RAPID URBANIZATION AND ENVIRONMENTAL CHANGE IN GEO-DISASTER PRONE FOOTHILL LANDSCAPE OF THE HIMALAYA

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Abstract: Himalaya foothill zone has fragile geo-environment due to active tectonics and dynamic hydrological process and its associated reshaped geomorphology. Rapid urbanization and development of new colonies leads to high rate of land use change and natural resource degradation which has been accumulating the fragility of the area. Consequently entire Himalaya foothill zone required a comprehensive local level geo-environmental appraisal to support sustainable development and urban planning of the region. Keep in view this; the fast growing Ramnagar Himalayan Foothill area (RHFA) in district Nainital, Uttarakhand (India) has been selected for the case illustration. Key objective of the study was to investigate rapid unplanned urban growth and its socio-environmental impacts by GIS based land use mapping for year 1995 and 2015. The land use change statistics revealed that annually about 1.25% area of the natural landscape (comprises of forest, horticulture, shrubs and barren land) has been changing into built-up land (comprises of settlements and colonized waste land with associated infrastructural development). In order to that the urban growth resultant to increased population density in RHFA as the spatial data of population density revealed that the area under moderate (1000-4000 person/km2), high (4000-8000 person/km2) and very high (> 8000 person/km2) population density zone have been increasing with the annual rate of 0.75%, 0.49% and 0.03% respectively.

Keywords: Himalaya, Foothills, unplanned, urban growth, environmental change

Introduction: The process of urbanization is integrally associated to the three pillars of sustainable development: economic development, social development and environmental protection (Wubalem, 2000; Weber and Puissant, 2003; Malcolm et al, 2007). Unfortunately worldwide, particularly in developing countries rapid and unplanned urban growth threatens sustainable development when the necessary infrastructure is not developed or when policies are not implemented to ensure that the benefits of urban life are equitably shared (United Nations, 2009). Today, despite the comparative advantage of cities, urban areas are more unequal than rural areas and hundreds of millions of the world's urban poor live in sub-standard conditions (Lusugga, 2006; Ellen et al, 2011; Firman, 2004; Sean, 2014; Brian and Vincent, 1990). In some cities, unplanned or inadequately managed urban expansion leads to rapid sprawl, pollution, and environmental degradation, together with unsustainable production and consumption patterns (Eija, 2005; Peter and Valdinir, 2008; Saibal and Sugata, 2009; Wekesa et al 2011). Most recent report of United Nations on world prospects of urbanization (2014) declared that the earth is rapidly urbanizing with 0.5% annual growth rate since last two decades (1994-2014). As a result presently (2014) about 54 % of the world's population residing in urban areas whereas it was about 44 % of total world population in 1994. This report presents India as one of the rapidly unplanned urbanizing countries of the world with increased urban population by 26% to 32% of total population during last two decades (1994-2014). In India, according to the 2011 Census, the urban population grew to 377 million showing a growth rate of 2.76% per annum during 2001-2011.

Worldwide there is no standard definition of urbanization; it varies from country to country (United Nations 2014). In India urban areas are defined on the basis of two principles. First, the state government grants munici¬pal status corporation, municipal coun¬cil, notified town area committee or nagar panchayat, etc. to the settlements. Such settlements are known as municipal towns in the census definition of urban areas. Second, the unplanned settlement area exist in the fringe area of municipal cities and towns, does not have an urban civic status, but satisfies demographic and economic crite¬ria, like a population of more than 5,000, a density of 400 persons per square kilo¬metre and 75% male workforce in the non-agricultural sector, it can be declared urban. The second way of urban growth is very horrifying in India particularly in adjoining downstream foothill-plain area of the Himalaya. Since last two decades, a significant proportion of the rural population of Himalaya Mountain has been migrating to adjoin foothill plain area to have benefits of urban life and livelihood. This trend has been accelerated in Uttarakhand Himalaya state after its separation from U.P. as a new state of India in 2000. The senses data of India (2011) shows 3.74 % current annual rate of urbanization in Uttarakand Himalaya state, which is more than present national and international rate of urbanization, about 2.47 % and 0.5% respectively. Consequently numbers of unplanned new settlements, colonies, service centers and sub urban areas, are being developed in the fertile agricultural,

horticultural land even in geo-disaster prone areas under barren, shrubs and forest land.

