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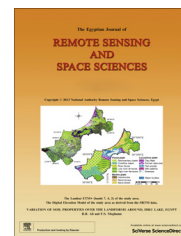


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RESEARCH PAPER

# Changes in land use/cover using geospatial techniques: A case study of Ramnagar town area, district Nainital, Uttarakhand, India

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technique

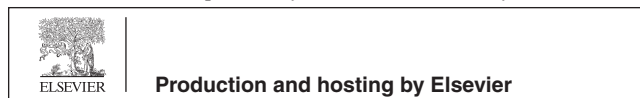
**Abstract** The present study illustrates an integrated approach of remote sensing and GIS (Geographical Information System), i.e., Geospatial techniques for assessment of land use/cover dynamics of a town located in the foothill zone of the Uttarakhand State viz., the Ramnagar. Landsat satellite imageries of two different time periods, i.e., Landsat Thematic Mapper (TM) of 1990 and 2010 were acquired by USGS Earth Explorer and quantified the land use/cover changes in the Ramnagar town from 1990 to 2010 over a period of two decades. Supervised Classification methodology has been employed using Maximum Likelihood Technique in ERDAS 9.3. The images of the study area were categorized into five different classes, viz. built-up area, vegetation, agricultural land, water bodies and sand bar. The results indicate that during the last two decades, built-up area and sand bar of the Ramnagar town area have been increased about 8.88% (i.e., 2.83 km<sup>2</sup>) and 3.98% (i.e., 1.27 km<sup>2</sup>), respectively, while area under other land categories such as vegetation, agricultural land and water body have decreased about 9.41% (i.e., 3.00 km<sup>2</sup>), 0.69% (i.e., 0.22 km<sup>2</sup>) and 2.76% (i.e. 0.88 km<sup>2</sup>), respectively. The study reveals that the Ramnagar town is expanding maximum towards the southern direction along the National Highway-121. The paper also highlights the importance of digital change detection techniques for nature and location of change of the Ramnagar Town area.

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## 1. Introduction

Land use/cover change has become a central and important component in current strategies for managing natural resources and monitoring environmental changes. Land use is a product of interactions between a society's cultural background, state and its physical needs on the one hand and the natural potential of land on the other (Balak and Kolarkar, 1993). Land use is the intended employment of land management strategy placed on the land cover by human agents or land managers to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging and mining among many others (Zubair, 2006). On the other hand, land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and ice and the immediate subsurface, including biota, soil, topography, surface and groundwater and it also includes those structures created solely by human activities such as mine exposures and settlement (Lambin et al., 2003; Baulies and Szejwach, 1997).

Land use/cover change is a dynamic process taking place on the bio-physical surfaces that have taken place over a period of time and space is of enormous importance in natural resource studies. Land use/cover change dynamics are important elements for monitoring, evaluating, protecting and planning for earth resources. Land use/cover changes are the major issues and challenges for the eco-friendly and sustainable development for the economic growth of any area. With the population explosion, human activities such as deforestation, soil erosion, global warming and pollution are very harmful for the environment. This causes land use/cover changes with the demand and supply of land in different activities. Change detection in land use and land cover can be performed on a temporal scale such as a decade to assess landscape change caused due to anthropogenic activities on the land (Gibson and Power, 2000). Land use/cover change is influenced by various natural and human activity processes. In order to improve the economic condition of the area without further deteriorating the bio-environment, every bit of the available land has to be used in the most rational way. This requires the present and the past land use/cover data of the area (Chaurasia et al., 1996). Land use/cover dynamics are widespread, accelerating and significant processes being driven by human actions but also produce changes that impact humans (Agarwal et al., 2002). (Prakasam, 2010) studied the land use and land cover change in the Kodaikanal region of Western Ghats in Tamil Nadu State of India to observe changes during a span of 40 years from 1969 to 2008. Some recent studies (Samant and Subramanyan, 1998), Jaiswal et al. (1999), Minakshi et al. (1999) have shown the use of remote sensing and GIS in land use change detection.

