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Land Use/Cover change detection analysis for Thandava Reservoir Catchment of Visakhapatnam using Geo-Spatial technologies

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Abstract: *Mapping land use/land cover changes at regional scales is essential for a wide range of applications like landslide, erosion, land planning, global warming etc. Land use/ Land cover alterations based especially on anthropogenic activities, negatively affect the patterns of climate, the natural hazard and also socio-economic dynamics in global and local scale. Monitoring and analysing the recent land cover/land use changes through the integration of remote sensing and GIS to detect change in its pattern by providing more reliable direct quantitative information could also provide base information for documenting water salinity, soil change and expansion in surface lakes. Therefore, the present study is made to detect the land use/ land cover change between 2001 and 2011 for the Thandava Reservoir Catchment of Visakhapatnam district, Andhra Pradesh, India using geo-spatial technologies. Landsat TM data for the year 2001 and IRS-1D-LISS-III data for the year 2011 have been used for extraction of thematic information on the analysis of land use/ land cover change detection. In this analysis, both digital and visual interpretations of land use/land cover have been carried out. National land use/land cover classification for India, which is fairly compatible with the user's needs, was developed under National Remote Sensing Agency. The land use/land cover analysis has been delineated by the standard visual interpretation technique as suggested by NRSA, Hyderabad. The land use/land cover categories delineated from the study area are as following: Built-up land, Deciduous Forest, Degraded forest, Water body, Reservoir, Agriculture land, Dry land and other, Plantations, Barren rocky land.*

Keywords: *Land use, Land cover, anthropogenic, Thandava Reservoir Catchment*

1. INTRODUCTION

The word "land use" specifies how a piece of land is utilized, whereas land cover describes the materials present on the surface (Sabins, 1987). "Land cover" denotes the permanent features such as water bodies, rocky knobs and forest lands, etc. These are more or less permanent features. Within the land cover, often land use may take place. For example, agriculture and lumbering in forest area.

The overall objective of the image classification procedure is to automatically categorize the pixels in an image into land use/land cover classes. Normally, multispectral data are used to perform such a classification. The spectral pattern present within data for each pixel is used as the numerical basis for categorization (Lillesand, 1994).

A sudden change in land use/land cover may be indicative of change in terrain character. The land use pattern and land management of an area reveal indirectly the conditions of the people of the area, their economic status and resources. The information for land use planning comprises of reliable, up-to-date and comprehensive data on physical, ecological and socio-economic framework of a region. National land use/land cover classification for India, which is fairly compatible with the user's needs, was developed by land use/land cover division under National Remote Sensing Agency (1989). In this analysis, both digital and visual interpretations of land use/land cover have been carried out. The land use/land cover categories delineated from the study area are Built-up land, Deciduous Forest, Degraded forest, Water body, Reservoir, Agriculture land, Dry land and other, Plantations, Barren rocky land.

2. LITERATURE REVIEW

Adinarayana & Rama Krishna (1995)formulateda treatment-oriented land-use planning scheme, involving soil depth and slope steepness characteristics, through the use of multidisciplinary knowledge-based rules and field checks in an integral manner through use of Geographical Information Systems (GIS),

Abd El hay AlyFarrag, El Sayed Ahmed El Sayed, and Hanaa Ahmed Megahed (2016) studied Land Use/Land Cover Change Detection and Classification using Remote Sensing and GIS Techniques at Siwa Oasis, Northwestern Desert of Egypt.

Bergsma (1986) foundout theaspects of mapping units in the rain erosion hazard catchment survey.

Chauhan et al. (2005) have studied land use/land cover changes near Hazira region, Gujarat using IRS-LISS-III sensor data. In this study, land cover information of the period 1970 - 1972 from the Survey of India topographical maps, and satellite data of the year 1989 and 1999 to 2002 have been used and visual analysis has been carried out to measure the land use/land cover changes. Erosion and deposition have been observed around the newly constructed jetty. Forest area and agriculture area are found decreased, whereas built-up area has increased. This analysis can be used further for developing a regional model for predicting short range land use/land cover changes and impact on climates.

