



Land use and land cover changes in Kullu valley of Himachal Pradesh

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ABSTRACT

Land use changes are the land conversions from one type to another that alter the earth surface to satisfy mankind's immediate demand. Land use change detection using satellite imageries has emerged important mean to gather information on regional scale changes. Present study envisaged the spatio-temporal land use land cover changes of Kullu valley of Himachal Pradesh using LANDSAT imageries of 1989 and 2016. The results were verified through the secondary data as well as primary data collected by detailed survey of the Kullu valley (Kullu and Naggar blocks) and drivers for such changes were also identified. The studies were carried out for major land use type, viz. agriculture, orchard, forest and built up in the valley over a period of 27 years. Supervised classification was done using Maximum Likelihood Classification Algorithm through ERDAS Imagine 14 software. The results indicated that during last 27 years, the built up area has increased to the extent of 90.81% followed by orchards (12.39%) and forest (6.26%), whereas area under agriculture was decreased by 56.88%. The primary data revealed that farmers are abandoning the wheat, paddy, maize and barley crops and are pursuing cultivation of vegetable and fruit crops. Increased economic returns and climate change emerged as the probable drivers for the changes in the valley.

Key words: Climate change, Kullu, Land use change, Remote sensing, Traditional agriculture, Urbanization

Human-induced disturbances such as land use changes, pollution of air, water, soil and losses of productive lands are increasingly threatening ecosystem health on local, regional and global scales. Among these processes, land use and land cover changes have been recognized as one of the main factor in the decline of the ecosystem integrity. Different factors and mechanisms drive land use and its changes. However, climate, technology and socio-economic status of people have been recognized as the determinants of land-use change at different spatial and temporal scales. At the same time, land transformations seem to be an adaptive feedback mechanism that farmers use to counteract the impact of climate variability. Globally area under traditional crops such as barley, oats, millets etc. is decreasing, however it is increasing under cereals, vegetables, fruit and oil crops. Many studies have also observed and projected changes in land cover and land use as a result of climate change (Backlund *et al.* 2008, Iverson *et al.* 2008). Urbanization is

increasing alarmingly at the rate of 20000 km²/year which reportedly have intruded 80% of agricultural land and 10% each of forest and grassland (Holmgren 2006).

Like other parts of the world India is also experiencing land use change. In India during last 50 years, net sown area has increased from 41.8% to 46.1%, whereas the forest area has increased from 14.2% to 22.8% (Anonymous 2013). The areas under non-agriculture uses, which include industrial complexes, transport network, mining, heritage sites, water bodies, urban and rural settlements have increased from 3.3% to 8.5%. Other uncultivated lands excluding fallow ones have drastically decreased by nearly half from 40.7% to 22.6%. According to the World Population Prospects by the United Nations, 55% population of India will be urban by the year 2050. With this pattern of urbanization, the urban population of 377 million as in 2011 will be 915 million by the year 2050. However, with rapid industrialization and urbanization, and associated infrastructure development, the demand for land has been projected to increase. In such cases, the demands for additional lands will be resorted from agricultural or forests which would be detrimental for ecosystem functioning.

Kullu valley in Himachal Pradesh has also undergone a tremendous transformation in land uses due to changes in agricultural cropping pattern, urbanization, industrialization, hydropower generation and tourism in past three decades. Further the changes in climatic conditions have also lead

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to change in land use preferences. The study area has also witnessed changes in cropping pattern from paddy wheat based to commercial vegetable and fruit production systems. A number of perception based studies has already carried out in the region depicting change in area under orchards, shift in apple growing belt etc (Bhardwaj and Sharma 2013, Rana *et al.* 2009). But the study on actual land use changes scenario has not being done so far. Therefore, the study was undertaken with the objective to identify and quantify the extent of different land use changes and the dominant drivers for such changes in the region.

MATERIALS AND METHODS

The study was carried out in Kullu valley (Kullu and Naggar blocks) of Himachal Pradesh at an elevation ranging from 650 to 1800 m above mean sea level with gentle to steep slope ranging from 3 to more than 50% marked with few steep gorges formed by cutting action of small streams and rivulets. The climate type in the study area is sub-humid temperate and there is a considerable variation in the seasonal and diurnal temperature.

