

An Appraisal of Land Use/Land Cover Change Scenario of Tummalapalle, Cuddapah Region, India—A Remote Sensing and GIS Perspective

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How to cite this paper: Sreedhar, Y., Nagaraju, A. and Krishna, G.M. (2016) An Appraisal of Land Use/Land Cover Change Scenario of Tummalapalle, Cuddapah Region, India—A Remote Sensing and GIS Perspective. *Advances in Remote Sensing*, 5, 232-245.

<http://dx.doi.org/10.4236/ars.2016.54019>

Received: August 30, 2016

Accepted: November 13, 2016

Published: November 16, 2016

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Abstract

The study was aimed at appraising the changing land use/land cover scenario of Tummalapalle region in Cuddapah district of Andhra Pradesh using Remote sensing data and GIS technology. The region is considered as it has rich uranium reserves and is experiencing a remarkable expansion in recent times. The land use/land cover change analysis was carried out using IRS P6 LISS-III and LANDSAT-8 OLI multi-temporal data pertaining to the years 2006 and 2016. The image classification resulted in five major land use/land cover classes namely built-up, agricultural, forest, wasteland and water bodies. The study noticed that the areas under built-up and agricultural classes are found increased from 0.94 km² (0.84%) to 2.75 km² (2.44%) and 61.68 km² (54.84%) to 63.91 km² (56.82%), respectively during 2006-2016. Area under forest, wasteland and water bodies are found decreased considerably from 3.09 km² (2.75%) to 0.86 km² (0.76%), 43.71 km² (38.56%) to 42.60 km² (37.88%) and 3.05 km² (2.71%) to 2.35 km² (2.09%), respectively. The study recommends development of industrial based economy by optimally utilizing the existing land resource (scrub and wasteland classes) and simultaneously extending the agricultural practices to other possible areas to make them more productive.

Keywords

Remote Sensing and GIS, Image Classification, Land Use/Land Cover, Tummalapalle

1. Introduction

The land use/land cover pattern of any region is an outcome of various physical, cultural factors and their utilization by man in time and space. In general, the term “land use” refers to the human activity or economical functions associated with a specific

geography. Lillesand and Kiefer [1] described the land cover as a type of natural features present on the surface of the earth. It is widely recognized that study of land use/land cover change (LU/LC) phenomena at local, regional, and global levels is crucial for understanding the negative impacts on environment, which include impact on climate, water resource, soil, ecosystem, human health, safety etc. [2]-[13]. Therefore, the proper understanding of the influence of the various human induced land use practices with regard to the environmental change essentials as it helps to simulate the changes [14]. The knowledge is also essential for deriving an appropriate developmental plan which also addresses the impeding issues like uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands and loss of natural habitats etc. On the other hand, in order to use the land resource optimally, it is vital to have the information on existing land use/land cover as well as the capability to monitor the dynamics of land use resulting out of changing demands of increasing population [15]-[20]. The underlying causes are complex as they originate from a highly diversified variables such as social, political, economic, demographic, technological, cultural, and biophysical which evolve from human and environment interactions and are structural (or systemic) in nature [21] [22] [23].

Remote sensing technology is considered most effective as it provides timely and authentic information about the spatial distribution of land use/land cover, while Geographical information System (GIS) provides a flexible digital environment for collecting, storing, visualising and analyzing the spatial data [24]. Remote sensing as a vital tool helps for rapid assessment and monitoring of natural resource. When combined with GIS, it makes it possible to map land use/cover phenomena in detailed for further planning, development and decision making, which is essential for meeting the increasing demands and welfare of ever growing population [25] [26] [27] [28].

The rich uranium reserves and mining activity of Tummalapalle experience a remarkable expansion in recent times. Hence, an attempt is made to analyze the existing land use/land cover pattern, temporal dynamics and its impact on the environment of the region.

2. Study Area

Tummalapalle is located in Vemula Mandal of Cuddapah district of Andhra Pradesh. It is situated between the Northern latitudes of 14°16'30" to 14°24'0" and Eastern longitudes of 78°13'30" to 78°22'30" with an area of 112.48 km² (Figure 1). The entire area is covered by Survey of India 1:50,000 scale topographic map numbered 57J/7. Geologically the area is characterized by Papaghni and Chitravati group of rocks belongs to Cuddapah Super Group. The radioactive minerals identified in the ore zone are pitchblende, coffinite, U-Ti complex [29] [30]. The climate of the region is categorised as semi-arid, experiences a minimum temperature of 25°C during winter (December-January) and a maximum of 32°C to 43°C during summer (April-May). The average rainfall is of the order of 700 - 760 mm/year. June to September is the rainy month which receives a maximum due to South-West monsoon. The area also receives rainfall

due to North-East monsoon during November-December.

