CHANGES IN LAND USE LAND COVER USING GIS OF NORTH INDIAN CITY, SONIPAT

Rajeev Dahiya[1], Pratibha Sharma[2] and Nisha Kumari[2*]

[1]*Department of Management Studies, Maharaja Surajmal Institute, Janakpuri, New Delhi-110058 (INDIA)*

[2]*Centre of Excellence for Energy and Environmental Studies, Deenbandhu Chhotu Ram University of Science and Technology, Murthal,Haryana- 131039 (India)*

ABSTRACT: *This study was employed using USGS (United States Geological Survey) earth explorer and sentinel-2 data to study the Land use land cover changes (LULC) of a city located in North India. Land use land cover changes (LULC) were determined for the six classes which are agricultural fallow land, settlement, water bodies, grass and bushes, bare soil and dense trees. On comparing land use and land cover in 2017 and 2021 indicated that there's a significant increase in settlements of about 3251.7 hectares and in dense trees class of nearly 70.79 hectares in the study area. The study indicated that the area is experiencing a continuous human intervention. The land-use change finding shows a major decrease in the agricultural and fallow land during the study period. This is because of the fact that the area is experiencing a sudden and vast increase in population and urbanization.*

Keywords: LULC, GIS, remote sensing, software, settlements etc.

1. Introduction

The last few decades have made it clear that studying changes in land use and land cover is crucial to understanding how the ecosystem is changing globally. Recent decades have seen a rapid transformation of the LULC dynamics. Both natural and human forces have contributed to this change in the LULC pattern. The term Land Use and Land Cover (LULC) refers to the ways in which land is used for agriculture, conservation, development, recreation, wildlife habitats, urban areas, or any other activity, as well as the results of human-environment interactions in a given area that are impacted by socioeconomic dynamics and climate change processes [1,2,3]. Therefore, one of the most effective ways to manage and comprehend the landscape modification is through quantitative analysis of LULC change dynamics. Identification of LULCs has become an essential component of sustainability research and is critical for assessing local, regional, and global environmental change [4,5]. Multiple forces acting at the local, regional, and global levels are responsible for the changing land use in a dynamic way. There are numerous factors that could contribute to LULC changes, including urbanisation, climate change, population growth, industrialization, and policy considerations [6,7,8]. There have been a lot of reasons for the land use land cover changes including population growth, climate change, urbanisation, industrial growth, deforestation etc. Population growth has been one of the major reasons for land use land cover changes as it affects every other aspect in the environment directly or indirectly [9]. Landuse classification is important because it provides data that may be used as input for modelling, particularly environmental modelling (e.g., models that deal with policy formulation and climate change [10]. There has been a sudden increase in the population from last the last decade. This in turn has affected the social as well as the economic balance of the society. Due to the population growth, there has been a dramatic increase in the food supply, which has caused the need for more built-up and agricultural land. The overall dynamics of population and quality of life in the district of Kanyakumari's land use and land cover changes were observed using the adaptive coherence classification technique [11]. Nearly every sector has been affected by population growth. When the population of an area is increased, there is an increase demand on the production and the land resources are scarcer, hence there is a need to farm intensively which in turn leads to land degradation. Sudden increase in change of demands cannot be completed in a very short period of time therefore problems start to occur in the supply of food as well as other resources. The land use land cover changes in the middle mountain regions of Chandragiri, Kathmandu by using a geographic

information system and remote sensing examined changes in land use and cover between 1996 and 2017 [12] (Joshi et al., 2021). The land use land cover change map of the Lower Mekong Basin's was created using layers of existing land use land cover geographic information system data for the years 1997 and 2010 [13] (Spruce et al., 2020). The satellite photos for supervised categorization of Land Use and Land Cover was taken during the months of March and November in 2007 [14]. The main objective of this study is to investigate the dynamics of LULC changes that occurred in the Sonipat region between 2017 and 2021 using remote sensing and GIS. For this study, satellite images for the month of October 2021 were used for LULC change detection.

