words unplanned urbanization, hydrological disruptions, natural disasters, emergence of slums, urban land use policy

I. Introduction

Mountains which extend over approximately 24% of the land surface of earth (UNEP-WCMC, 2002) and constitute home for nearly 12% of the world's population (Huddleston et al., 2003) are highly crucial from the view point of marginality, environmental sensitivity, climate change, constraints of terrain, geographical inaccessibility and less infrastructural development (Meybeck et al., 2001). Mountains constitute the sources of a variety of ecosystem services, including freshwater, biodiversity and soils that sustain livelihood and economy of large population both in mountains and adjoining plains. Mountain headwaters provide freshwater to approximately to half of the world population inhabiting the large river basins located far away from mountains (Viviroli et al., 2007; FAO, 2008). The largest trans-boundary river systems of the planet have their origin in high mountains; and mountains have still the largest proportion of world's forests which not only constitute global biodiversity hot spots and the pool of genetic resources, but they also regulate and modify climatic conditions and contribute towards mitigating global warming through serving as carbon sinks (ICIMOD, 2010). Mountain agriculture and farming systems constitute the principal source of food and livelihood for about half a billion population (FAO, 2008). The indigenous people inhabiting mountain regions since time immemorial have evolved diversity of cultures that comprise traditional knowledge, resource development and environmental conservation practices, agricultural and food systems, and adaptation and coping mechanism to environmental changes (ICIMOD, 2010).

However, mountain regions have long been marginalized from the view point of their sustainable development (ICIMOD, 2012). However, we are experiencing an emergence of responsiveness of the ecological significance of mountain systems and their environmental significance for the sustainability of global community, particularly after the United Nations Conference on Sustainable Development – Rios Earth Summit in 1992 (UN, 2012). As a result, our understanding about the dilemmas of mountain ecosystems and approach to their development has undergone drastic changes, during the last two decades (ICIMOD, 2012). Currently, mountain ecosystems as well as mountain communities are particularly threatened by the ongoing processes of global environmental change, population dynamics and economic globalization and resultant exploitation of mountain resources (Borsdorf et al., 2010; Ives and Messerli, 1990). During the recent years, a variety of changes have emerged in the traditional resource use structure in mountain areas, particularly in developing and underdeveloped regions of the world mainly in response to population growth, changing global economic order, transforming political systems and rapid urban growth. As a result, mountain regions of the world are passing through a process of rapid environmental, socio-economic and cultural transformation and exploitation and depletion of their natural resources leading to ecological and socio-economic un-sustainability both in upland and lowland areas (Haigh et al., 2002; Tiwari, 2000).

Himalaya which represents tectonically alive, densely populated, and one of the most marginalized mountain regions of the world has experienced rapid urban growth during last three decades (Anbalagan, 1993). However, the process of urbanization has been mostly unplanned and unregulated. As a result, urbanization has emerged as one of the important drivers of environmental change transforming the Himalayan mountains (Walker, 2011). More recently, comparatively less accessible areas have also come under the process of rapid urbanization mainly owing to improved road connectivity, publicity and marketing of new tourist sites and the resultant growth of domestic as well as international tourism; development of horticulture; economic globalization and gradual shift from primary resource development practices to secondary and tertiary sectors; and due to absence of urban land use policy (Ghosh, 2007). Consequently, there has been tremendous increase in size, area, number and complexity of urban settlements in the Himalaya resulting into the expansion of urban processes (i.e., expansion of urban land use in surrounding agricultural zone, forests and rural environments) as well as increase in the intensity of urban land use (i.e., increase in the density of covered area, density of building, and increase in the density of population) within the towns (Walker, 2011).

Undoubtedly, the urbanization in Himalaya has created employment opportunities, provided a variety of socio-economic services and contributed towards the development of infrastructure which is disseminated socioeconomic growth in their vast hinterland through trickledown effect (Tiwari and Joshi, 2016). However, the sprawling and unplanned urban growth in fragile mountains has disrupted the critical ecosystem services, depleted natural resources, increased socio-economic inequalities and increased vulnerability of both towns and their fringe areas to a variety of natural risks (Anbalagan, 1993). The speedy and unregulated urbanization has perturbed the hydrological regimes of Himalayan watersheds and reduced ground water recharge, and decreased the availability of water for drinking, sanitation and crop production; depleted forests and biodiversity; increased risks of natural hazards and disasters both in urban areas as well as in their peri-urban zones; and increased vulnerability of mountain inhabitants to water, food, livelihood and health insecurity (Patra and Kantariya, 2014). Moreover, climate change has stressed urban ecosystems by increasing the frequency, severity and intensity of extreme weather events in densely populated Himalayan mountains (Durga Rao et al., 2014; Balk et al., 2009). As in other parts of the world, urban growth cannot be stopped or reduced in Himalaya, but it can be steered in a sustainable manner through an integrated urban-rural land use planning. In order to attain this, an effective urban land use policies need to be evolved and implemented for the protection and conservation of urban environment and ecosystem services and for making urban systems climate resilient (Planning Commission of India, 2014).

