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ORIGINAL ARTICLE

Assessment of tourism impact on land use/land cover and natural slope in Manali, India: a geospatial analysis

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Abstract Demand for tourism has increased the pressure on hill stations and is becoming a major concern for change in land use/land cover in Manali, India. A geospatial approach has been applied in the present study to assess the impact of tourism on land use/land cover and natural slope. For this, satellite images of 1989, 2000, 2005 and 2012 were used for change detection and ASTER digital elevation model was used for slope analysis. Impact of tourism in the study area was assessed through change in built-up and its sprawl on various slope classes over the years. Built-upincreased from 4.7 to 15.7 % during 1989–2012 indicating fast growing development in the area. At the same time, exponential increase in number of tourists from 1.4 to 28 lakhs from 1980 to 2011, respectively, confirms excessive pressure of tourism in the study area. Even, the number of hotels has increased over the years. Built-up is observed in gentle slope to very steep slope and increasing year by year. Since the study area is prone to landslide and an increment in built-up especially in extreme, steep and very steep slope becomes a matter of grave concern. This study suggests immediate attention of city developers and planners to achieve the long-term viability of tourism industry through sustainable developments.

Keywords Digital elevation model · Land use/land cover · Change detection · Tourism · Overlay analysis · GIS

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Introduction

Tourism is an activity highly dependent on environmental resources but due to lack of planning and management is likely to erode its environmental base (Bualhamam 2009). Although tourism-related environmental issues have been empirically studied, the number of spatial examples is limited (Atik et al. 2010). Human interference in mountainous terrains makes them more susceptible to natural hazards because of construction activities. In addition, the past events of landslides show that these have close association with the land use and were confined to the built-up (roads) and agricultural lands (Chandel et al. 2011). Land use is the key factor to be considered for assessing the human impact on ecosystem. It is important to understand the contribution of anthropogenic activities to land use change, and how these activities might reduce the ecosystems' capacity to maintain a continuous flow of services (Rounsevell et al. 2006). Ecosystem provides services to humanity, which in short can be described as supporting life, supplying materials and energy, absorbing waste products, and providing culturally valuable assets (Gossling 2002).

In the tourism industry, GIS and remote sensing are recognized as valuable tools for sustainable tourism development (Bahaire and Elliott 1999; Boers and Cottrell 2007; Dye and Shaw 2007; Shirazi et al. 2013). Geospatial techniques and technologies provide wide applications pertaining to tourism development including location, condition of the area, trends and changes, routing to and through the site, and patterns associated with resource use (Perez et al. 2003; Chhetri and Arrowsmith 2008; Chang and Caneday 2011; Antonellini et al. 2014). Demand for tourism exaggerates the pressure on hill stations of high natural and visual value, and is becoming a major concern in the Manali area located in Himachal Pradesh, India (Kirch 2002). As the area is a hilly region, the natural slope and its level of stability become important aspects from the land use point of view. Therefore, the aim of the study was to assess the changes in land use/land cover (LU/LC) in Manali region and to find out the impact of tourism on the land use and natural slope. A special emphasis has been given on the change in built-up for a specified period to understand the pattern of urban sprawl over the different slope classes using geospatial techniques.

Study area

Manali is an internationally acclaimed tourist spot and is one of the best hill stations in India because of its forests, river, natural springs, meadow slopes, fresh air and mountains, which together renders a bucolic charm to this area. Tourism industry was grounded in leisure tourism right from its inception and eventually evolved as a major source of income for local residents (Singh 2008).The study area comes under the Pir Panjal range of the Himalaya that connects the Kullu valley with Lahul and Spiti valleys of Himachal Pradesh (Chetwode 1972). The study area is considered as 2 km buffer from Manali and lies between 32°13′38″ and 32°15′48″E latitude and 77°10′6″ to 77°12′40″N longitude (Fig. 1). Apart from Manali town, study area also includes settlements namely Mathiana, Kalang, Sial, Chijoga, Balsari, Chhayal and Aloe. Since landslide occurs in the study area, a Landslide Hazard Zonation Mapping for Manali was done by National Remote Sensing Agency (NRSA), Hyderabad (NRSA 2001) consisting five classes of hazard as very high, high, moderate, low and very low. The map suggests that Mathiana, Manali, Sial and Aloe come under low hazard class and Kalang, Balsari and Chhayal come under moderate hazard class while Chijoga comes under high hazard class. A very high hazard class is also mapped on the eastern side of Beas River in an immediate proximity of Chijoga and Mathiana villages. The climate in Manali is predominantly cold during winters and moderately cool during summers. The average temperature during summer is between 14 and 20 °C and between −7 and 10 °C in winter (Pandey et al. 1998). The snowfall in the region occurs usually in the month of December (Cole 2000).