Kullu valley has a potential for growing variety of crops. Major food-grain crops grown in the valley include maize, wheat, paddy, pulses and barley. Apple, pomegranate, kiwi, stone fruits like plum, peach and apricot, and off- season vegetables like peas, tomato, beans, capsicum, cucumber etc are fetching huge interest of the farmers. Intensive vegetable cropping systems comprising three crops followed in this area are: cauliflower-French bean-cauliflower, tomato-radish-peas, tomato-tomato-cauliflower, tomato-tomato-peas and brinjal-cabbage-cauliflower. Forest ecosystems of the study area contain diverse species from *Pinus roxburgii*, *Grewia optiva*, *Toona ciliata*, *Celtis australis*, *Melia azedarach* at lower elevations to *Cedrus deodara* and *Quercus* sp above 1500 m.

In order to obtain information on land use changes in the Kullu valley two Landsat imageries were acquired from US Geological Survey (USGS) for the years 1989 and 2016. The images were acquired in October month with dense vegetation and low cloud cover. The images were of good quality with less than 10% cloud coverage. Specifications of satellite images used in the study are given in Table 1. From the imageries Kullu valley falling between 650 to 1800 m was extracted by using Digital Elevation Model (DEM).

Based on the requirement of the study and prior knowledge, change detection studies for land use types, viz. agriculture, orchards, forests and built up were identified in time series of Landsat data. A supervised classification was done by using Maximum Likelihood Classification Algorithm through ERDAS Imagine 14 software. In this approach, training samples were selected for all the four classes. The samples were equally distributed and scattered over the study area. The land use type for each sample was identified according to the colour, size, shape, texture and its spatial relationships with neighbours. During this process, when it comes to an unknown type, Google Earth with high spatial resolution images and other auxiliary

data including soil and vegetation type and DEM were combined to identify the land use type. Some samples of reference data acquired from field were used for accuracy assessment. The test areas were used as a reference to check classification accuracy by comparing the total number of training points used was 38175 and 35198 for LANDSAT-5 and LANDSAT-8 data respectively. Acceptable values of overall classification accuracy and kappa coefficient were retrieved for the datasets.

In order to identify drivers for land use changes a detailed semi-structured survey was carried out in the study area. Simple random sampling was carried out to select the households in Kullu and Naggar blocks (Fig 1). In total 100 households were selected and data on their land use pattern of present and thirty years ago and determinants of land use changes were collected using pre-tested questionnaire.

The primary data collected through personal interviews by using questionnaires was expressed as average and percentages and tabulated. The people’s perception data was coded and analyzed by using SPSS v 20.0.

RESULTS AND DISCUSSION

Land use and land cover analysis for 1989 to 2016

The land use/ land cover map of 1989 shows that the area under agriculture in the Kullu valley was 2767 ha (Fig 2a, Table 2). The dominant land use in the valley was orchards covering 4172 ha of the area valley during 1989. Forest and built up classes cover an area of 2828 ha and 566 ha respectively.

The classified land use/land cover map of 2016 in (Fig 2b) shows a considerable land use change in the valley during 1989 to 2016. The built up area which was just 566 ha has increased to 1080 ha exhibiting a growth of 90.81% suggesting significant urbanization the valley. Two forms of urbanization have occurred: the growth of town following inclining population concentration, and rural urbanization based on the growth of smaller towns in rural areas. The

Table 1 Specification of satellite data used for the study

Sensor	Date	Path/ Row	Spatial resolution (m)	Cloud coverage (%)
Landsat-5 TM	09-Oct-1989	147/38	30, (120 for band 6)	2.49
Landsat-8 OLI/ TIRS	19-Oct-2016	147/38	30, (100 for TIR bands but resampled to 30)	1.41

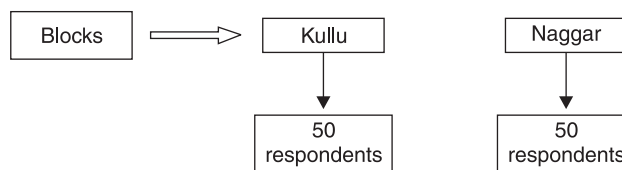


Fig 1 Simple random sampling of households in Kullu valley of Himachal Pradesh.