3. Materials and Methods

3.1 Data Used

Multi-temporal image acquired by LISS-III sensor of IRS-P6, ResourceSat-1 of 23.5 m resolution and LANDSAT-8's Operational Land Imager sensor data of 30 m resolution was used for the study. The details of satellites, sensors and spatial resolutions are mentioned in **Table 1**.

3.2 Methodology

The process of geodata creation and analysis involves various digital image processing techniques such as, data preparation, georeferencing, image enhancement, classification, data interpretation, delineation etc. Description of the methodology adopted for the study is provided in the following sections.

- A set of multi-temporal satellite images were collected and processed to show the aerial extent of seasonal crop mapping such as Rabi, Kharif and Zaid from 2006 up to 2016.
- Topographic map with number 57 J/7 of 1:50,000 scale is used as the base reference layer for field verifications as well as for georeferencing of the satellite image.
- Ground truth data was collected for pre-determined locations carefully determined

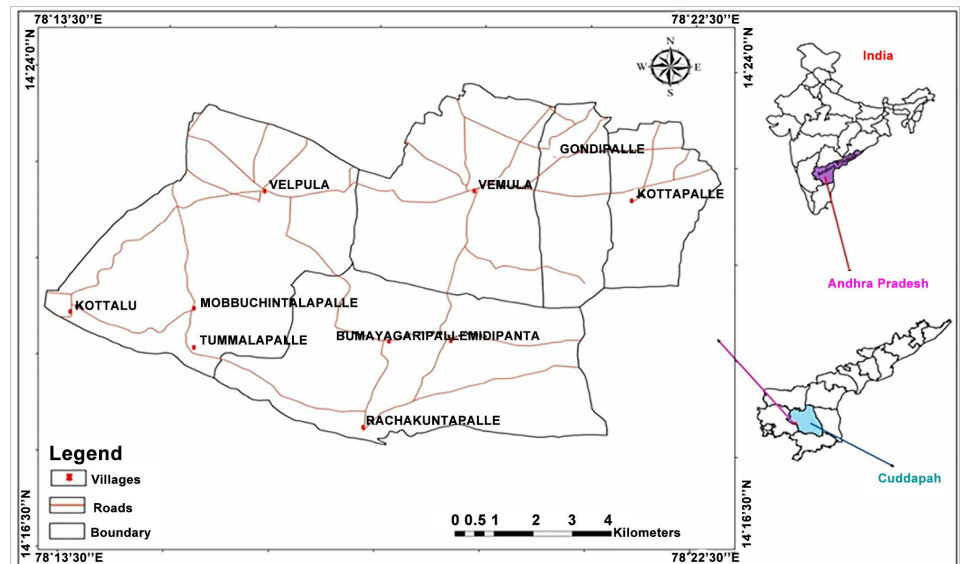


Figure 1. Location map of the study area.

Table 1. Details of the satellite images.

S. No.	Date of acquisition	Path-row, scanner, data type	Spatial resolution (m)
1	15-May-2006	100-63, IRS-P6-LISS III, Multi-spectral	23.5
2	30-Apr-2016	143-50, LANDSAT-8 OLI, Multi-spectral	30.0

from the sample grid generated for the study. The ground truth data was used to determine the authenticity of the image classification results obtained statistically.

- The images data was georeferenced using WGS84 geographical projection system. Standard radiometric and spectral enhancement techniques (cubic convolution) are applied to enhance the interpretability of the image.
- A three level classification schema recommended by NRSC, Govt. of India was adopted for the data classification at different levels. The schema aggregates various land use/land cover features into broad categories such as, Built-up, Transportation, Water bodies, Agricultural and Natural.
- Creation of digital database pertaining to the land use/land cover phenomena through online digitization process involves identification and delineation of feature class as polygon geometry through onscreen digitization using different graphical symbols and color patterns. The follow-up GIS process involves integration of land use/ land cover phenomena into basic topographic layers.
- Multi-temporal land use/land cover maps were generated using the data created using the visual interpretation and onscreen digitization techniques principally based on the image properties like shape, size, pattern, association, tone and textural variations.
- Post field verification was conducted to verify the certainty of the classification results, by establishing the relationship between image elements and tentatively identified land use/land cover categories through visual interpretation.