Methodology

Geospatial technologies in terms of remote sensing, Geographic information system (GIS) and global positioning system (GPS) are used in the present methodology for assessment of tourism impact on LU/LC and natural slope.

Data collection

Since the study area was covered by snow during December to April, images were collected for the months

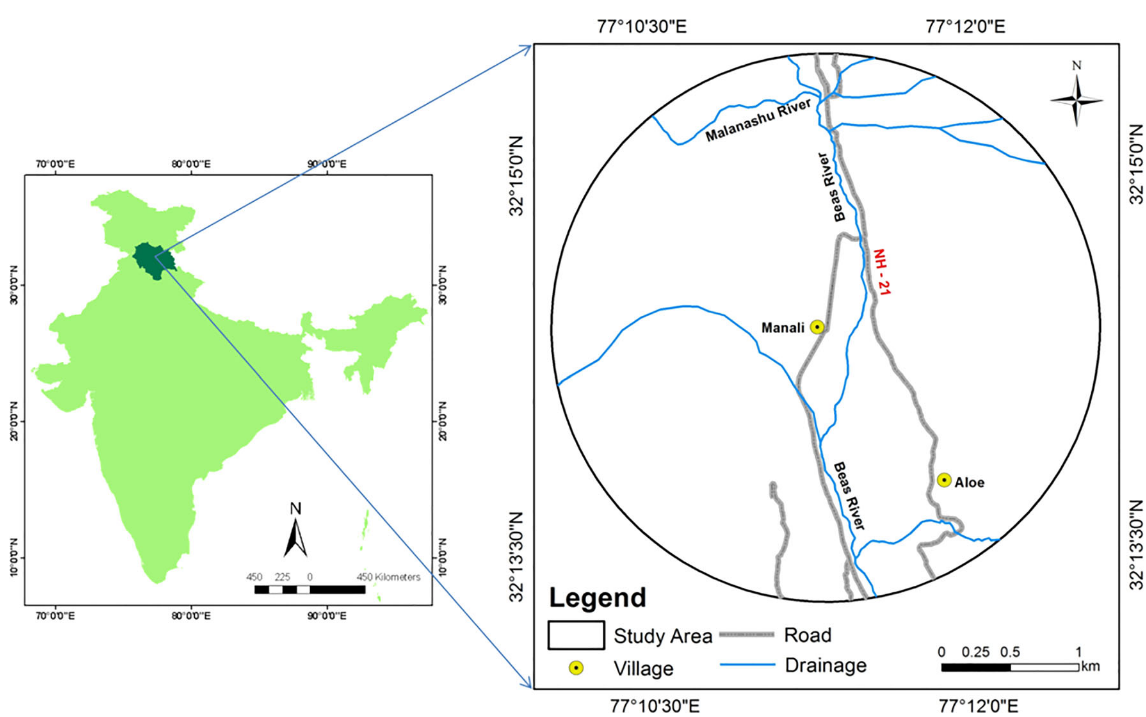

Fig. 1 Details of study area

of July and October. Indian Remote Sensing (IRS) P6 Linear Imaging Self Scanning (LISS) III satellite image of 17 July 2012 was procured for the assessment of current LU/LC practices in the study area. Images of 29 October 2005, 15 October 2000 and 9 October 1989 were also procured due to availability of same month and being free from cloud and snow cover. The spatial resolution of LISS III data (17 July 2012) is 23.5 m with swath width of 141 km. The sensor of 29 October 2005 image is LISS IV having a resolution of 5.8 m and swath width of 23.9 km. The images of Landsat TM dated 15 October 2000 and 9 October 1989 with resolution of 30 m and swath width of 185 km were used for LU/LC analysis.

For the assessment of tourism impact on LU/LC in terms of built-up on natural slope, ASTER DEM with a resolution of 30 m (Abrams 2000) was used in the present study. ASTER is an imaging instrument built by METI (Japan's Ministry of Economy, Trade and Industry) and operates on the NASA Terra platform (Hirano et al. 2003). ASTER DEM standard data products are produced with 30 m postings, and have Z accuracies generally between 10 and 25 m root mean square error (Nikolakopoulos et al. 2006).

Image processing and analysis

The satellite images were geo-referenced and rectified as per ground control points and toposheet number 52H/3 and 52H/4. Each image was classified with the help of training data collected during ground truth survey using global positioning system (Trimble-Juno SD) during July 2012. The maximum likelihood classifier was used for image classification which is one of the most popular methods in remote sensing (Ahmad et al. 1992). The likelihood is defined as the posterior probability of a pixel belonging to its corresponding class (Bose et al. 2004). The classes were assigned as per Anderson classification system (Anderson 1976).