With the invention of remote sensing and GIS techniques land use/cover mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selcuk et al., 2003). Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwala, 1985) in association with GIS that provides suitable platform for data analysis, update and retrieval (Star et al., 1997; Chilar, 2000). Digital change detection

techniques based on multi-temporal and multi-spectral remotely sensed data have demonstrated a great potential as a means to understanding landscape dynamics-detect, identify, map, and monitor differences in land use/cover patterns over time, irrespective of the causal factors.

The present study demonstrates the application of multi-temporal satellite imageries in defining land use/cover dynamics of a Himalayan town, viz. Ramnagar located in the foot hill zone of the Uttarakhand State in the Central Himalayan region.

## 2. Study area

The study area, viz. Ramnagar town (Fig. 1) in Uttarakhand, India extends between 29°20'13"N and 29°24'42"N latitudes and 79°04'15"E to 79°08'22"E longitudes. As per the Ramnagar Master Plan Town (RMPT) area developed by Kumaun Urban Planning Office at Haldwani, encompasses an area of 31.55 km<sup>2</sup>. Out of the present RMPT area only about 2.49 km<sup>2</sup> (or 7.89%) area falls under the Ramnagar Municipal area (Fig. 1) which indicates that the town is sprawling very rapidly. The average elevation of the town stands at 305 m above mean sea level which varies between 271 m in the extreme south and 419 m at the extreme north. Physiographically, Ramnagar is settled on a foothill region (locally called Bhabhar) made-up of quaternary deposits, i.e., coarse alluvium where the mountain rivers debauch and re-emerge in the adjacent Indo-Gangetic plain. Ramnagar is also famous for an international "Litchi farming". Climatically, the town enjoys sub-tropical climatic conditions. The mean annual rainfall is 205 cm and the mean annual temperature varies from 15 to 35 °C. The town was established and settled by Commissioner H. Ramsay during 1856–1884. During the British Rule tea gardens were developed in Ramnagar. But these tea gardens have been closed since a long time.

