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**Research Article**

# Creation of Land Resources Information System Using Geospatial Technology

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**ABSTRACT**

**Introduction**: One of the biggest and most noticeable changes in the surface of earth has been land cover from a variety of angles, including land use planning, environmental conservation, resource management and sustainable development, evaluating the LU/LC change at different levels geographical scales is essential.

**Objectives**: This study's primary objective was to examine changes in land cover and usage that occurred in Guntur Mandal, Andhra Pradesh, between 2004 to 2024.

**Methods**: In order to do this, the vegetation index like Normalized Difference Vegetation Index (NDVI) algorithm and a set of Landsat satellite images, including, two Thematic Mapper (TM) scenes and three Operational Land Imager (OLI) scenes from 2004 to 2024, were used to identify and enhance the discrimination between LU/LC categories. The image classification method like supervised classification method with the minimum distance classification algorithm was applied and generated the LU/LC maps.

**Results**: The built-up land was increased 12.74% from 2004 to 2024, the vegetation land was decreased 11.29% from 2004 to 2024, where the area occupied by vegetation is 73.89 per cent in 2004 where it is decreased to 62.599 per cent. The water bodies remained constantly (below 1 percent) in the study area.

**Conclusions**: The major change in vegetation area is in 2014 to 2019, it is about 6.95 percent area is decreased. This is mainly taken place after the declaration of Amravati declared as coming capital city of Andhra Pradesh.

**Keywords:** LU/LC; GIS; NormalizedDifference; Remote Sensing; Spatial Data.

## INTRODUCTION

The word "Land Use" describes the various types of structures made of land by human. It also refers to assessment of land within a range of natural features. Planners and decision-makers involved in land resources management require access to data on land use and land cover (Babu, et al., 2014). In order to sustain or improve living conditions and standards at the existing level, LU/LC data are required for the investigation of different aspects of environmental procedures and problems (Anderson et al., 1976). Effective tools for monitoring, charting, and managing natural resources as well as for analyzing the dynamics of land use in the area are Geographic Information Systems (GIS) and Remote Sensing (RS) approaches. Land use change is a dynamic process that has occurred across time and space on biophysical surfaces. It is crucial to understanding natural resource research. The LU/LC changes are crucial components of resource monitoring, assessment, protection, and planning. The main problems and obstacles to an area economic growth based on sustainable development are the changes of that particular environment and land use land cover. Two periodical data sets are required to identify the LU/LC changes of an area. Current and historical satellite images data can be used to monitor changes in LU/LC brought about by human and natural activity (Luong,

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1993). The availability of remote sensed data with high spatial, spectral, and temporal resolution provides an accurate LU/LC maps in less time with cheaper cost (Kachhwaha,1985). The goal of the current project is to employ remote sensing data to create multi-date maps of Guntur's urban mandal's land use and cover, and to use geographic information systems (GIS) to observe changes in these classes over time.

Assessment of LU/LC change has become a central part of different aspects of the human and natural environment and their interactions (Herold et al., 2002, Foody 2002, Diallo et al., 2009 and Ji et al. 2005). Assessment of cultivation and land changes is necessary to overcome several environmental problems at the regional level, such as un-regulated land use, loss of crop land, wetlands degradation and decrease in wildlife habitats (Anderson et al. 1976). Furthermore, changes in land use and land cover (LU/LC) are receiving more attention because they typically have a detrimental impact on the condition and preservation of ecosystems (Quintas Soriano et al., 2016). Due to the increasing demand for land resources driven by urban expansion and population growth, LU/LC plays a crucial role in disaster risk reduction (DRR) and the development of policies for addressing climate change adaptation (David et al. 2016, Shaw and Banba 2017).