Accuracy assessment of remotely sensed data improves after acceptance of the error matrix as standard descriptive tool (Foody 2002). The error matrix presents a tabulated view of map accuracy which allows the calculation of specific accuracy measures such as overall accuracy and user's and producer's accuracies (Congalton 1991; Jensen 1996). Kappa coefficient incorporates the off diagonal observations of the rows and columns as well as the diagonal of error matrix to give a more robust assessment as compared to overall accuracy measures (Herrera et al. 2005).

ASTER DEM was used to calculate slope in percentage for further classification in various categories. Built-up was extracted from classified images of 1989–2012 and overlaid on slope classes to assess the impact of tourism in the study area.

Results and discussion

False color composite (FCC) images of the study area of 1989, 2000, 2005 and 2012 are presented in Fig. 2a–d, respectively. Visual interpretation of the images indicates that major area is occupied by the evergreen forest. Apart from this, scrub forest, vegetation, built-up and waterbody were also distinguished in the study area. Images were classified by maximum likelihood classifier algorithm. Supervised classification of the images is presented in Fig. 3a–d for the years of 1989, 2000, 2005 and 2012, respectively. Images are classified under the LU/LC classes of Built-up, Evergreen forest, Scrub forest, Vegetation/plantation, Bare rock and Water body.

Abstraction of the real landscape is best presented in LU/LC classification maps (Wilson 2006). Therefore, it is necessary to check the accuracy of any land cover classification with ground reference sample data (Anderson 1976). Generally, classification accuracy refers to the extent of correspondence between the remotely sensed data and reference information (Congalton 1991). Accuracy assessment for LU/LC classification of 2012 was performed using 35 ground truth points to assess the extent of credibility of the image analysis through error matrix (Table 1). The user accuracy was found to be 82.5 % and corresponding producer accuracy was 80.2 %. The overall accuracy of classified image was estimated to be 82.8 % and kappa coefficient of 0.7864 that validates the use of images for impact assessment study. Kappa value implies a substantial agreement between reference and classified data (Congalton 1996).

The inventory of LU/LC from 1989 to 2012 is graphically presented in Fig. 4. Built-up is increased significantly from 4.7 to 15.7 % in the study area. Based on the image analysis it is observed that built-up has increased maximum during 2005–2012 in the recent years. There is a decrease in the evergreen forest from 45.2 to 36.3 % and also slight decrease in scrub forest from 14.2 to 13.1 % during 1989–2012. Vegetation/plantation includes bushes, apple orchards, farms etc. in the study area. Percentage occupancy by the vegetation/plantation has increased over the years. Bare rock occupies area along the river and places of high elevation (Fig. 3). The percentage occupancy of the water body is more or less same in the study area.

Since study area is internationally acclaimed tourist spot and one of the best hill stations in India, the number of tourists is increasing exponentially every year as per Singh 2008 and Dutta 2012. The statistics of the inflow of tourists shows a persistent steep rise from 140,000 visitors in 1980 to 400,000 recreationists and 300,000 pilgrims in 1990. Even in year 2003, an estimated one million tourists visited Manali which has thereafter increased exponentially and

