Change detection analysis in LULC of the upstream Thandava reservoir using RS and GIS applications

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Abstract. Change detection is a time series process to analyze Land use/land cover (LU/LC) changes within a specific period. This analysis will help to take the necessary decisions for policymakers. In this study for this purpose, we collect the data in the form of topographical maps from Survey of India (SOI), Satellite remote sensing data from USGS (United States Geological Survey) and software like Arc GIS 10.3 and ERDAS IMAGINE 2014 were used for analyzing the data between the periods of 1995-2008, 2008-2020 and 1995-2020. The study area was classified into eight land use and land cover categories based on the most likelihood classified approach and quantifying the changes in the above mentioned period time. It was observed that the forest area has vanished and barren land was increased during 1995-2020.

Keywords: Land use Land cover, Survey of India, remote sensing, USGS, Arc GIS, ERDAS IMAGINE

1. Introduction
The earth is covered by natural resources mainly forests, hilly areas, open lands, water bodies refers land cover whereas land use refers to how people are using these resources for development, conservation, or mixed uses. As the population of a given area increase, the demand for land cover such as built-up area also increases, while other land cover classes such as bare land, vegetation, decreases as a result of the increased demand for the built-up area [1]. The impacts of Land Use Land Cover (LULC) on the sustainability of the ecosystems are becoming increasingly important issues in global changes research [2]. In most cases, LULC Classification is the result of different anthropogenic activities, i.e., cutting down trees and conversion of forest land into agricultural land or human settlement which cause disturbance of biodiversity [3]. LULC and climate are two important aspects that govern the hydrological behaviour of any region. The slight change in LULC affects the resultant energy fluxes of the region thereby altering the climate [4]. The human and livestock population, different agricultural practices, urbanization, drought prevalence, and poor land-use planning are the main drivers of LULCC. However, different places have different driving factors and consequences [5]. Natural disasters like floods, hurricanes, volcanic eruptions, earthquakes, etc. are the factors that influence forest degradation, soil erosion, and damaging of manmade constructions. Hence, LULC classification is needed for planners, resource managers, scientists, and decision-makers to effectively manage the environment as well as living conditions. For analyzing change detection between past and present land use land cover, the preliminary data like surveying data, topographical data, necessary information collected from the surroundings people and analyzing existing conditions play a vital role everywhere. But getting the required time-related data is a tough job. In this regard, satellite data plays an important role throughout the world to fulfil the needs of decision-makers. Remote sensing has an important contribution to making
and documenting the actual change in land use/land cover in regional and global scales [6]. So, the development of remote sensing plays a major role for risk analysis, early warning, monitoring, and mapping with the help of one of new software technology named as GIS (Geographical Information System). Land use and land cover classification can be done with the help of topographical maps at different scales, satellite images with different band combinations for accurate data acquisition, and analyzed with the help of field surveys and standard classification data in that region. From the output results of required time intervals, we can take preventive measures and mitigate the risk.

2. Literature review
Adel Shalaby and Ryutaro Tateishi [7] carried out supervised classification and post-classification change detection performed on the satellite images of 1987 and 2001. Based on six field visits and 1987 land cover map they had been done accuracy assessment and classified land cover classes accordingly. The major results showed vegetation degradation and waterlogging in the study area. Ashraf and Yasushi [8] focused on urban expansion in Greater Dhaka, Bangladesh and land use/cover changes between 1975 and 2003. The Supervised classification had been derived land cover results 85 to 90% using GIS techniques. The results showed that the growth of built-up areas resulted in a significant decrease in the area of water bodies, cultivated land, vegetation and wetlands. Aydoner and Maktav [9] analyzed the adverse effects of the Marmara earthquake on the land use/land cover (LULC) of Kocaeli province in Turkey using different satellite data. Damage in the urban texture and changes to the coastline had been studied through settlement suitability analysis and the results were interpreted by the information generated through satellite data before and after the earthquake. Canute et al. [10] used different software like Arc Map 10.1, ERDAS Imagine, SPSS and IDRISI Selva in their study to assess the factors influencing LULC change. The results showed in this study that the variations in annual rainfall, population density, and distance from road networks are the main factors for LULC change in this study. Christoph et al. [11] carried out the well-established Maximum Likelihood classifier and the random forest classifier were used to study LULC with a combination of x-and c-band microwave data. This study results showed a comparison between microwave and optical remote sensing images for LULC classifications. Chauhan and Nayak [12] studied land use/land cover changes and its implications on coastal systems using remote sensing and GIS. Erosion and deposition have been observed along with the declination of the forest area and agriculture area in this study. Daniel and Ayobami [13] have been assessed the changes in land use/land cover over a period of 16 years using the Maximum Likelihood classification method through GIS techniques in their study. From the results, they identified that the degraded forest has the most extensive type of land use/land cover in their study area. Khalid et al. [14] attempted analyses and monitor the LULC changes on the selected soil properties of cultivated land, fallow land and woodland. Texture, bulk density, organic matter, soil pH, electrical conductivity, sodium adsorption ratio, phosphorous, and potassium were analyzed from the collected soil samples for each of the LULC types by the laboratory tests. The results showed that Soil productivity has been declined through land degradation. Zope et al. [15] investigated the impact of land use–land cover (LULC) change and urbanization on flood during the years 1966 and 2009. The impact of LULC on flood hydrograph for different return periods was ascertained by using the HEC-GeoHMS and HEC-HMS models. The authors analyzed that the overall total flood hazard area is increased by 22.27% in this study.