2. Study Area

The study area, Sonipat is a district in the state Haryana in India, as shown in figure 1. It is often referred to as Haryana's Golden City. The total area of this district is nearly about 2,122 Kilometer squares. Out of this 82 kilometre squares area is urban whereas 2,040 kilometer square area is rural. The Yamuna River comes along the eastern boundary of the study area and 28.98^0 north and 77.02^0 east are its coordinates. As per 2021 census the total population of the district was 1,653,001[15]. Due to the rapid spread of urbanisation, the district's population is growing continuously. It shares its border with the national capital Delhi on the south and comes under the NCR (national Capital Region). It also shares boundary with Panipat district in the North, Rohtak in the west and Uttar Pradesh state in the east. It is located on the Grand Trunk Road, the Delhi Western Peripheral Expressway, and the Eastern Peripheral Expressway (NE II) (NH 44).

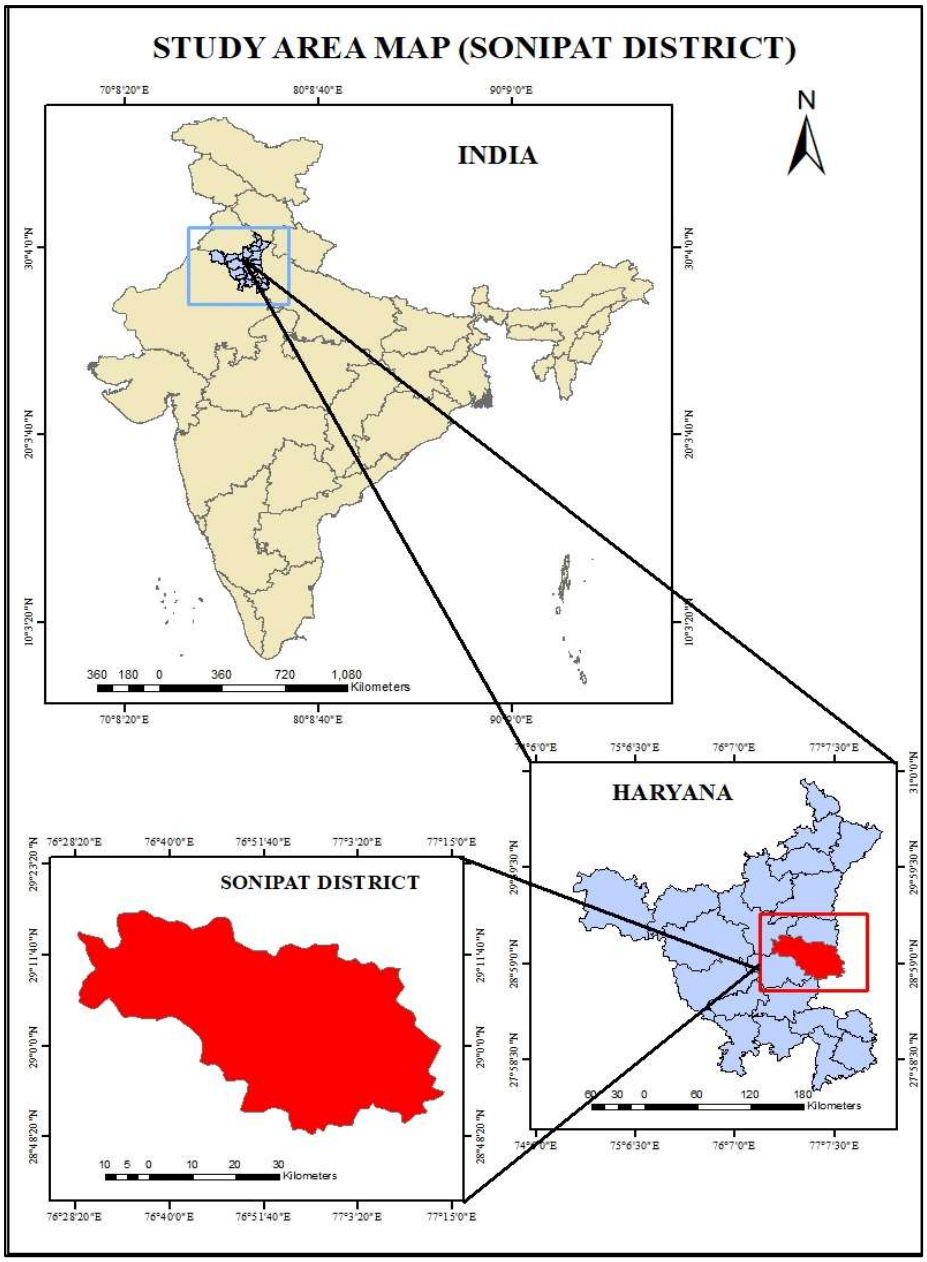

Figure 1. Study Area Map

3. Materials and Methodology

Research methodology forms an important aspect of conducting a scientific study. The materials used and the methods followed for the research is briefly discussed in this study as shown in figure 2, while bearing in mind the goals of the current study.

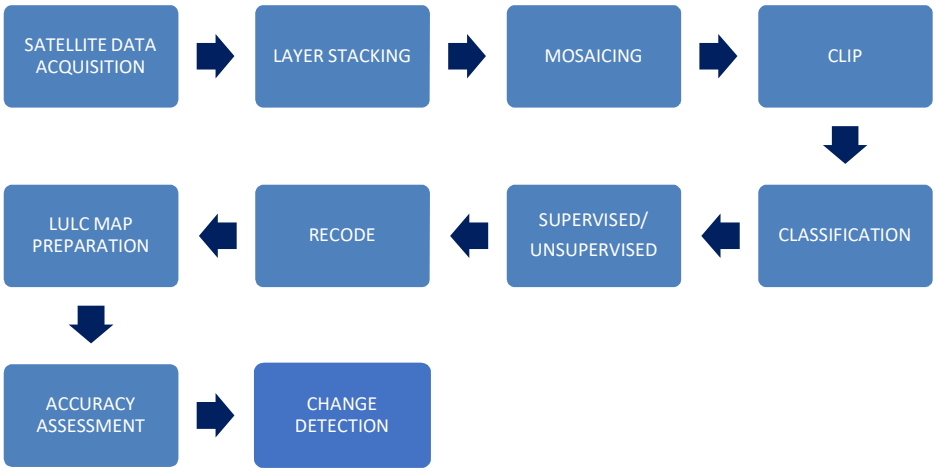

Figure 2. Methodology Flow Chart

3.1. Datasets Used

3.1.1 Primary Data

Satellite data: Sentinel-2 Satellite data (2019) having spatial resolution of 10 m was used for mapping LULC. It was accessed from the USGS earth explorer portal. Google Earth Application was used to take prints of different locations at different intervals of time.

