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DYNAMICS OF LAND USE AND LAND COVER CHANGE DETECTION BY USING GEOSPATIAL TECHNOLOGIES: A CASE STUDY OF DISTRICT BILASPUR IN HIMACHAL PRADESH

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Abstract

Understanding land use and land cover changes has become a necessity in managing and monitoring natural resources and development. Remote sensing and geographical information system jointly known as Geo-Spatial technologies are proven tools for assessing land use and land cover changes that help planners to advance sustainability. This requires the present and past land use/land cover information of the area. LULC maps also help us to study the changes that are happening in our ecosystem and environment. If we have an inch by inch information about Land Use/Land Cover of the study unit we can make policies and launch programmes to save our environment. Present study used Geo-Spatial technologies to detect and predict land use and land cover changes in District Bilaspur in Himachal Pradesh India. Multi-temporal satellite images of 1989, 1999, 2009 and 2019 were pre-processed, geo-referenced, and mapped using the supervised maximum likelihood classification to examine land use and land cover changes. The change detection examined decadal basis i.e. 1989-1999, 1999-2009 and from 2009-2019 and also for the period from 1989-2019 as a whole. We found that over a period of 30 years (from 1989 to 2019), the Bilaspur district has lost 5.24% of its forests, 8.03% of its pastures and open land. The gain of 5.16% in agricultural and horticulture land, 5.31% gain in built up area observed. The highest gain in built up area is due to rapid constructional activities in rural and urban areas as well construction of roads is another factor. These changes are associated with loss of ecosystem which will negatively impact human and also the environment of the study area. We recommend planners to mainstream ecosystem-based adaptation and plans supported by strong policy and funds.

Key Words: Land Use and Land Cover Changes, Geo-Spatial Technologies, Geographical Information System (GIS), Multi-Temporal, Sustainable Development, Change Detection.

Introduction

Land use and land cover change are perhaps the most prominent form of global environmental change as they occur at spatial and temporal scales and therefore the issue is relevant to our daily existence. Technically, land use and land cover change mean quantitative changes in areal extent (increase or decrease) of a given type of land use and land cover respectively. The land use and land cover change are a manifestation of forces both anthropogenic and environmental climate driven factors (Liu et al. 2005). The changes in land use in various spatial and temporal domains are the material expressions, and also indicate environmental and human dynamics and their interactions mediated by land availability (Lambin et al. 2001). The land use and land cover changes, apart from changing the physical dimension of the spatial extent of the land use and land cover classes, also influence many of the secondary processes which lead to the eventual degradation of the ecosystems of the earth (Dregne and Chow, 1992). The use of RS and GIS for LULCC detection has been widely studied and applied in various fields. Some examples include

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monitoring deforestation in tropical regions (Miettinen et al., 2016), detecting urbanization and land use changes in China (Liu et al., 2017), and assessing the impacts of land use changes on hydrological processes (Vaze et al., 2010). Remote Sensing has been widely used in updating land use/land cover maps and land use/land cover mapping has become one of the most important applications of remote sensing (Lo and Choi, 2004; Ibrahim et al., 2005; Laha et al., 2006). Therefore, this chapter includes pattern of land use/land cover, changes in land use/land cover in Bilaspur district from 1989 to 2019 with the help of Remote Sensing and Geographic Information System. The satellite Remote Sensing and Geographic Information System techniques are useful tools for assessing the land use/land cover which is one of the important aspects for planning and development of an area (Gaur, M.K. 2011).

Study area

Bilaspur district is located in the south western part of Himachal Pradesh, extending between latitudes 31˚12`30`` and 31˚35`45`` N and longitudes 76˚23`30`` E and 76˚55`40`` E. The study area is spread over an area of 1167 square kilometres which is 2.10 percent of whole Himachal Pradesh, with a total population of 3,81,956 persons (Census 2011) having 1061 villages (953 inhabited and 108 uninhabited) and 04 Urban centres. It is bounded by the districts of Mandi and Solan in the east, Hamirpur and Una in the west, Mandi and Hamirpur in the north and Nalagarh area of Solan district & Punjab state in the south. The maximum extent of the district is about 43 kilometres from north to south and about 51 kilometres from east to west.

