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Change Detection Analysis of Land Use Land Cover;
A Case Study of Peri-Urban Area of Eastern Pune, M.S., Western India.

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Abstract:

Urban expansion has been creating an alarming situation in all countries of the world. High rates of migrant urban population has led to serious unplanned land use problems such as loss of agricultural land, unauthorized urban sprawl, high land values, pollution, poverty and social unrest making urban governance a difficult task to maintain healthy urban environment. In the emerging scenario it is essential to have up-to-date information in existing land use information system.In the recent times, remote sensing and geographical information systems (GIS) are very valuable and advantageous in providing contemporary land use information. The present study highlights significance of remote sensing in the study of land use /land cover ofurban land use changes for the time periods using LISS III satellite imageries from the BHUVAN portal. The satellite imageries of LISS III for two consecutive dates were merged to produce a single image. These merged images were further introduced to GIS environment and subjected to supervised classification for land use land cover analysis. The study area is a typical peri-urban region located towards the eastern extent of the Pune Metropolitan region in the state of Maharashtra. The result obtained from the land use / land cover analysis shows a significant decrease of agricultural area and an increase in built-up area from year 2009 to 2018. The spatial information from the remote sensing satellite plays a vital role in analysis of changing land use/land cover pattern. The study area was classified into eight categories on the basis of field study, geographical conditions, and remote sensing data.

Key words: ***Land use / Land cover, GIS & Remote sensing, Change detection*****.**

1. Introduction:

Land cover refers to the physical characteristics of Earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Land use refers to the way in which land has been used by humans and their habitats (such as agriculture, settlements, industry etc.). Although land use is generally inferred based on the cover, yet both the terms land use and land cover are being interchangeably used by physical and human geographers.

Viewing the Earth from space is now crucial to understand man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the Earth from space provide objective information of human utilization of the landscape. Over the past years, data from the Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change (Zubair, 2006). There are many studies, in which many researchers or scientists have used varied Geo-information basedsoftware for the classification purpose activity, which shows the land use component. Land is one of the prime natural resources of a country. Any city grows not only by population but also by changes in spatial dimensions. Land use change, including land conversion from one type to another and land cover modification through land use management, has greatly altered a large proportion of the earth’s land surface to satisfy mankind’s immediate demands for natural resources (Meyer and Turner, 1992; Vitousek et al.,1997; Foley et al., 2005).

Hence, there is a need to accurately describe land use/land cover for sustainable environmental planning. The present research, work emphasizes on mapping land use/land cover of Pune city over a period of last four decades (1973-2014) by employing modern technology like remote sensing and Geographical Information System (GIS).

Information on land use/land cover in the form of maps and statistical data is the essential component for utilization of land for agriculture, economic production, spatial planning and sustainable management. In contemporary times, Land use is a complex term. Natural scientists define land use in terms of syndromes of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity.

Social scientists and land managers define land use more broadly to include the social and economic purpose and contexts for and within which lands are managed (or left unmanaged), such as subsistence versus commercial agriculture, rented versus owned, or private versus public land. While, land cover may be observed directly in the field or by remote sensing. Observations of land use and its changes generally require the integration of natural and social scientific methods (expert knowledge, interviews with land managers) to determine which human activities are occurring in different parts of the landscape, even when land cover appears to be the same. As a result, scientific investigation of the causes and consequences of LULC requires an interdisciplinary approach integrating both natural and social scientific methods, which have emerged as new disciplines of land-change science. In an urban environment natural and human induced environmental changes are of concern today because of deterioration of environment and human health. The study of land use/land cover changes is very important to have proper planning and utilization of natural resources and their management. Traditional methods for gathering demographic data, censuses, and analysis of environmental samples are not adequate for multicomplex environmental studies, since many problems are often presented in environmental issues, having great complexity of handling the multidisciplinary data set, new technologies like satellite remote sensing and Geographical Information System (GIS) are required. The land use land cover change and its modelling (LULCC-M) approach have recently been considered by the scientific community to observe environmental changes.

2.Study area:

Pune, formerly known as Poona till 1978, is the second largest metropolitan city in the Indian State of Maharashtra and the eighth most populous city in India, with an estimated population of 7.4 million as of 2020. It has been ranked as “the most liveable city in India” several times. Along with the municipal corporation limits of PCMC. According to the 2011 census the urban area had a combined population of 5.05 million whilst the population of the metropolitan region was estimated at 7.4 million. Situated 560 meters above sea level on the Deccan plateau on the right bank of the Mutha river, Pune is also the administrative headquarters of its namesake district.

The longitudinal extent of the study is73°57’0.94’’E to 74°3’21.96’’Ewhile latitudinal extent is 18°25’4.96’’N to 18°32’43.8’’N. Eastern peri urban covers the 66.187 sq.km. of total area. The study area of this research work is situated along the Pune – Solapur national highway. Manjari, Shewalwadi,Lonikalbhor and Kadamwakvasti these are the key villages of the study area. Manjari railway station is one of the Pune Suburban Railway stations located on Pune-Solapur section. Serum Institute of India Pvt. Ltd. Is one of the world's largest vaccine manufacturer companies situated in Manjari.Shewalwadi is one of the largest vegetable markets of eastern of Pune. Lonikalbhor has one of the largest petrol bunks of the Hindustan petroleum. Kadamwakvasti is the one of the micro real estate markets of the eastern suburban area of Pune city.