Software's Used: ERDAS IMAGINE 2014 was used for pre-processing of satellite data and LULC mapping. All the steps regarding preparation of satellite data to preparation of maps were done using this software solely.

3.1.2 Secondary Data

The supporting data was collected in the form of published reports. The satellite images were collected from the Google earth website for the different years. The data pertains to population, net migration rate, death and birth rate were downloaded from the Govt. of India census sites [16]).

3.1.3 Satellite Data Downloading

The images were downloaded for the study area from the USGS earth explorer portal for the month of October from 2017 to 2021 which is a time period of five years. Sentinel-2 data was used for mapping LULC with a resolution of 10m.

3.1.4 Software

ERDAS IMAGINE 2014 software was used for the study. All the steps such as layer stacking, mosaicing and classification etc were done using this software.

3.2 Layer Stacking

The several bands obtained as a .zip file are composited to form a single image one after another; this process is known as layer stack. The data obtained from Sentinel-2 sensor comprised of 12 bands however, 3 bands (Red, Green, Blue) were stacked to form the imagery as it fulfils our requirement for land use classification. After the process of layer stacking of different bands, FCC image was

obtained and exported in TIFF format. The steps followed in this process were: ERDAS IMAGINE 2014 > Raster > Spectral > Layer Stack followed by addition of different bands in sequence.