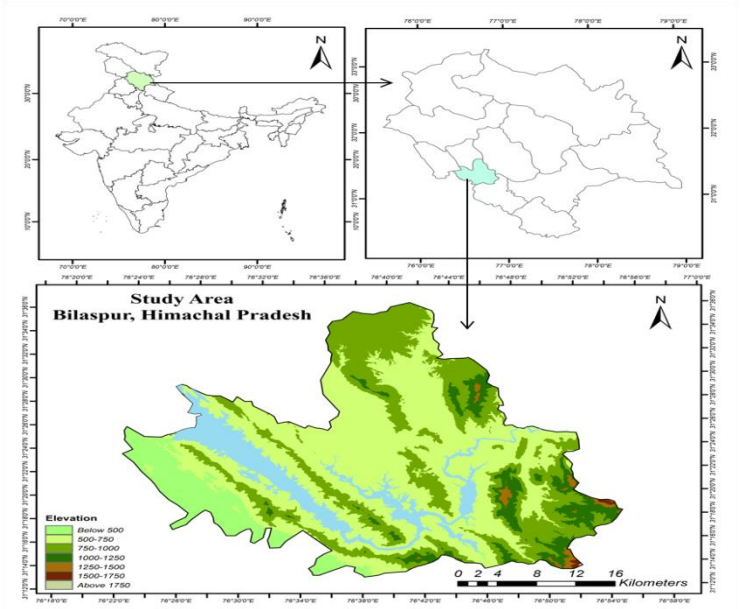

Fig.1 Location Map of Study Area

According to 2011 census, Bilaspur district ranks 10th in terms of population in Himachal Pradesh out of twelve districts. The density of population is 327 persons per sq. km that is higher than the state average i.e. 123 persons per sq. km. The decadal growth rate of Bilaspur district is 12.05 percent and literacy rate is 84.59 percent.

Material and Methodology

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Satellite Data

To study Land use /Land cover, secondary data for 30 years (1989-2019) of Bilaspur district were collected. In this investigation Landsat imageries are used primarily due to their high spatial and radiometric resolution and availability of uninterrupted multispectral dataset from 1972 onwards which make them suitable for spatio-temporal study. A set of four Landsat 8 OLI/TIRS, Landsat 7 ETM and Landsat 5 TM land surface reflectance product images from 2019, 2009, 1999 and1989 were chosen to map and extract the dynamics of land use/ land cover change in the region The required imageries were downloaded in L1TP land surface reflectance data type and GeoTIFF format from USGS's Earth Explorer website (http: //earthexplorer. usgs.gov).

Table 1: List of Landsat satellite images with their specification, used during the research work.

Year	Satellite	Sensor	Path	Date of Acquisition	Projection	Datum	UTM zone	Cell Size
1989	Landsat 5	TM	147/38	06-08-1989	UTM	WGS84	43	30
1999	Landsat 7	ETM	147/38	13-10-1999	UTM	WGS84	43	30
2009	Landsat 5	TM	147/38	16-10-2009	UTM	WGS84	43	30
2019	Landsat 8	OLI/TIRS	147/38	12-10-2019	UTM	WGS84	43	30

As orbital remote sensor multi temporal data were demonstrated to be essential [5], so data from multi-temporal 4 satellite imageries were analyzed for the present study.

Data Analysis

Pre classification Information about Land Use /Land Cover

From the satellite image thematic maps are derived with 7 land use classes. The present study followed the scheme of classification of land use and land cover used by NRSA (1989) and ICAR (1982) with slight modification. The following seven class i.e. Built-up land, Agricultural land, Forests, Wastelands, Water bodies, Pastures, Barren land selected for the present study. Detail description is given in Table No.2

Table 2. Different Land Use Classes and Descriptions

LU/LC classes	Class Name	Description
1	Agricultural/Horticultural Land	Area under crops, fruits, vegetables and gardens
2	Barren Land	Rocky, rocky knobs, rocky outcrops without vegetation cover
3	Built-up Land	Settlements, commercial area, industrial area, roads etc.
4	Forest Cover	Area under forests with dense and sparse vegetation.
5	Pasture/Open Land	Thorny bushy areas and areas with grass.
6	River/Stream Channel	Rivers, Streams, Lakes and Ponds are under this body
7	Sandy surface	Dry river bed full of sand and sand accumulated area