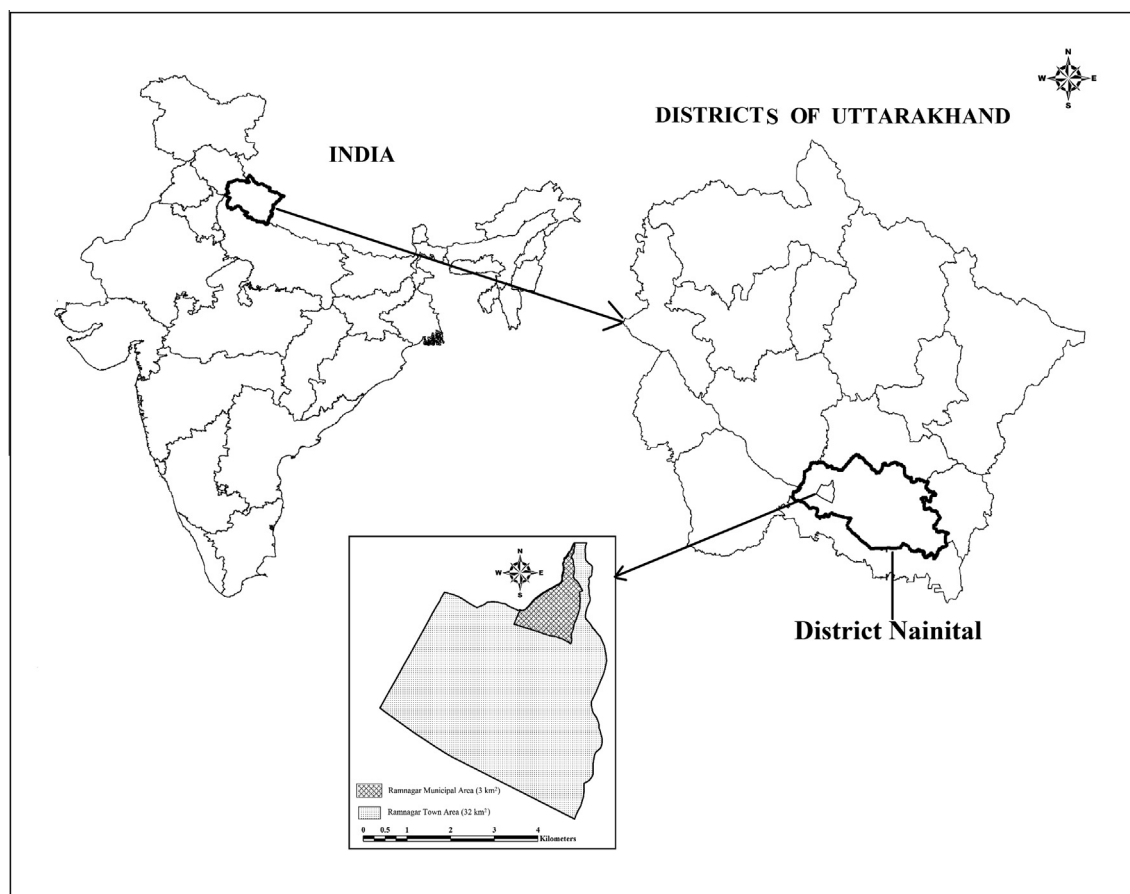
## 3. Methodology

### 3.1. Land use/cover detection and analysis

To work out the land use/cover classification, supervised classification method with maximum likelihood algorithm was applied in the ERDAS Imagine 9.3 Software. For better classification results some indices such as normalized difference vegetation index (NDVI), normalized difference water index (NDWI) and normalized difference built-up index (NDBI) were also applied to classify the Landsat TM images at a resolution of 30 m of 15th November, 1990 and 2010. With the help of GPS, ground verification was done for doubtful areas. Based on the groundtruthing, the misclassified areas were corrected using recode option in ERDAS Imagine 9.3. Five land use/cover types are identified and used in this study, namely (1) built-up land (2) vegetation cover (3) agricultural land (4) water body and (5) sand bar.

### 3.2. Land use/cover change detection and analysis

For performing land use/cover change detection, a post-classification detection method was employed. A change matrix (Weng, 2001) was produced with the help of ERDAS Imagine 9.3 software. Quantitative areal data of the overall land use/



**Figure 1** Location map of the study area.

**Table 1** Area and amount of change in different land use/cover categories in the Ramnagar master plan town area during 1990–2010.

Land use/cover categories	1990		2010		Change 1990–2010	
	km <sup>2</sup>	Percentage	km <sup>2</sup>	Percentage	km <sup>2</sup>	Percentage
Built-up area	1.25	3.91	4.08	12.79	2.83	8.88
Vegetation	10.29	32.26	7.29	22.85	–3	–9.41
Agricultural land	16.06	50.36	15.84	49.67	–0.22	–0.69
Water body	2.3	7.22	1.42	4.46	–0.88	–2.76
Sand bar	1.99	6.25	3.26	10.23	1.27	3.98
Total	31.89	100	31.89	100		

cover changes as well as gains and losses in each category between 1990 and 2010 were then compiled.

#### 4. Results and discussions

The data obtained through the analysis of multi-temporal satellite imageries are registered in Table 1–3 and the results are diagrammatically illustrated in Figs. 2–5. Fig. 2 depicts land use/cover status of two study periods i.e., 1990 (Fig. 2A) and 2010 (Fig. 2B); Fig. 3 depicts land use/cover change from 1990 to 2010 in different land use categories in built-up area (Fig. 3A), vegetation (Fig. 3B), agricultural land (Fig. 3C) and water bodies (Fig. 3D). Fig. 4 diagrammatically

illustrates directional change in the built-up area in 2010 while Fig. 5 depicts the direction-wise areal expansion in built-up area during the last two decades. A brief account of these results is discussed in the following paragraphs.

