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Amanpreet Singh
Assistant Professor,
Department of Geography,
Govt. Rajindra College,
Bathinda, Punjab, India

Dr. Lakhveer Singh
Assistant Professor,
Department of Geography,
Govt. Rajindra College,
Bathinda, Punjab, India

Jaskaran Singh
Assistant Professor,
Department of History, Govt.
Rajindra College, Bathinda,
Punjab, India

Corresponding Author:
Amanpreet Singh
Assistant Professor,
Department of Geography,
Govt. Rajindra College,
Bathinda, Punjab, India

Assessment of land use land cover (LULC) change using remote sensing, GIS and machine learning approach: A case study of Bathinda local planning area (LPA)-(2005-2025)

Amanpreet Singh, Dr. Lakhveer Singh and Jaskaran Singh

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Abstract
Land-use and Land-cover analysis is important to investigate the patterns of how land is being utilized and what changes occur in it with the passage of time. In Countries like India having massive base of population, land always remain under pressure of increasing demand for housing and various economic activities. The present study is based on Bathinda, city of Punjab State of India which incorporates urbanized limit of the same. The spatio-temporal dynamics of land-use and land-cover that increase pressure on agricultural land and vegetation around the expanding City are analyzed and examined from 2005 to 2025. Landsat 7 and Landsat 8 images for year 2005, 2015 and 2025 are exploited in Google Earth Engine (GEE) and QGIS to study the changes in the area of Water-Bodies, Built-up, Crop-land, Vegetation and Fallow-land. For accuracy assessment Error Matrixand Kappa analysis along with the use of‘ smile Random Forest’ classifier was done in GEE.

Keywords: Built-up, agriculture, major roads, expansion, patterns

Introduction
Land-use Land-cover(LULC) becomes an important component to manage resources and to make policies for sustainable development. Remote Sensing and GIS have major role in analyzing LULC changes. The rapid urbanization leads to the expansion of cities and the changes in patterns of land-use. The Expansion of Urban Built-up on Agricultural areas does not alter only LULC but makes an impact on local Environment also. Haphazard growth leads to not only the deterioration of Environment but also have economic, social and health implications. Therefore, LULC analysis has importance in academia, policy making and future planning.

Area of Study
The current study focuses on Bathinda city Local Planning Area (LPA). Bathinda city is the headquarter of Bathinda District of Punjab, located in south western part of Punjab State of India. Located at the coordinates of 30°4’30’’ N. to 30°21’20’’N and 74°47’50’’E to 75°10’00’’ E. Bathinda is famous for its semiarid Climate, Historical roots, fort ‘Qila Mubarak’, Cantonment, Railway Junction and more for its growth, for instance, the establishment of All India Institute of Medical Sciences (AIIMS) and Central University of Punjab(CUPB). The shape file of study area is created by taking ‘Bathinda: proposed land-use plan 2009-2031’, a map prepared by Punjab Urban Development Authority (PUDA) as base Map. The research coversa total of 574.27 km^2 area in its analysis. Bathinda LPA along with Bathinda City includes two towns, Bhucho Mandi and Goniana Mandi and 46 villages.
It is important to note that the Physiographical Bathinda LPA has primarily sandy soils. There is no major river in the area; only Bathinda Branch of Sirhind Canal flows through the study area. Temperatures range from as high as 48º C in Summers to as low as 0º C in Winters. Due to Semi-Arid Climate, rainfall is relatively low as compared to North -Eastern parts of the Punjab.

Methodology
Landsat 7 and Landsat 8 images for the years of 2005, 2015 and 2025 are used for the present study to analyze the changes in LULC in last three decades.

The images are first filtered for Cloud Cover less than5% and median is taken to Google Earth Engine. True and False Color composite images are created by assigning suitable bands to each channel (Red, Green, and Blue). A Supervised Classification method is exploited to train the algorithm for five major land-use and land-cover classes of ‘Water-bodies’, ‘Built-up’, ‘Crop-land’, ‘Vegetation’ and ‘Fallow-land’ in GEE. About 100 training samples for each class are taken and 70:30 ratio is used for training and testing. Assigned training samples are cross verified through truth ground points by visiting in the field and with the help of satellite view of Google Earth pro. Smile Random Forest classifier is employed to classify data. Error matrix and Kappa statistics for all images are created in GEE.