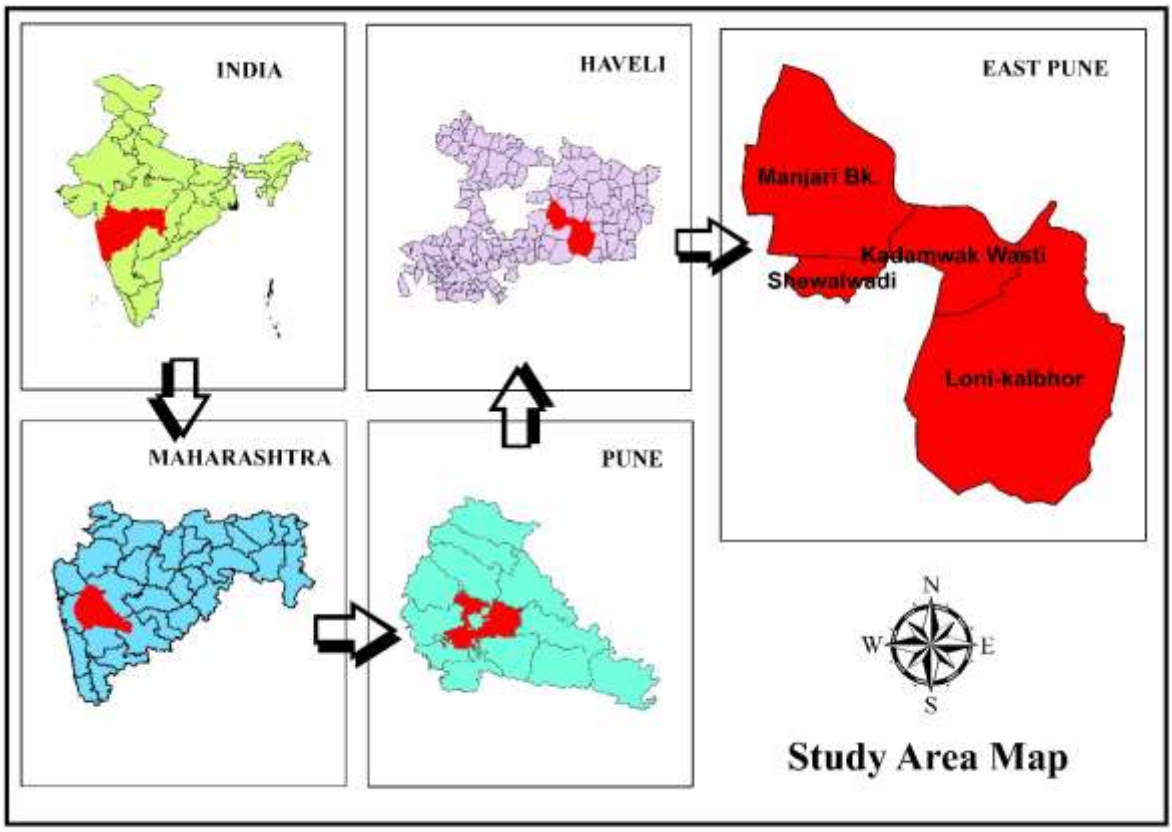

Figure 1: Study Area Location Map

3. Research Objectives:

1) To assess the Land Use /Land Cover of study area.
2) To execute the change detection analysis of the study area.
3) To suggest the future plan for the peri-urban area.

4. Data collection:

The data collection for the present study involved the collection of demographic details, toposheets and satellite data. The nature of these data and their sources are shown in Table provided below.

Table 1: Primary and Secondary Data Details for the Study Area.

Segment: Eastern Pune	**Sources**
Satellite Imagery-LISS III imagery	(BHUVAN, NRSC)www.bhuvan nrsc.gov.in
Study area village boundary	Maharashtra Remote sensing and Application centre

Table 2: Satellite Imagery used for the study area.

Satellite	**Band**	**Acquisition Date**	**SpatialResolution(m)**
LISS-III	4 bands	17th Nov, 2008	23.5
LISS-III	4 bands	09thNov, 2018	23.5

In the Present Study, the Data required for Remote Sensing has beenobtained from ISRO's BHUVANPortal.Cloud free Digital Data of LISS III (2008), and LISS III (2018) satellites were selected for the assessment of land use and land cover changes for easy demarcation and accurate analysis. The Satellite Image of the month of July shows the maximum water-logged area and the images captured during the month ofMarchshows maximum vacant land surface, due to harvesting of all crops in summer season. Hence, the periods (March and July) are not suitable for clear cut delineation of Land Use and Land Cover Changes. The Remotely Sensed Data of October to February months are ideal and have been used to delineate the spatio-temporal changes of Land Use/Land Cover. The maps have been prepared using Geo-spatial techniques.