Dudal (1987)quoted that the current rate of agricultural land degradation worldwide by soil erosion and other factors is leading to an irreparable loss in productivity on about 6 million hectares of fertile land a year.

DugumaErasu (2017) performed Remote Sensing based Urban Land Use/Land Cover Change Detection and Monitoring.

Joshi, et al. (2005) have studied land use/land cover identification in an alpine and arid region Nubra valley, Ladakh using satellite remote sensing. In this study, satellite data have been used for mapping vegetation types in the tropical landscapes. In this study, IRS-ID-LISS-III data have been analysed in ERDAS 8.4, Arc View 3.2a and Arc/Info 8.1 for map generation. DEM was used to identify herbaceous and sedge meadows. Similarly, the drainage pattern is one of the clues to delineate the vegetation cover. NDVI, PCA was used in the study to enhance the classes and for better interpretation. This study has focused on different land use/land cover classes in the cold deserts and the methodology used in this can be used elsewhere for the similar types of studies.

Naik et al, (2011) have studied reservoir impact assessment on land use/land cover and infrastructure- a case study on Polavaram project. In their study, land use/land cover has been carried out using LISS-III sensor of IRS P6 data. The land use/land cover has been compared with the administrative boundary and other infrastructural facilities. They observed the area below the 45.72 m contour above mean sea level submerge the area due to construction of the dam. The Scheduled Tribes population is the major chunk of rehabilitation than the other categories which includes several infrastructural facilities.

Sarkar et al. (2006) have extensively studied soil resources appraisal towards land use planning using satellite remote sensing and GIS-A case study in Patloinala microwatershed, District Puruliya, West Bengal. They used IRS-ID LISS-III merged with PAN of Patloinala micro watershed of Puruliya district to delineate physiographic units based on the variations in image characteristics. In this, the major physiographic units identified were upland, medium land and low land. On the basis of physiographic variation and soil or soil site characteristics such as texture, depth, slope, erosion, etc. the problem areas were identified and land use plan has been suggested for the overall development of the micro watershed.

Selçuk Reis (2008) analysed Land Use/Land Cover changes using Remote Sensing and GIS in Rize, North-East Turkey.

3. STUDY AREA

The base map of the study area is prepared by the Survey of India (SOI) topographic maps numbered 65 K/5, 65K/6, 65K/9, 65K/10 on 1:50,000 scale.Thandava reservoir is located between 17°45’50” North latitude and 82°15’20” East longitude (Fig. 1).The study area, Thandava reservoir catchment area is located in the hilly terrain of the Eastern Ghats region of Visakhapatnam district, Andhra Pradesh with catchment area of 467 km^2 and is constructed with the gross storage capacity of 4960Mcft. The non-perennial Thandava Reservoir Catchment (TRC) is characterized by undulating topography, with hill ranges (320m-540m above M.S.L) on Northern, Southern and Western sides, and Bay of Bengal on the eastern side.

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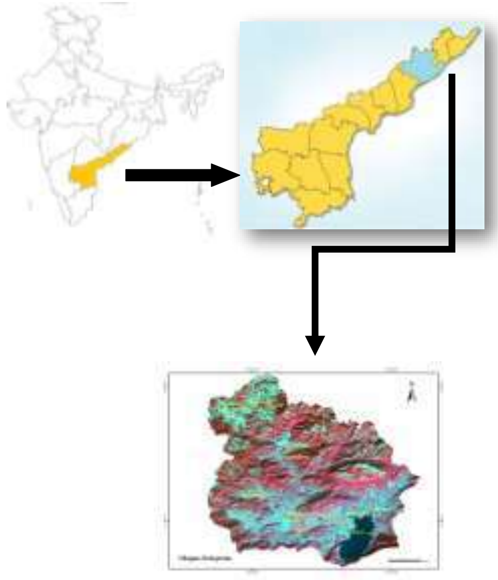

(Study area as viewed on IRS-ID-LISS III, dated on 11th Jan 2011)