Studies of LU/LC change attempt to explain (a) change occurring spots, (b) change in land type to different land cover, (c) type of land use transformation (d) the rates or magnitudes and (e) the driving force and proximate causes of the change (Loveland and Acevedo 2006). A necessary dimension of such studies is also what the future LU/LC change models would be, which are mostly derived with a simulation model. To find the driving forces which, when, where and why these changes occur to LU/LC, there are so many models, empirically fitting methods are developed. An assessment system developed to understand the pattern of historical change and predict the extend of the changes in future (Brown et al. 2000). The current study aims to quantify changes in LU/LC map for the years 2004 to 2024.

## DESCRIPTION OF STUDY AREA

The study area covers Guntur city mandal with an area of 191.08 sq km. It is located between latitude 16°14' - 16°16' N and longitude 80°19' - 80°30' E. Guntur City is the district headquarters. Mandal is well connected by rail and road transport. Guntur is an export center for crop products and is also known as a textile center. The research study area map is shown in **Figure 1**. The aim of the current study is to preparing the land use and land cover maps for assess the change in landscape LU/LC from 2004 to 2024 using temporal Landsat satellite data.

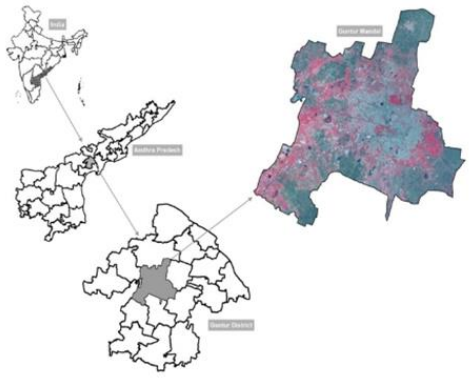

**Figure 1.** Study area - Map Illustrating Study Area Location

## OBJECTIVES

To create spatial digital database consisting of Land use/Land cover, for years 2004, 2009, 2014, 2019 and 2014 using the Satellite images and SOI toposheets

To generate attribute data and evaluation of land use pattern changes.

## METHODS

To monitor LU/LC change, at least two periods of data are needed for differentiation. The change detection of a land mostly used satellite images from two or more dates to measure changes in cultivation and land use in an area. In this study, images were downloaded from USGS portal with30mcorresponding spatial resolution. The Landsat

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satellite images quite compatible with data from previous surveys, allows the assessment of long-term regional LU/LC change (Irons et al. 2012). While selecting the images the cloud-free scenes are preferred. The satellite images like Landsat 5 satellite Thematic Mapper (TM-1992) and Landsat 8 Operational Land Imager (OLI -2015) to analyze LU/LC changes in Guntur Mandal. The level 2 images which are already pre-processed, corrected with all destructions, however, all the satellite images were recorded at sub pixel resolution in image processing in ERDAS IMAGINE 2014 software to remove inconsistencies. The satellite data is shown in **Table 1**

**Table 1.** Satellite data characteristics and acquired date

| Satellite | Type of Sensor | Resolution(m) | Range(lm) | Used Bands | Path/row | Date of Acquisition |
|---|---|---|---|---|---|---|
| Landsat 5 | Thematic Mapper | 30 | 0.45-0.90 | 1,2,3,4 | 142/049 | 21/03/2004 |
| Landsat 5 | Thematic Mapper | 30 | 0.45-0.90 | 1,2,3,4 | 142/049 | 17/03/2009 |
| Landsat 8 | Operational Land Imager | 30 | 0.43-0.88 | 1,2,3,4,5 | 142/049 | 17/03/2014 |
| Landsat 8 | Operational Land Imager | 30 | 0.43-0.88 | 1,2,3,4,5 | 142/049 | 15/03/2019 |
| Landsat 9 | Operational Land Imager | 30 | 0.43-0.88 | 1,2,3,4,5 | 142/049 | 17/02/2024 |