5.Research Methodology:

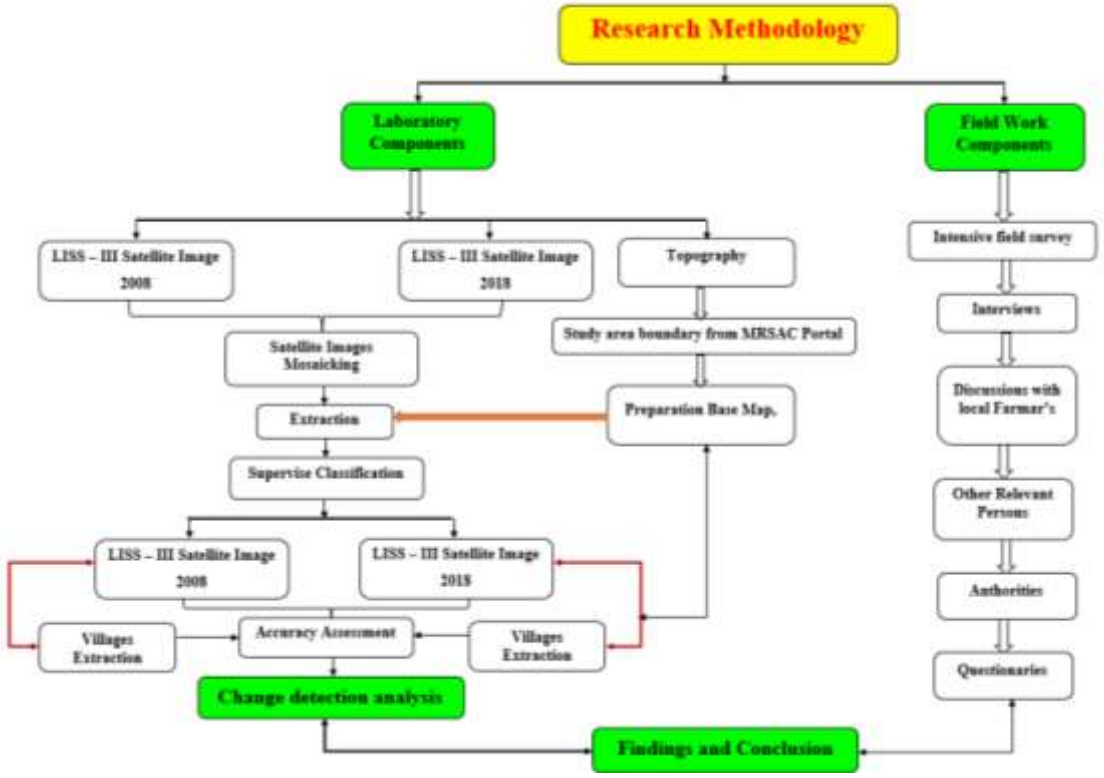

Figure 2: Research Methodology

Land Use land Cover Classification:

Land cover is the observed (bio)physical cover on the Earth's surface. When considering land cover in a very pure and strict sense it should be confined to describe the vegetation and the man-made features. Consequently, areas where the surface consists of bare rock or bare soil describe land itself rather than land cover. Also, water surfaces can be disputed as being real land cover. However, in practise the scientific community is used to describe those aspects under the term land cover. Land cover is not to be confused with land use. Example: woodland or forest are land covers, but the land use may be hunting or rubber tapping" (Prof. Dr. Christiane Schmullius).

Maximum likelihood Classifier:

Once classifier receives training data it computes means and variances for each band of each class, which are Gaussian in nature and can be described by the mean vector and covariance matrix. The statistical probability is computed for a given pixel value being a member of particular land use and land cover class. Beside means and variance, the variability of brightness values in each class is also considered while defining membership. For every unknown pixel as per the equation 1 distance is calculated using the mean of a class and the probability of occurrence of that pixel in the class, class having minimum distance to the pixel is assigned to the that pixel in the class, the class having minimum distance to the pixel is assigned to the pixel. (Ritu Saini2019, PradeepAswal 2019, MohdTanzeem 2019, Sanyam S. Saini2019)

AccuracyAssessment:

Accuracy assessment is the final step in the analysis of remote sensing, which helps us to verify how accurate our results are. It is carried out once the interpretation/classification has been completed. Here, we are interested in assessing accuracy of thematic maps or classified images which is known as thematic or classification accuracy. (AnupamAnand January 2017)

Change Detection Analysis

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh 1989).

6. Results and Discussion:

In this study land use land cover operation is carried out by using LISS – III satellite images having 23.5 spatial resolutions. For the land use land cover analysis, supervisedclassification algorithm which helps to calculate the accurate land use land cover features, has been used. The land use land cover classification is carried out with 6 land use land cover classes namely, agriculture, built-up area, fallow land, open land, vegetation and water body.