Results and Analysis

The classified images for each study year are presented in figure 1, 2, and 3. The overall accuracy of each year’s classification is 86.3%, 93.3%, and 94.5% with Kappa coefficient 0.823, 0.91 and 0.95 for the years of 2005,2015 and 2025. The Attribute table prepared from these images demonstrates area under each Class in km^2. Crop-land with area of 329.88 km^2 (57.44%) in 2005, 345.64. km^2 (60.19%) in 2010 and 367.56km^2 (64.00%) in 2025 remains at first rank. Second rank was occupied by Vegetation in 2005 with area of 118.26 km^2 (20.59%) but ended up at third rank in 2025 with significant loss of area under it which remains only at 40.31 km^2 (7.02%). Built-up which was at third rank in 2005 with an area of 90.99 km^2 (15.84%) shows constant increase in area with 123.26 km^2 (21.46%) in 2015 and ended up at second rank in 2025 with significant increase of area under it, that is 151.75km^2 (26.42%). There can be seen continuous decrease of area under Fallow-land because of reclamation of land for agriculture and Built-up. The artificial Lakes near Thermal Plant, small pounds, Bathinda Canal andstagnant water in low laying areas were major Water-Bodies in study area in 2005. The recent reclamations of land from stagnant water in low laying areas causes decline in area under Water Bodies.