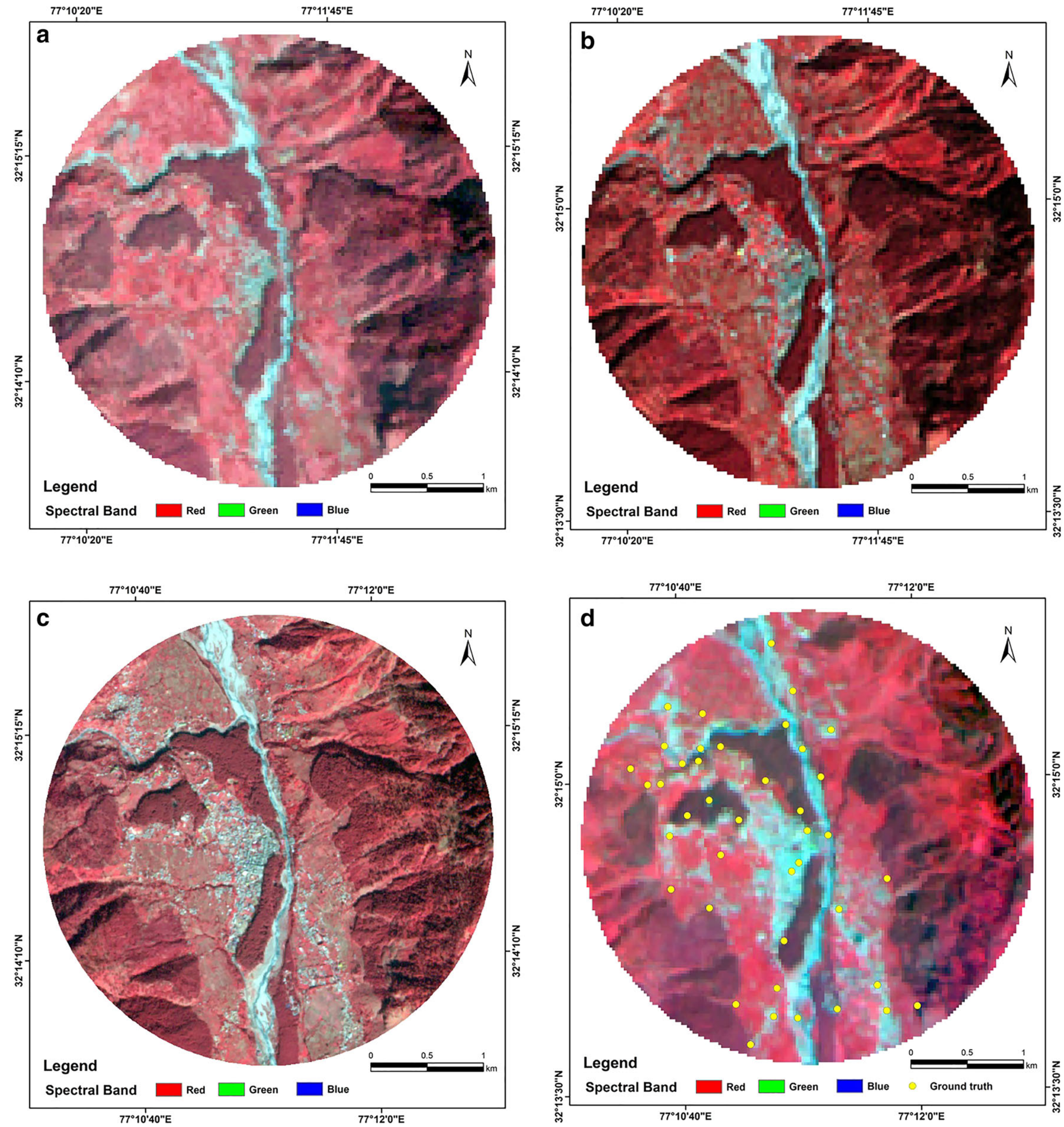

Fig. 2 False colour composite (FCC) images of the study area (**a** 09 Oct 1989; **b** 15 Oct 2000; **c** 29 Oct 2005; **d** 17 July 2012)

around 2.8 million in 2010–2011 (Fig. 5a). On the contrary, change in population of the city has not shown any abrupt increase as evident from census data of 1971, 1981, 1991, 2001 and 2011 with population of 1800, 2301, 2433, 6265 and 8095, respectively (Census of India 2011). Thus growth of city population is not a major contributor for increase in built-up in the area. Further, accommodation capacity also showed an abrupt increment from few guest houses with 234 beds in 1968 and thereafter in a span of 35 years, 395 licensed hotels with a capacity of 12,000 beds (Singh 1989, 2008). This implies impact of tourism activities in the study area resulting tremendous growth in number of tourists and hotels for their accommodation. As per remote sensing analysis, built-up is also increasing exponentially from 4.7 to 15.7 % during 1989–2012 (Fig. 5b). This could typify the drastic increase observed in built-up from 2005 to 2012 due to increased demand for accommodation for both tourists and seasonal labors. To establish a relation between number of tourist and built-up over the years, a statistical analysis was performed with a strong correlation coefficient of 0.99 (Fig. 5c).

Digital elevation model (DEM) of the study area is presented in Fig. 6a indicating elevation range from 1809 to 3121 m above mean sea level. Slope map was prepared using Spatial Analyst tool of Arc GIS 10 and classified gentle (0°–5°), moderate (5°–16.5°), strong (16.5°–24°)