Land use/land cover change analysis was performed to identify the scale and magnitude of changes occurred in the study area. The results were incorporated into accuracy matrix which helps validating the percent accuracy of the results obtained. The methodology flow implemented for the study is represented schematically as a flow chart (Figure 2).

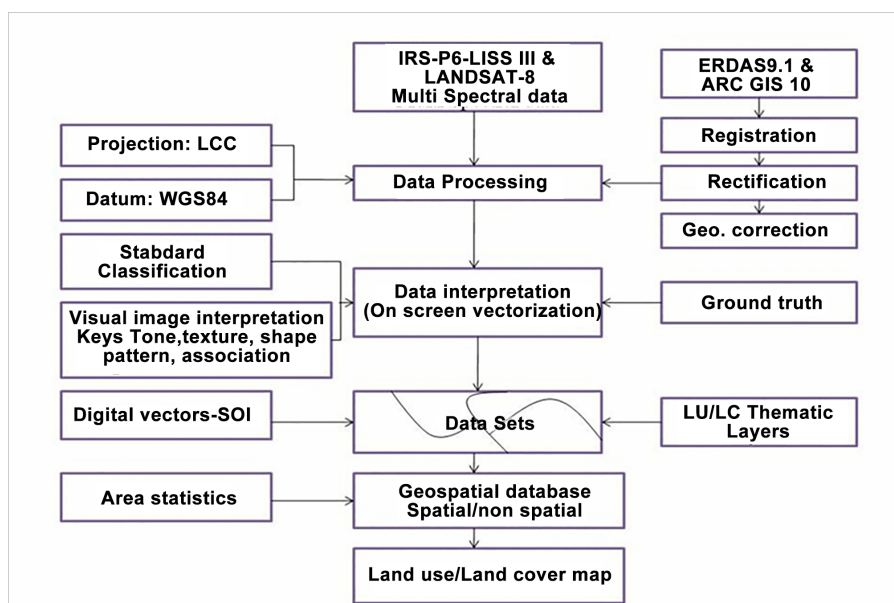


Figure 2. Schematic representation of the process flow of land use/land cover change analysis.

3.3. Land Use/Land Cover Classification

Georeferenced and rectified image were classified according to the schema specified by NRSC, 2006 [31]. Various land use/land cover categories have been enlisted in a hierarchical form of 3 levels. The first level contains broad land use/land cover category such as built-up land, agricultural land, plantation, forest, water bodies and waste lands (un-utilized land) which can be delineated using a satellite image of coarser resolution on 1:50,000 scale with minimal assistance from supplemental information. Such information is useful for general planning purposes at regional level. Land use/land cover categories in level-II and level-III will further breakdown to deeper levels in terms of the feature details, which is only possible using high resolution satellite imagery at map scales 1:10,000 and 1:5000 or less, respectively. With the support of ground truth information, visual interpretation techniques have been used to classify the land use/land cover phenomena which take into consideration various image properties such as, size, shape, color, tone, texture, association and pattern.

4. Results

The various land use/land cover categories identified, delineated and mapped (**Figure 3**) through image classification techniques are enlisted and presented along with their areas and percentages in **Table 2**. The broad categories thus mapped such as built-up, agricultural, forest, water bodies and wastelands are discussed in detailed in the following sections.

The review of classified Landsat-8 image of 2016 scenario highlights that majority of the area (54.8%) is still under agricultural land which include kharif (26.44 km²), rabi (14.11 km²), double crop (1.55 km²) and current fallow (19.53 km²) followed by scrub land (36.3%) which include both dense (27.63 km²) and open (13.19 km²).

4.1. Built-Up (Rural)

Interpretation of satellite images reveals island like areas of smaller size having population less than 5000, mainly associated with non-commercial and agricultural activities and with allied classes are identified as built up (rural) category. All the built up land increases gradually towards mining site indicates that there is a significant expansion in the mining industry and it amplifies its development during period of study. The population of the study area includes the inhabitants of settlements with a high proportion and their additional demands of daily commuters and workers of the mining sector encompasses economic success and human development. These underpinned developments might change rapidly in the future. Proper evaluation and consideration of the growth rate and its implication on environment should be assessed more precisely for the sustainable development of the study area.