II. Objective and Methodology

The study aims at presenting an overview of the process of urbanization and its environmental and socio-economic impacts across the Himalayan region of India with specific case illustrations from the Himalayan State of Uttarakhand. The data and information used in the present work has been derived from various sources including Census of India records and various handbooks and reports of both Government of India and Governments of different Himalayan States. Besides, necessary data has also been generated from various primary sources including empirical research and field surveys specifically in case

of Uttarakhand. Fast growing towns one each from 10 mountainous districts of Uttarakhand have been selected for comprehensive assessment of impacts of urbanization on natural ecosystem. The selected townships include Almora, Bageshwer, Chapawat, Nainital and Pithoragarh in Kumaon Division; and Gopeshwer, Mussoorie, Rudraprayag, Srinagar and Tehri in Garhwal Division of Uttarakhand. Besides, analyzing the impacts of urbanization on water resources, forests, biodiversity, traditional agricultural and food systems and rural livelihood; the vulnerability of urban systems to climate change and climate change natural disasters was also assessed. The relevant data and information on these parameters have been collected through comprehensive socio-economic surveys. The Himalayan State of Uttarakhand encompassing a geographical area 53,066 km^2 in varying geographical transacts ranging from narrow Foothill belt in the south to the Lesser, Great and Trans Himalayan ranges in the north was created in the year 2000. It constitutes headwaters of the Ganges System which is one of the largest trans-boundary river basins of the world. The state is divided up into 13 districts of which 10 extend across Himalayan Mountains and 3 are located in their foothill zone (Figure 1). The total population of Uttarakhand is 6 million, of which 26% lives in 86 fast growing and emerging urban centres (Office of the Registrar General and Census Commissioner, 2013). Tourism is one of the fast growing economic sectors and therefore emerging as important driving force of urban growth in the State.

Figure 1. Location of Uttarakhand
Source: made by Tiwari based on Census of India maps 2011

III. Pattern of Urban Growth and Its Drivers

Himalayan mountains have experienced rapid urban growth during the recent past. Population growth, improved road connectivity and development of tourism has contributed significantly to urban development in the region. The fast expansion of road linkages has facilitated

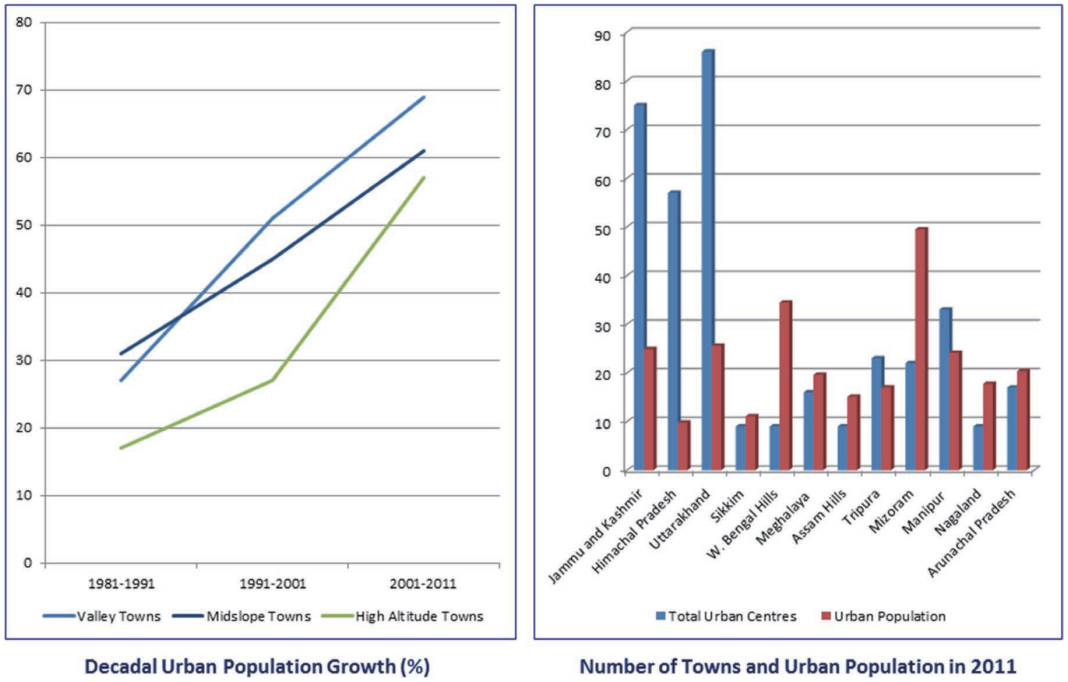

Figure 2. Urban growth in the Himalayan States
Source: made by Tiwari based on Census of India, Population Data of 2011