## LU/LC Classification

Land use land cover information is acquired from multi band raster images using image processing software, through the image classification and interpretation process (Li et al., 2014). Image classification (supervised or unsupervised) is an algorithm which is designed to automatically classify the pixels in a common reflectance area into a certain land cover type (Tarantino et al., 2015). In the image classification like supervised classification a user centered approach is adopted in which schools are chosen as the benchmark for classification (Campbell 1996). In supervised classification many approaches are available to implement and justify the classification, such as parallelogram classification, minimum distance classification, K-nearest neighbor, etc. (Zhu et al. 2006). In this study, classification method like maximum likelihood classification (Platt and Goetz 2004) was used for LU/LC classification in image analysis software like ERDAS IMAGINE (2014) software. The variance and covariance of spectral patterns were quantified by maximum likelihood algorithm and classes are classified with vast probability with in pixel association (Shalaby and Tateishi 2007). Anderson et al identified a total of nine LU/LC classes like agriculture, wetlands, urban, crops, forests, plantations, pastures, water, and shrubland in light of the proposed system. (1976) The four main LU/LC classes—vegetation, built-up, waterbodies, and barren/rocky land—were identified and adopted, with minor adjustments, to fit the study area.. References was made with Google Earth and confirm the unclear points during the ground visit and collected the control points on site to refine the land use and land cover classification. Finally, multi-temporal (2004 to 2024) raster-based layers were generated and their respective statistics were analyzed to assess LU/LC change.

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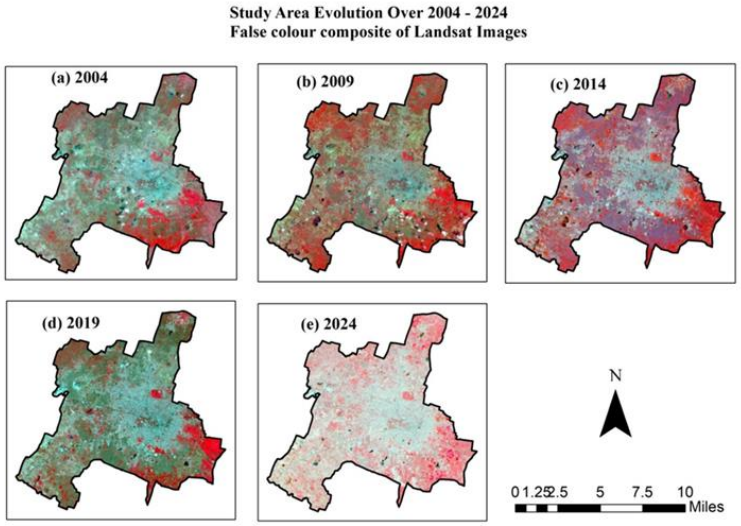


**Figure 2**. False color composite of study area for 2004, 2009, 2014, 2019 and 2024

## Accuracy Statement

There may be errors in the classification of LU/LC, therefore, the accuracy assessment must be tested using the reliable statistical analysis tools before generating the output (maps). Therefore, land use and land cover maps were generally followed by an accuracy assessment method, which show a detail of the sampling plan (including stratification information and sample size which is necessary), an error matrix and the area or area ratio of each class. According to the map and accuracy assessment, the report shows the descriptive measures as user and producer accuracy (Olofsson et al., 2013). The accuracy is often used to measure the "correctness" of the obtained map (classification), which is evaluated by constructing an error matrix (Foody 2002). Creating an error matrix allows for the calculation of various accuracy evaluation metrics, including overall accuracy, omission error, commission error, and the kappa coefficient (Lu and Weng 2007). The kappa (k) statistic developed by Cohen (1960) is a reliable and commonly employed statistical measure to assess the agreement between categorical variables.