##### 4.1. Land use/cover status

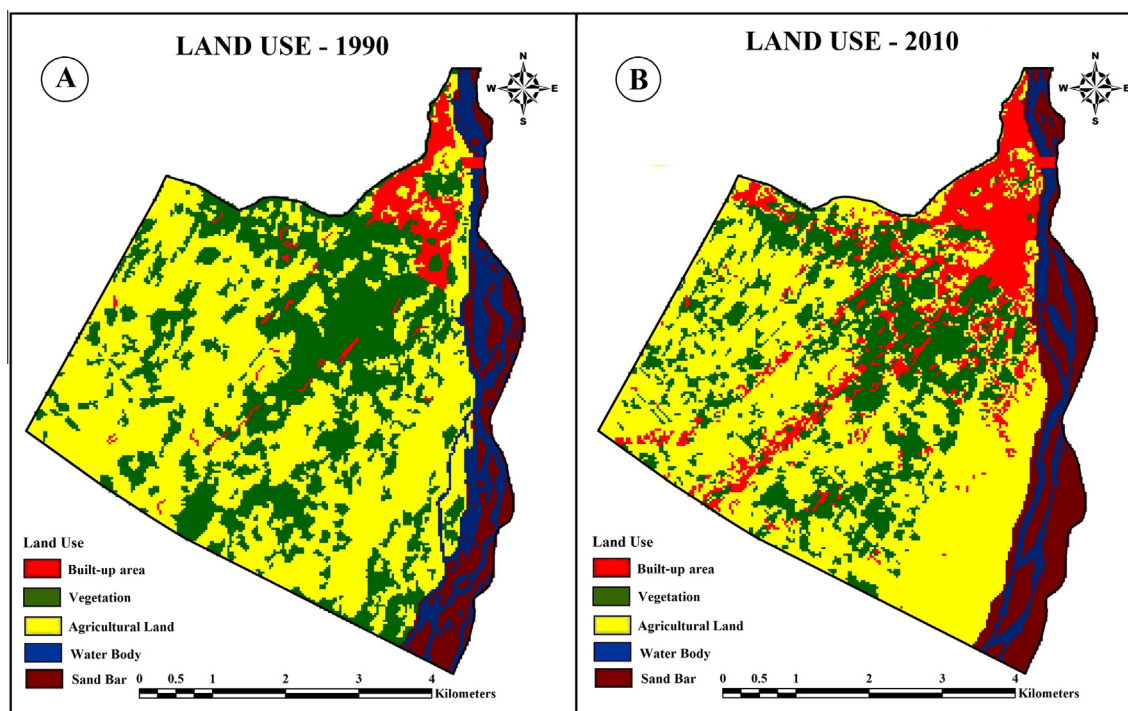
Fig. 2 and Table 1 reveal that in 1990, about 3.91% (or 1.25 km<sup>2</sup>) area of Ramnagar Master Plan Town (RMPT) area was under built-up land, 32.26% (or 10.29 km<sup>2</sup>) under vegetation, 50.36% (or 16.06 km<sup>2</sup>) under agricultural land, 7.22% (or 2.3 km<sup>2</sup>) under water body and 6.25% (or 1.99 km<sup>2</sup>) area was covered by sand bar. During 2010 the area under these land cat-

**Table 2** Land use/cover change matrix showing land encroachment (in %) in Ramnagar town master plan area.

Land use/cover categories		Year 1990				
		Built-up area	Vegetation	Agricultural land	Water body	Sand bar
Year 2010	Built-up area	100.0	11.07	10.45	0.00	0.00
	Vegetation	0.0	46.33	15.74	0.00	0.00
	Agricultural land	0.0	41.50	71.49	3.78	0.00
	Water body	0.0	0.49	0.80	34.06	23.13
	Sand bar	0.0	0.58	1.50	62.15	76.86
	Class total	100	100	100	100	100
Class change		0.0	53.66	28.50	65.93	23.13

**Table 3** Directional expansion of built-up area (in km<sup>2</sup>) during 1990–2010) in the RMPT area.

Year	Direction								
	North	North-East	East	South-East	South	South-West	West	North-West	Average change
1990	1.61	0.26	0.13	0.26	2.25	1.05	1.05	0.67	0.91
2010	5.18	0.71	0.39	1.06	9.21	5.78	6.56	3.68	4.07
Change 1990–2010	3.57	0.45	0.26	0.8	6.96	4.73	5.51	3.01	3.16