Multi-temporal satellite images of 1989, 1999, 2009 and 2019 were pre-processed, geo-referenced, and mapped using the supervised maximum likelihood classification to examine land use and land cover changes. The change detection examined decadal basis i.e. 1989-1999, 1999-2009 and from 2009-2019 and also for the period from 1989-2019 as a whole

Results and Discussions

Land Use / Land Cover Classification for the year 1989

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For the classification of 1989 image, Landsat-5 TM satellite image was used. The land use land cover status is given in the **table 6.1** and also shown through LU/LC map **(Fig. 6.1)**. The analysis of Landsat image, data shows that forest occupies more than half of total land and it is the most important land use land cover of the study area. The Agricultural/Horticultural Land occupies about 6.75 percent of the total geographical area , Barren Land covers 1.32 percent, Built-up Land occupies 0.58 percent, Forest Cover area is 61.88 percent, Pasture/Open Land occupies 19.66 percent , River/Stream Channel covers about 8.49 percent and Sandy surface covers about 1.32 percent of the total geographical area of the study area.

Land Use / Land Cover Classification for the year 1999

For the classification of 1999 image, Landsat-7 ETM satellite image was used. The land use land cover status is given in the **table 6.1** and also shown through LU/LC map **(Fig. 6.2)**. The analysis of Landsat image, data shows that forest occupies more than half of total land and it is the most important land use land cover of the study area. The Agricultural/Horticultural Land occupies about 15.08 percent of the total geographical area , Barren Land covers 1.79 percent, Built-up Land occupies 2.18 percent, Forest Cover area is 57.08 percent, Pasture/Open Land occupies 13.56 percent , River/Stream Channel covers about 10.27 percent and Sandy surface covers about 0.04 percent of the total geographical area of the study area.

Land Use / Land Cover Classification for the year 2009

For the classification of 2009 image, Landsat - 5TM satellite image was used. The land use land cover status is given in the **table 6.1** and also shown through LU/LC map **(Fig. 6.3)**. The analysis of Landsat image, data shows that forest occupies more than half of total land and it is the most important land use land cover of the study area. The Agricultural/Horticultural Land occupies about 15.58 percent of the total geographical area, Barren Land covers 1.44 percent, Built-up Land occupies 2.68 percent, Forest Cover area is 67.29 percent, Pasture/Open Land occupies 3.00 percent, River/Stream Channel covers about 8.76 percent and Sandy surface covers about 1.25 percent of the total geographical area of the study area.

Land Use / Land Cover Classification for the year 2019

For the classification of 2019 image, Landsat – 8 OLI/TIRS satellite image was used. The land use land cover status is given in the **table 6.1** and also shown through LU/LC map **(Fig. 6.4)**. The analysis of Landsat image, data shows that forest occupies more than half of total land and it is the most important land use land cover of the study area. The Agricultural/Horticultural Land occupies about 11.91 percent of the total geographical area, Barren Land covers 2.75 percent, Built-up Land occupies 5.89 percent, Forest Cover area is 56.64 percent, Pasture/Open Land occupies 11.63 percent, River/Stream Channel covers about 9.77 percent and Sandy surface covers about 1.40 percent of the total geographical area of the study area.

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Table 6.1: Land Use Land Cover Pattern in District Bilaspur of 1989-2019

LULC Pattern (1989-2019)								
Class_ Name	Area (1989)	Per Cent	Area (1999)	Per Cent	Area (2009)	Per Cent	Area (2019)	Per Cent
Agricultural/Horticultural Land	78.76	6.75	176.01	15.08	181.80	15.58	139.02	11.91
Barren Land	15.40	1.32	20.86	1.79	16.84	1.44	32.15	2.75
Built-up Land	6.78	0.58	25.44	2.18	31.31	2.68	68.77	5.89
Forest Cover	722.19	61.88	666.14	57.08	642.04	55.02	660.97	56.64
Pasture/Open Land	229.42	19.66	158.24	13.56	178.28	15.28	135.70	11.63
River/Stream Channel	99.09	8.49	119.82	10.27	102.19	8.76	114.06	9.77
Sandy surface	15.36	1.32	0.49	0.04	14.54	1.25	16.33	1.40
Total	1,167.00	100.00	1,167.00	100.00	1,167.00	100.00	1,167.00	100.00