## Land use and Land Cover change Detection

Post classification process include the comparison of bi-temporal maps of LU/LC for different years, to carry out the study of change detection in the Land use. This method is most commonly used to study the change detection (Jensen, J.R. 1996) by many studies such as (Manandhar, R., 2010, Yuan. F., 2008). The cross-tabulation matrix was created to show the changes in LU/LC from 2004 to 2009, 2014, 2019, and 2024. This transitional matrix shows the persistent relationships between LU/LC classes from the beginning time (t1) to a later time (t2) through diagonal values in each matrix. The remaining diagonal entries show the transitions of land use and land cover classes from one class to another. An unique process of land use and land cover change is a random transition which include the permanent change in classes like vegetation land to built-up land which is stable or a process of change in class due to the season like agricultural land which show in seasonal variations and water logged areas which show in monsoon season. The identification of a class as having a consistent, enduring, or regular pattern of change is considered a structured shift. It is determined that the process is random if there is no difference between the expected and observed values.

# RESULTS

## Land use and Land Cover classification

In this study the spatio-temporal patterns of LU/LC classes for 2004, 2009, 2014, 2019 and 2024 obtained from the Landsat images using the maximum likelihood classification in ERDAS 2014, these images are shown in **Figure 3. The Table 2** is showing the temporal changes in land use and land cover classes from the year 2004 to 2024. The results are shown as, the Vegetation was the main occupied land use and land cover category in the study area. In the

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year 2004, vegetation is 73.90 percent of the total area followed by built up land 20.90 percent, bare/rocky land 4.62 and water bodies occupied below 1 (0.59) percent respectively. There have been distinct changes in LU/LC in 20 years of period in the study area, these changes are mainly increase in the built-up area and decrease in the vegetation and barren/rocky land classes. The water bodies remained constantly below 1 percent of the study area. Water bodies shown some variation due to the water-logged area where the barren land conversion occurred.

**Table 2.** Distribution of Land use (LU/LC) for Guntur

| LU/LC Class Name | Area 2004 | | Area 2009 | | Area 2014 | | Area 2019 | | Area 2024 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hectare | % | Hectare | % | Hectare | % | Hectare | % | Hectare | % |
| Barren/Rocky Land | 882.81 | 4.62 | 802.01 | 4.20 | 724.79 | 3.79 | 625.3 | 3.27 | 585.16 | 3.062 |
| Built up Land | 3994.29 | 20.90 | 4504.05 | 23.57 | 4597.41 | 24.06 | 6054.13 | 31.68 | 6428.36 | 33.642 |
| Vegetation | 14119.02 | 73.89 | 13700.16 | 71.70 | 13597.34 | 71.16 | 12268.81 | 64.21 | 11961.42 | 62.599 |
| Water Bodies | 112.77 | 0.59 | 102.67 | 0.54 | 189.35 | 0.99 | 160.65 | 0.84 | 133.41 | 0.698 |
| Total | 19108.89 | 100 | 19108.9 | 100 | 19108.9 | 100 | 19108.89 | 100 | 19108 | 100 |