Densely populated Himalaya foothill terrain represents highly fragile geo-environment on the planet due to active tectonics and dynamic upstream-downstream hydrological process under global climate change impacts (Hamilton, 1987; Haigh et al., 1988; Ives, 1989; Valdiya, and Bartarya, 1989, Valdiya, 1991, 2003; Shukla and Bora, 2003; Thakur, 2004; Goswami and Pant, 2008). Beside that the rapid unplanned urbanization leads to high rate of land use change and natural resource degradation which has been accumulating the geo-environmental fragility and its socioeconomic risks in the region (Rawat, et al., 2011, 2012, 2012a; 2015). Consequently entire Himalaya foothill zone required a comprehensive study on dynamics and causes of rapid unplanned urbanization and its socioeconomic and environmental impacts. Keep in view this; the Ramnagar Himalayan Foothill area (RHFA) in district Nainital, Uttarakhand (India) has been selected for the case illustration (Fig. 1). Key objective of the study was to investigate rapid unplanned urbanization and its socioeconomic and environmental impacts using geoinformatic techniques.

2. Methodology:

2.1 GIS development: Proposed GIS module deals the land use informatics of the study area as it is a key aspect to monitor anthropogenic activities on land surface (such as residential zones, agricultural fields, industrial zones, grazing, logging and mining) and its impacts on natural environment (such as vegetation, water, air, desert and ice and the abrupt subsurface etc.) to carry out decadal and annual change in spatial distribution of different existing land use classes under natural and built-up landscape as consequent of fast urbanization. The data and methods used for the study have been disused below:

2.1.1 Data used: Indian Remote Sensing Satellite (IRS-1C) LISS III (23.50 m spatial resolution) and PAN merged data of 1995 and 2015 was used for the analysis and mapping of land use for the respective years (Fig. 2). Supplementary data and information required for the study have been generated from various primary as well as secondary sources. The primary information was generated through field surveys, mapping, interviews etc., and the relevant secondary data was collected from various sources, such as Census of India – 20011, Government, Land Records, forests maps etc. Radiometric corrections were done employing dark pixel subtraction technique. The satellite images of the study area were registered geometrically using SOI Topographical Sheets (56 O/3) of the area at scale 1:25000.

2.1.2 Methods and techniques for land use/cover classification: For carrying out this important exercise uniformly distributed common Ground Control Points (GCPs) were selected and marked with root mean square (rms) error of one pixel and the images used were resampled by nearest neighborhood resampling method. Both the data sets were then co-registered for further analysis initially, the LISS and PAN data were co-registered with root mean square (rms) error of 0.3 pixel and the output FCC (False Colour Composite) was transformed into Intensity, Hue and Saturation (IHS) colour space images. The reverse transformation from IHS to RBG was performed substituting the original high-resolution image for the intensity component, along with the hue and saturation components from the original RBG images. This merge data product obtained through the fusion of IRS –1C LISS – III and PAN was used for the generation of land cover/land use map of the study area and digital image processing techniques supported by intensive ground truth surveys were used for the interpretation of the remote sensing data. In the Himalayan foothill terrain the interpretability of the remote sensing data to a large extent is affected by the complexity of the terrain as due to the effect of elevation and slope and its aspect, the spectral signature of same objects are often different or vice versa. In order to overcome these constraints and also to attain the best possible level of accuracy in the interpretation, intensive ground truth surveys were carried out in the study region and a visual interpretation key was evolved for primary land cover/land use classification. This was followed by the supervised digital classification of land cover/ land use through on screen visual recording and rectification.

2.1.3 Land use change detection: To monitor the dynamics of land utilization pattern in the study area the land use maps generated for the years 1995 and 2015 were overlaid using Geographic Information System and land use changes were detected and mapped. Normalized Difference Vegetation Index (NDVI) - based time series have been used to track extensive vegetation dynamics throughout the study area. Principle component analysis (PCA) is a linear transformation of correlated variables into uncorrelated variables which does not change the number of variables (spectral and temporal bands). It's utilizing the correlation matrix, was applied to NDVI composite images for year 1995 and 2015.