3.3. Mosaicing

Mosaicing is used to assemble several overlapping images in order to constitute the global frame. One image created by merging several individual images or photographs of adjacent areas. The steps followed in this process were: ERDAS IMAGINE 2014 > Raster > Mosaic> Mosaic Pro.

3.4. Create AOI

The Clip Tool cuts out an input layer to a defined feature boundary. The district boundary shape file was downloaded and with the help of it, clipping is done.

3.5. Classification

There are two different types of classifications which are done for preparing LULC maps. The Supervised classification and the other one is unsupervised classification. The Supervised classification is most frequently employed for the quantitative analysis of remote sensing picture data. In this the signature file is made from pre-defined, well-known classes (for instance, land-use type), which were represented by pixels inside of polygons. In Unsupervised classification Clusters, not classes, are derived from the statistical characteristics of the pixels. With unsupervised classification, pixels from a remote sensing image are automatically divided into categories based on their spectral characteristics. A statistical procedure known as "clustering" is used for classification, which divides pixels into groups based on the spectral fingerprints they share. For this study, unsupervised type of classification is done for the preparation of LULC maps.

3.6. Accuracy Assessment

Two methods were adopted for the accuracy assessment. First is by going to actual location and keeping a check on the location coordinates. Photographs were taken so as to keep a check on the coordinates of the location by keeping the location on mode in the mobile phone. Second is done by using Google earth. Online data was used for gaining the related images of a particular area where land use land change was detected.

3.7. Change Detection

In the step, the change in different classes is studied. A total of six classes were classified in the study area. These are agricultural and fallow land, settlements, bare soil, dense trees, grass and bushes and water bodies. During the study period, there occurred a changed in the area associated with a particular class. The total land associated with an area cannot be expanded or contracted in any way. The only way to expand an area is by adding more land which comes under any other nearby region. In this step, the area associated with each class was calculated using the software for each year and then the change in the land area was calculated. This change is due to the conversion of land from one class to another. The land which is associated to a particular class gets converted to another class due to different reasons. This means how much area of a particular class is converted into which other class, this variation is examined under this particular step.

4. Result and Discussion

According to the results of the land cover research, the study area was largely covered by mixed vegetation in 2017—this included agricultural land, dense trees, fallow ground, grass, and bushes. A low percentage of the area is under bare soil land. Agricultural field is concentrated in areas nearly human settlements. Areas influenced by humans appeared to be concentrated. Water bodies cover around 1470.27 hectares of the total area in the year 2017. Land use is categorised into six groups for analysis purposes:

i) Agriculture and fallow land: Ranching and cultivation activities

ii) Settlement: Presence of streets connecting buildings that are arranged in blocks

iii) Water bodies: Natural as well as artificial water bodies

iv) Grass and Bushes: Mixed vegetation other than agriculture

v) Bare soil: Land area covered by grass or other live ground covers

vi) Dense trees: Natural extension of trees

Between 2017 and 2021, there was a decrease in the trees classes which are agricultural and fallow land, grass and bushes and bare soil land. Whereas during this same period, there is an increase in land area for the other three classes which are settlements, water bodies and dense tree land.

Noteworthy is the increase in the area of Sonipat city, the largest human settlement. The growth in the settlements during the 5 year period is about 3251.7 hectares. The elaborated results can be dictated as follows for the study area during the time period 2017 to 2021 i.e. for five consecutive years. During the first study period year i.e. 2017 - 2018, there was a decrease of around 564 hectares of land area. In 2017, the total area under agriculture and fallow land was 189912 hectares which reduced to 189348 in the year 2018, as given in table 1.

Table 1. Magnitude (in Hectares) of land under different classes for different years (2017 to 2021)

Class Name	2017	2018	2019	2020	2021
Agriculture and fallow land	189912	189348	188596	188324	187030
Settlement	23399.6	24188.9	24913.3	25237.8	26651.3
Waterbodies	1470.27	1427.65	1556.97	1661.65	1555.17
Grass and Bushes	540.48	534.92	419.12	252.56	246.91
Bare Soil	472.24	331.47	381.7	249.27	240.85
Dense Trees	129.44	93.12	57.29	199.28	200.23

The above table describes the amount of land associated with the six classified in the study area. These six classes are agriculture and fallow land, settlements, water bodies, grass and bushes, bare soil and dense trees. In the year 2017 the total area under agriculture and fellow land was 189912 hectares. This area got decreased to 1870 30 hectares in the year 2021. Similarly, the total area under settlement, water bodies, grass and bushes, bare soil and dense trees in the year 2017 were 23399.6, 1470.27, 54 0.48, 47 2.24, 129.44 hectares respectively.