Fig-1: *Location map of the Thandava Reservoir catchment*

4. METHODOLOGY

Land use/ land cover maps were prepared by using Landsat TM data for 2001 year satellite imagery and IRS-LISS-III data for 2011 year satellite imagery and verified through necessary field check. Two season satellite data were used in the preparation of land use/ land cover; SRTM (90m spatial resolution) satellite data was downloaded to generate DEM of the study area. Different source data have been used to generate thematic layers in Erdas-Imagine-9.1 and ArcGIS-9.2 environment (Fig. 2). Various land use/ land cover classes were delineated from both the images to finally produce the land use/ land cover datasets and maps for the two references years. In order to properly ascertain the areas and magnitude of land use/ land cover change occurred between 2001 and 2011, a land use/ land cover change map was generated finally.

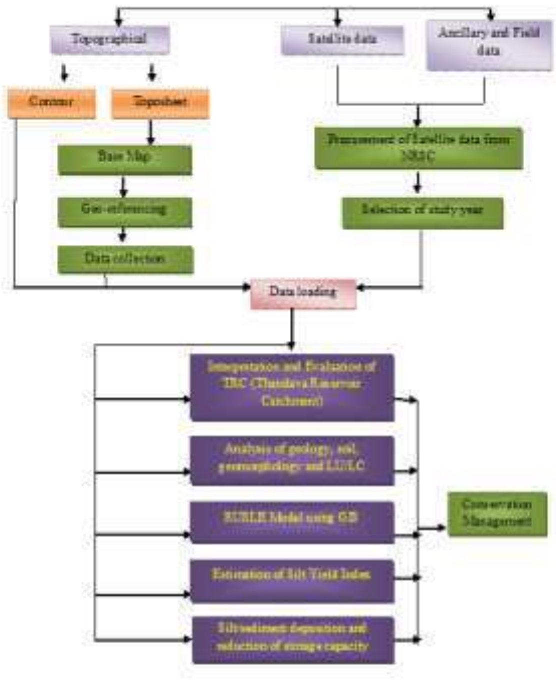

Fig-2: *Methodology (flow chart)*

5. RESULTS AND DISCUSSIONS

On the basis of the Land use/ land cover classification provided by NRSC, 1989 (Table 1), the change detection analysis is ultimately carried out and following results have turned out that are mentioned below.

Table 1: *Land use/land covers classification (NRSC, 1989)*

Level – I	*Level – II*
1. Built up land	*1.1 Urban* *1.2 Rural* *1.3 Transport*
2. Agricultural land	*2.1 Crop land* *I. Irrigated,* *II. Un-irrigated* *2.2 Fallow* *2.3 Plantation* *2.4 Shifting cultivation*
3. Forest	*3.1 Evergreen forest* *3.2 Deciduous forest* *3.3 Scrub/degraded forest* *3.4 Forest plantation*
4.Waste land	*4.1 Salt affected land* *4.2 Gullied or Ravenous land* *4.3 Water logged and marshy land* *4.4 Upland with or without scrub* *4.5 Sandy area* *4.6 Barren rocky land/stony waste*
5. Water bodies	*5.1 Rivers/Streams* *5.2 Lakes/Reservoirs/Tanks* *5.3 Canals*
6. Others	*6.1 Snow covered/Glacial area* *6.2 Grassland/Grazing land* *6.3 Derelict land due to mining and industrial waste*

5.1 Supervised Classification:

The computer algorithm/ numerical descriptions of various land cover types present on classification is performed by the image analyst by choosing the pixel categorization process by specifying signature points (Rao, 2002). Each pixel in the data set is then compared numerically to each category in the interpretation key and labelled with the name of the category it "looks most like" (Lillesand, 1994). The three basic steps involved in a typical supervised classification procedure are 1.Training stage 2.Classification stage and 3.Output stage (Greenways, 1987).

In the training stage the analyst identifies representative training site areas and develops a numerical description of the spectral attributes of each land cover type of interest in the scene.

In the classification stage, each pixel in the image dataset is categorized into the land cover class it most closely resembles. If the pixel is insufficiently similar to any training data set, it is usually labelled "unknown". The category label assigned to each pixel in this process is then recorded in the corresponding cell of an interpreted data set (an "output image"). Thus, the multidimensional image matrix is used to develop a corresponding matrix of interpreting land cover category types (Cambell, 1996).