2.1.4 Land use classification accuracy assessment: The study adopted a stratified random sampling approach to select land use sample sites for assessment of the classification accuracy [28]. Land use maps for year 1994 and 2014 produced by the highest probability classification were subdivided into individual land use strata. Sample sites were then arbitrarily disseminated throughout the study area for respective years land use map using a random number generator in GIS. The x,y

coordinates of the sample pixels were then identified in the digital reference data. Study also computed overall classification accuracy for all three periods land use maps, as well as producers and user's accuracies to measure omission and commission errors for individual land use/land cover categories. Because of the traditional error matrix presents information on sampled locations only, adjusted the overall accuracy by taking into account the proportion of each stratum (land use/land cover category) in the classified maps. In this way, we estimated the total proportions of pixels that were classified correctly and incorrectly in the land use maps for year 1995 and 2015.

3. Results and Discussions:

3.1 Dynamics of urbanization and Environment Change: To understand the dynamics of urbanization and its encroachment on natural landscape, the decadal and annual trends of urban growth has been carried out by comprehensive GIS mapping of land use land cover for year 1995 and 2015 (Fig. 2 and Table 1). The land use change statics revealed that about 25% area of the natural landscape has been changed in built-up area during last two decade (1994-2014). It varies maximum for horticultural land (11%) and crop land (9%) to minimum for forest land (1%) and barren land (1%) whereas shrubs land has been changed by 3%. Consequently this change transformed into built-up environment as 16% settlement area with infrastructural setup and 9% colonized waste land (Table 2). The detailed characteristics of urbanization under different land categories of built and natural environment is given below:

3.1.1 Shrinking natural environment: It poses non built-up area of the land surface, comprises of vegetation cover, agriculture land and barren land of the study area. Comparative study of two study period reveals that in 2015 the area under non built-up land covers about 72% (46.67 km2) proportion of the study area whereas twenty years back it was quit high up to about 97% (62.83 km2) part of the study area (Fig. 2 and Table 1). The spatial variability of natural non-built-up area varies maximum for forest land to minimum for barren land as discussed below:

3.1.1.1. Reducing vegetation cover: It comprises of forest and shrubs land area (Fig. 2 and Table 1). The species of forest and shrubs throughout the study area varies greatly according to elevation and climatic conditions from foothill plain to Siwalik Hills. In the foothill plain, the main species of the forest are Sal (Shorea robusta), Sheesam (Dalbergia sissoo) and Sagwaun (Tectona grandis) whereas multiple tropical shrubs species exists under the trees of this forest. The forest in Siwalik hill of the study area comprises of 'sain' (Terminadia chibuca), 'Sandar' (Ovgeinia balbiraginrtes), 'Aaonla' (Ambica officinalis), 'Chyara' (Madhuca buryracca whereas shrubs species are Dhaula (Woodfordia fruilicoss), Hisalu (Rubus), Tungla (Bhespani flora) etc. Fig. 2 and Table 2 reveal that in 2015, about 31% (20.09 km2) area is under forest land and about 9% (5.83 km2) area covered by shrubs land whereas twenty year back in 1995 the area under these categories was 32% (20.74 km2) and 12% (20.09 km2) respectively.

3.1.1.2. Reducing agricultural land: It comprises of crop land and horticultural land (Fig. 2 and Table 1). The crop land occupied by rice, millets, maize, maduwa, madir, soyabean, pulses (rajma, urad, gahat), groundnut, ginger, turmeric and beans during monsoon season (June to September) whereas wheat, mustard, pulses (masur, arhar), gram, radish, pea, patato, onions garlic and chilly during non monsoon season (October to May). The horticultural land occupied by fruit farming; that includes mainly mango, litchi, guava and amla. Spatial variability of crop pattern and horticulture practice also varies greatly according to elevation and climatic conditions from foothill plain to Siwalik Hills of the study area. The area under crop land and horticultural land respectively covers about 24% (15.56 km2) and 6% (3.89 km2) part of study area whereas twenty year back in 1994 the area under these categories was 33% (21.39 km2) and 17% (11.02 km2) respectively(Fig. 2 and Table 1).