In the year 2018, the total and associated with agriculture and fallow land, settlement, water bodies, grass and bushes, bare soil add dense trees was 189348, 24188.9, 1427.65, 534.92, 331.47 and 93.12 hectares respectively.

In the year 2019, the total and associated with agriculture and fallow land, settlement, water bodies, grass and bushes, bare soil add dense trees was 188596, 24913.3, 1556.97, 419.12, 381.7, 57.29 hectares respectively.

In the year 2020, the total and associated with agriculture and fallow land, settlement, water bodies, grass and bushes, bare soil add dense trees was 188324, 25237.8, 1661.65, 252.56, 249.27, 199.28 hectares respectively.

In the year 2021, the total and associated with agriculture and fallow land, settlement, water bodies, grass and bushes, bare soil add dense trees was 187030, 26651.3, 1555.17, 246.91, 240.85, 200.23 hectares respectively. This table shows that in the year 2017 most of the area was occupied by settlement and agricultural and fallow land. But during the study period the agricultural land kept on decreasing whereas the settlement kept increasing. There is change in the amount of land associated with every class.

Table 2. Magnitude (in Hectares) of LULC change from 2017-2021

CLASS NAME	**2017 and 2018**	**2018 and 2019**	**2019 and 2020**	**2020 and 2021**	**2017 and 2021**
Agriculture and fallow land	-564	-752	-272	-1294	-2882
Settlement	789.3	724.4	324.5	1413.5	3251.7
Water bodies	-42.62	129.32	104.68	-106.48	84.9
Grass and Bushes	-5.56	-115.8	-166.56	-5.65	-293.57
Bare Soil	-140.77	50.23	-132.43	-8.42	-231.39
Dense Trees	-36.32	-35.83	141.99	0.95	70.79

Table 2 shows the amount of LULC change taken place over a period of 5 years in the study area. The five classes' agriculture land fallow land, settlement, water bodies, grass and bushes, bare soil and dense trees observed changes in the magnitude of the land associated with them. Each class occupied amount of land in each year which kept increasing or decreasing respectively with time. During the year 2017-18 the most change in the magnitude of land associated is in the settlement with increase of 789.3 hectares. Similarly the most affected class which showed the most amount of decrease is the agriculture and fallow land class showing 564 ha decrease. The agricultural and fallow land class showed decrement of 2882 ha from the years 2017-2021. Classes such as water bodies and dense trees also showed increment of 84.9 and 70.79 hectares respectively.