Most of these built-up areas are the combination of residential, commercial, transportation (roads) etc. classes and meant for the habitation of the population [32] [33]. These areas are appeared in dark bluish-green tone in the core and bluish in the periphery. The size of these areas are found to vary between small to big with irregular and

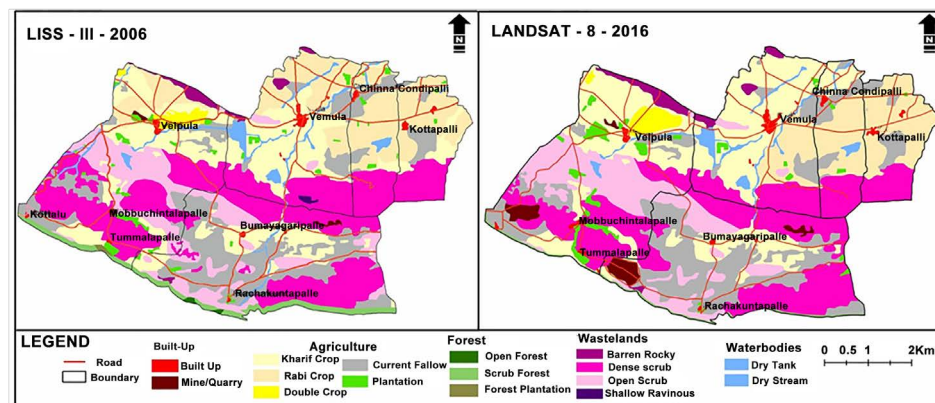


Figure 3. The land use/land cover categories mapped in the study area in 2006 and 2016.

Table 2. Different land use/land cover classes, their area and percentage distribution.

LU/LC Category	2006		2016		Change 2006-16	
	Area (km ²)	% to TGA	Area (km ²)	% to TGA	Area (km ²)	% to TGA
Built Up	0.73	0.65	0.95	0.84	0.22	0.19
Mine/Quarry	0.21	0.19	1.8	1.60	1.59	1.41
Kharif Crop	22.85	20.31	26.44	23.51	3.59	3.20
Rabi Crop	17.65	15.69	14.11	12.55	-3.54	-3.14
Double Crop	1.09	0.97	1.55	1.38	0.46	0.41
Current Fallow	18.43	16.38	19.53	17.36	1.1	0.98
Plantation	1.67	1.49	2.29	2.04	0.62	0.55
Open Forest	0.13	0.12	0.00	0.00	-0.13	-0.12
Scrub Forest	2.86	2.54	0.86	0.76	-2.00	-1.78
Forest Plantation	0.10	0.09	0.00	0.00	-0.1	-0.09
Barren Rocky	1.15	1.02	1.78	1.58	0.63	0.56
Dense Scrub	30.53	27.14	27.63	24.57	-2.9	-2.57
Open scrub	11.89	10.57	13.19	11.73	1.3	1.16
Shallow Ravenous	0.14	0.13	0.00	0.00	-0.14	-0.13
Dry Tank	1.16	1.03	1.32	1.17	0.16	0.14
Dry Stream	1.89	1.68	1.03	0.92	-0.86	-0.76
Total	112.48	100	112.48	100		

% of TGA = Percentage of Total Geographical Area.

discontinuous pattern. Change analysis revealed that the area under built-up (rural) is increased from 0.94 km² (0.84%) to 2.75 km² (2.44%) indicating an overall increase of 1.81 km² (1.6%) in the area.

4.2. Agricultural Land

The land use category primarily used for the production of food and fiber [34] and is the function of land utilization for agricultural productivity over a period of time. The

category includes both cultivated (single crop) and irrigated (double crop). From the image the agricultural fields are discerned with the chief indication of distinctive geometry (cadastral bounds) associated with agriculture activity and traces produced by livestock equipment. In a false color image, agricultural areas appear bright red to red in color with tessellation mostly with rectangular shape and varying size in contiguous pattern. Kharif (August-November), Rabi (January-March), zaid rabi crops (April-May) are the three cropping seasons usually found in the study area as in the places elsewhere in India. Agricultural class is found as the major category covering 61.68 km² (54.84%) in 2006 and increased to 63.91 km² (56.82%) in 2016. The extent of change is accounted as 5.77 km² which is 5.14% of the total area. Most of the agricultural land in the study area is being used for growing both kharif and rabi crops. Alternatively during the summer season it is left vacant (current fallow). Interpretation of both the images pertaining to 2006 and 2016 reveals that there is no significant change in area under the agricultural class.