3. Study Area
Thandava River (Bodderu) is the common boundary for Visakhapatnam and East Godavari districts. Thandava reservoir project was constructed across Thandava River during the years 1965-1975. The purpose of Thandava reservoir construction is to provide irrigation facilities for both Visakhapatnam and East Godavari districts. The project is completed and commenced for serving the needs of the ayacut since the year 1975 to provide irrigation facilities to an extent of 51,465 acres, out of which 32,689 acres are lying in Visakhapatnam district and 18,776 acres in East Godavari district. The ayacut is spread over in Kotauratla, Narsipatnam, and Nathavarammandals of Visakhapatnam district and Kotananduru,
Tuni and Routhulapudi mandals of East Godavari district. The reservoir is the most naturally formed reservoir due to its oval-shaped topographical configuration as it is surrounded by hills. Hence, the construction of an earth dam for a length of 201 m facilitated for the formation of a reservoir of capacity 4960 Mcft. In this study, we selected upstream of Thanadava reservoir having 349 Square Kilometers study area consisting majorly, Pakalapadu, Cheedigummala, Yarakampeta, Yerravaram, Nallanki, Gundupala, KothaYellavaram, Gulugonda, Ammapeta, Jogumpeta, Sreerampuram, Narasinguballi, Pappusettipalem, Kothapalem, Hukkumpeta, Bangarammapeta, Gummalapalem, Teegalametta, Thotaluru, Chittimpadu, Patamallampeta, Lingampeta, krishnadevipeta, Konakasingi, Ratnampeta and Agency Laxmipuram. The map of the study area location is shown in figure 1.

**STUDY AREA LOCATION MAP**

![Map of the study area](image_url)

Figure 1. Study Area – Upstream Thandava Reservoir
4. Methodology
The following points have followed in the methodology
1. Toposheets of 65K5, 65K6, 65K9, and 65K10 (scale: 1:50000, First edition) were taken and geo-rectification was done and mosaic all these top sheets.
2. Delineation of the study area from the mosaic image
3. Download satellite images from USGS
4. Delineation of the study area from geo-rectified satellite images
5. Ground truth
6. Image processing using ERDAS software
7. Supervised Classification and finalizing the Classes
8. Change detection Analysis
9. Results and Discussion
10. Conclusion

The study area was delineated from the mosaic image and ground truth was done for more accuracy. Based on ground truth accuracy, supervised classification was done individually in 1995, 2008, and 2020 geo-rectified satellite images and various land use/land cover classes were defined using ERDAS IMAGINE 2014. For accuracy purpose, study area was converted into KMZ file and used this file in GOOGLE EARTH Pro. for identification of classes. Finally, the classified results were compared between the period time of 1995-2008, 2008-2020 and 1995-2020 and the work was concluded. The information about satellite data is presented in Table 1.