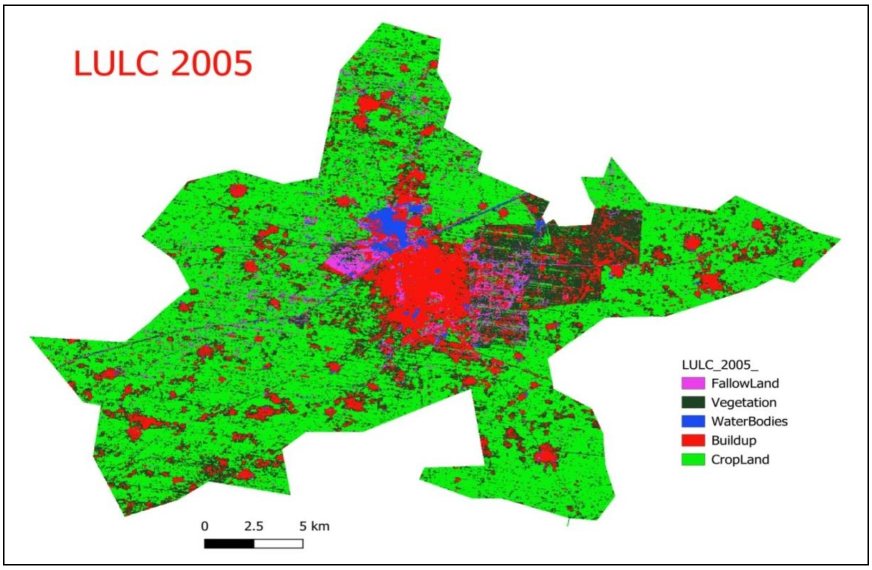

Fig 1: LULC 2005

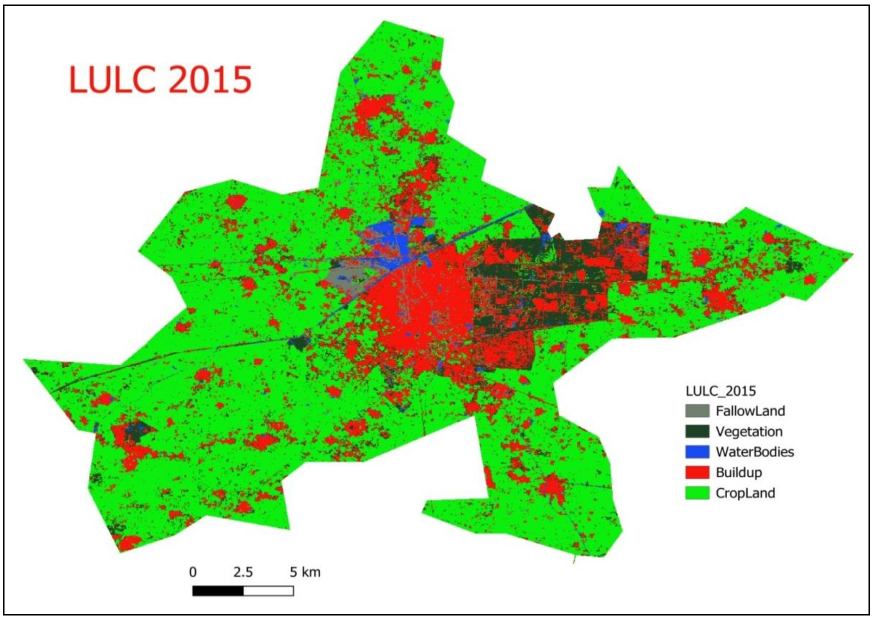

Fig 2: LULC 2015

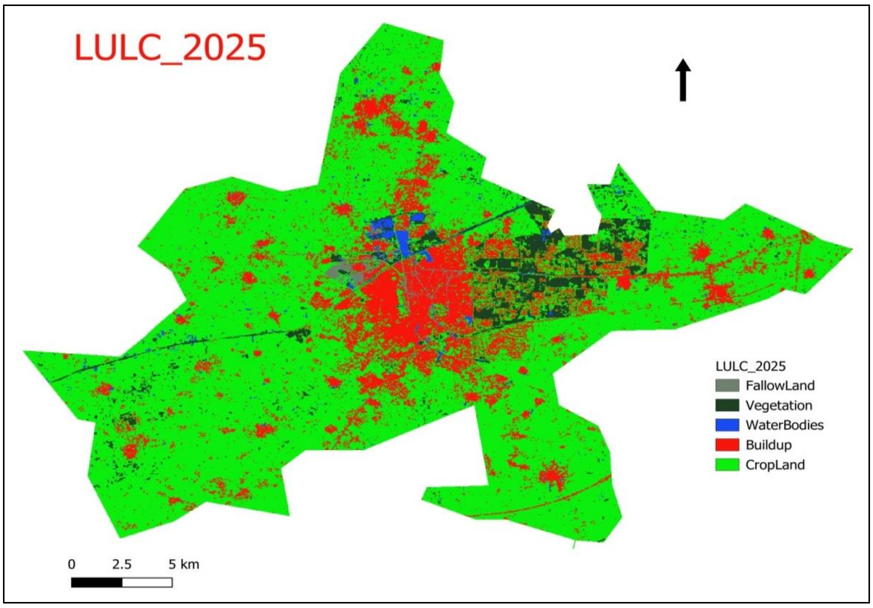

Fig 3: LULC 2025

Area under Vegetation continues to decrease mainly because of the pressure of Built-up and the clearing of land by farmers for cultivation. Large part of vegetation remains concentrated in pockets in Cantonment and at the banks of Bathinda Canal in 2025 whereas most of the vegetation in rural areas is now cleared for agriculture.

Fallow Land at the vicinity of the city which was used for ash deposition from thermal power plant and other Industries also decreases due to reclamation by housing projects. The fallow land in rural areas is also decreased due to continuous expansion of agriculture and allied activities.

Punjab is known for its fertile soil and agricultural activities. It is also important to remember that agriculture boosts its economy at large scale.. Therefore, one can witness an intensive increase in agricultural activities and farm output after Green Revolution of 1960s in Punjab. The study also shows the same trend with progressive increase of area brought under agriculture by farmers. This increase in Crop-land is due to bringing up of Fallow-land, Barren land and Natural Vegetation areas under agriculture.

Urban Growth of Bathinda City and its satellite towns to their fringe areas leads to major shift in land-use patterns around the city. The City is continuously spreading to all directions. Industrial Units, new Residential Colonies and Commercial Colonies are establishing in suburbs on Crop Land. From 2005 to 2025, there is an upsurge of 60.76 km^2 (66.78%) in Built-up category. In 2025, Built-up covers 10 % more Geographical area than 2005. The recent decadal trend (2015-25) demonstrates that all the Land Use types are losing area except Crop-Land and Built-up. Expansion of the city is observed along the Major Roads viz. Bathinda-Dabwali road, Bathinda-Faridkot road, Bathinda-Mansa road and Bathinda -Chandigarh highway.

Table 1: LULC 2005, 2015, 2025

LULC Classes	2005		2015		2025	
	Area (km)^2	Area (%)	Area (km)^2	Area (%)	Area (km)^2	Area (%)
fallow Land	24.50	4.27	15.41	2.68	7.07	1.23
Vegetation	118.26	20.59	79.51	13.85	40.31	7.02
waterbodies	10.64	1.85	10.46	1.82	7.58	1.32
Buildup	90.99	15.84	123.26	21.46	151.75	26.42
Cropland	329.88	57.44	345.64	60.19	367.56	64.00

***Source*:** Computed from Classification Images.

Table 2: LULC changes from 2005 to 2025

LULC Classes	2005-2015		2015-2025		2005-2025	
	Change in Area (km)^2	Change in Area (%)	Change in Area (km)^2	Change in Area (%)	Change in Area (km)^2	Change in Area (%)
fallow Land	-9.09	-37.08%	-8.34	-54.10%	-17.43	-71.12%
Vegetation	-38.75	-32.76%	-39.20	-49.30%	-77.95	-65.91%
Waterbodies	-0.19	-1.77%	-2.88	-27.51%	-3.07	-28.80%
Buildup	32.27	35.46%	28.49	23.12%	60.76	66.78%
Cropland	15.75	4.77%	21.93	6.34%	37.68	11.42%

***Source*:** Computed from Classification Images (TGA=Total Geographical Area).

Conclusion

Based on this study, it can be concluded that the Land Use Land Cover analysis of Bathinda Urbanised area (juxtaposition of City and its satellite towns) exhibits how a constant expansion of city along major Highways in multi-directions and on agricultural land around its periphery, resulting increased rates per square feet and expanding slum areas. Next, it is observed that the area under agriculture increases in rural parts of study area due to decrease in Vegetation and Fallow-land. The decreasing trend of Vegetation appears a sign of degrading environment in the study region. Decreasing area under agricultural land near City is correlated with horizontal expansion of Built-up areas. It is the need of the hour that the policy makers must be conscious about the occurring changes in LULC around the study area while preparing plans for the development of region.

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