After the entire data set has been categorized, the results are presented in the output stage. Being digital in character, the results may be used in a number of different ways. Three typical forms of output products are thematic maps, tables of full scene or sub scene area for the various land cover classes, and digital data files amenable to inclusion in a GIS. Supervised classification of land use/ land cover with the homogeneous training sites selected in signature editor and executed in an Erdas-9.2 environment have been assigned to obtain the output (Fig. 3).

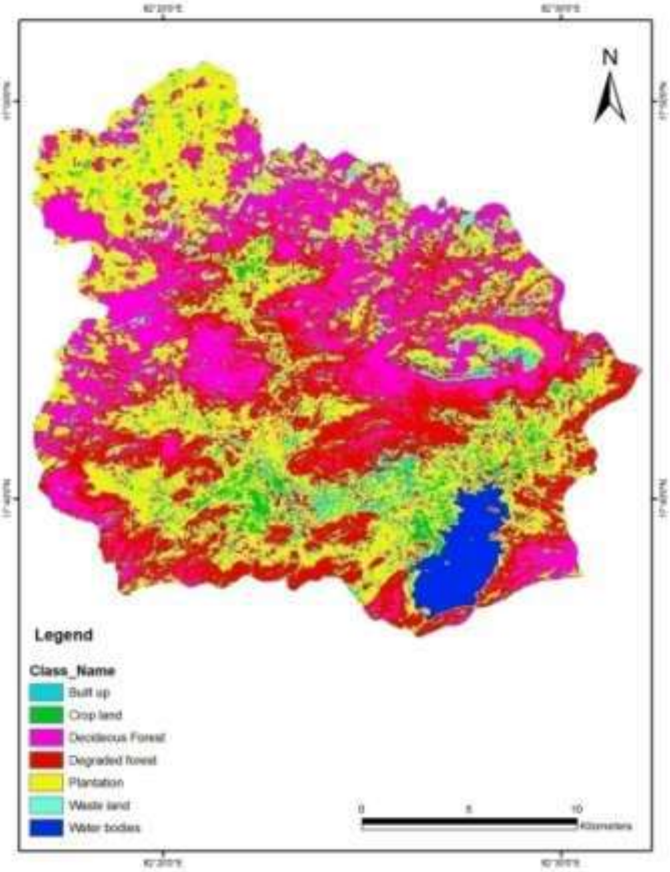

Fig-3: *Land use/land cover based on supervised classification*

5.2 Land use/ land cover Mapping and Analysis for the year 2001

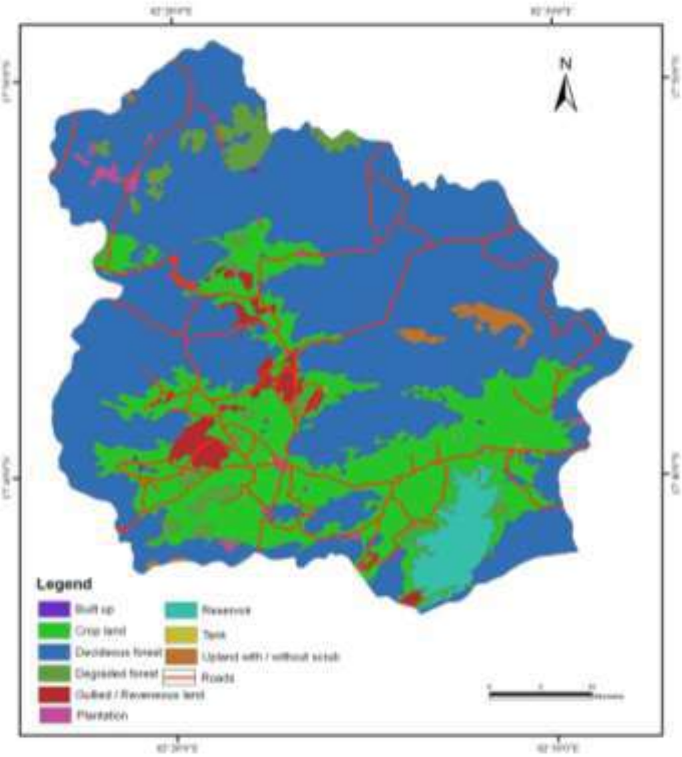

Fig-4: *Land use / land cover based on Landsat TM 2001*

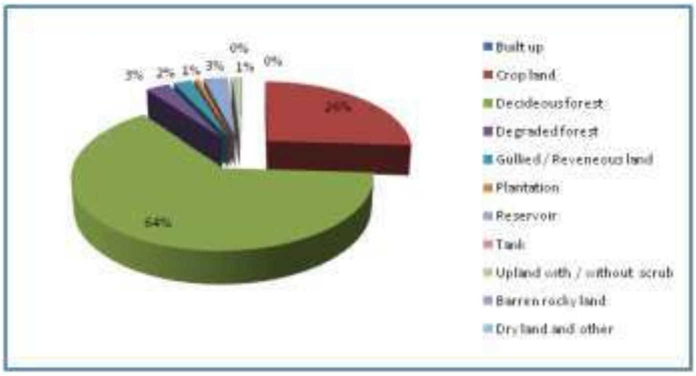

Chart-1: *Land use/land cover classes in 2001*

5.3 Land use/ land cover Mapping and Analysis for the year 2011

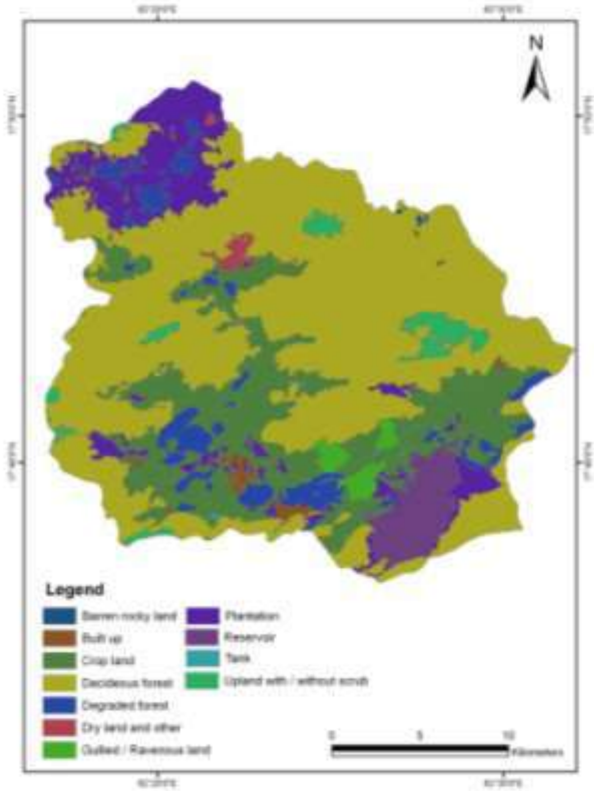

Fig-5: *Land use / land cover map based on IRS-LISS-III 2011*

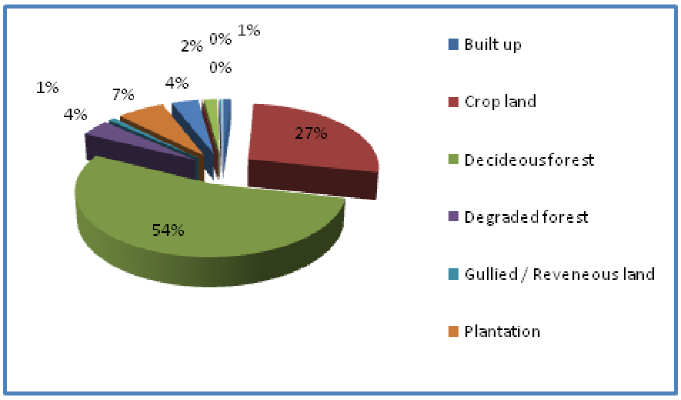

Chart-2: *Land use/land cover classes in 2011*

5.4 Land use/ land cover change pattern analysis during 2001 and 2011 years

Table 2: *Observed land use/ land cover classes in the study area*