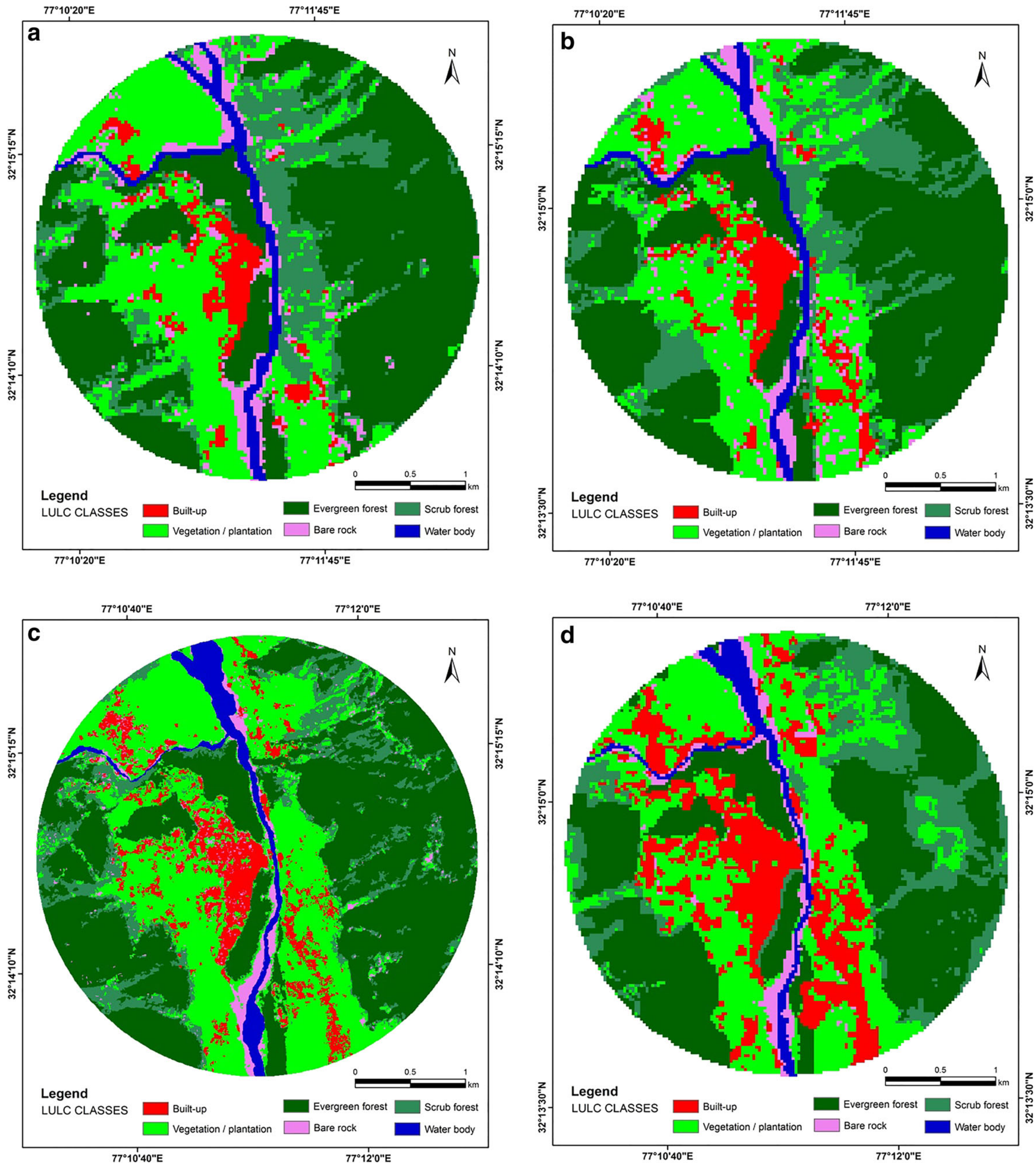

Fig. 3 Supervised classification for LU/LC (**a** 09 Oct 1989; **b** 15 Oct 2000; **c** 29 Oct 2005; **d** 17 July 2012)

extreme (24°–35°), steep (35°–45°) and very steep (45°–70.3°) slopes as per soil classification system (NRC 1998). The areas occupied under these slope classes are 9.9, 28.0, 17.1, 24.4 13.9 and 6.7 % for gentle, moderate, strong, extreme, steep and very steep slope, respectively.