3.1.1.3. Reducing Barren Land: The streams, flows from upslope to down slope valleys; brings huge level of sediment load and deposit it in downstream river beds formed sandbars. Fig. 2 and Table 1 reveal that, in 2015, barren land covers about 2% (1.30 km2) area of the study area whereas twenty year back in 1994 the area under this category was 3% (1.90 km2) of the study area.

3.1.2 Enlarging built-up environment: It poses structured environment of the land surface, comprises of existing settlements with road network, bridle paths, canals and river dams etc. Apart from that the waste land category; emerged by newly developing colonies, throughout the Ramnagar Himalayan foothill area recognized as built up area which covers about 28% (18.15km2) part of study area while in 1994 only 3% (1.99 km2)area was under this category (Fig. 2 and Table 1). It clearly shows extremely high rate of urbanization in the Ramnagar Himalayan foothill area. Brief description on each category of built up area is given below:

3.1.2.1. Increasing settlements with related infrastructural setup: Mainly three types of settlements exists in the RHFA; these are domestic (residential houses, farmhouses), official (individual and governmental offices, schools and colleagues) and commercial (shops, workshops, hotels, restaurants, guesthouses) buildings beside road network, canals and river dams etc. (Fig. 2 and Table

1). These all types of settlements simultaneously covered about 19% (12.32 km2) area of the Ramnagar Himalayan foothill area in 2015 whereas before two decade during 1994 it was limited under a small patch with the area of 1.99 km2 which accounts about just 03% part of the study area.

3.1.2.2. Emerged Colonized waste land: Since last two decades, a significant proportion of the rural population of Himalaya Mountain has been migrating to adjoin foothill plain area for better life style and livelihood. This trend has been accelerated in Uttarakhand state after its separation from U.P. as a new state of India in 2000. Consequently in RHFA; numbers of new colonies are being developed in the agricultural, horticultural land, shrubs land and even in barren land by the colonizers and builders for sell to the peoples coming from mountainous region. Unfortunately out of total area of each newly developed colony, only 30% area is being acquired by immigrant people to build their houses whereas left 70% area is being acquired by the local brokers for business purpose as they used to sellout it with increased cost in future. Keep in view the increasing cost of such types of land; the brokers do wait for a long period of years to decades and desires of maximum profit. Subsequently the broker's land in newly developed colonies have emerged a new land use category throughout the study area which have been recognized as waste land built up area because of no use of this land under developing colonies. Waste land built up area covers about 7% (4.54 km2) area of the study area (Fig. 2 and Table 1).

3.2 Decadal and annual urban growth and environmental change: Twenty years changes (1995-2015) of land use pattern reveals that the natural or non-built environment (comprises of forest land, shrubs land, crop land, horticultural land and barren land) have been badly affected by high rate of urbanization as changed by 25% land into settlements and associated socioeconomic infrastructural development which accounts a decadal change about 12.47% with the rate of 1.25% each year (Table 1). The highest rate of urbanization stands in horticultural land (0.55% each year to 1.25% each decade) and crop land (0.45% each year to 4.50% each decade). The lowest rate of urbanization found under forest land and barren land (0.45% each year to 4.50% each decade) whereas shrubs land area represents the moderate rate of urbanization (1.15% each year to 1.50% each decade).

Consequently the area of built-up landscape (comprises of settlements and newly developing colonies) has been spread out and increased by 25% during last twenty years (1995-2015) which suggests the decadal change about 12.47% with the rate of 1.25% each year (Table 1). It varies maximum for settlement area (0.80% each year to 7.97% each decade) to minimum for newly developing colonies (0.45% each year to 4.50% each decade).

3.3 Socioeconomic impacts of fast urbanization and environmental changes in RHFA: Although there are some general benefits of urbanization but they are scanty instead of their multiple long-term socioeconomic loses in RHFA. The main socioeconomic problems which can often see in the Ramnagar town and its surrounding urbanized rural area are:

3.3.1 Increased population density: The population density varies greatly from 150-10000 person/km2 throughout the study area; which has been categorised in five classes between very low to very high. Fig. 3 and Table 2 are demonstrating comparative data analysis of population density for year 1995 and 2015. During two decades period (1995-2015) the area under moderate, high and very high population density increased about 14.91%, 9.72% and 0.65% respectively with the annual rate of 0.75%, 0.49% and 0.03% respectively. Consequently the area under low and very low population density decreased about 0.65% and 24.63% with 0.03% and 1.23% annual rate.