Land use/land cover classes	*Area in (Km²) 2001*	*Change in Percentage (%)*	*Area in (Km²) 2011*	*Change in Percentage (%)*
Deciduous forest	*299.31*	*63.95*	*251.91*	*53.94*
Degraded forest	*14.09*	*3.01*	*19.37*	*4.01*
Crop land	*120.99*	*25.85*	*127.76*	*24.16*
Gullied / Ravenous land	*10.91*	*2.33*	*4.30*	*0.70*
Reservoir	*14.38*	*3.07*	*17.31*	*4.03*
Tank	*0.24*	*0.05*	*0.38*	*0.09*
Plantation	*3.18*	*0.68*	*30.89*	*6.9*
Built-up	*0.68*	*0.15*	*4.99*	*1.22*
Upland with/without scrub	*4.23*	*0.10*	*8.48*	*1.59*
Barren rocky land	-	-	*0.42*	*0.10*
Dry land and other	-	-	*1.19*	*0.28*

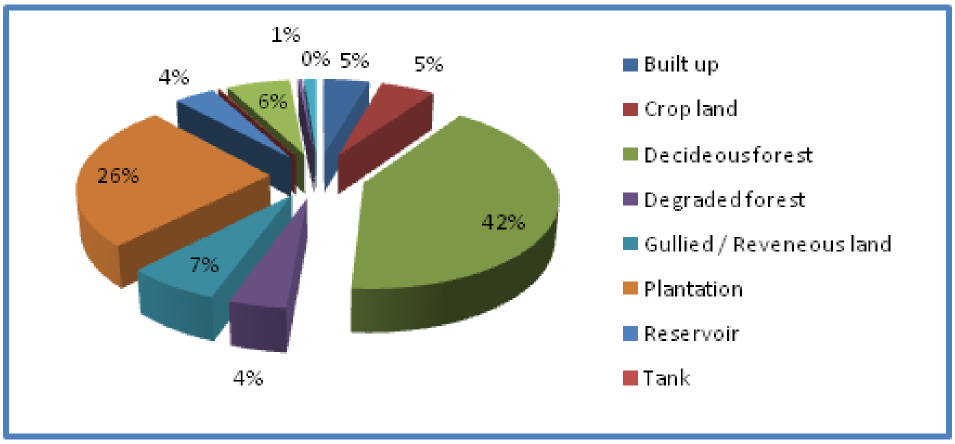

Chart-3: *Change of land use/land cover classes from 2001 to 2011*

5.4.1 Built -up land

In the Thandava Reservoir catchment area, about 4.99 Km² built-up areas are delineated through visual interpretation. It implies the ratio 1.22% shows a very low dweller in the study area. In this analysis, there are no urban developments and even the rural settlement comes under the jurisdiction of the Agency Authority. The built-up area appears in cyan colour, coarse texture, connected with road network which are some of the features through which this class is demarcated on the satellite image. Major villages with greater spatial extent were mapped. Some major villages Kongasingi, Nagapuram, KrishnadeviPeta, Kottapadi are extended as a built-up land (Fig.6).

Fig-6: *Built-up area near Golugonda*

5.4.2 Agriculture

The agriculture crop of two seasons i.e. January 2001 and January 2011 data have been used. The area in 2001 crop covers 120 $km^2$and in 2011 crop covers 127.76 km^2. The area is associated with mainly in the deep valley area which indicates that the agricultural activity depends on the surface as well as groundwater resources. Sugarcane is the major food crop besides different varieties of vegetables, cotton crop grown depending on the availability of water (Fig.7).

Fig-7: *Cotton crop near Chodyam*

5.4.3 Forest

Deciduous forest, degraded forest and forest plantation areas were identified in the study area of land use/land cover analysis. Degraded forest land has been located in main hill ranges of Kongasing, Poradesipaka hill and UraKonda hills. Deciduous Forest is in Bointi reserved forest, Dharakonda Reserved forest and Sarugudu reserved forest. Some of the deciduous forest is converted into plantations in the foothill of the Bointi reserved forest. (Fig. 8)

Fig-8: *A view of the hill mass with forest plantation in Karaka reserved forest*

The reserved forest covers an area of 299.31 km^2 in 2001 and 251.91 km^2 in 2011which shows the rural settlements, crop land, plantations are accelerating change of the land cover of the forest into land use.