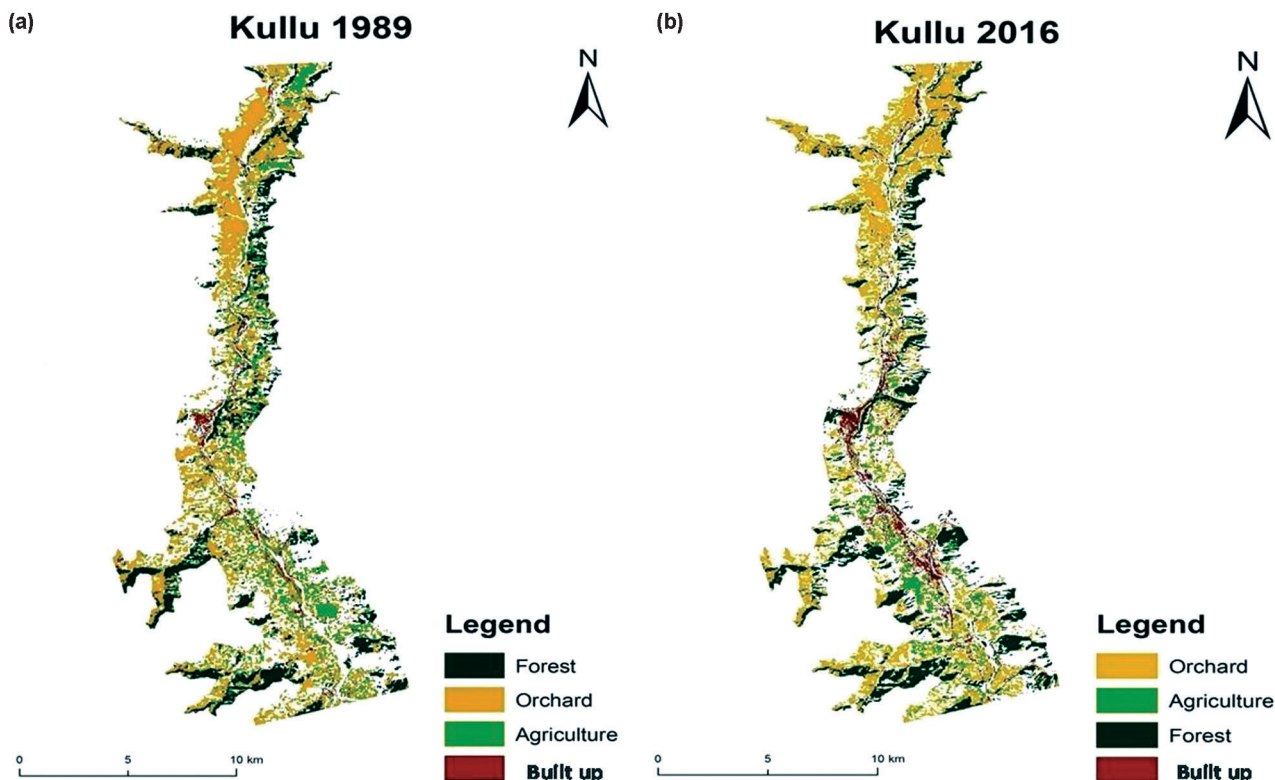


Fig 2 Landuse map of Kullu valley during 1989 (a) and 2016 (b).

forest area has increased from 2828 ha in 1989 to 3005 ha in 2016. The forest area has increased by 6.26% due to afforestation activities by forest department (Fig 3).

Area under agriculture exhibited a sharp decline of 56.88% from 2767 ha in 1989 to 1193 ha in 2016 (Fig 3; Table 2). It is clear (Fig 2a and 2b) that agriculture area has been increased in Southern end of Kullu valley owing to increase in area under vegetable cultivation (Table 3), whereas Northern part of Kullu valley has witnessed an increase in orchard. The study also showed that the increase in built up is coming on fertile agricultural land and hence it is decreasing.