the emergence and growth of large number of rural service centres which are developing into urban areas. This is clearly indicated by fast growing urban population as well as number of towns all across the Himalayan States of India. The State of Uttarakhand had the largest number of notified towns whereas the State of Mizoram in North East India registered the highest proportion of urban population in the entire Indian Himalayan region in 2011 (Figure 2). In Uttarakhand the urban population increased from 16.36% of the total in 1971 to 20.7% in 1981, 22.97% in 1991, and 25.59% in 2001. The State registered 56.38% growth of urban population during 1971–1981, however, decadal urban population growth declined slightly during 1981–1991 (42.20%) and 1991–2001 (32.81%) (Directorate of Economics and Statistics Planning Division, Government of Uttarakhand, 2010). Nevertheless, growth of urban population in Uttarakhand during 1971–1981 and 1981–1991 was much higher than the national decadal growth of urban population in India (46.39% and 36.24% respectively). The State of Uttarakhand registered a growth of nearly 5% over the urban population of 2001 recording a decadal urban growth of approximately 10% during 2001 and 2011 (Table 1). Table 1 shows that the proportion of urban population increased with the growth of total population in State.

This shows that population growth contributed significantly to phenomenal increase in urban population mainly through rural-urban migration. In Himalaya, geo-environmental constraints impose severe limitations on the carrying capacity of natural resources (ICIMOD, 2008). As a result, forest based subsistence agriculture constitutes main source of rural food and livelihood although the availability of arable land is only 15% of the total area and food production is just enough to meet 35% of annual food-grain requirement of the region. Owing to constraints of subsistence economy, a large proportion of adult male population out-migrates the region in search employment. Therefore, the urbanization in Himalaya is primarily an outcome of livelihood constraints induced rural out-migration. During recent years, the trends of rural outmigration has further increased due to deple-

Table 1. Trends of urban growth in Uttarakhand (1901–2011)

Census Years	Total Population	Urban Population	Urban Content (%)	Decadal Growth (Urban) (%)
1901	1,979,866	154,424	7.80	—
1911	2,142,258	179,332	8.37	16.13
1921	2,115,984	191,660	9.06	6.87
1931	2,301,019	195,797	8.51	2.16
1941	2,614,540	270,503	10.35	38.15
1951	2,945,929	400,631	13.60	48.00
1961	3,610,938	495,995	13.74	23.80
1971	4,492,724	734,856	16.36	48.16
1981	5,725,972	1,149,136	20.07	56.38
1991	7,113,483	1,634,084	22.97	42.20
2001	8,479,562	2,170,245	25.59	32.81
2011	10,116,752	3,091,169	30.55	42.43

Source: Office of the Registrar General and Census Commissioner, 2013

Bottlenecks in Sustained Agricultural Productivity	Community Response (%)
Irratic and Reduced Rainfall	71
Reduced Water for Irrigation	20
Labour Scarcity	3
Lack of Improved Seeds	3
Lack of Extension Services	2
Lack of Fertilizer	1

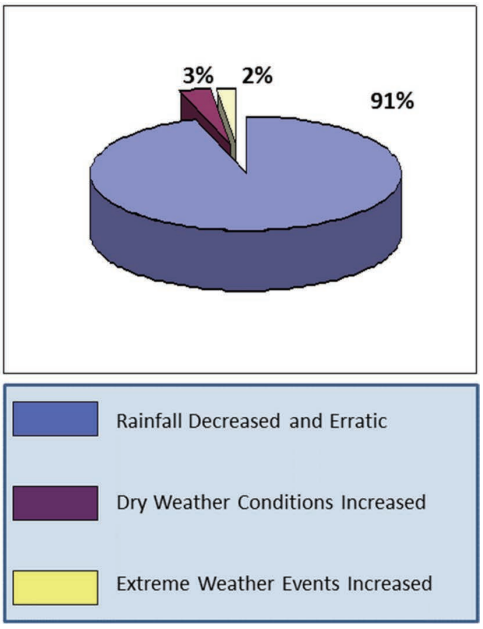

Figure 3. Climate change, emerging driver of urban growth—community perception
Source: Field Surveys in Uttarakhand, October-November 2015

tion of agricultural resources, impact of climate change on farming system and rural livelihood, and increasing frequency and severity of natural disasters in the region (Tiwari and Joshi, 2015). The field survey conducted in 500 villages across the 10 mountainous districts of Uttarakhand revealed that farm production has declined and livelihood opportunities in agricultural sector decreased due reduced rainfall, decreasing rainy days and resultant decline in irrigation potential and the incidences of crop failure increased (Figure 3). These changes are increasing trends of rural out-migration and contributed significantly to urban growth in all parts of Himalaya (Tiwari and Joshi, 2015).