Source: Data calculated by author from Landsat Imagery

Land Use Land Cover Pattern in District Bilaspur of 1989-2019

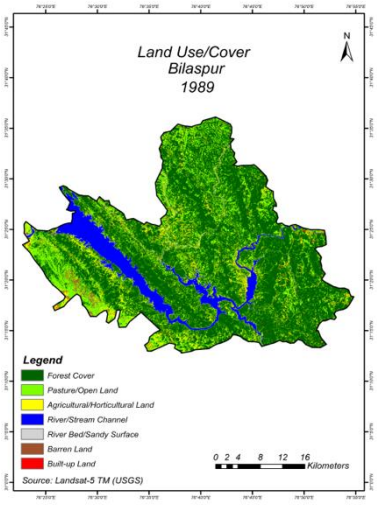


Fig.6.1

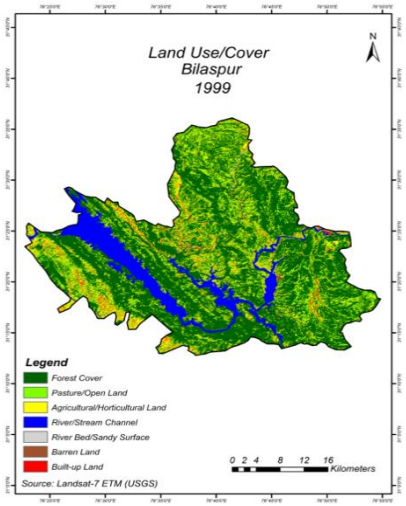
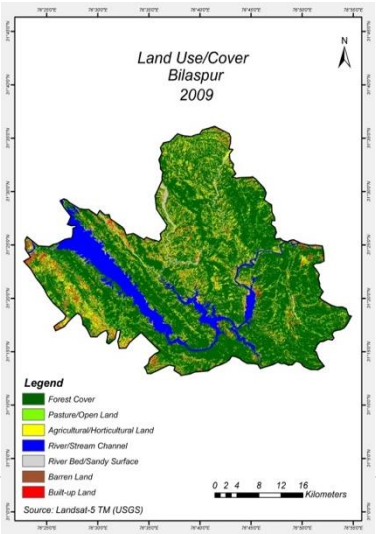


Fig.6.2



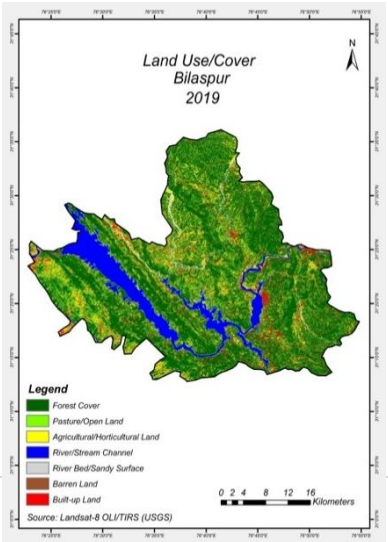


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Fig.6.3 **Fig.6.4**

Land Use and Land Cover Changes in district Bilaspur

Change detection refers to identifying differences in the state of an object or phenomenon by observing it at different times. Essentially, it includes the ability to quantify changes using multi temporal data sets one of the major applications of remotely sensed data obtained from earth-orbiting satellites is change detection because of repetitive coverage at short intervals and consistent image quality (Anderson, 1977). To study and identify the changes in land use and land cover pattern change detection is very important application. The change detection involves the use of multi-temporal data sets to discriminate areas of land use and land cover change between data of imaging. In the study area i.e. district Bilaspur change detection has been studied between 1989-1999, 1999-2009, 2009-2019 and 1989-2019.

Land Use and Land Cover Changes between 1989-1999

The comparison of land use/ land cover maps of 1989 and 1999 showed the considerable changes in land use and land cover **(Table 6.6, Fig 6.6)**, between 1989 to 1999. Agricultural/Horticultural Land area increased about 8.33 percent of the total geographical area, Barren Land increased 0.47 percent, Built-up Land about 1.60 percent, while Forest Cover area is decreased 4.80 percent, Pasture/Open Land decreased about 6.10 percent, and Sandy surface decreased about 1.28 percent of the total geographical area of the study area.