Table 1. Information about Satellite data

| Sl. No. | Satellite    | Sensor     | Path /Row | Acquisition Date | Spatial Resolution | Spectral Bands |
|---------|--------------|------------|-----------|------------------|--------------------|----------------|
| 1       | Landsat-8    | OLI/TIRS   | 141/048   | 23-02-2020       | 15 meters          | B2 to B8       |
| 2       | Landsat 4-5  | TM         | 141/048   | 06-02-2008       | 30 meters          | B1 to B7       |
| 3       | Landsat 4-5  | TM         | 141/048   | 06-03-1995       | 30 meters          | B1 to B7       |

5 Results and Discussion
5.1 Results
In the supervised classification with the help of ERDAS Imagine 2014, the land use land cover categories were defined and add area field for determination of the area of each class. After that accuracy assessment process was done with already defined class values that are replaced by the given reference values and then generates the reports. The magnitude change for each class was calculated by subtracting latest year values from the previous year values and percentage change is calculated as the magnitude change is divided by the base year and this value is multiplied by 100. For calculation of Annual rate of change, the magnitude change is divided by the number of corresponding study years.

Example:
B is the latest year and A is the previous year, study period between A and B is N, now
i) Magnitude change= B-A = C
ii) % change = (C/A) X 100
iii) Annual rate of change = (C/N)

The figures 2, 3 and 4 present the LULC of upstream Thandava reservoir during 1995, 2008 and 2020.
5.2 Discussion
A total of 8 numbers of classes are commonly defined in the supervised classification of 1995, 2008 and 2020 images using ERDAS.

5.2.1 Land Use pattern of the study area in 1995, 2008 and 2020 (Table 2)
Forest class occupies 76.65% in the total study area. It is a major land occupancy when compared to the remaining classes. Barren land is 8.58% but later it was increased in the years 2008 and 2020. In 2008 the forest occupancy is decreased up to 42.4% but 9.46% of upland covers with scrub. At the same time, the vegetation vanished and most of the land up to 30.31% is converted into barren land. Agricultural land occupancy is almost the same in 1995 and 2008 that is 3% in total area. But development in the
plantation is almost double when compared to 1995. Unfortunately, agricultural activities are dropdown in the year 2020. At the same time protection of forestation is improved when compared to 2008. But plantation activities are dropdown when compared to 2008. There is no development in built-up land during the period 1995 to 2020. It is observed that nearly half of the built-up occupancy is faded in the years 1995, 2008 and 2020. Reservoir occupancy is the same in the years 2008 and 2020 and it is vast coverage when compared to 1995.

5.2.2 Relative change in Land use in the study area
Relative change in land use of study area was assessed from Tables 3, 4 and 5. The relative changes showed some irregular patterns in this study area from 1995-2020. Land-use changes from 1995-2008 showed positive changes in most of the categories. But a negative trend showed in 2008-2020 when compared to the 1995-2008 period. Barren land showed a positive change (+256.71%) in 1995-2008, whereas a negative change (-2.8%) showed in the same land use category in 2008-2020. Similarly, plantation, upland with/without scrub, reservoir classes showed a positive trend during 1995-2008 but a negative trend followed in the same classes during 2008-2020. The overall annual rate of change in the forest showed a negative trend (-342.1%) and barren land showed a positive trend (+292%) during 1995-2020. At the same time, it was observed that these two classes were highly varied and a positive annual rate of change observed in vegetation and reservoir during the same period time.

### Table 2. Land use classification of the study area from 1995-2020

| Sl. No. | Land Use Category | 1995 Area (Hectare) | 1995 % of Land | 2008 Area (Hectare) | 2008 % of Land | 2020 Area (Hectare) | 2020 % of Land |
|---------|-------------------|---------------------|----------------|---------------------|----------------|---------------------|----------------|
| 1       | Plantation        | 1576.35             | 4.51           | 3195.24             | 9.14           | 1263.58             | 3.61           |
| 2       | Upland with/without scrub | 927              | 2.65           | 3306.69             | 9.46           | 1350.62             | 3.86           |
| 3       | Forest            | 26772.6             | 76.65          | 14808.1             | 42.4           | 18220.9             | 52.17          |
| 4       | Barren Land       | 2998.62             | 8.58           | 10585.3             | 30.31          | 10291.6             | 29.47          |
| 5       | Vegetation        | 410.94              | 1.17           | 210.795             | 0.6            | 1795.81             | 5.14           |
| 6       | Built-up Land     | 848.16              | 2.42           | 485.505             | 1.39           | 301.737             | 0.86           |
| 7       | Agricultural Land | 988.02              | 2.82           | 1085.79             | 3.1            | 481.973             | 1.38           |
| 8       | Reservoir         | 399.78              | 1.14           | 1244.05             | 3.56           | 1215.25             | 3.47           |