4.2.1. Kharif Area

Agricultural area cultivated during monsoon season (August-November) is considered as kharif. The areas appear bright red to red color on image and prominently found with irrigation facilities. Kharif is found to be the major agricultural category with an extension of 22.85 km² (20.31%), which has been increased to 26.44 km² (23.51%) in 2016. The increase in the area *i.e.*, 3.59 km² is accounted for 3.20% of the total study area.

4.2.2. Rabi Area

Rabi season usually extends from November-March but unlike kharif the areas may be with are without irrigation source. Similar to kharif, rabi crop is also interpreted based on its bright red to red color. This is the second major agricultural land category mapped in the study area. However the extent in rabi was noticed a decrease from 17.65 km² (15.69%) in 2006 to 14.11 km² (12.55%) in 2016, which accounts for -3.54 km² (-3.14%) of the total study area.

4.2.3. Double Crop Area

Double crop areas are noticed both in kharif and rabi seasons. The areas are found with 1.09 km² (0.97%) in 2006 and increased to 1.55 km² (1.38%) in 2016. The increase in the area accounts for 0.46 km² (0.41%) of the total study area.

4.3. Current Fallow

The agricultural land which is being used for cultivation but is temporarily allowed to rest or un-cropped for one or more seasons, but not less than a year is referred to as current fallow [35]. In the image current fallow is found devoid of crops both in kharif and rabi seasons. They appeared in yellow to dark greenish blue tone with varying rectangular shapes and sizes. Current fallow is found increased from 18.43 km² (16.38%) in 2006 to 19.53 km² (17.36%) in 2016, which accounts for a change of 1.1 km² (0.98%) of the total area.

4.4. Plantation

Plantation can be described as an agricultural area with trees planted adopting certain agricultural management techniques. Plantation appear in dark-red to red tone of different sizes with regular and sharp edges indicating the presence of a fence around it. Depending on the location, they exhibit a dispersed or contiguous pattern and may depend on the lithology. Plantation is found increased from 1.67 km² (1.49%) in 2006 to 2.29 km² (2.04%) in 2016, which accounts for a change 0.62 km² (0.55%) of the total area.

4.5. Forest

Anderson [36] describes the forest as the areas bearing an association predominantly of trees and other vegetation types capable of producing timber and other forest products and exerts an influence on the climate and water regime. Forest areas are found within the notified boundaries as marked in the Survey of India toposheets. The areas are easily identified on imagery with bright red to dark red tone. Forest areas are found manifested with different sub-categories such as open forest, scrub forest, forest plantation which are explained in detail below. It is noticed that open forest has lost 0.13 km² of area during 2006-2016 which accounts for 0.12% of total area. The change in the loss of forest area is mainly due to mining activities in the region.

4.5.1. Open Forest

Open forest is a mixture of trees and scrubs where the tree species are less in nature and can be identified with pink to dark in tone in the image. Open forest is found decreased by 0.13 km² (0.12%) during 2006-2016.

4.5.2. Scrub Forest

Scrub forest is typically manifested with extensively grown scrubs. Scrub forest appeared with light red to dark brown in the image depending on the canopy cover and soil background. The size is found varying from small to big, irregular to discontinuous in shape, contiguous to non-contiguous in appearance. These areas are found on hill slopes within notified forest areas, at times closer to habitations. Area under this category is decreased from 2.86 km² (2.54%) in 2006 to 0.86 km² (0.76%) in 2016 which accounts for -2.00 km² (1.78%) of the total study area.

4.5.3. Forest Plantation

The category has tree species of forestry importance (like Teak, Sal, Eucalyptus, Casuarina, Bamboo etc.) raised and managed especially in notified forest areas. They appear in light red to red color of varying sizes mostly in contiguous pattern and at times non-contiguous. The category is decreased from 0.10 km² to 0.09% during 2006-2016, which accounts for -0.1 km² (-0.09%) of the total study area.