Table 6.6 Land Use and Land Cover Changes in district Bilaspur between 1989-1999

	Land Use /Land Cover 1989		**Land Use /Land Cover 1999**		**Land use Land Cover Change**	
Class-Name	**Area (1989) km2**	Per Cent	**Area (1999)**	Per Cent	Area	Per Cent
Agricultural/Horticultural Land	78.76	6.75	176.01	15.08	97.25	8.33
Barren Land	15.40	1.32	20.86	1.79	5.46	0.47
Built-up Land	6.78	0.58	25.44	2.18	18.66	1.60
Forest Cover	722.19	61.88	666.14	57.08	-56.05	-4.80
Pasture/Open Land	229.42	19.66	158.24	13.56	-71.18	-6.10
River/Stream Channel	99.09	8.49	119.82	10.27	20.73	1.78
Sandy surface	15.36	1.32	0.49	0.04	-14.87	-1.28
Total	**1,167.00**	**100.00**	**1,167.00**	**100.00**	**0**	**0**

Source: Data calculated by author from satellite imageries, Landsat 1989 and 1999

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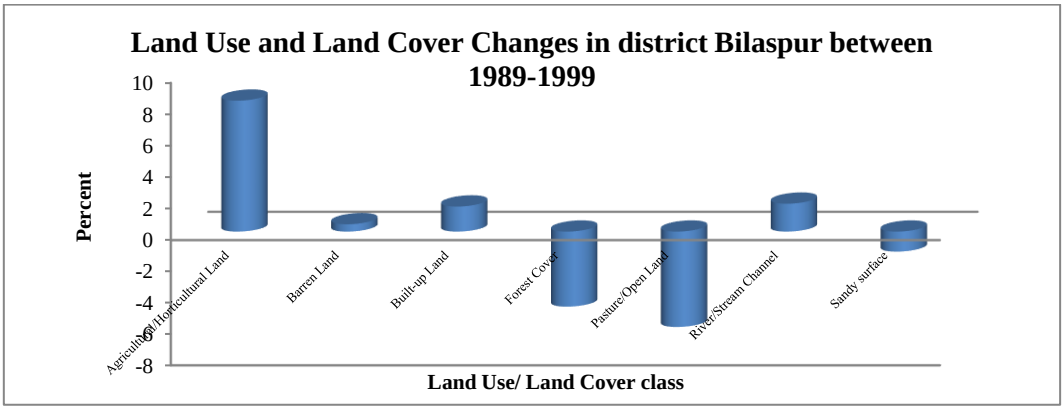

Fig 6.6

Land Use and Land Cover Changes in district Bilaspur between 1999-2009.

The comparison of land use/ land cover maps of 1999 and 2009 showed the considerable changes in land use and land cover **(Table 6.7, Fig 6.7)**, between 1999 to 2009. Agricultural/Horticultural Land area shows a minor increase during this period, increased about 0.5 percent, in the same way Barren Land shows a minor decrease, decreased 0.35 percent, Built-up Land increase about 0.5 percent, while Forest Cover area is decreased 2.06 percent, Pasture/Open Land increased about 1.72 percent, Sandy surface increased about 1.21 percent of the total geographical area of the study area.

Table 6.7: Land Use and Land Cover Changes in district Bilaspur between 1999-2009

	Land Use /Land Cover 1999		**Land Use /Land Cover 2009**		**Land use Land Cover Change**	
Class-Name	**Area (1999) km2**	Per Cent	**Area (2009)**	Per Cent	Area	Per Cent
Agricultural/Horticultural Land	176.01	15.08	181.80	15.58	5.79	0.5
Barren Land	20.86	1.79	16.84	1.44	-4.02	-0.35
Built-up Land	25.44	2.18	31.31	2.68	5.87	0.5
Forest Cover	666.14	57.08	642.04	55.02	-24.1	-2.06
Pasture/Open Land	158.24	13.56	178.28	15.28	20.04	1.72
River/Stream Channel	119.82	10.27	102.19	8.76	-17.63	-1.51
Sandy surface	0.49	0.04	14.54	1.25	14.05	1.21
Total	**1,167.00**	**100.00**	**1,167.00**	**100.00**		