People’s perception on land use changes

A detailed survey was conducted to get acquainted with the farmers by asking them the land holding, crop preferences at present and thirty years ago and the reasons for changes. Farmers of Kullu valley revealed that land use changes have occurred in the region in past thirty years.

Table 2 Spatial land use changes in Kullu valley of Himachal Pradesh

Land use	Area (ha)		Percent change
	1989	2016	
Agriculture	2767	1193	-56.88
Orchards	4172	4689	12.39
Built up	566	1080	90.81
Forest	2828	3005	6.26

Data (Table 3) depict that there is a decrease of 83.30% in the land under traditional agriculture, i.e. wheat, paddy, maize etc., as area under traditional agriculture crops has decreased from 0.12 ha per household in 1989 to 0.02 ha per household in 2016. However, per household area under commercial vegetable farming exhibited a sharp increase of 300% from 0.02 ha in 1989 to 0.08 ha in 2016. Orchards showed a slight increase of 12.50 % from 0.08 to 0.09 ha per household. The built up area, i.e. non-agriculture area and the area under buildings and permanent structures was also increased from 0.09 to 0.12 ha exhibiting an increase of 33.33% from 1989 to 2016.

Farmer’s preferences to various crops were also observed in the study area through survey and observed

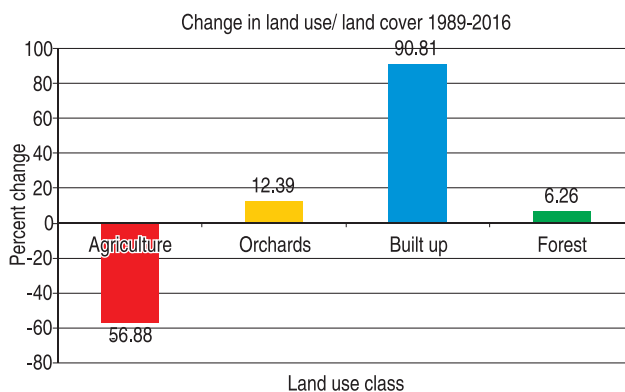


Fig 3 Transformation in land uses in Kullu valley of Himachal Pradesh.

Table 3 People’s perception on land use changes in Kullu valley of Himachal Pradesh

Land uses	Temporal change in area (ha per household)		Percent change
	1989	2016	
Traditional agriculture	0.12	0.02	-83.30
Vegetable	0.02	0.08	300.00
Orchard	0.08	0.09	12.50
Built up	0.09	0.12	33.33

that most of the farmer’s preference to grow traditional agriculture crops such as wheat, paddy, maize, barley etc has sharply declined. In the region out of 100 farmers 82% perceived that they used to grow wheat during the year 1989. During the year 2016 only 20% of the respondents grow wheat (Table 4). Similar trends were noticed in paddy, barley and pulses, before 1989 nearly 44%, 36% and 70% of total farmers preferred to grow paddy, barley and pulses in their fields, which in 2016 has reduced to a share of 2%, 4% and 20% respectively. The farmer’s preference for maize has been witnessed a decrease from 78% to 40% of the total farmers during last 30 years. However the preference of the farmers of the valley for vegetables has seen a surge from 8% in 1989 to 58% in 2016. Among fruit crops the respondents were of the opinion that the area under apple, plum and apricot has decreased from 60%, 50% and 20% to 58%, 46% and 14% respectively, however the preference for pomegranate has witnessed an increase from 0% to 38% in the valley. Therefore it is clear that people in Kullu valley are abandoning the farms under traditional agriculture at the cost of vegetable, orchards and built up area. Similar results were reported by Chen (2007) who observed a reduction in cereal cultivated area between 1986 and 1995 owing to conversion of crop production to other agricultural purposes, such as orchards and cash-crop plantations mention which country. Therefore it is an established fact and indicated

Table 4 Frequency distribution of farmer’s crop preferences in Kullu valley

Crops	Years	
	1989	2016
Wheat	82	20
Paddy	44	2
Barley	36	4
Pulses	70	20
Maize	78	40
Vegetable	8	58
Apple	60	58
Pomegranate	0	38
Plum	50	46
Apricot	20	14
Pear	46	48

by primary and spatial data analysis that land use changes have occurred in the Kullu valley which may be because of more shift towards urban and commercial land uses.