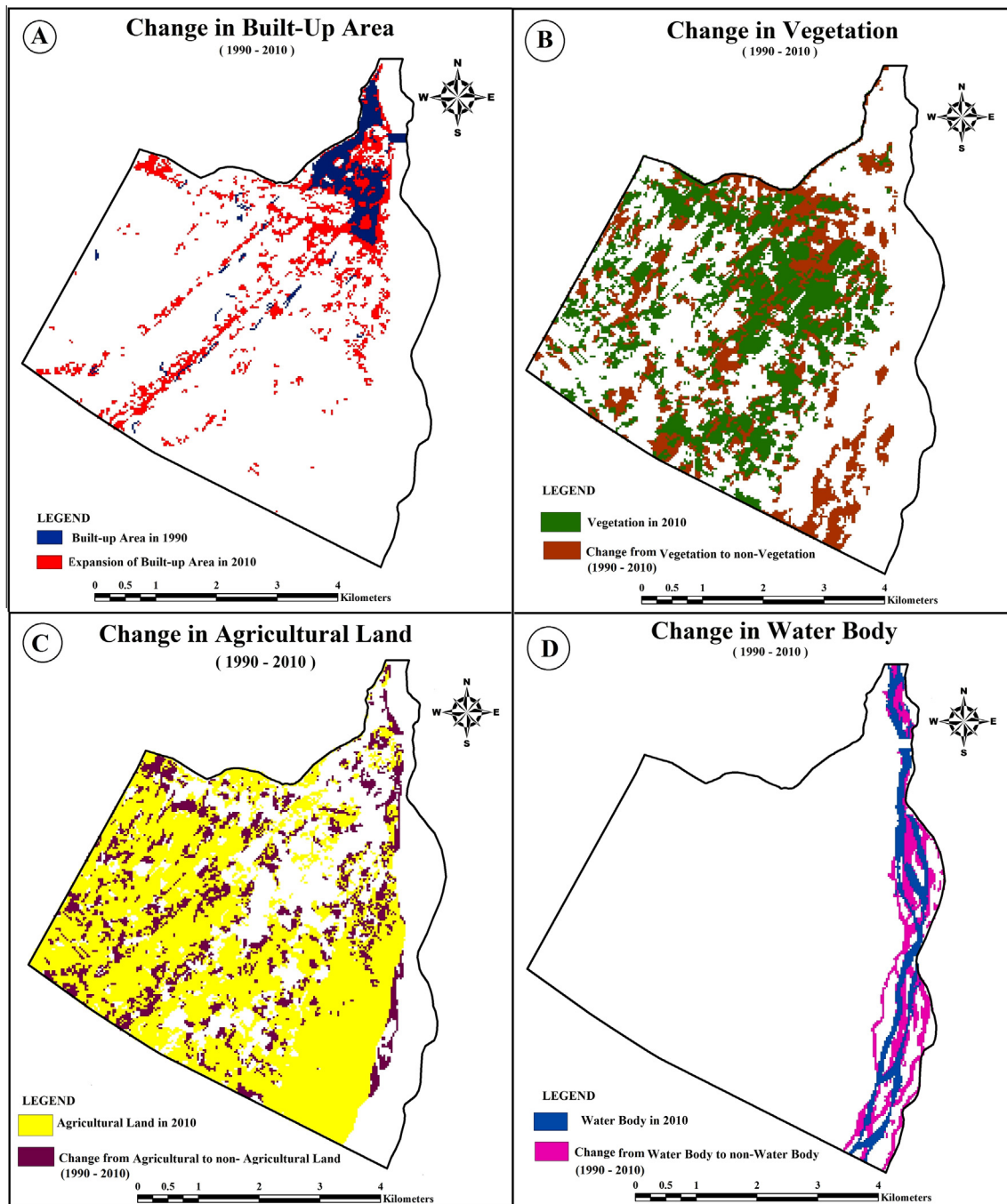
**Figure 2** Land use status of the Ramnagar Town Master Plan area; (A) – in 1990, (B) – in 2010 (based on Landsat Thematic Mapper Satellite Imagery).

egories was found 12.79% (or 4.08 km<sup>2</sup>) under built-up land, 22.85% (or 7.29 km<sup>2</sup>) under vegetation, 49.67% (or 15.84 km<sup>2</sup>) under agricultural land, 4.46% (or 1.42 km<sup>2</sup>) under water body and 10.23% (or 3.26 km<sup>2</sup>) under sand bar.