Source: Data calculated by author from satellite imageries, Landsat 1999 and 2009

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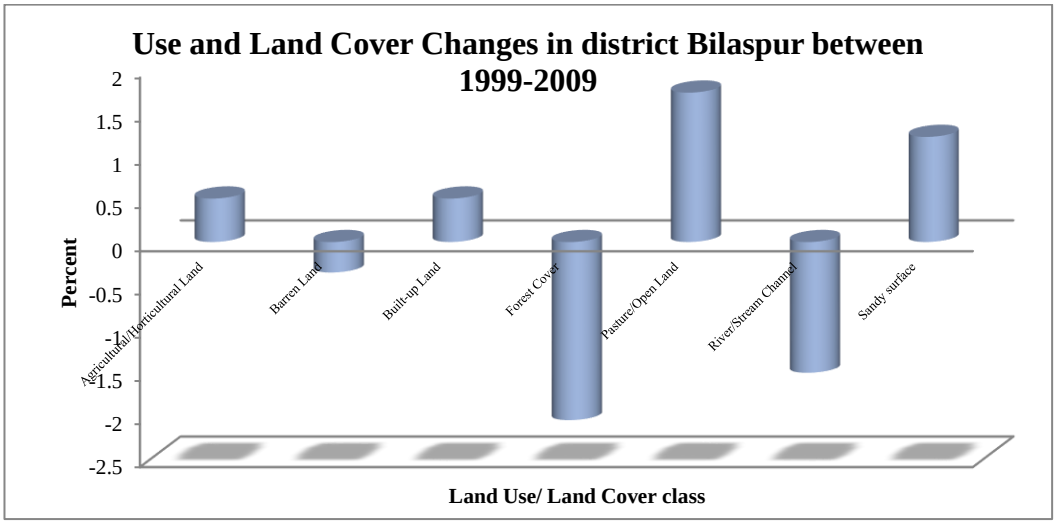

Fig 6.7

Land Use and Land Cover Changes in district Bilaspur between 2009-2019.

The comparison of land use/ land cover maps of 2009 and 2019 showed the considerable changes in land use and land cover **(Table 6.8, Fig 6.8)**, between 2009 to 2019. Agricultural/Horticultural Land area shows decrease during this period, decreased about 3.67 percent, Barren Land increased about 1.31 percent, Built-up Land shows rapid increase of about 3.21 percent, while Forest Cover area is increased 1.62 percent, Pasture/Open Land decreased about 3.67 percent , Sandy surface increased about 0.15 percent of the total geographical area of the study area.

Table 6.8 Land Use and Land Cover Changes in district Bilaspur between 2009-2019.

	Land Use /Land Cover 2009		Land Use /Land Cover 2019		Land use Land Cover Change	
Class-Name	**Area (2009) km2**	Per Cent	**Area (2019)**	Per Cent	Area	Per Cent
Agricultural/Horticultural Land	181.80	15.58	139.02	11.91	-42.78	-3.67
Barren Land	16.84	1.44	32.15	2.75	15.31	1.31
Built-up Land	31.31	2.68	68.77	5.89	37.46	3.21
Forest Cover	642.04	55.02	660.97	56.64	18.93	1.62
Pasture/Open Land	178.28	15.28	135.70	11.63	-42.58	-3.67
River/Stream Channel	102.19	8.76	114.06	9.77	11.87	1.01
Sandy surface	14.54	1.25	16.33	1.40	1.79	0.15
Total	**1,167.00**	**100.00**	**1,167.00**	**100.00**		

Source: Data calculated by author from satellite imageries, Landsat 2009 and 2019