3.3.2 Unplanned infrastructural developments and urban growth in geo-disaster prone areas: As carried out in land use section that since last two decades a numbers of unplanned colonies and associated infrastructural facilities are being developed by colonizers and builders in the geo-disaster prone area under agricultural land, horticultural land, shrubs land and barren land to accommodate increased population density in the study area. Unfortunately this unplanned urban growth is under threat of geo-disaster risks (flood, landslide and earthquake). Fig. 4 is demonstrating development of some of those geo-disaster prone colonies in the study area.

3.3.3 Increased pollution: Rapid urban growth and population pressure accelerated the process of urbanization and consequent industrialization in the study area which lead to raise pollution index due to poor waste management, water pollution, increasing wooden industry (i.e. furniture, wooden board), tourism industry (i.e. hotels, resorts, restaurants, shopping halls) and transport industries (i.e. increased number of road motor vehicle and their workshops).

3.3.4 Over stressed public service centers and consequent problems: Due to increased population and rapid urban growth; all the main public service centers (i.e. public food distribution shops, hospitals, water distribution department, educational institutes, cooking gas agencies, fuels distribution centers etc.) suffering from over population presser which resultant to food-water-health-education insecurity,

increased crimes, uncontrolled irritating traffic system, increased road accidents etc.

4. Conclusion: The study concluded that the rapid urbanization and colonization leads to high rate of land use change and natural resource degradation which has been accumulating the geo-disaster fragility of the area and consequent disaster risks to the society, economy and environment. Urban growth statistics revealed that annually about 1.25% area of the natural landscape has been changing into built-up land. In order to that the urban growth resultant to increased population density in RHFA. The area under moderate (1000-4000 person/km2), high (4000-8000 person/km2) and very high (> 8000 person/km2) population density have been increasing with the annual rate of 0.75%, 0.49% and 0.03% respectively. The increasing rate of population density raised several socio-environmental problems in the region (i.e. unplanned urban growth and infrastructural development on geo-disaster prone area, increased pollution, over stressed public service centers, food-water-health-education insecurity, increased crimes, increased road accidents due to poor traffic management etc.).