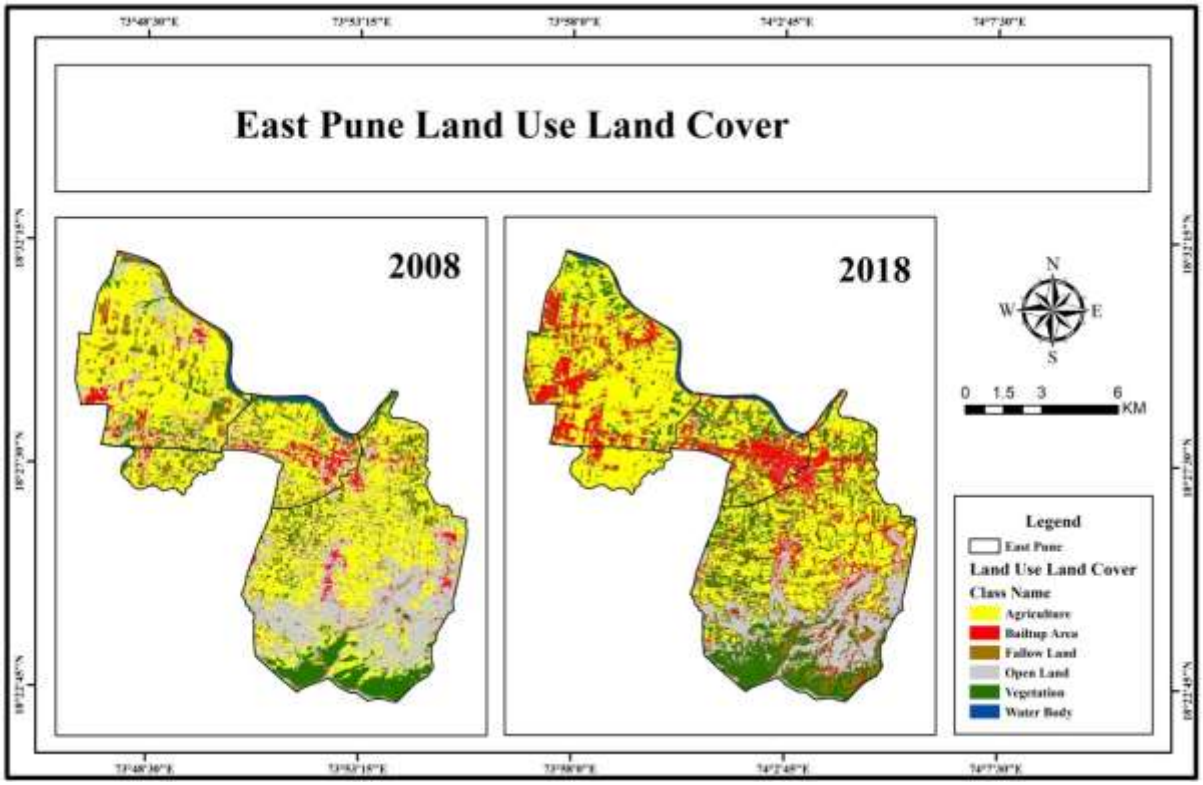

Figure 3: Land Use Land Cover of theStudy Area

Table 3: Study AreaLand Use Land Cover Area in Hector and Percentage.

Sr. No.	Land use land cover classes	Year 2008		Year 2018	
		Area in (%)	Area in ha.	Area in (%)	Area in ha.
1	Agriculture	46	3054	46	3056
2	Built-up Area	5	326	16	1041
3	Open Land	28	1873	13	870
4	Vegetation	12	812	20	1379
5	Water Body	1	60	2	82
6	Fallow land	8	491	3	188
	Total	**100**	**6616**	**100**	**6616**

The main components of this area are the Pune-Solapur National Highway and Pune-Solapur Railway Line. The study area is about 20 km from the main city of Pune. Therefore, the skilled and unskilled population is heavily dependent on the city of Pune for employment. Also, the study area is a major educational centre, which is the primaryfactor enabling communication of this area with Pune. Similarly, Manjari and Shewalwadi villages in the study area have major vegetable sales centres in Pune Eastern Division.Manjari and Shewalwadi villages are the main vegetable sales centres of Eastern Pune Division. The internationally renowned pharmaceutical company,Serum Institute is situated in the Manjari Village. The study area has been developed vide a bits and pieces approach seen in the small scale real estate centres situated in the local villages.

All of the above observations indicate at a conversion of land cover classes to land use classes. The above characteristic change in the study areacan be studied from the above image(Figure.3)and table. It can be observed that the size of agricultural land in the year 2008 was 3054 ha. but in the year 2018, there has been an increase. Similarly, the area of the built-up land in 2008 was 326 ha. but in 2018 its size had increased to1041 ha.

The area of Open Land was 1873 ha in 2008,which in2018 appears to have declined sharply to 870 ha. In the year 2008, 812 haarea appears to be under the land use class of vegetation. This area has been found to have increased to 1379 ha.in the year 2018. Considering the water body class, 60 ha area was coveredby water in the year 2008. But in 2018, the area of waterbodiesincreased to 82 ha. The proportion of fallow land in year 2008 was 491 ha. Which has decreased to 188 ha in year 2018.

The internal correlation between all these classes have to be taken into account in order to explain the reason for the uneven distribution of land use land cover for a period of 10 years between year 2008 and year 2018 found in Image no.3.

The increase in rainfall indicates a positive change in the water bodies, greenery and agriculture. The rainfall in 2018 is higher than that of 2008, impacting the size of water body and greenery in 2018 (fig. no.3).