4.6. Wastelands

The degraded and under-utilized land could be brought under productive use with

proper soil and water management practices [37] [38]. Wastelands may result from various environmental and human factors. The various wasteland categories mapped at level II and level III in the study area are as follows.

4.6.1. Barren Rocky Areas

The barren rock exposures are especially confined to hilly terrain with down slope with rock outcrops, stony waste and fragments. Depending on the rock type, they appear greenish blue to yellowish color on image. The area under this category is increased from 1.15 km² (1.02%) in 2006 to 1.78 km² (1.58%) in 2016 which accounts for 0.63 km² (0.56%) of the total area.

4.6.2. Scrub Land

Scrub is usually confined to topographically elevated areas, on the hill slopes generally surrounded by agricultural lands [39]. Scrub is demarcated by its light yellow to brown to greenish blue color in image which may vary depending on the surface moisture. It is found with varying sizes of small to large areas having contiguous or dispersed pattern. Dense scrub is mostly identified on the hills and found decreased from 30.53 km² (27.14%) in 2006 to 27.63 km² (24.57%) in 2016 which accounts for -2.9 km² (-2.57%) of the total study area. Open scrub is found foothills surrounded by agricultural lands found increased from 11.89 km² (10.57%) in 2006 to 13.19 km² (11.73%) in 2016 which accounts for 1.3 km² (1.16%) of the total study area.

4.7. Ravenous Land

Ravenous land is the result of the action of surface runoff on unconsolidated rock/soil terrain. They appear in light yellow to bluish green in tone depending on the depth of erosion and exposure of parent material. Ravenous category is found having 0.14 km² (0.13%) in 2006 to nil in 2016 which accounts for a decrease of -0.14 km² (-0.13%) of the total study area.

4.8. Waterbodies

Waterbodies include running waterbodies (streams, rivers etc.) and lakes/tanks/reservoirs which may be natural or man-made. Waterbodies are easily identified from the image as they appear light blue to dark blue or cyan color depending on the depth of the water. Streams (dry streams) are found having an area of 1.89 km² (1.68%) in 2006 and slightly decreased to 1.03 km² (0.92%) in 2016, which accounts for -0.86 km² (0.76%) of the total study area. While lakes/tanks/reservoirs (mostly dry) are found slightly increased from 1.16 km² (1.03%) in 2006 to 1.32 km² (1.17%) in 2016, which accounts for 0.16 km² (0.14%) of the total area.

5. Discussion

The extent of the change in land use/land cover phenomena is represented using a graph (Figure 4) which indicates the change occurred in each category during 2006-2016.

It is noticed that the agricultural land is the major land use/land cover category

which include various sub-categories such as kharif (increased by 3.59 km² or 3.20%), rabi (decreased by -3.54 km² or -3.14%), double crop (increased by 0.46 km² or 0.41%), current fallow (increased by 1.1 km² or 0.98%), agriculture plantation (increased by 0.62 km² or 0.55%), followed by the next single major category *i.e.*, dense scrub (decreased by -2.9 km² or -2.57%). The other important categories are open scrub (increased by 1.3 km² or 1.16%), scrub forest (decreased by -2.00 km² or -1.78%), dry stream (decreased by -0.86 km² or -0.76%), dry tanks (increased by 0.16 km² or 0.14%), barren rocky (increased by 0.63 km² or 0.56%), built-up rural (increased by 0.22 km² or 0.19%), industrial/mine/quarry (increased by 1.59 km² or 1.41%), open forest (decreased by -0.13 km² or -0.12%), forest plantation (decreased by -0.1 km² or -0.09%), shallow ravenous (decreased by -0.14 km² or -0.13%) (Figure 5).