Reasons for land use changes

In Kullu valley of Himachal Pradesh 42 % of people perceived that the reason for land use change is the increased economic returns from the cash crops such as vegetables and fruits and other developmental activities in the valley (Fig 4). Whereas 34% people perceived that climate change being the main reasons for land use changes. The 10% of the people were of the opinion that availability of cheap and new crop varieties led to change in land use from traditional agriculture to vegetable and fruits based land uses whereas decline in soil productivity was described as the reason by 4% people. However, 10% people were uncertain about the driving forces for land use changes and told that they don’t know the exact reason for land use changes in Kullu valley of Himachal Pradesh. As the vegetables are short duration crops and 3-4 crops of vegetables can be taken by the farmers per annum to augment their income, therefore this came out to be the main reason for farmer’s preference on vegetable cultivation as compared to traditional crops. However climate change is also another reason as it led to shift of apple belt to higher altitudes in Kullu valley owing to non-fulfillment of chilling hour requirement for apple cultivation therefore some of the farmers of southern stretch of the valley have shifted to either pomegranate or vegetable cultivation. Thakur (1994) also supported that off-season vegetable production and marketing is the most profitable

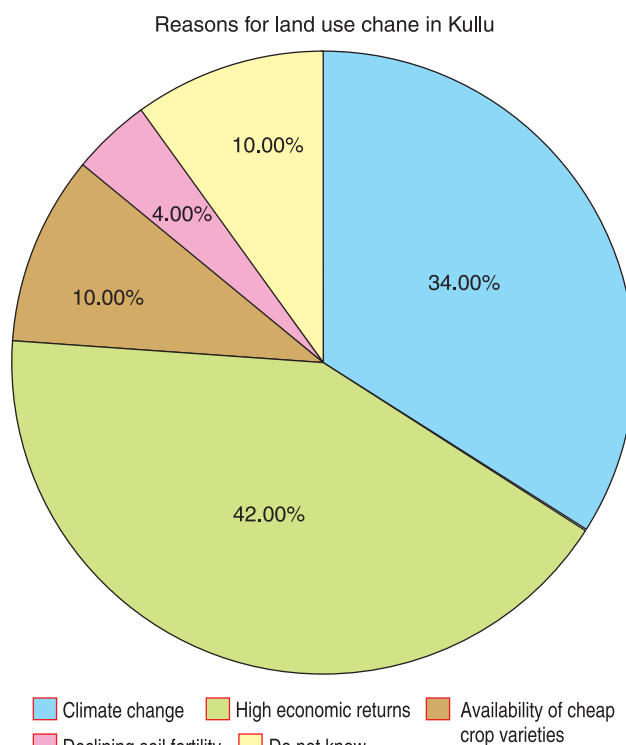


Fig 4 People’s perception with respect to causes for land use changes in Kullu Valley.

farm business giving very high production and income to farmers per unit area of land. The present findings are also in accordance with the findings of Sen *et al.* (2015) and Chand *et al.* (2016) who reported that there was a decreasing trend in the apple productivity of the order of (0.016 tonnes/ha/year) during the period 1985-2009 in the Kullu valley due to non fulfillment of chill units.

The study revealed that built up, orchards and forest area increased by 90.81, 12.39, 6.26% respectively during 1989-2016 resulting in substantial decrease of 56.88% in area under agriculture in Kullu valley. In the region farmers now prefer to grow vegetable and fruit crops over traditional crops such as wheat, paddy, barley, maize, pulses as compared to the situation prevalent during 1989. Increased economic returns from highly remunerative cash crops as perceived by 42% respondents followed by climate change (34%) came out to be the major driving for land use changes in Kullu valley of Himachal Pradesh.

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