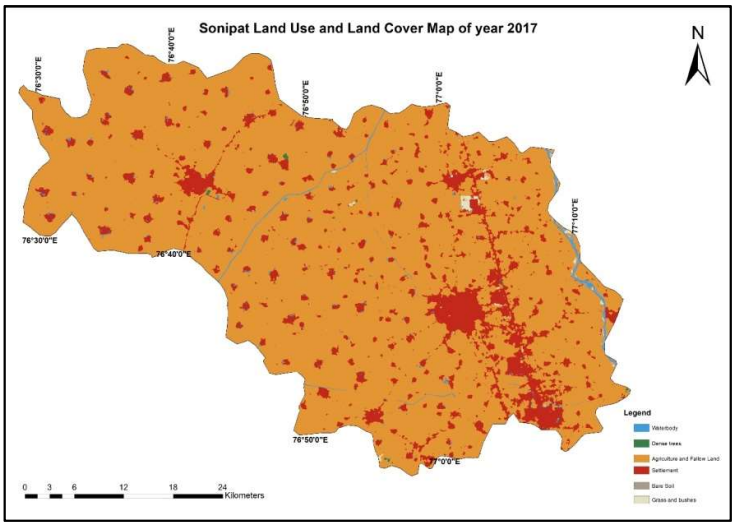

Figure 3. LULC MAP 2017

There was a continuous decrease in the agricultural and fallow land during the study period. Whereas the settlements have seen an observational increase during the study period. Figure 3 and 4 shows the land use land cover map of the Sonipat city in the year 2017 and 2021. The Settlement area was around 23399.6 hectares which increased to 24188.9 hectares and this is an increase in settlement land which is about 789.3 hectares. The change in water bodies land or area has seen both increment as well as decrement. In the year 2017, the total area under water bodies in the study area was about 1470.27 hectares which then decreased to 1427.65 hectares. This is a decrease of about 42.62 hectares and mainly due to lack of rainfall during the study period. Another class classified is grass and bushes which also seen continuous decrease in the area under it. The magnitude of the change in land use land cover of grass and bushes class is about 5.56 hectares.

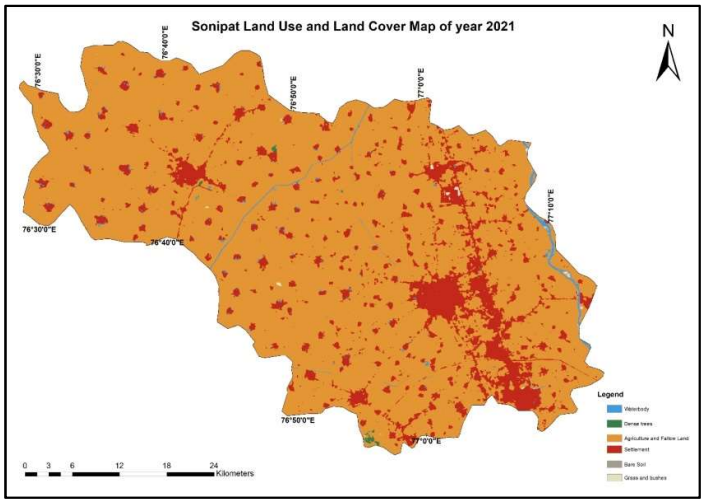

Figure 4. LULC MAP 2021

In year 2021 the total area under this category was found to be 187030 hectares and it shows a massive decrease in land associated with this class. There is a decrease of about 1294 hectares land in one year period. Another major change was detected in the settlement category in the year 2021 as a total of 26651.3 hectares of land was detected under settlement category. It has undergone a change of about 1413.5 hectares increase in the area as compared to the last year other classes also undergo drastic changes in the area during the period 2020-2021. There was a change of about 106.48 hectares of land for the water bodies its decline in the area associated with this class. Also there was a minute change in area associated with dense trees class. There is an increase of about 0.95 hectares of land associated with this class. The bare soil and also got decreased by 8.4 to hectares. Again, grass and bushes class experienced a decline of 5.65 hectares of land in the period 2020- 2021.