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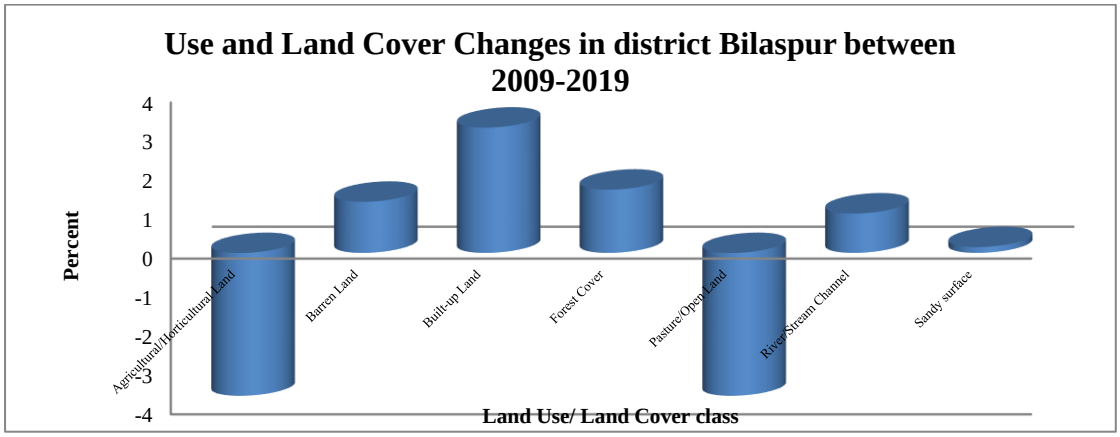

Fig.6.8

6.5.4 Land Use and Land Cover Changes in district Bilaspur between 1989-2019.

The study has been carried out for thirty years (from 1989 to 2019) to analyse the changes in land use. The share of various land use categories along with the total area and their percentage to the total geographical area are shown in **table 6.5**. The comparison of land use/ land cover maps of 1989 and 2019 showed the considerable changes in land use and land cover **(Table 6.9, Fig 6.9)**, between 1989 to 2019. Agricultural/Horticultural Land area shows increase during this period, increased about 5.16 percent, Barren Land increased about 1.42 percent, Built-up Land shows rapid increase of about 5.31 percent, while Forest Cover area is decreased 5.31 percent, Pasture/Open Land decreased about 8.03 percent, River/ stream Channel area increased about 1.28 percent, Sandy surface increased about 0.08 percent of the total geographical area of the study area.

Table 6.9 Land Use and Land Cover Changes in district Bilaspur between 1989-2019.

	Land Use /Land Cover 1989		Land Use /Land Cover 2019		Land use Land Cover Change	
Class-Name	**Area (1989)**	Per Cent	**Area (2019)**	Per Cent	Area	Per Cent
Agricultural/Horticultural Land	78.76	6.75	139.02	11.91	60.26	5.16
Barren Land	15.40	1.32	32.15	2.75	16.75	1.43
Built-up Land	6.78	0.58	68.77	5.89	61.99	5.31
Forest Cover	722.19	61.88	660.97	56.64	-61.22	-5.24
Pasture/Open Land	229.42	19.66	135.70	11.63	-93.72	-8.03
River/Stream Channel	99.09	8.49	114.06	9.77	14.97	1.28
Sandy surface	15.36	1.32	16.33	1.40	0.97	0.08
Total	**1,167.00**	**100.00**	**1,167.00**	**100.00**		

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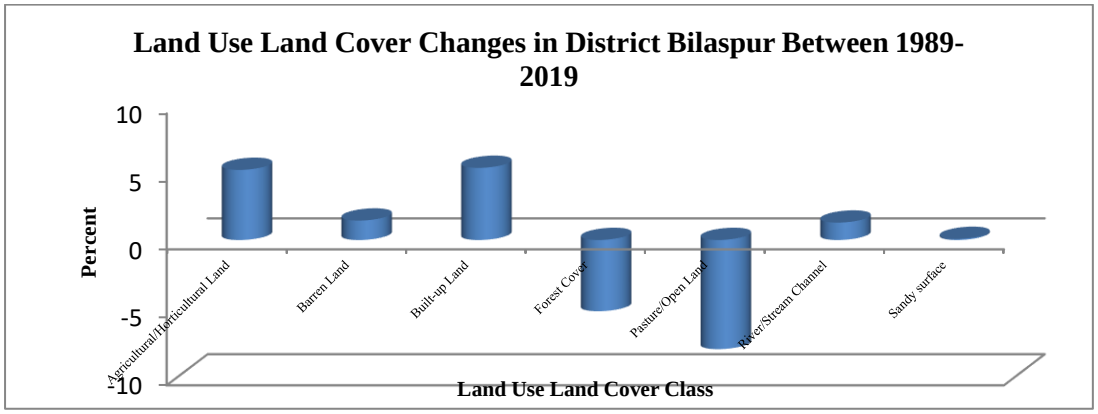