In Himalaya, the spatial pattern of urbanization has transformed during the last three decades as the process of urbanization extended from the mid-slopes and ridges to higher elevations and down to the valleys as a result of improved road connectivity and growth of tourism (Figure 2). In Uttarakhand, the network of roads increased from 44,332 km in 1991 to 46836 in 2001, and to 49,277 km road-length in the year 2011 providing a road-length of 92.14 km per 100 km^2 and 487.08 km per 100,000 population (Government of India, 2012). The growing road-network provided connecting to more 70% rural settlements to fast growing urban centres and also facilitated emergence and growth of large numbers of urban centres along the roads in the State, and thus improved access from local to global market. As a result, there is a regional shift from traditional crop farming and animal husbandry system to village-based production of fruits, vegetables, flowers and milk for sale both in the nearby and far-off urban markets, in the villages situated in the influence zone of urban centres and market places, and along and near the roads. This has large impact on the traditional resource development process and land use pattern that contributed significantly to the emergence and growth of large number of rural service centres along all types of roads (Tiwari and Joshi, 2015; 2016).

Besides, tourism has emerged as one of the fastest growing sectors all across the Himalayan region (Joshi and Pant, 1990). The rapidly growing tourism industry has contributed significantly to economic development and played important role in the development of infrastructure, specifically roads and growth of urbanization in Himalaya (Kruk et al., 2007). In popular tourist destinations like Mussoorie and Nainital tourism industry provided temporary employment to 35% local youths each year during 2001–2015. It is expected that the growth of tourism will further contribute to the urban growth in Himalaya as the global economic crisis that started in 2008 did not affect the tourism growth in the region. This is clearly brought out by the trends of tourist growth during 2008–2009 as the region registered respectively 11.73 and 41.81 growth in domestic and foreign arrivals during the period. It is expected that tourism would emerge as one of fastest growing development sectors in the State in coming years mainly because: (i) the Government of Uttarakhand has identified tourism as one of the 'Lead Sectors' of the economy of the State (Government of Uttarakhand, 2010; Shakya, 2008); and (ii) the recent 'Vision' Document of Uttarakhand Government which present a multi-sectoral strategy for the development of the State has targeted 12% and 15% growth respectively in domestic and international tourist-arrival; increased participation of private sector and enhanced public-private sector partnership in tourism during next 10 years (Government of Uttarakhand, 2010). These new tourism development policies of Government may further boost urbanization in the State even in higher mountains (ICIMOD, 2012; UNWTO, 2009).

IV. Environmental Impacts of Unplanned Urbanization

The rapid growth of urban settlements in the high Himalayan Mountains, particularly in tectonically alive and ecologically fragile Lesser Himalayan ranges has been resulting in the depletion of natural resources, particularly, water, forest and biodiversity as well as increased incidence and severity of natural risks, such as, flash floods, slope failures and landslides within the urban ecosystems as well as in their surrounding areas. More recently, comparatively less accessible areas of the region are also being affected by the process of fast urbanization mainly owing to the extension of road network in high and remote mountains and the growth of tourism through the publicity and marketing of new tourist sites. Consequently, there has been tremendous increase in size, area, number and complexity of urban settlements in the region resulting in the continuous expansion of urban land use (Tiwari and Joshi, 2016). The natural risks of this unplanned urban growth are now clearly discernible in most of the urban centres and their surroundings, in the densely populated Lesser Himalayan ranges, such as, Shimla, Nainital, Mussoorie and Almora. Most of the densely populated towns are situated in tectonically active domain, and therefore are susceptible to the processes of slope failure and landslides. Nainital located in the close proximity of the Main Boundary Thrust (MBT) has experienced devastating landslides since its evolution

(Oldham, 1880; Disaster Management and Mitigation Centre, 2011). The urban development in the region is also having long-term impacts on the fragile ecosystem and environment of the urban fringe areas consisting of natural forests, wildlife habitats and water sources including, lakes, streams, wetlands and natural springs; and agricultural land (Rautela et al., 2014). The natural components of the urban fringe zone are being degraded and depleted steadily and significantly through the expansion of urban land use, deforestation, habitat destruction, mining of building material for construction, waste and sewage disposal, and facilitating changes in the traditional land use and resource management practices through the multiplier effect of urban growth (Tiwari and Joshi, 2015; and 2016).

Land use changes are now being considered as one of the major driving forces transforming the natural landscape and affecting ecosystem services in the mountain regions (Jandl et al., 2009; Ives, 1989; Haigh, 2002). Further, it is anticipated that anthropogenic interventions and resultant land use changes will become increasingly dominant in 21st century Urban growth often results in intensive and rapid land use changes with consequent degradation and disruption of critical ecosystem services (Buytaert et al., 2011). These changes in ecosystem structures and functions particularly in headwaters are causing great loss of biodiversity and disruption of hydrological processes in the mountains (Tiwari, 2000; Borsdorf et al., 2010). Studies indicated that the rapid urbanization and resultant land use intensifications have disrupted the hydrological regimes of Himalayan headwaters (Tiwari and Joshi, 2012a; 2012b; Ives, 1989). The studies carried out in other parts of middle Himalaya revealed that the amount of surface runoff from urban areas is much higher compared to the amount of runoff from other categories of land, particularly, forests and horticulture. The increasing density of urban built-up area in Himalaya is causing great damage to the underground water resources by reducing the groundwater recharge and resultant decline in water generating capacity of land to springs and streams in the region (Tiwari and Joshi, 2015; Haigh, 2002; Rawat, 2009).