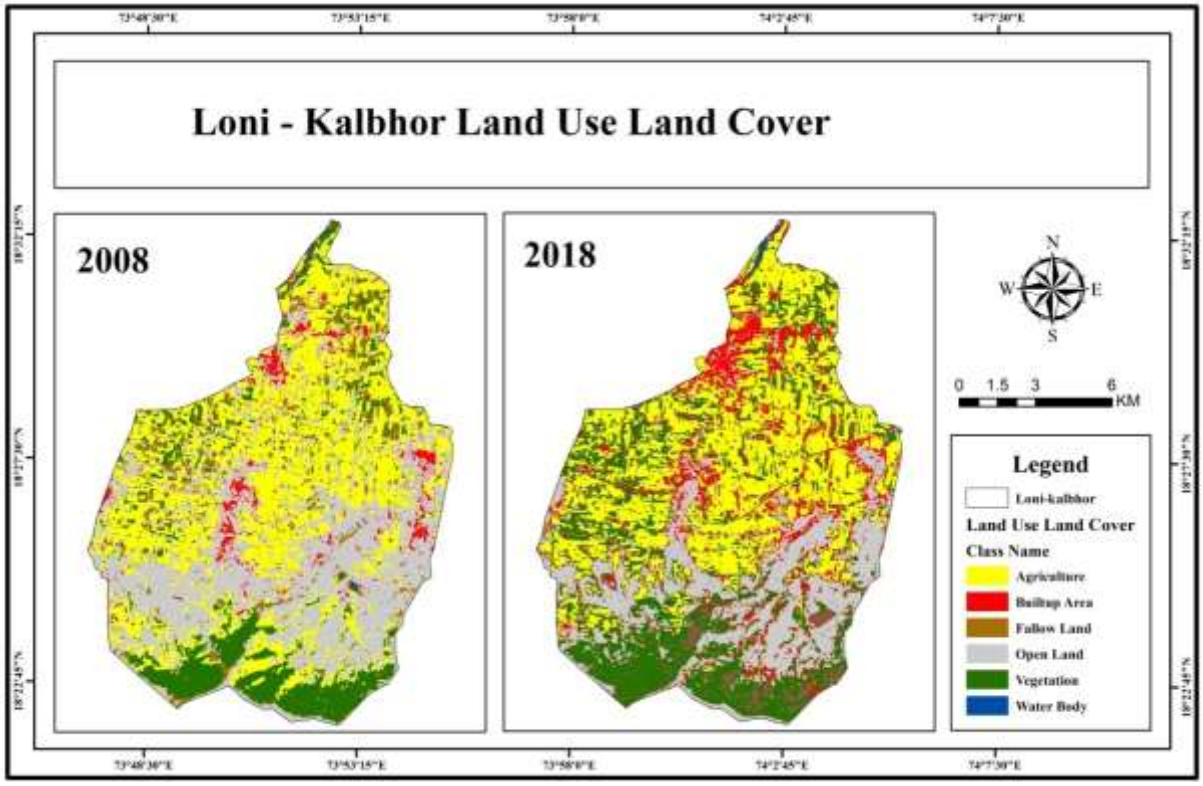

Figure 4: LoniKalbhorVillage Land Use Land Cover Map

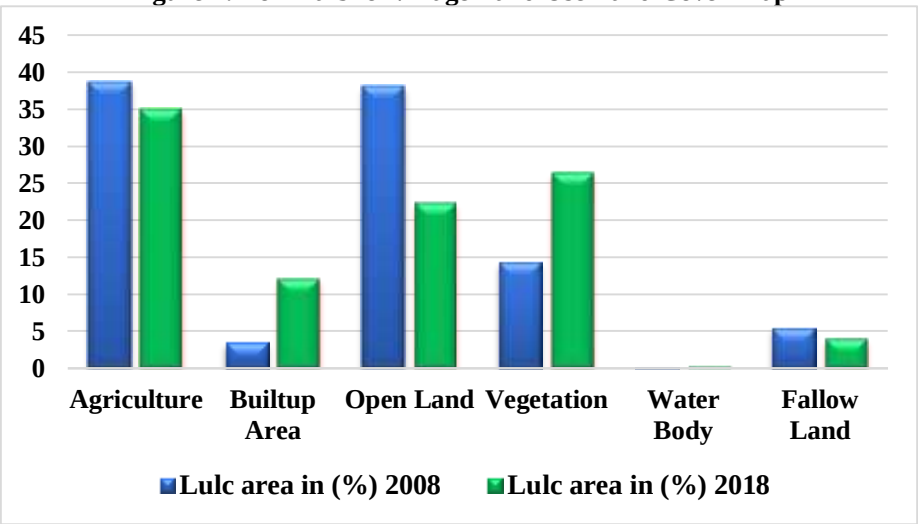

Figure 5.LoniKalbhorVillage Land Use Land Cover Area in Percentage.

The above Landuselandcover map and the decadal change detection bar graph of LoniKalbhor depicts around 5% decline of land associated with agricultural activities and a significant decline of landcover under the category of open land, which has been replaced by Built-up. The dominance of built-up over the landuse of this area is a key observation of this maximum likelihood classification.

The analysis also shows an increase in the vegetation of the study area, which is evident due to the practice of nursery farming along the highway. The share of waterbodies in the landcover of this area is negligible.