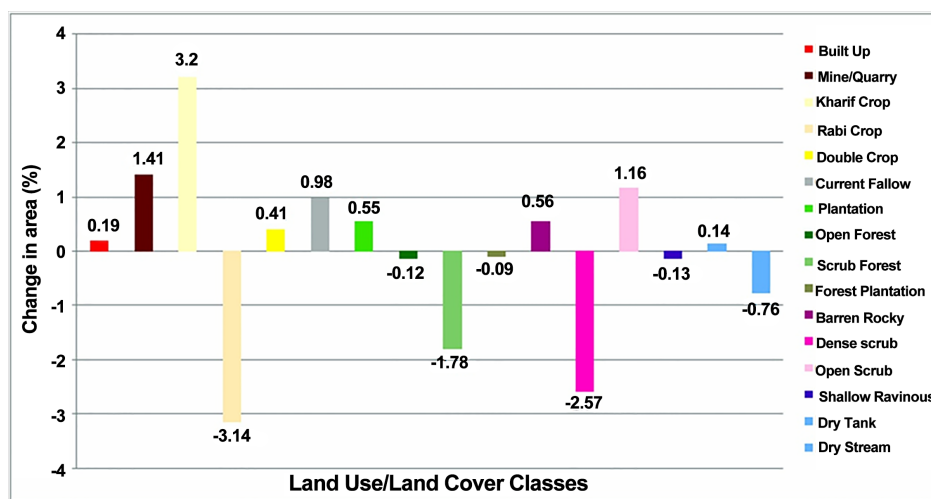


Figure 4. Graph showing the change in extent of land use/land cover categories in 2006-2016.

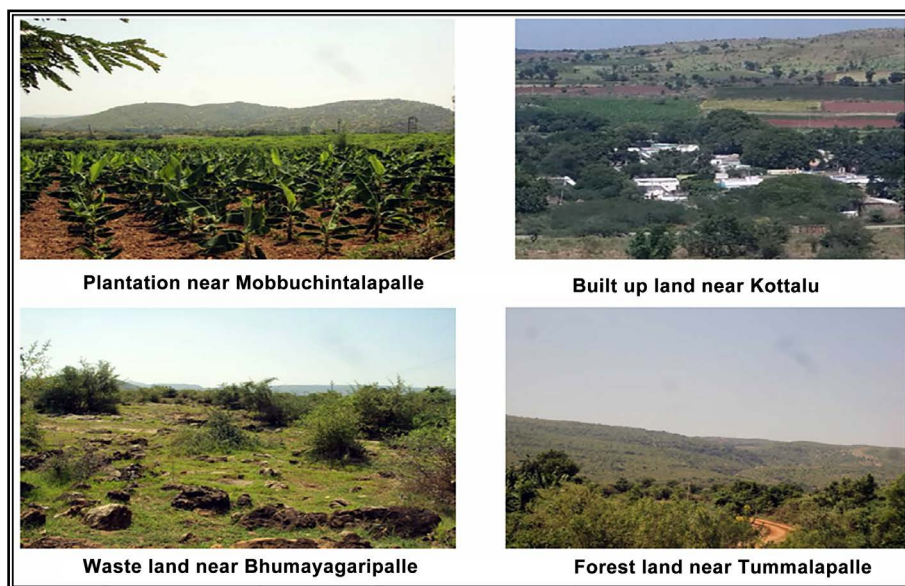


Figure 5. This figure shows the field photos of land use/land cover category.

It is noticed that there is a significant increase in area (1.41%) under mining due to the availability of uranium reserves in the study area. However, it is important to development industry based on the availability of mineral resource that would certainly benefit the local economy. The increase (0.19%) in built-up class which includes the sub-classes like, residential, commercial transportation etc. can be attributed to the growth in population as well as migration. It is noticed that the built-up class has registered an annual growth rate of 0.019% and is expected that the growth likely increase further due to rapid growth of population. This necessitates more focused approach by the local bodies for the provision of necessary infrastructure and living amenities, so that the growth would be sustainable.

6. Conclusion

The present study aimed at mapping and detecting the land use/land cover change during 2006-2016 in the Tummalapalle region by effectively employing the Remote Sensing and GIS technology. Kharif (agricultural), mining and scrub are the three major land use/land cover categories noticed a major change in terms of their increase during 2006-2016 with 3.2%, 1.41% and 1.16% respectively. On the other hand, rabi (agricultural), dense scrub and scrub forest are the land use/land cover categories witnessed a major change in terms of decrease in their extent *i.e.*, -3.14%, -2.57% and -1.78%, respectively. The study has indicated that there is a lot of scope for further development of the study area as most of the areas covered by the land use/land cover categories are un-utilized or un-productive like dense scrub, open scrub, wasteland etc. In addition to this, it is also important to bring mineral based industrial units as the location is rich of uranium and other mineral resources, which also helps in well balanced economic development along with the existing agricultural based economy.

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