Nearly 65% urban centre located on the ridges and mountain slopes in Himalaya constitute the headwaters of a large number of water sources, particularly springs and streams. These natural springs and streams not only constitute source of water-supply to the towns themselves; but they are also provide 15–50% freshwater to the downstream rural areas. The changing land use pattern and decline in forest area have disrupted the hydrological system of towns and cities in Himalaya and decreased ground water recharge (Ives, 1989). Since, a large proportion of the rainfall is lost through surface run-off without replenishing the groundwater reserves in urbanized landscape, the groundwater reserve is depleting alarmingly (Rai and Sharma, 1995, 1998; Rai et al., 1998; Tambe et al., 2012; Valdiya and Bartarya, 1991; Tiwari and Joshi, 2012a). These hydrological changes are resulting into (i) long-term decreasing trend of stream discharge, (ii) drying of springs, and (iii) dwindling capacity of urban lakes (Rawat, 2009; Valdiya and Bartarya, 1991; Tiwari and Joshi, 2012a). The hydrological investigations revealed that 25% to 41% natural springs dried; 3% to 7% wetland depleted; and 11% to 47% water discharge declined in springs and streams within and around Shimla, Solan and Hamirpur town in Himachal Pradesh and Almora, Pauri and Ranikhet towns in Uttarakhand during 1985 and 2015 (Table 2). Further, it was observed that 45% natural springs have dried and 21% have become seasonal, and stream discharge declined by 11% in the heavily urbanized Lake Region of Nainital during 1985–2015. Consequently, 87% urban centres and 65% villages situated in the rural fringe of towns and cities in Himalaya are facing acute shortage of freshwater (Tiwari and Joshi, 2012). Anthropogenic impact on urban lakes has increased resulting into their silting and pollution. Bathymetric investigations revealed that capacity of Bhimtal and Nainital lakes has decreased respectively by 5,494 m^3 and 14,150 m^3 during the last 100–110 years due to rapid siltation. It was observed that run-off generated by urban systems (65% of total rainfall) is much higher than that of forests (4.5%) and agricultural land (15%), consequently, peak flood rate of urban areas is 35 times higher compared to flood rate of forests in the region (Rawat, 2009). These hydrological disruptions have increased the incidences of landslides and flash floods respectively by 15% and 17% in the urban areas and their surrounding rural regions during the last 3 decades. Urban growth in Himalaya is not only disrupting

Table 2. Status of urban freshwater ecosystem services in Western Himalaya (1985–2015)

State	Town	Natural Springs Dried (%)	Wetland Depleted (Nos.)	Water Discharge Declined (%)
Himachal Pradesh	Shimla	25	5	11
Himachal Pradesh	Hamirpur	31	7	15
Himachal Pradesh	Solan	39	3	25
Uttarakhand	Almora	41	6	47
Uttarakhand	Pauri	35	3	37
Uttarakhand	Ranikhet	40	7	41

Source: Field Surveys by Tiwari and Joshi in April 2015

hydrological system; but also destructing wildlife habitats, depleting biodiversity, increasing vulnerability of urban systems and their surrounding rural areas to a variety of natural risks, and undermining rural food and livelihood security through encroachment of prime agricultural land (Tiwari and Joshi, 2015). Studies indicated that unplanned rapid urban growth caused depletion of 5.85% natural forests during 1985–2015 in the Lake Region of district Nainital. Besides, 47% of total forest-area situated in the towns and their peri-urban zones in Uttarakhand has been characterized as highly disturbed and fragmented causing rapid loss of biodiversity and genetic resources.

V. Socio-Economic Implications

A large proportion of cultivated land and other areas are being encroached upon by the process of rapid urbanization and expansion of infrastructure, services and economic activities in Himalaya, every year (Tiwari and Joshi, 2015; 2016). Study indicated that the most densely settled and rapidly growing urban centres of Uttarakhand Himalaya have been fast intruding upon productive agricultural land in their surrounding rural regions. This has caused huge transformation of cultivated land within urban centres as well as in their peri-urban zones leading to land use intensifications. Rural areas surrounding these urban centres have lost their prime agricultural land ranging between 4.71% to as much as 12.97% due expansion of urban land use in urban fringe during the last 30 years. The highest encroachment of cultivated land (12.97%) was recorded in Pithoragarh which is the largest township of Uttarakhand Himalaya and headquarters of district Pithoragarh followed by Bageshwer (11.36%) and Almora (11.36%). These fast growing large towns besides being the densely settled urban areas of the region are also the seats of district and sub-district level administration. Besides, urban growth also contributed to the degradation of 2.06%–9.63% natural forests and reduced the proportion of irrigated land between 4.34% and 21.07% due to hydrological disruption and resultant depletion of water resources around different towns (Table 3). The continued depletion and loss of critical agricultural resources, such as agricultural land, biomass manure, water for irrigation, deforestation caused by the development of urban structure contributed 19% to 55% decline in agricultural productivity in 10 urban zones. Consequently, rural settlements situated in fringe of these urban complexes are currently facing food deficit between 65% and 95%. Undoubtedly, urbanization has contributed significantly to socio-economic betterment of the region through development of infrastructure, generation of employment opportunities in various emerging areas, such as, tourism, trade and services sectors. However, depletion of forest resources and decline in agricultural economy decreased off-farm employment opportunities in traditional forestry and agricultural sectors in the urban fringe of 10 studied towns between 42% and 81%. As a result, rural households in peri-urban zones have lost 7% to 12% of their food purchasing power. The depletion of forest resources and decline in agricultural economy decreased off-farm employment opportunities in traditional forestry and agricultural sectors between 42% in Rudraprayag and 87% in Almora urban areas reducing rural income (Table 4). This will have long-term impacts on local food security affecting particularly the poor and socially marginalized communities constituting nearly 75% of total population (Tiwari and Joshi, 2015).