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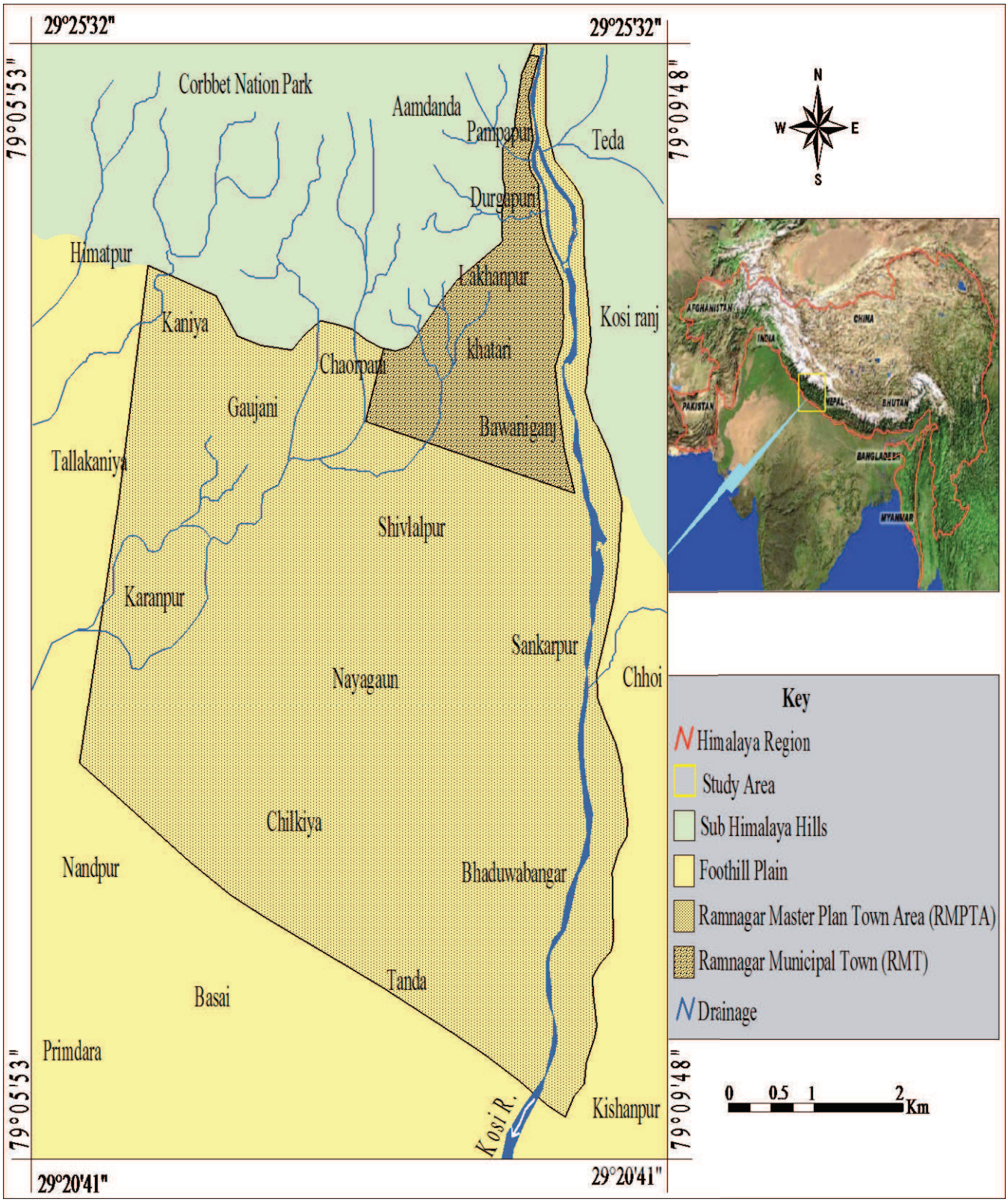

Fig.1: Location of the Ramnagar Himalaya Foothill area (RHFA)