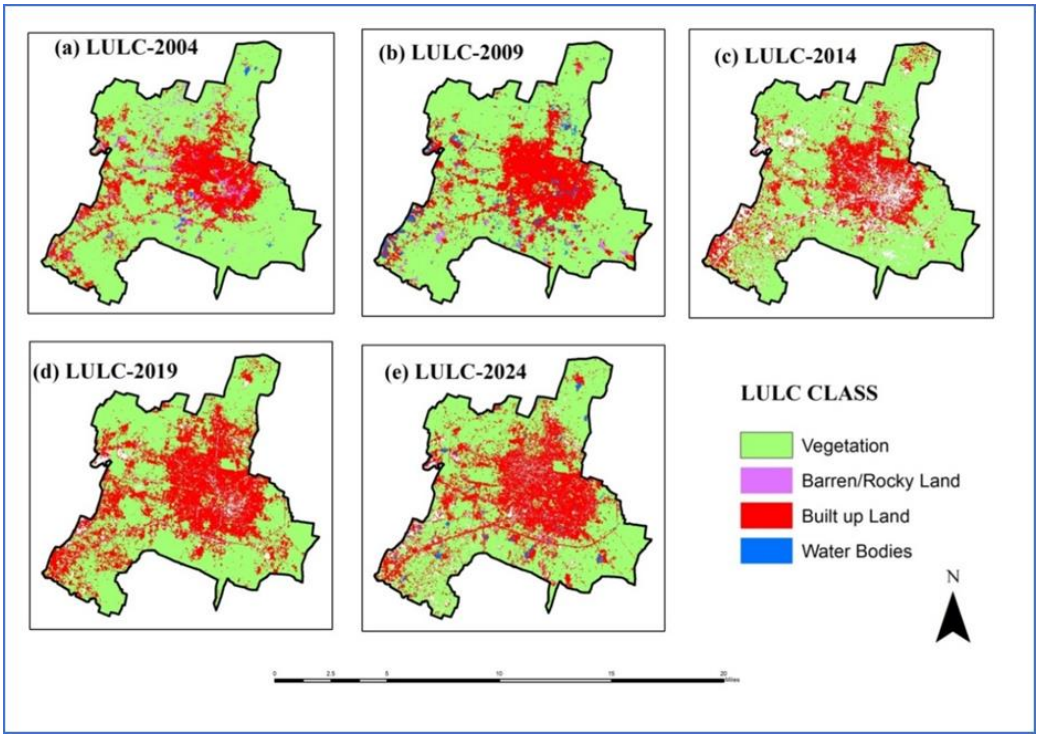


**Figure 3.** LU/LC maps for Guntur (a) 2004, (b) 2009 and (c) 2014 (d) 2019 (e) 2024.

The built-up land was increased 12.74% from 2004 to 2024, where it is observed from 2004 to 2009 the built-up area is increased by 2.67 percent, between 2009 and 2014 it is only 0.49. Where the major development in the urban area is shown in between 2014 to 2019 about 7.62 percent (approx. 1500 hectare) land was increased in this period. In 2019 to 2024 it is shown 1.958 per cent of increase in built up land. The vegetation land was decreased 11.29%

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from 2004 to 2024, where the area occupied by vegetation is 73.89 per cent in 2004 where it is decreased to 62.599 per cent. It is observed the major vegetation area loss is in 2014 to 2019, it is about 6.95 percent area is decreased. Where 2.19 percent decrease in between 2004 and 2009, and 1.6 percent decrease in between 2019 and 2024. There is a negotiable change was observed (0.54 per cent) in 2009 to 2014 year. The barren/rocky land was decrease by 1.56% from 2004 to 2024. It shows the major change was occurred in the period 2014 to 2019. Throughout the study period (2004-2024) the major LU/LC change is shown in the built-up land which increased from 3994.29 hectare to 6428.36 hectare, and vegetation land decrease from 14119.02 hectare to 11961.42 hectare.

### LU/LC Accuracy Assessment

The accuracy assessment results for the classified LU/LC maps from 2004, 2009, 2014, 2019, and 2024 are displayed in **Table 3.** The overall accuracy percentages for the images from 2004, 2009, 2014, 2019, and 2024 were 89.5, 87.5, 86, 87.5, and 87 percent. The results are near to the minimum overall accuracy which is greater than 85 per cent, and these can be used for comparisons respectively. The Kappa coefficient of the respective images 2004, 2009, 2014, 2019 and 2024 (between 0.75 and 0.79) are shown in good agreement between the reference data and classified maps.

### Change Detection in Post Classification

In **Table 4** shows the transition matrix of LU/LC was presented from the classified maps for the period (a) 2004-2009, (b) 2004-2014, (c) 2004-2019 and overall period (d) 2004-2024. In the **Table** 4 a-d, the proportion of the land use and land cover classes which were persistent and present in the diagonal entries of each matrix. During the 2004-2009 the table shows 2.57 per cent in land use is changed from one class to other, in 2009-2014the change was 0.94 per cent where as in 2014-2019 it shows 7.62 percent and in 2019-2024 table shows 1.958 percent of land use is changed from one class to other class. The rapid change was observed in the period of 2014-2019.