Table 3. Impacts of urban growth on agricultural resources in Uttarakhand (1971–2010)

District	Urban Area	Impacts of Expansion of Urban Land Use		
		Losses of Agricultural Land (%)	Losses of Forest Area (%)	Decline in Irrigated Land (%)
Uttarkashi	Mussoorie	5.37	3.17	15.22
Chamoli	Gopeshwer	4.71	5.14	21.07
Rudrapryag	Rudrapryag	5.27	5.22	17.73
Pauri Garhwal	Srinagar	10.15	6.49	5.22
Tehri Garhwal	Tehri	6.22	3.54	4.34
Pithoragarh	Pithoragarh	12.97	9.63	11.91
Bageshwer	Bageshwer	11.36	7.92	15.44
Champawat	Champawat	7.14	3.44	7.15
Almora	Almora	11.21	2.21	9.71
Nainital	Lake Region	9.12	2.06	7.92

Source: Field Surveys by Tiwari and Joshi in October 2010

Despite rapid urban growth and unplanned constructions of houses and hotels the pressure of heavy influx of tourists and other seasonal population has far exceeded the carrying capacity of urban amenities in the Himalayan towns. Furthermore, the expansion of urbanization and population increase facilitated the emergence and growth of a large number of slums in almost all towns of Himalaya. In a small township of Nainital with a total population of 49,000 as many as 12 slum pockets have been identified that have emerged in the close proximity of lake, along the drainage channels, fragile slope and other such environmentally critical and unsafe areas. The total population of these slums was 9,667 persons in 2011 accounting for about 19% of the total population of the town. The growth and expansion of slums have further

Table 4. Impacts of urban land use expansion on agricultural and food systems in Uttarakhand (2001–2015)

Name of District	Name of Urban Area	Decline in Local Food Production (%)	Increase in Local Food Deficit (%)	Losses of Rural Livelihood Opportunities (%)	Decline in Food Purchasing Power (%)
Dehradun	Mussoorie	31.17	71.00	67.0	7.0
Chamoli	Gopeshwer	35.22	65.00	74.0	11.0
Rudrapryag	Rudrapryag	21.14	74.00	42.0	9.0
Pauri	Srinagar	41.45	76.00	61.0	5.0
Tehri	Tehri	19.0	85.00	65.0	12.0
Pithoragarh	Pithoragarh	37.23	86.00	45.0	8.0
Bageshwer	Bageshwer	44.17	79.00	87.0	11.0
Champawat	Champawat	31.77	67.00	64.0	7.0
Almora	Almora	55.00	95.00	81.0	12.0
Nainital	Lake Region	39.00	85.00	73.0	6.0

Source: Field Surveys by Tiwari and Joshi from March 2001 to December 2015

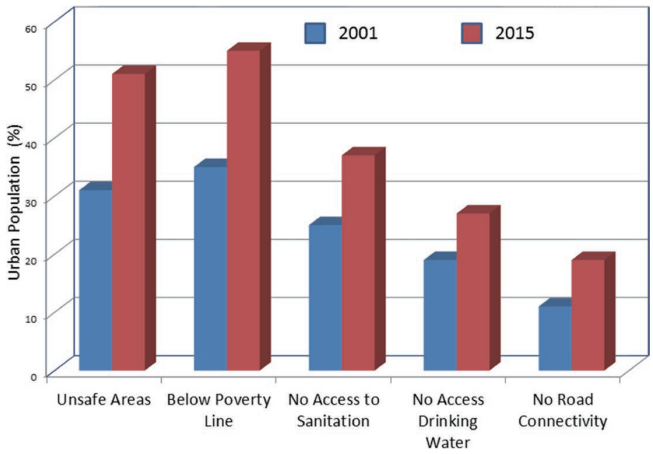

Figure 4. Growing urban inequalities in Himalaya
Source: Field Surveys in Uttarakhand, October-November 2015