Based on built-up from remote sensing and slope classes from GIS, an overlay analysis was carried out to assess the impact of tourism in terms of built-up on natural slope. Overlay analysis provides occupancy of built-up from 1989 to 2012 on different slope classes as illustrated in Fig. 6b. Built-up is sprawling on both sides of the valley which is a matter of concern in hilly region. Area occupied by built-up from 1989 to 2012 on slope classes was extracted based on overlay analysis and represented graphically in Fig. 7. Built-up was observed in all the slope classes and increasingly from 1989 to 2012. Maximum area occupied by built-up was on gentle slope and increased from 15.5 to 32 % during 1989–2012. Similarly, built-up was increased in moderate slope (from 9.2 to 30.4 %), strong slope (from 2.7 to 14 %), extreme slope (0.3–4.9 %) and steep slope (from 0 to 0.4 %). Based on the overlay analysis, it is found that rate of increase in built-up is uniform during

Table 1 Confusion matrix for accuracy assessment

Reference data								
Class name	Built-up	Evergreen forest	Scrub forest	Vegetation/plantation	Bare rock	Water body	Total	User accuracy
Classified data								
Built-up	4	0	0	0	1	0	5	80
Evergreen forest	0	10	0	0	0	0	10	100
Scrub forest	0	1	6	0	0	0	7	85.7
Vegetation/plantation	3	0	0	5	0	0	8	62.5
Bare rock	0	0	0	0	2	1	3	66.7
Water body	0	0	0	0	0	2	2	100
Total	7	11	6	5	3	3	35	
Producer accuracy	57.1	90.9	100	100	66.7	66.7		

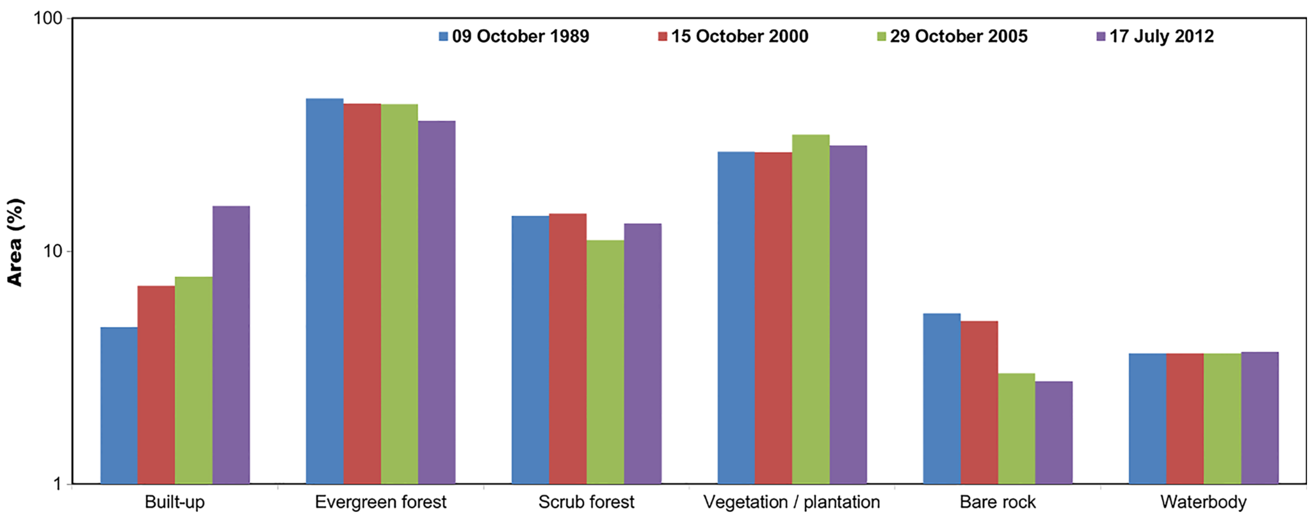

Fig. 4 Inventory of LULC in the study area

1989–2005 in slope classes of gentle to steep slope while in 2005–2012, drastic increase is observed in built-up in all slope classes. There is no built-up observed on steep and very steep slope till 2000. However, an alarming development is noticed towards these slopes in 2005 and 2012. Due to the inherent characteristics, steep and very steep slopes are more vulnerable to landslides. Sprawl of built-up on these slope classes is symbolizing the disproportionate ratio of land use due to rapid and unplanned urbanization leading to natural hazards causing human risks (Gardner et al. 2002; Kuniyal et al. 2004). This could further implicate the growth of tourism industry and in turn on associated residents. Even during the period of 1971–2009, 49 landslide events took place in Kullu district out of which majority occurred in the proximity of built-up especially roads and agricultural land situated at higher degree slope areas (Chandel 2001). Therefore, there is a need of provision of compliances for tourism activities through sustainable planning and developments (Shirazi et al. 2013; Paulo et al. 2014; Antonellini et al. 2014).