**Table 3.** Accuracy assessment for 2004, 2009, 2014, 2019 and 2024 classified maps

| LU/LC Class | 2004 | | 2009 | | 2014 | | 2019 | | 2024 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | User's Accuracy (%) | Producer's Accuracy (%) | User's Accuracy (%) | Producer's Accuracy (%) | User's Accuracy (%) | Producer's Accuracy (%) | User's Accuracy (%) | Producer's Accuracy (%) | User's Accuracy (%) | Producer's Accuracy (%) |
| Barren/ Rocky Land | 100 | 86 | 91 | 76 | 88 | 91 | 100 | 100 | 96 | 100 |
| Built up Land | 67 | 100 | 100 | 72 | 79 | 71 | 76 | 63 | 72 | 100 |
| Vegetation | 61 | 100 | 76 | 63 | 90 | 75 | 100 | 72 | 63 | 100 |
| Water Bodies | 100 | 100 | 100 | 100 | 90 | 100 | 91 | 76 | 100 | 86 |
| Over all Accuracy | 89.5 | | 87.5 | | 86.6 | | 87.5 | | 87 | |
| Over all Accuracy | 0.79 | | 0.76 | | 0.75 | | 0.79 | | 0.76 | |

**Table 4.** Land use and land cover (LU/LC) Transition matrix

| Tabulation Table of LU/LC changes from 2004 to 2009, 2014, 2019 and 2024 (Area in Ha) | | | | | | |
|---|---|---|---|---|---|---|
| (a) 2004-2009 | | | | | | |
| Year | 2009 | | | | | |
| 2004 | Class name | Barren / Rocky Land | Built up Land | Vegetation | Water Bodies | Total |
| | Barren / Rocky Land | 636.27 | 181.52 | 40.64 | 24.38 | 882.81 |

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|---|---|---|---|---|---|---|
| | Built up Land | 21.32 | 3731.52 | 224.39 | 17.06 | 3994.29 |
| | Vegetation | 125.41 | 564.64 | 13410.2 | 18.77 | 14119.02 |
| | Water Bodies | 19.67 | 26.37 | 24.93 | 41.8 | 112.77 |
| | Total | 802.67 | 4504.05 | 13700.16 | 102.01 | 19108.89 |

**(b) 2009 - 2014**

| **Year** | **2014** | | | | | |
|---|---|---|---|---|---|---|
| **2009** | **Class name** | **Barren / Rocky Land** | **Built up Land** | **Vegetation** | **Water Bodies** | **Total** |
| | Barren / Rocky Land | 640.36 | 89.79 | 127.48 | 25.18 | 882.81 |
| | Built up Land | 39.29 | 3802.49 | 92.21 | 60.28 | 3994.27 |
| | Vegetation | 36.97 | 690.37 | 13351.91 | 39.97 | 14119.22 |
| | Water Bodies | 8.28 | 14.76 | 25.56 | 63.99 | 112.59 |
| | Total | 724.9 | 4597.41 | 13597.16 | 189.42 | 19108.89 |

**(c) 2014 - 2019**

| **Year** | **2019** | | | | | |
|---|---|---|---|---|---|---|
| **2014** | **Class name** | **Barren / Rocky Land** | **Built up Land** | **Vegetation** | **Water Bodies** | **Total** |
| | Barren / Rocky Land | 494.75 | 197.91 | 167.74 | 22.49 | 882.89 |
| | Built up Land | 12.24 | 3696.09 | 209.84 | 75.22 | 3993.39 |
| | Vegetation | 116.04 | 2123.95 | 11858.47 | 21.36 | 14119.82 |
| | Water Bodies | 2.09 | 36.18 | 32.76 | 41.76 | 112.79 |
| | Total | 625.12 | 6054.13 | 12268.81 | 160.83 | 19108.89 |