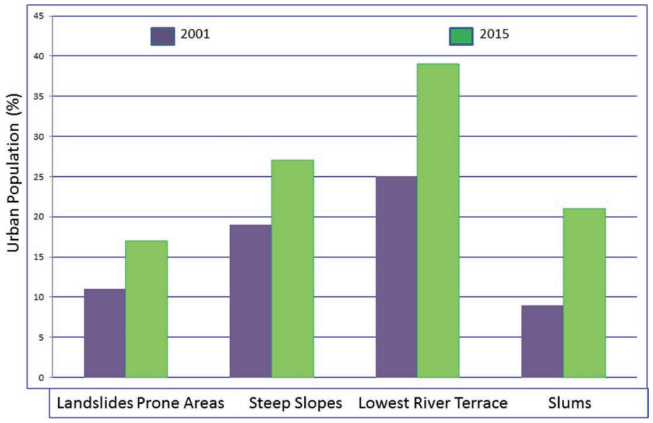

Figure 5. Environmental implications of unplanned urban growth
Source: Field Surveys in Uttarakhand, October-November 2015

increased the vulnerability of large population particularly poor and marginalized to climate change induced risks. Moreover, the rapid and unplanned growth has increased social, economic and environmental inequalities in the Himalayan towns. The proportion of urban population living in environmentally unsafe areas, below poverty line, without access to sanitation, without drinking water and without road access increased by nearly 20%, 25%, 10%, 7% and 6% in the Himalayan urban areas during 2001 and 2011 (Figure 4). Moreover, the percentage of urban population inhabiting landslide prone zones, steep-slopes, lower river terraces and slums has increased respectively 6%, 8%, 14% and 12% all across the Himalayan States during 2001 and 2011 (Figure 5). Nainital town was hit by high intensity rain in the years 2008, 2010 and 2013 affecting respectively 3,735, 2,771 and 3,755 urban families out of which the proportion of poor families was respectively 69%, 75% and 77%. During 2001–2015 on an average 2,401 urban households were affected by extreme weather events of which 55% were poor; 29% inhibited fragile areas; 15% had poor access to road; and 11% households had very limited options of livelihood (Table 5).

VI. Climate Change Vulnerability

The unplanned and rapid urbanization is increasing the vulnerability of Himalayan towns to variety of climate change induced natural hazards and disasters, such as flash floods, slope failures and landslides, drought and water scarcity, and health risks. A scoping exercises was carried out based on the survey of available literature, assessment and status reports, action plans; series of discussion and meetings held with various stakeholders; and field observations in 10 selected towns of Uttarakhand.

Table 5. Extreme weather events and urban vulnerability in nainital, Uttarakhand (2001–2015)

Years	Urban Households Affected by Extreme Weather Events During 2001–2015				
	Urban Households Affected	Poor Urban Households Affected (%)	Urban Households Inhibited Fragile Areas (%)	Urban Households Inhibiting Areas with Poor Infrastructure (%)	Urban Households with Limited Livelihood Options (%)
2001	2,747	51	25	11	13
2002	2,511	45	37	10	08
2003	2,731	67	27	03	03
2004	2,215	39	41	15	05
2005	2,417	65	17	09	09
2006	1,977	35	37	15	13
2007	2,125	47	35	15	03
2008	2,735	69	35	17	11
2009	1,955	37	17	14	09
2010	2,771	75	31	19	17
2011	1,955	55	27	15	15
2012	1,971	57	25	14	16
2013	3,755	77	39	25	25
2014	2,177	51	25	19	11
2015	1,977	55	21	17	14
Average	2,401	55	29	15	11

Source: Field Surveys by Tiwari and Joshi from March 2001 to December 2015

The results of the scoping exercises revealed that all the 10 towns of Uttarakhand are highly exposed to rainfall variability and increase in temperature. The important observations of the scoping exercise are as follows:

- The analysis of the past trends revealed that annual, winter and monsoon precipitation has shown significant decline. There has been about 40% reduction in rainfall during 1987–2009. Approximately 17% decrease in rainfall was observed from 1996 onwards.
- The decreasing trend of seasonal snowfall has been observed since 1990 and was lowest in 2009.
- Past trend of temperature over last 100 years indicated that there has been an increase at a rate of 0.86°C/100 years in temperature in the region. However, during 1970 to 2000 the temperature has increased at a rate of 0.46°C/10 years, which is quite alarming.

Although the climate projections are currently not available for urban areas, yet the regional projections indicate towards changes in rainfall patterns with increased variability and overall decline in precipitation. This is likely to increase the incidences of high intensity rainfall and cause frequent droughts in the region affecting the urban areas. It is being anticipated that the Western Himalayan region including Himachal Pradesh and Uttarakhand may experience 1.7°C to 2.2°C increase in the mean annual temperature by 2030 (UCCRN, 2015). These observed and projected changes in the key climatic phenomena may affect the ecosystem services, particularly the availability, supply and quality of freshwater; and increase the vulnerability of urban systems to climate change induced natural risks, specifically high intensity rainfall, flash-floods, slope failures landslides, droughts causing devastation of life, property, urban services, infrastructure, livelihood and health of people, particularly that of marginalized and poor households.