Conclusion

Remote sensing and GIS based analysis were carried out to assess the impact of tourism on LU/LC and natural slope. Based on the statistics of LULC, built-up increased from 1989 to 2012 with an incremental increase after 2005. Due to the tourism potential of the study area, inflow of tourists as well as number of hotels is exponentially increasing which implies that Manali is confronted with excessive pressure of tourism. Impact of tourism on natural slope was also assessed based on overlay analysis of built-up extracted from LU/LC classifications on slope derived

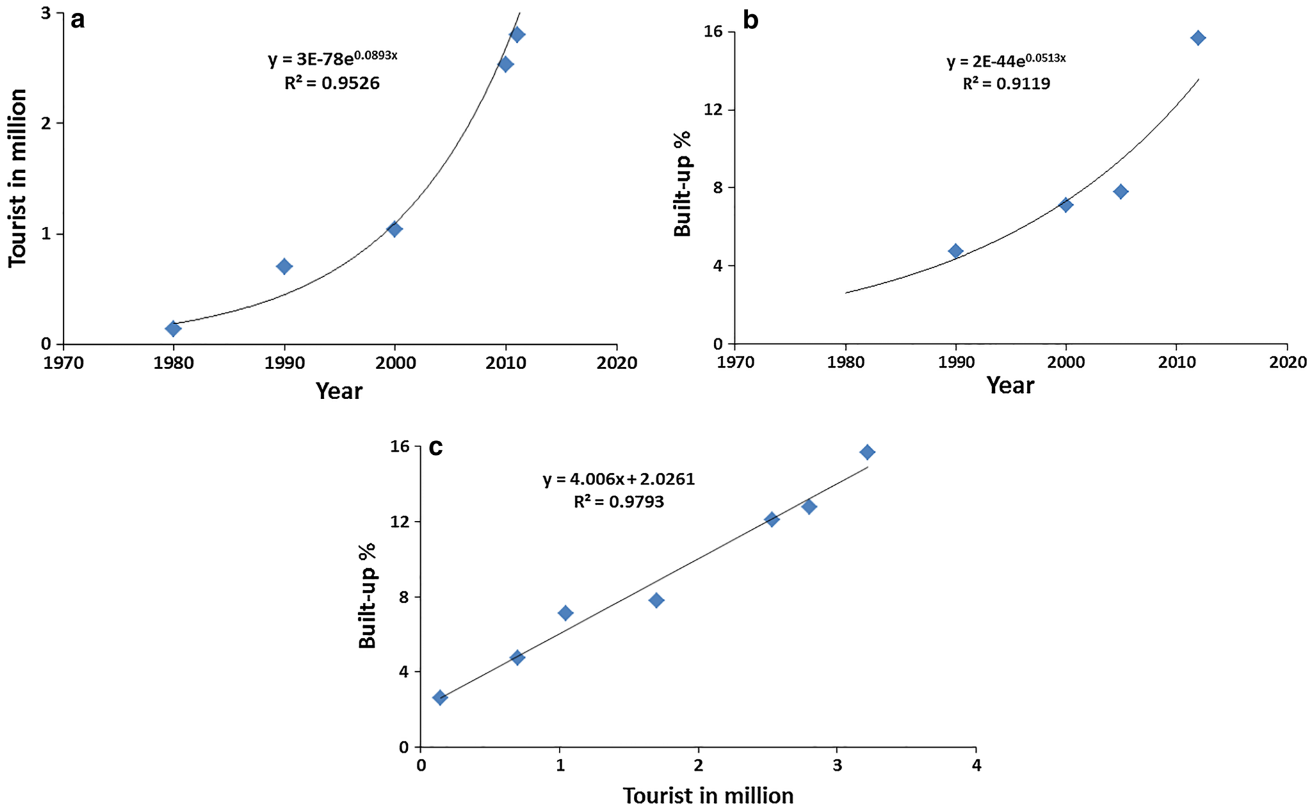

Fig. 5 Relation between tourist and remote sensing analysis. **a** Tourist vs year. **b** Built-up (%) vs year. **c** Built-up (%) vs tourist