**(c) 2019 - 2024**

| **Year** | **2024** | | | | | |
|---|---|---|---|---|---|---|
| **2019** | **Class name** | **Barren / Rocky Land** | **Built up Land** | **Vegetation** | **Water Bodies** | **Total** |
| | Barren / Rocky Land | 485.52 | 196.1 | 174.54 | 26.95 | 883.11 |
| | Built up Land | 51.43 | 3776.98 | 138.23 | 27.49 | 3994.13 |
| | Vegetation | 43.08 | 2425.49 | 11619.31 | 31.14 | 14119.02 |
| | Water Bodies | 5.13 | 29.79 | 29.34 | 48.37 | 112.63 |
| | Total | 585.16 | 6428.36 | 11961.42 | 133.95 | 19108.89 |

Overall, the change in the land class was 12.738 from 2004 to 2024. The 75 percent of the land use is remained stable, this revealed the area of interest showed to the transitions one land use and land cover class type to a different land use and land cover class type. It is observed that built up land and barren/rocky classes exhibited a swap type of changes in throughout the period, because it shows more than 10 percent change in barren/rocky land towards built up land classes. The exchange of classes might be a result of mistakes made in categorizing, either by including or excluding certain items. **Table 3** displays how the user's and producer's accuracies are linked to the error of commission and omission. The spatial resolution of Landsat TM and OLI is 30m and the effects in the determination of the change along with the difficulties in spectrum confusion also lead to some misclassification in between the barren/rocky and built-up class in the city environment.

These is a drastically change in the vegetation land class to the built-up land was there in the observed 20 year period. The 12.74 percent of the transition is observed in study period, where 11.29 percent vegetation land converted into built-up and 1.56 percent barren/rocky land. This is a systematic process of change where some other random changes also observed which are shown in **Figure 4**. The study area is shown a change of land cover from vegetation to built-up over past 20 years. The observations shown as the built-up area is increased from 20.9 percent to 33.64 percent, Initial period the changes in the study area is very less when compare to latest years (2014-2019). Decrease in vegetation and barren land, vice versa increase in built up land was observed in the particular city area. At starting of the study period (2004 to 2009) it shown 2.67 percent growth rate of built up land. The growth rate was increased in the period of 2014 -2019, which show increase of 7.62 of built up land. This development is taken place after the Andhra Pradesh state bifurcation as Andhra Pradesh and Telangana, The Andhra Pradesh capital city was declared to be Amravati near to Guntur, there it took a improved administration to ensure a plan for the sustainable development of urban areas. The transitional matrix analysis from 2004 and 2024 is classified maps shown in **Table 4** has revealed the two-way changes in systematic process, that the built-up land gains, vegetation, and barren/rocky land are losses the land. Water bodies are shown difference for one period to another period, but these are shown less than 1 percent of the area where the change is only 0.3 to 0.4 variation. This is because of the land development area water logged areas are shown as water bodies in 2014 and 2019 images. This was identified by observing in the Google Earth history images.

## DISCUSSION

In this study Landsat images are used with 30 m resolution, the changes below the pixel size are not captured in this study. The high-resolution data gives more detail information in change detection studies with high accuracy. This study gives the details of LU/LC classification changes in Guntur mandal from 2004 to 2024. It is observed by an increase settlement land and decline of crop and barren/rocky land area. In this study it is observed that initial period 2004-2014 there is a slow expansion of the urban area, where in 2014-2019 it is shown drastically change in the built-up land increase by 7.62 per cent, decline in vegetation (6.95 per cent), barren/rocky land class to the built-up class. This is clearly explaining the existence of the management of urban growth in the city. The observations show the built-up land increase due to the urban growth and expansion of the city to reach the priority to meet the capital city Andhra Pradesh (Amravati) which is near to Guntur. Regarding the observation of vegetation and barren/rocky land loss, some innovative policy measures identify and apply to this study area, where to protect the agricultural lands. There is a need of enhance cooperation to local residents and farmers to conserve the agricultural lands and allow to regeneration on barren lands within the city boundary.

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