#### 4.2. Land use/cover change

The data presented in Table 1 and Fig. 3 depict that both positive and negative changes occurred in the land use/cover

pattern in the RMPT area. During the last two decades, the built-up area has increased from 1.25 km<sup>2</sup> in 1990 to 4.08 km<sup>2</sup> in 2010 which accounts for 8.88% of the total sprawl area. The vegetation cover has been decreased from 10.29 km<sup>2</sup> in 1990 to 7.29 km<sup>2</sup> in 2010. This decrease in vegetation accounts for 9.41% of the total RMPT area. The agricultural land has slightly decreased from 16.06 km<sup>2</sup> in 1990 to 15.84 km<sup>2</sup> in 2010 which accounts for 0.69% of the total master plan town area. The water body is also de-

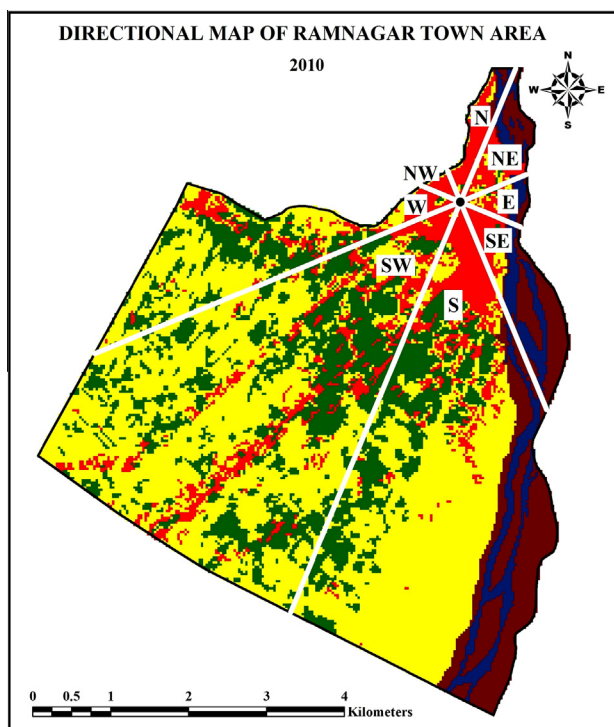


**Figure 3** Land use/cover change in different categories during the last two decades (1990–2010) in the RMPT area; (A) – in built-up area, (B) – in vegetation cover, (C) – in agricultural land and (D) – in water bodies. (Based on Landsat Thematic Mapper Satellite Imageries).

creased from 2.3 km<sup>2</sup> in 1990 to 1.42 km<sup>2</sup> in 2010 which accounts for 2.76% of total land cover area. Due to depletion in area under water bodies, area under sand bar has been increased from 1.99 km<sup>2</sup> in 1990 to 3.26 km<sup>2</sup> in 2010 which accounts 3.98% in area of total master plan town area.

To understand land encroachment in different land categories, a change detection matrix (Table 2) was prepared which reveals that during the last two decades (1990–2010):

- i. about 41.50% (or 4.27 km<sup>2</sup>) area of vegetation cover has been converted into agricultural land, 11.07% (or 1.14 km<sup>2</sup>) area under built-up land, 0.58% (or 0.06 km<sup>2</sup>) area under sand bar and 0.49% (or 0.05 km<sup>2</sup>) area under water body;
- ii. about 15.74% (or 2.53 km<sup>2</sup>) area of agricultural land has been converted into vegetative area, 10.45% (or 1.68 km<sup>2</sup>) area into built-up land, 1.5% (or 0.24 km<sup>2</sup>) in sand bar and 0.8% (or 0.13 km<sup>2</sup>) into water body;