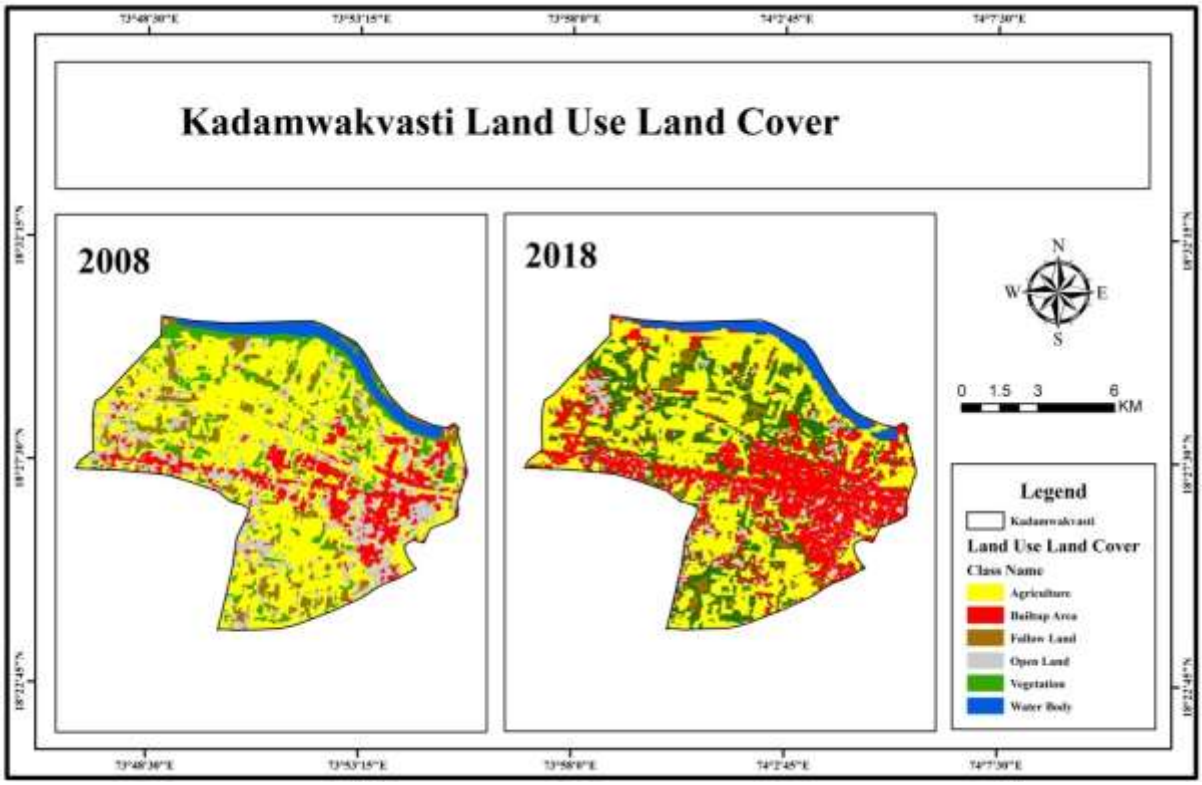

Figure 6: KadamwakvastiLand Use Land Cover Map

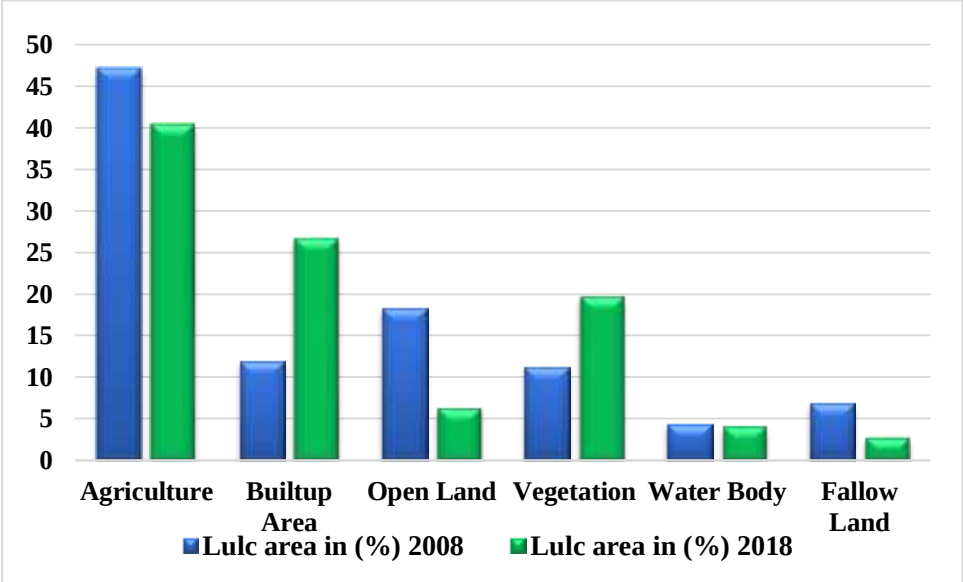

Figure 7: KadamwakvastiLand Use Land Cover Area In Percentage.

The enumeration of the landuselandcover map and decadal change detection bar graph of Kadamwakvasti reveals the dominance of built-up area over agriculture, open land and fallow land, steering a decline in the share of these landuse types.

The increase in vegetation is influenced by the practice of nursery farming in Kadamwakvasti as well, in addition to which, there is a slight decline in the share of the landcover associated to waterbodies.