Figure 5. Unclassified Image of Location in the year 2017 and 2021

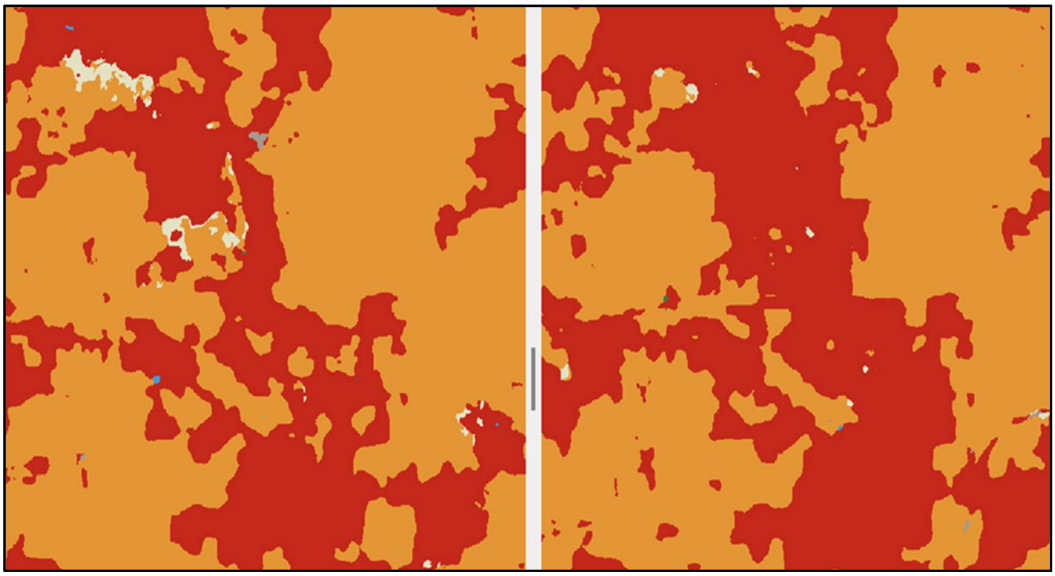

Figure 6. LULC Change detection of location in year 2017 and 2021

In the figure 5 and 6, the left side shows the image of the particular study (Location Coordinates, 28 58 59.2224 N, 77 4 36.3709 E) in 2017 where is the right side image depicts the same part of the study area in the year 2021. From this image it can be clearly certain part of the agricultural land has been converted into settlements, the agricultural land is depicted by orange colour where is the settlements are depicted by red colour it is clearly observed that a large part of the agricultural land has been converted into settlements. This means that the area under agricultural land had reduced where is under settlements had increased subsequently. This change in land use land cover would have happened due to a lot of reasons. The main reasons behind these changes are population growth and urbanization. There is a continuous increase in the population of the study area in the last few years that is during the study period. As population increases there is a continuous need for the establishment of this increased population. Hence agricultural areas good converted into settlement another land use land cover change can be detected in the same picture conversion of fallow land into settlements a certain part of the fallow land area which is depicted in white colour into the settlements area. Settlement area had increased because of the growing demand of humans.

Figure 7. Google Earth image of location in 2021

5. Conclusion

For our way of life, land is a crucial natural resource. Planning and implementing actions to preserve land cover can be aided by monitoring LULC changes. The study uses ERDAS IMAGINE 2014 software tools and Sentinel 2 satellite photos to assess and calculate changes in land use and land cover in Sonipat from 2017 to 2021. The study's findings revealed that Sentinel 2 data, with their outstanding overall quality and moderate spatial resolution, are definitely suitable for performing LULC change detection and map construction. There had been a sizable LULC change in the research region over the preceding five years, according to a field survey and the outcomes of digital picture categorization and change detection. The present study has found that there is an overall trend toward less agricultural and fallow land, grass, and shrubs, with matching fluctuation tendencies toward dense trees, water bodies, and bare soil land. The approach employed for the study can properly identify areas of settlements, water bodies, grass and bushes, bare soil, and dense trees, producing LULC change patterns over the entire Sonipat district, an area of 2,26,000 hectares. The study effectively demonstrates the use of LULC change using Remote Sensing data and change detection algorithms. The study area's agricultural and fallow lands are where the biggest changes are expected to occur from 2017 to 2021. On the society and environment of the studied area, land use change has a mild impact. Lack of agricultural and fallow land, as well as grass and bushes, was caused by the area's intense development; yet, bare soil classes' reduced land cover was a positive development. The study demonstrates that there is a lack of management and knowledge necessary for development, which may be remedied with remote sensing data that can offer chances for routine monitoring of changes in land use and land cover.

Using GIS techniques, the study's primary goal was to categorise and map the land use and land cover of the study area. The results of this study show the necessity for a thorough evaluation of human activities in the study region and the adoption of sustainable LULC practises, such as careful oversight of bare land restoration, the preservation of forest and bush land, and restricting the growth of agricultural areas. Therefore, to prevent undesirable outcomes brought on by LULC changes in the study region, sustainable land use planning and management, proper implementation of forest, soil, and water conservation measures, and provision of alternative livelihood strategies should be put in place.