VII. Climate Change Adaptation Measures Priorities, Efforts and Gaps:

Almost all the Himalayan towns, have grown in an completely unplanned manner causing immense pressure on the natural ecosystem, limited urban infrastructure and services resulting into degradation of the urban environmental conditions and increasing vulnerability of large population to emerging threats of climate change. Major environmental concerns associated with such unplanned urban development are emerging risks of climate change induced geo-hydrological hazards and depletion of water

resources. Despite realizing the increasing vulnerability of urban areas to climate change induced risks no specific climate change adaptation plan has been evolved for any of the cities of Himalaya by the Governments including Government of Uttarakhand. During the recent decades, climate change driven fluctuations in the precipitation pattern have shown increasing trends which pose serious threats to ecologically fragile, tectonically active and densely populated urban ecosystems particularly located in the Lesser Himalaya. Increasing uncertainty in precipitation patterns in Western Himalaya is highlighted by the fact that in the years 2007–08 and 2008–09 the region faced severe drought conditions. In the years 2007–2008 and 2008–2009, several districts of Western Himalaya were notified as being drought affected; and 2015–2016 the entire mountainous part of Uttarakhand and Himachal Pradesh was under prevailing dry conditions from August 2015 to January 2016. Whereas, in 2010 and 2013 the entire region witnessed excess monsoonal precipitation, and massive losses were reported from across the region due to repeated flash flood, landslide and cloudburst events. However, no detailed climate vulnerability risk assessments so far has been carried out from the view point of natural disasters, and particularly climate change induced geo-hydrological risks for any of the townships of Uttarakhand and Himachal Pradesh. A series of urban development plans funded by both Central Government and State Governments are currently under implementation in the Himalayan Provinces. However, these urban development initiatives did not incorporate the climate change impacts on urban ecosystem and a mechanism for adaptation (Urban Development Department Government of Uttarakhand, 2007). Moreover, urban climate change adaptation and disaster risk reduction have not been incorporated in the State Action Plan for Climate Change of Uttarakhand (Government of Uttarakhand, 2016; Disaster Management and Mitigation Centre, 2011).

VIII. Conclusions and Recommendations:

As in other parts of the world, urban growth cannot be stopped or reduced in Himalaya, but it can be steered in a more sustainable manner through an integrated urban-rural land use planning. Effective land use policies need to be evolved and implemented for the protection and conservation of forests, biodiversity, water resources and agricultural land. It would also be imperative to develop pragmatic framework for sustainable development of agriculture in peri-uban zone as it is not only an important economic activity, but also constitutes fundamental source of rural food and livelihood, an integral part of culture, history and traditions, and an invaluable treasure of traditional ecological knowledge required for adapting to climate change. The unplanned urban growth in Himalaya is not only depleting natural resources and disrupting ecosystem services, but also increasing the socio-economic and environmental inequality both within the towns and in their surrounding per-urban zones. Besides, the rapid and unplanned urbanization is also increasing the susceptibility of intensively modified and densely populated fragile slopes to the active processes of mass movement and landslides. Further, the rapidly changing climatic conditions, particularly the climate change induced hydrological extremes are posing severe threats to the sustainability of fast growing urban ecosystem by increasing the frequency, intensity and severity of geo-hydrological hazards in the towns and their vast hinterland. The climate change is likely to trigger the slope instability and disrupt the hydrological regime of urban watersheds which are already under stress of increasing urbanization. The city development plans and also the state disaster risk reduction frameworks and climate change adaptation plans did not make any provision for addressing the emerging risks of climate change, particularly the geo-hydrological disasters in fast growing towns of Himalaya. In view of this the following recommendations are made:

- A comprehensive climate change vulnerability assessment and mapping of all the Himalayan towns should be carried taking into account all the critical parameters of exposure, sensitivity and adaptive capacity of urban ecosystem.
- A detailed and large-scale risk zone mapping of the town should be carried out analyzing the parameters of geology, structure, litho-logy, geomorphology, demography, economy and livelihood, infrastructure and services.
- A comprehensive urban land use policy should be evolved and implemented taking into conservation, developmental, climate change adaptation, disaster risk reduction needs and priorities of the town.
- A participatory framework for the conservation of water resources particularly through reducing anthropogenic intervention in the urban headwaters should be evolved and implemented.

An integrated climate change adaptation governance plan need to be formulated incorporating the above-mentioned points involving a range of institutions and

Picture 1. Densely built-up areas in tectonically active slopes in Nainital, Uttarakhand
Source: Tiwari, October 2015

Picture 2. Unplanned urbanization in Almora, Uttarakhand
Source: Tiwari, October 2017

Picture 3. Urban sprawl in environmentally unsafe slope in Almora, Uttarakhand
Source: Tiwari, October 2017

Picture 4. Unplanned urbanization in Dharamshala, Himachal Pradesh
Source: Tiwari, June 2013

Picture 5. Urban encroachment on agricultural land in Khurpatal, Uttarakhand
Source: Tiwari, November 2016

stakeholders (e.g., government line departments, private enterprises, civil society and non-governmental organizations, community based organizations and academic and research institutions).

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