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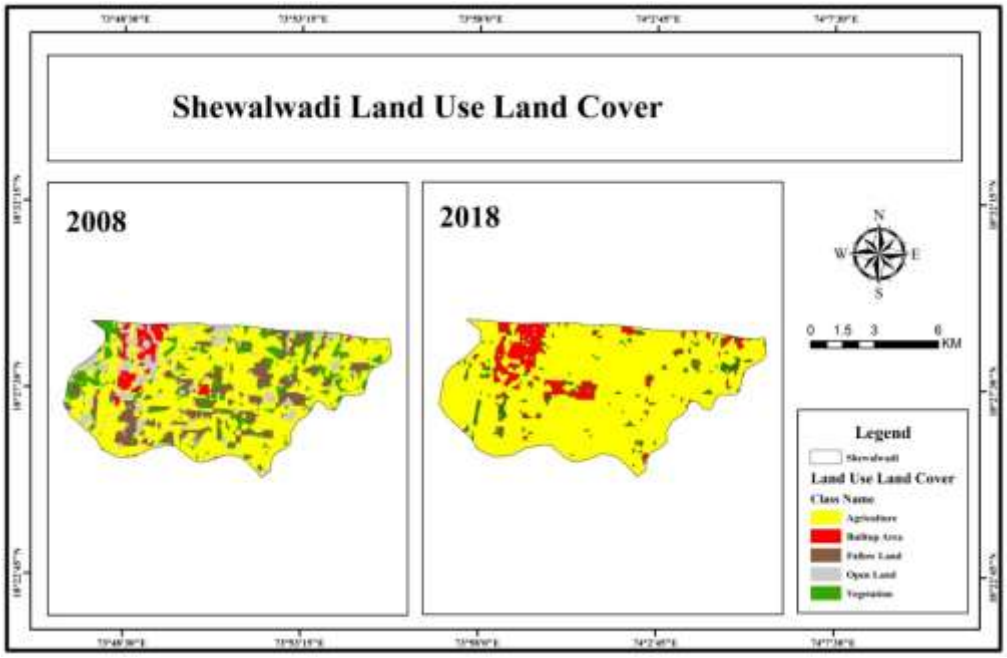

Figure 8: ShewalwadiLand Use Land Cover Map

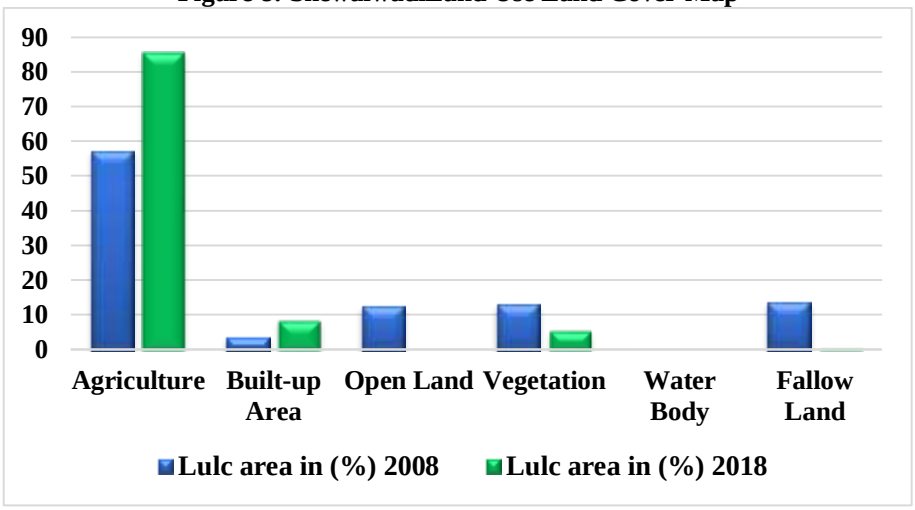

Figure 9: ShelwalwadiLand Use Land Cover Area in Percentage.

The landuselandcover map and decadal change detection bar graph of Shewalwadidetermine, that the landuse is dominated primarily by agriculture and allied landuse patterns. There has been negligible change in the landuse pattern of fallow and open lands. There has been a slight increase in built-up in Shewalwadi in the current decade. The growth of area under natural vegetation is due to nursery farming along the highway.