REFERENCES

[1] *S. Reis, Analyzing land use/land cover changes using remote sensing and GIS in Rize, North-East Turkey, Sensors, 8 (10)* ***(2008),*** *pp. 6188-6202, 10.3390/s8106188.*

[2] *C. Prakasam, Land use and land cover change detection through remote sensing approach: a case study of Kodaikanal taluk, Tamil Nadu, Int. J. Geomatics and Geosciences, 1 (2)* ***(2010),*** *p.p 46-55.*

[3] *J.S. Rawat, M. Kumar, Monitoring land use/cover change using remote sensing and GIS techniques: a case study of Hawalbagh block, district Almora, Uttarakhand, India, Egyptian J. Remote Sens. Space Sci., 18 (1)* ***(2015)****, pp. 77-84, 10.1016/j.ejrs.2015.02.002.*

[4] *G.N. Vivekananda, R. Swathi, A.V.L.N. Sujith, Multi-temporal image analysis for LULC classification and chang detection, Eur. J. Remote Sens., 54 (sup2)* ***(2021),*** *pp. 189-199, 10.1080/22797254.2020.1771215.*

[5] *Z. Zhang, X. Wang, X. Zhao, B. Liu, L. Yi, L. Zuo, Q. Wen, F. Liu, J. Xu, S. Hu, A 2010 Update of national land use/cover database of China at 1:100000 scale using medium spatial resolution satellite images, Remote Sens. Environ., 149* ***(2014****), pp. 142-154, 10.1016/j.rse.2014.04.004.*

[6] *Hegazy, I. R., & Kaloop, M. R. Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. International Journal of Sustainable Built Environment, 4(1),* ***(2015),*** *117–124.* https://doi.org/10.1016/j.ijsbe.2015.02.005

[7] *Imbernon, J., Pattern and development of land-use changes in the Kenyan highlands since the 1950s. Agriculture, Ecosystems & Environment, 76(1),* ***(1999).*** *67–73.* https://doi.org/10.1016/S0167-8809(99)00061-4

[8] *Solaimani, K., Arekhi, M., Tamartash, R., & Miryaghobzadeh, M., Land use/cover change detection based on remote sensing data (A case study; Neka Basin). Agriculture and Biology Journal of North America, 1(6),* ***(2010),*** *1148–1157.* https://doi.org/10.5251/abjna.2010.1.6.1148.1157

[9] *Hasan, Md. M. et al. Analysis of Land Use and Land Cover Changing Patterns of Bangladesh Using Remote Sensing Technology. American Journal of Environmental Sciences 17,* ***(2021),*** *64–74.*

[10] *Disperati, L., Gonario S. and Virdis, P. , Assessment of Land-Use and LandCover Changes from 1965 to 2014 in Tam Giang-Cau Hai Lagoon, Central Vietnam. Applied Geography, 58,* ***(2015)*** *, pp.48-64.*

[11] *Lekha, S. L. S. & Kumar, S. S. Classification and Mapping of Land Use Land Cover change in Kanyakumari district with Remote Sensing and GIS techniques. International Journal of Applied Engineering Research, Volume 13, Number 1* ***(2018),*** *pp. 158-166*

[12] *Joshi, S., Rai, N., Sharma, R. & Baral, N. Land Use/Land Cover (LULC) Change in Suburb of Central Himalayas: A Study from Chandragiri, Kathmandu. Journal of Forest and Environmental Science 37,* ***(2021), pp.*** *44–51.*

[13] *Spruce, J., Bolten, J., Mohammed, I. N., Srinivasan, R. & Lakshmi, V. Mapping Land Use Land Cover Change in the Lower Mekong Basin From 1997 to 2010. Frontiers in Environmental Science 8,* ***(2020).***

[14] *Kaul H.A., Sopan I., Land Use Land Cover Classification and Change Detection Using High Resolution Temporal Satellite Data. J. Environ. 1(4),* ***(2012).*** *pp.146-152.*

[15] *census of India, 2021 reports, Ministry of Home Affairs, Government of India, New Delhi, www.censusindia.gov.in.*

[16] *census of India, 2011 reports, Ministry of Home Affairs, Government of India, New Delhi, www.censusindia.gov.in.*