| Total Area | 34921.47 | 34921.47 | 34921.47 |

### Table 3. Land-use change Assessment of study area on time frame data 1995-2008

| Sl. No. | Land use category | Land-use change (1995-2008) | Area (Hectare) | % change | The annual rate of change |
|---------|-------------------|-----------------------------|----------------|----------|----------------------------|
| 1       | Plantation        | (+)1618.89                  | (+)102.7       | (+)124.53 |
| 2       | Upland with/without scrub | (+)2379.69          | (+)256.71      | (+)183.1  |
| 3       | Forest            | (-)11964.5                 | (-)44.7        | (-)920.34 |
| 4       | Barren Land       | (+)7586.68                 | (+)253         | (+)583.6  |
| 5       | Vegetation        | (-)200.145                | (-)48.7        | (-)15.4   |
| 6       | Built up Land     | (-)362.655                | (-)42.8        | (-)27.9   |
| 7       | Agricultural Land | (+)97.77                  | (+)9.9         | (+)7.52   |
| 8       | Reservoir         | (+)844.27                 | (+)211.2       | (+)64.94  |
Table 4. Land-use change Assessment of study area on time frame data 2008-2020

| Sl. No. | Land use category | Land-use change (2008-2020) | Area (Hectare) | % change | The annual rate of change |
|--------|------------------|-----------------------------|----------------|----------|--------------------------|
| 1      | Plantation       | (-)1931.66                  | (-)60.45       | (-)161   |
| 2      | Upland with/without scrub | (-)1956.07                  | (-)59.15       | (-)163   |
| 3      | Forest           | (+)3412.8                   | (+)23.04       | (+)284.4 |
| 4      | Barren Land      | (-)293.7                    | (-)2.8         | (-)24.5  |
| 5      | Vegetation       | (+)1585.015                 | (+)752         | (+)132.1 |
| 6      | Built-up Land    | (-)183.768                  | (-)38          | (-)15.3  |
| 7      | Agricultural Land| (-)603.817                  | (-)55.61       | (-)50.31 |
| 8      | Reservoir        | (-)28.8                     | (-)2.31        | (-)2.4   |

Table 5. Land use change Assessment of study area on time frame data 1995-2020

| Sl. No. | Land use category | Land-use change (1995-2020) | Area (Hectare) | % change | The annual rate of change |
|---------|------------------|-----------------------------|----------------|----------|--------------------------|
| 1       | Plantation       | (-)312.77                  | (-)24.8        | (-)13    |
| 2       | Upland with/without scrub | (+)423.62                  | (+)31.4        | (+)17    |
| 3       | Forest           | (-)8551.7                  | (-)46.93       | (-)342.1 |
| 4       | Barren Land      | (+)7292.98                 | (+)71          | (+)292   |
| 5       | Vegetation       | (+)1384.87                 | (+)77.11       | (+)54    |
| 6       | Built-up Land    | (-)546.423                 | (-)181.1       | (-)22    |
| 7       | Agricultural Land| (-)506.047                 | (-)105         | (-)20.24 |
| 8       | Reservoir        | (+)815.47                  | (+)67.1        | (+)33    |

5.2.3 Overall accuracy and Kappa statistics (K^)

Kappa statistics is a measurement between users identified class data and reference data after the classification process is done. Kappa value is useful for accuracy check-in for each defined class. As per Cohen if this value between 0.20 to 1.00, he classified as 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. The overall kappa statistics is 0.774 and overall classification accuracy is 80.24% obtained in supervised classification of the year 1995. It is substantial when compared to the 2008 and 2020 accuracy reports. Similarly, we obtained the overall kappa statistics and overall classification accuracy 0.84 and 86.72% in the 2008 classification and 0.88 and 89.84% in the 2020 classification.

6. Conclusions

The supervised classification had been performed and it showed satisfactory results. The authors faced difficulty in the identification of classes in the image classification of 1995 when compared to the 2008 and 2020 image classification. We had unable to understand the classes due to the lack of oral reports about the scenario of 1995. From the trend analysis of LULC in this study, majorly forestation, agricultural land declined by nearly 47% and 105% respectively from the year 1995 to 2020. We had noticed that the agricultural activities had been gradually declined and barren land increased in the overall study period. We suggest that using GPS instruments will give precise results along with RS and GIS techniques in a future study.
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