Fig 6.9

Agricultural/ Horticulture Land

Although agricultural land has been lost its area at a great level in Bilaspur district between 2009-2019, it has been recorded positive growth during 1989-2019. It increased from 78.76 km^2 (6.45 percent to the total geographical area) in 1989 to 139.02 km^2 (11.91 percent to the total geographical area) in 2019. The main reason behind it is that from 1989 to 2009 the converted area of pastures/ open land and forest area into agricultural land is more than converted area of agricultural land into built up land but between 2009 to 2019 converted area of agricultural land into built up land is more.

Barren Land

Barren lands are no use of land and it is the process of change of conversion. It is observed from the table 6.9 and figure 6.9 that vacant land has been recorded positive growth during 1989-2019. It increased from 15.40 km^2 (1.32 percent to the total geographical area) in 1989 to 32.15 km^2 (2.75 percent to the total geographical area) in 2019. The reasons observed, some of land owners have kept their land vacant due to steeply rising price of lands. In order to sale or purchase in future some land remains vacant.

Built-up Land

It is evident from the table 6.9 that the area under built-up land was reported as 6.78 km^2 which was 0.58 percent to the total geographical area in 1989 and 68.77 km^2 which was 5.89 percent to the total geographical area in 2019. The remarkable growth has been observed under built-up land i.e. increase of 5.31 percent during 1989 to 2019. This remarkable growth under built up land has been recorded due to conversion of agricultural lands into built up area, cutting down of trees for the construction of shops, restaurants, dhabas along the roads and highways.

Forest Cover

The total area under forest cover registered as 722.19 km^2 (61.88 percent to the total geographical area) in 1989 whereas it recorded as 660.97 km^2 (56.64 percent to the total geographical area) in 2019. A remarkable negative growth has been observed under Forest land i.e. decreases of -5.24 percent during 1989 to 2019. Forests areas have been cleared for

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the construction of highways or main roads, schools, colleges and shops etc. Many large construction and development projects are started by The State and Central government on forest area with the permission of Forest Department Govt of India and many are still waiting for clearance. Forest fires and other human activities also a major reason behind decline in forest area. From the Table no. 6.5 it is clear that decline in forest area which started since 1989 and continued till 2009, but after 2009 indicated a positive growth in the forest area. The total area under forest cover was 642.04 km^2 (55.02 percent) in 2009 increased to 660.97 km^2 (56.64 percent) in 2019.

Pastures /Open Land

Out of the total geographical area of the Bilaspur district, pastures/ open land contributed about 229.42 km^2 (19.66 percent to the total geographical area) in 1989 whereas it recorded as 135.70 km^2 (11.63 percent to the total geographical area) in 2019. A remarkable negative growth has been observed under Pastures/ open land i.e. decreases of -8.03 percent during 1989 to 2019. The main reason behind this decline is convergence of this land into built up and agricultural area in the study area.

Water Bodies

The area under water bodies seems more or less constant during span of thirty years. It covered 99.09 km^2 (8.49 percent to the total geographical area) in 1989 whereas it recorded as 114.06 km^2 (9.77 percent to the total geographical area) in 2019. A positive change has been recorded under water bodies of +1.28 percent. It has been observed that no major changes have been occurred and have no major transformation in major water bodies of the study area. The positive growth in water bodies may due to seasonal variations in rainfall, variation in water level of the lake and construction of new dam i.e. Kol Dam, in which some forest and some open land submerged and converted into water body.

Sandy Area

It is revealed from the table 6.9 that the total sandy area was 15.36 km^2 (1.32 percent to the total geographical area) in 1989 and registered 16.33 (1.40 percent to the total geographical area) in 2019. During 1989-2019, the sandy area was increased by only 0.08 percent. It increased due to fall in the water level of major tributaries due to illegal mining on the river beds in the study area. It is observed that sandy area has also been converted into agricultural land along the rivers.

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