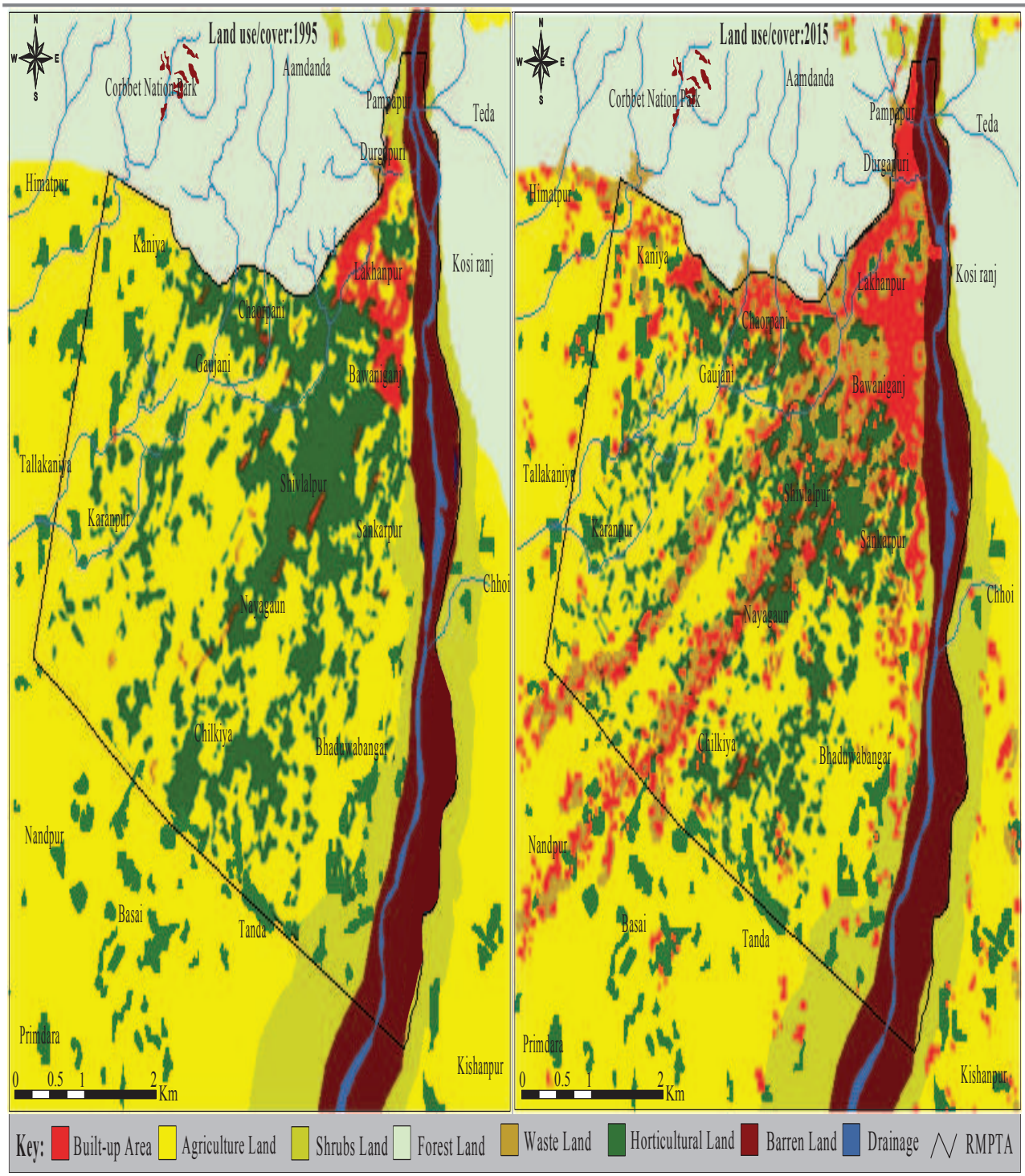

Fig. 2: Changed natural landscape into built environment due to fast urban growth during last two decades (1995-2015) in RHFA.