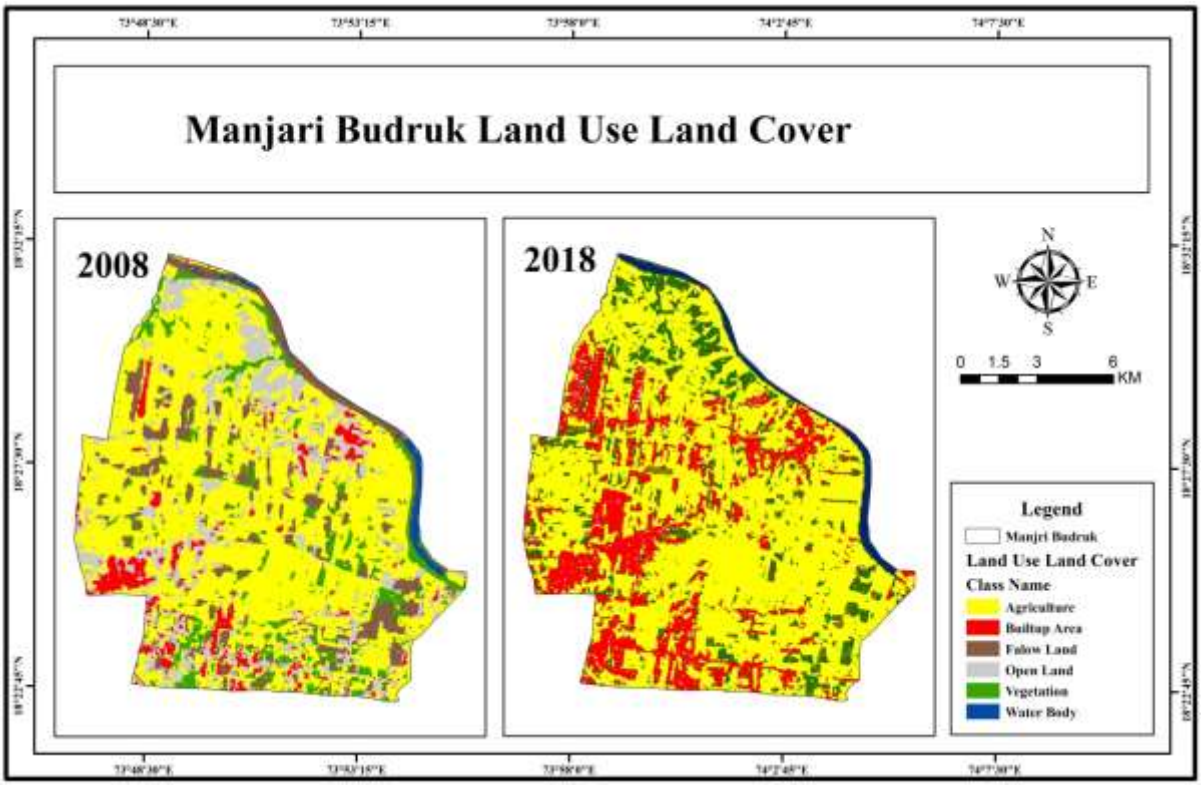

Figure 10: Manjari Budruk Land Use Land Cover Map

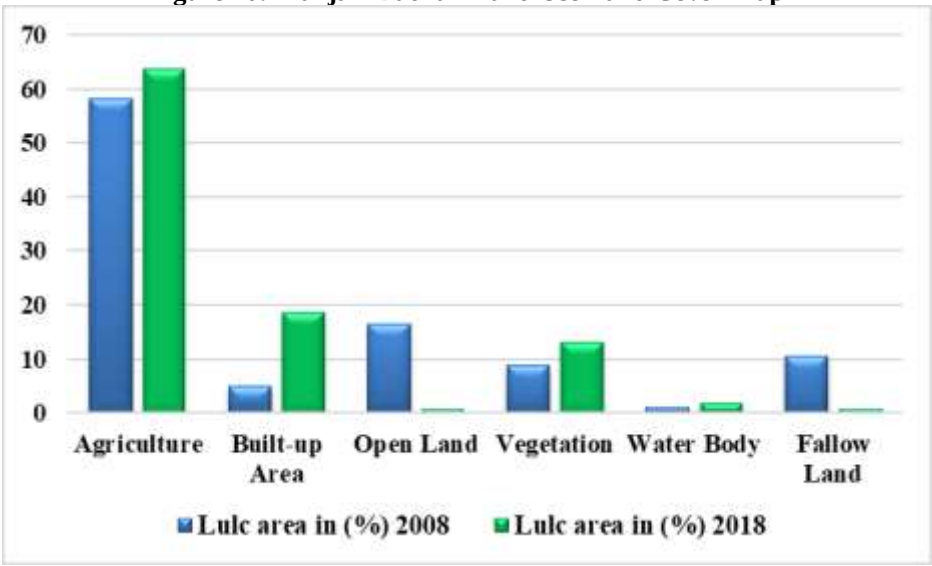

Figure 11: Manjari Budruk Land Use Land Cover Area in Percentage

The landuselandcover map and decadal change detection bar graph of ManjariBudruk indicates a significant rise in built-up area which has taken the shares of open land and fallow land under its landuse category in the recent decade. This development in the area has not affected the agricultural landuse, which has shown a fairly positive growth. The increase in natural vegetation is evident owing to nursery farming.

Conclusion:

Considering the relationship between agriculture and built-up sector, it can beinferred that since the study area is a micro real estate centre, the conversion of sub-agricultural land into a built-up area is visible.The extent of agriculture in the study area appears to have increased significantly due to large-scale Nursery farming practiced in this area. The presence of Nurseries, have enhanced the proportion of mixed farming in the study area. The study shows that the water level in the area is changing seasonally. And this change is more evidentnear the river.Large portions of open land are converted into construction areas to accommodate the increasing population.

Recommendation:

It is being put forward with the help of the present work, that the growing urban landscape is potentially the most proponent form of landuse which will impact on the landuse in the days to come. It is therefore recommended to administer a sustainable growth of the human settlements without impeding any obstruction in the maintenance of healthy natural vegetation and water resources in the study area and prevent human induced ecological depletion.

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