**Figure 4** Diagrammatic illustration of directional change in the built-up area in 2010 in the Ramnagar town area.

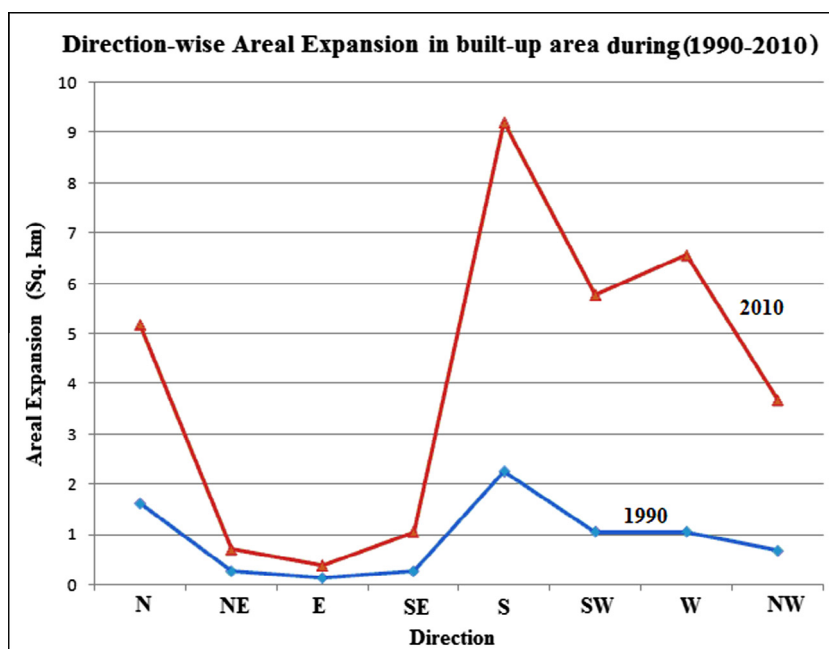
- iii. about 62.15% (or 1.44 km<sup>2</sup>) of area of water body has been converted into sand bar and 3.78% (or 0.09 km<sup>2</sup>) area under agricultural land; and
- iv. about 23.13% (or 0.46 km<sup>2</sup>) area of sand bar has been converted into water body.

### 4.3. Directional change in built-up area

To define pattern of changes in built-up area directional changes were worked out in built-up area from the heart of the city. The results are presented in Fig. 4 and diagrammatically illustrated in Fig. 5. During the last two decades, town has been expanded 6.96 km<sup>2</sup> towards the southern direction along the National Highway 121 while the town has expanded minimum (0.45 km<sup>2</sup>) towards the north eastern direction because of dominance of river bed and hilly terrain which limits the urban growth (Table 3).

### 5. Conclusion

The study conducted in one of the towns of the Uttarakhand state in the Central Himalaya located in the foothill zones of the Kumaun Lesser Himalaya advocates that multi-temporal satellite data are very useful to detect the changes in land use quickly and accurately. The study reveals that the major land use in the Ramnagar town area is built-up area. During the last two decades the area under built-up land has been increased by 8.88% (2.83 km<sup>2</sup>) due to construction of new buildings on agricultural and vegetation lands while the area under vegetation land is decreased by 9.41% (3 km<sup>2</sup>) due to deforestation activities by which the vegetation land is converted into agricultural and built-up land. The agricultural land has also decreased by 0.69% (0.22 km<sup>2</sup>). This depicts that the land under agriculture is cleared and sold out for the development of commercial and infrastructural activities. The built-up area is expanding maximum towards southern direction along the National Highway 121 while it expanded minimum towards the north eastern direction. The approach adopted in this study clearly demonstrated the potential of GIS and remote sensing techniques in measuring the change pattern of land use/cover in town area.



**Figure 5** Diagrammatic illustration of direction-wise areal expansion in built-up area during the last two decades (1990–2010) in the RMPT area.

## Acknowledgement

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