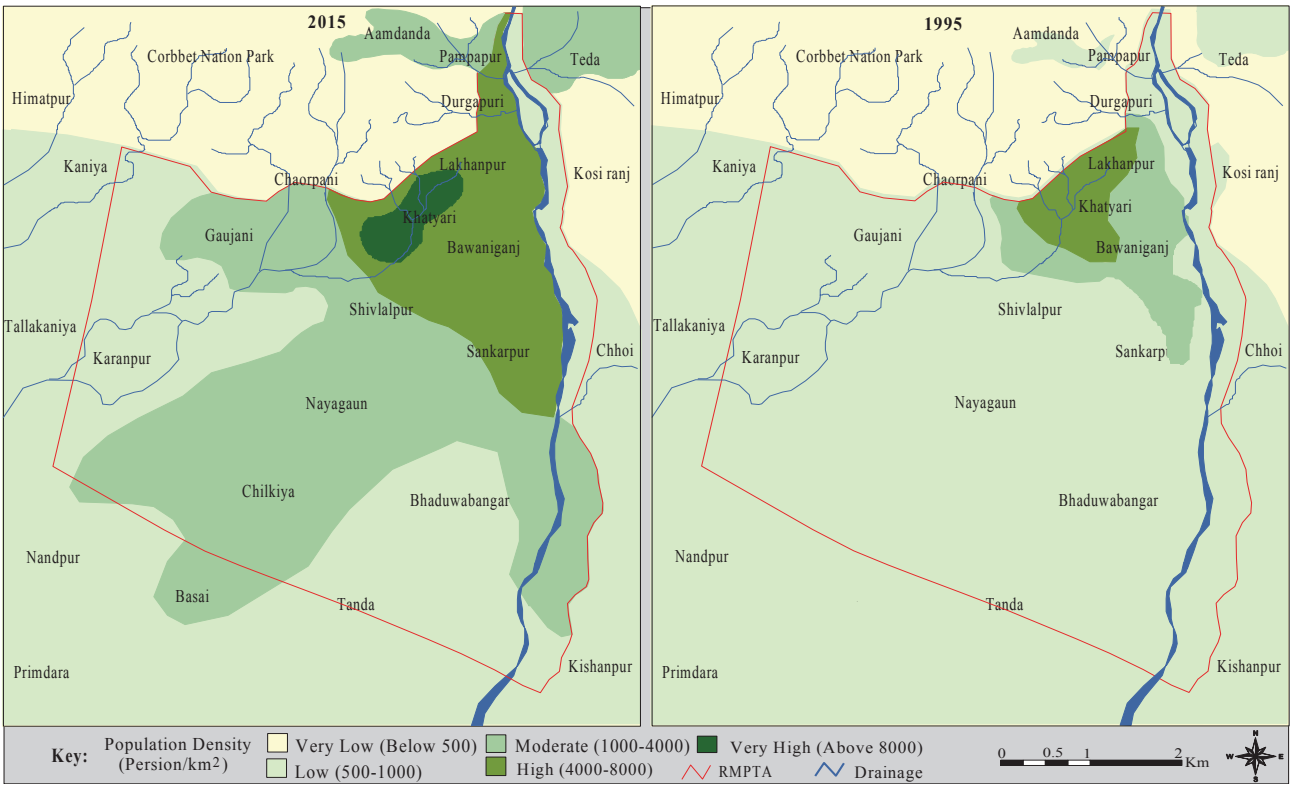

Fig. 3: Increased population density during last two decades period (1995-2015).

Fig. 4: Unplanned urban growth on extreme flood prone areas along Kosi River in Ramnagar town (a, b) and land surface of younger fluvial fans formed by non-Perennial Rivers.

Land use/cover Categories		Covered Area				Dynamics of urbanization and Environment Change							
		1995		2015		1995-2015		Decadal		Annual		Formed Land use	Rate of Urbanization
		km²	%	km²	%	km²	%	km²	%	km²	%		
Natural Environ-ment	Forest Land	20.74	32	20.09	31	-0.65	-1	-0.32	-0.50	-0.03	-0.05	Settlements	Low
	Barren Land	1.90	3	1.30	2	-0.60	-1	-0.30	-0.46	-0.03	-0.05	Settlements	Low
	Shrubs Land	7.78	12	5.83	9	-1.95	-3	-0.98	-1.50	-0.10	-0.15	Settlements	Moderate
	Crop Land	21.39	33	15.56	24	-5.83	-9	-2.92	-4.50	-0.29	-0.45	Settlements	High
	Horticultural Land	11.02	17	3.89	6	-7.13	-11	-3.57	-5.50	-0.36	-0.55	Settlements	Very High
	Total Non Built up Area	*62.83*	*97*	*46.67*	*72*	*-16.16*	*-25*	*-8.08*	*-12.47*	*-0.81*	*-1.25*	Settlements	Very High
Built up Environ-ment	Settlements, Road etc.	1.99	3	12.32	19	10.33	16	5.17	7.97	0.52	0.80	Settlements	Very High
	Colonized Waste Land	0	0	5.83	9	5.83	9	2.92	4.50	0.29	0.45	Waste Land	Very High
	Total Built up Area	*1.99*	*3*	*18.15*	*28*	*16.16*	*25*	*8.08*	*12.47*	*0.81*	*1.25*	Settlements	Very High
Gross Total		**64.82**	**100**	**64.82**	**100**	**19**	**-**	**-**	**-**	**-**	**-**	**-**	

Table 1: Attribute data of land use/cover pattern in Ramnagar Himalayan foothill area.

Population Density (Person/km²)		Covered Area				Changes in covered area					
		1995		2015		1995-2015		Decadal		Annual	
		km²	%	km²	%	km²	%	km²	%	km²	%
Very Low	<500	13.61	21	12.96	20	-1	-0.65	-0.5	-0.32	-0.05	-0.03
Low	500-1000	46.67	72	22.04	34	-38	-24.63	-19	-12.32	-1.90	-1.23
Moderate	1000-4000	3.89	6	18.80	29	23	14.91	11.5	7.45	1.15	0.75
High	4000-8000	0.65	1	10.37	16	15	9.72	7.5	4.86	0.75	0.49
Very High	> 8000	0.00	0	0.65	1	1	0.65	0.5	0.32	0.05	0.03
Total	**160**	**64.82**	**100**	**64.82**	**100**	**0**	**0.0**	**0**	**0.00**	**0.00**	**0.00**

Table 2: Increased population density during last two decades period (1995-2015).

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