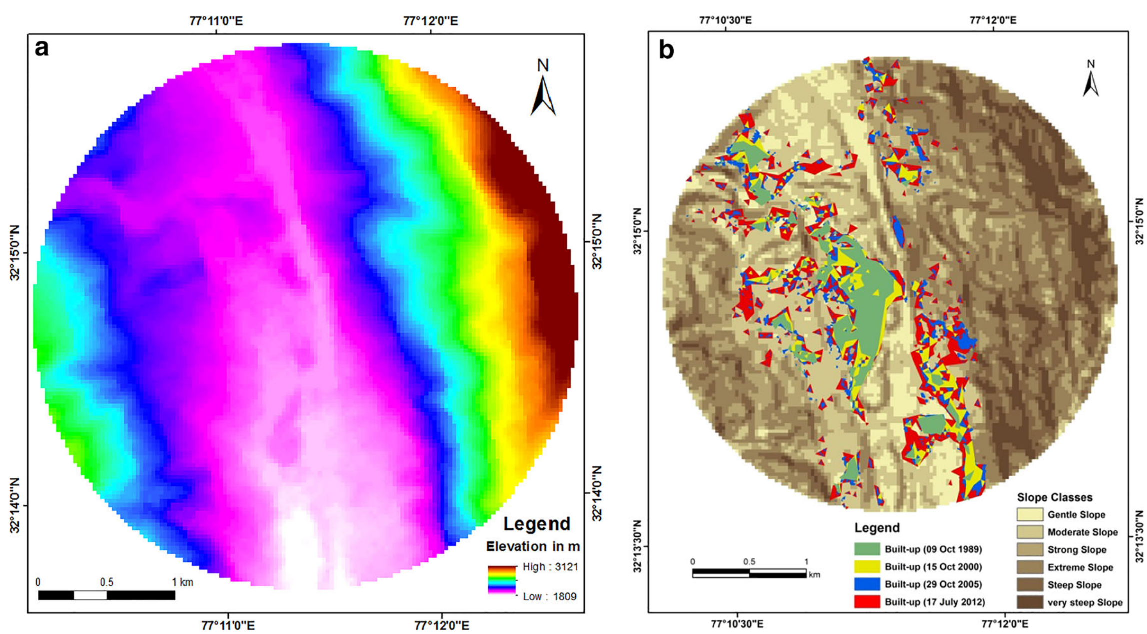

Fig. 6 Impact of built-up sprawl on slope classes. **a** Digital elevation model (DEM). **b** Overlay analysis

from digital elevation model. Built-up was observed in all the slope classes with incremental trend from 1989 to 2012. Built-up was not observed on very steep slope till 2000 but it was noticed in 2005 and 2012 due to developmental activities towards very steep slope. Since landslide occurs in the study area frequently and there is an increment in

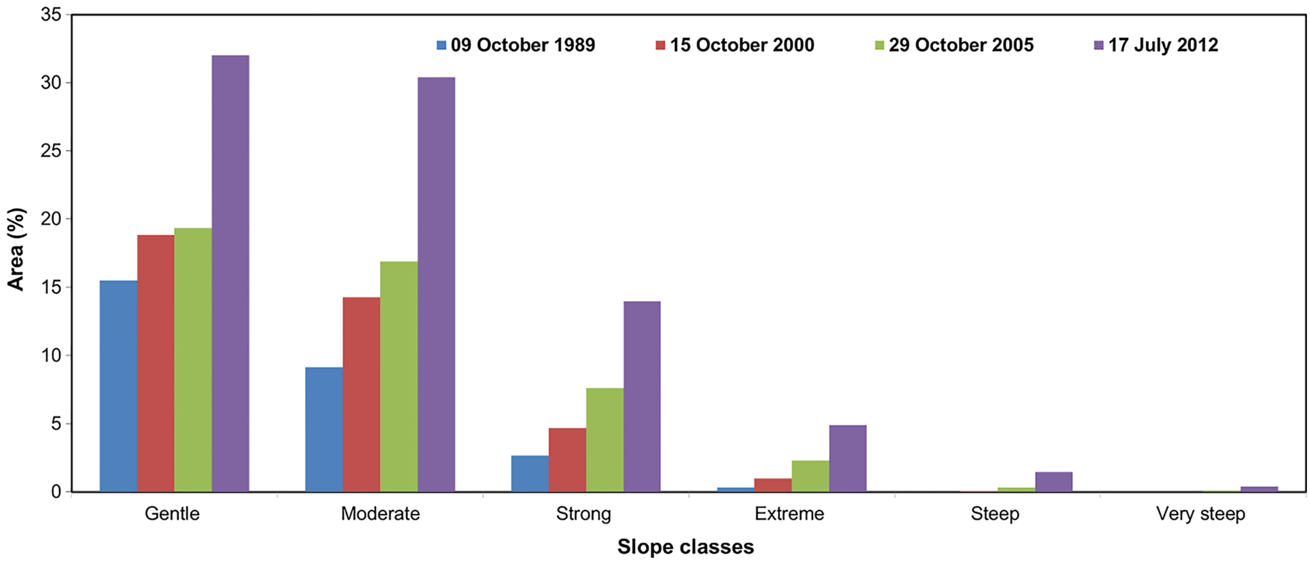

Fig. 7 Occupancy of built-up on different slope classes

built-up in extreme, steep and very steep slopes, it becomes a matter of grave concern for causative agents of natural hazards. This requires the immediate attention of competent authorities to achieve the long-term viability of tourism industry by sustainable planning and management.

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