5.4.4 Plantation

Plantation is developed along the river bed and across the reservoir in recent years in the study area. Most of the plantation has been identified in the Valasarajupadu, Kondagokiri, Makavaran and Kotragadda in west of Bonti reserved forest. Some of the few areas identified Scrub/Plantation in the foothills of the Bonti reserved forest. The total area cover in the plantation is nearly 3.18 km^2 in 2001 and 30.89 km^2 in 2011.

5.4.5 Waste Land

Dry land and other upland with/without scrub and barren rocky land are categorized as waste lands. The barren rocky land and dry land and other are magnificently observed with 0.42 km^2 and 1.19 km^2 2011. The upland with/without scrub observed significant changes. The villages are NimmalaPalem, Kamparegulu, Agraharam, Nimmalageddu, Singadhar, Gondampalli, etc.

5.4.6 Reservoir

The water bodies of the study area are confined to both river water and reservoir water by taking into consideration of the existing tanks. It is represented by light blue to very dark blue tone depending upon the depth and turbidity levels of the water bodies. Its texture is smooth and shape is irregular on the image. The total area of the reservoir is 14.38 km^2 and 17.31 km^2 in 2001 and 2011 respectively. Due to floods in 2011, the water spread in the reservoir is increased about 3 km^2 (Fig. 9).

Fig-9: *A View of Thandava reservoir*

6. CONCLUSION

Remote Sensing and Geographical Information System (GIS) are well accepted and more dependable advance techniques to detect change in land use and land cover pattern by providing more reliable direct quantitative information. Land use/cover change detection for the years 2000 and 2011 were studied to project the extent and severity of deforestation in the reservoir catchment. The study area is divided into ten sub-basins which were selected to evaluate the sediment delivery ratios at the basin. Initial analysis of ancillary spatial data sources gave insight for expected trends of development and land use/cover change, although they were not used for the assessment of change due to discrepancies in classification procedures used. The classification procedure used was able to distinguish eleven land use/cover classes with an overall accuracy of 86.49. Inadequacies in the accuracy results can be attributed to several factors, including, image quality, local climatic conditions, and assessment procedures.Overall changes in the landscape showed an increased trend for crop land (47.04%) in 2011 with non-forested vegetation and coastal wetlands suffering the consequences. The trends associated with this development appear to follow the existing high pressure on the reservoir. Degraded forests are contributing silt/sediment to the surface water bodies besides other land use.

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Ms. Madhuri Mulpuru has pursued Doctor of Philosophy in the Department of Geo-Engineering and Centre for Remote Sensing, Andhra University College of Engineering in 2016. She is working as Associate Professor at Malla Reddy Institute Of Technology for till date. She is very interested in subjects of Civil Engineering and Geo-Engineering and teaches subjects like Surveying and Geographic Information Systems. She has given a guest lecture in “Fundamentals of Remote Sensing and GIS and how the applications used in Water Resource Management” at Pydah College. She also organized guest lectures, one day-workshop, Faculty Developed Program(FDP), and other activities in present working institute. She is a life time member in GEO-SPATIAL Today magazine andIndian Society of Geomatics (ISG).

Ms. Aditya Allamraju is pursuing her final year,Bachelor of Technology in Geo-Informatics, Department of Geo-Engineering from Andhra University College of Engineering(A). She is an annual member of IEEE (Institute of Electrical and Electronics Engineers), IEEE Geoscience and Remote Sensing Society, IEEE WIE memberfrom 2018, World Research Council annual member and Lifetime member of ISRS (Indian Society of Remote Sensing) from 2019. She is a recipient of the ‘Green Thinkerz Emerging Researcher for the year 2018’ award. She also received the RULA International Awards’ for ‘Distinguished Engineer of 2018’ for her outstanding contribution in the field of research and co-curriculum. She is also rewarded four gold medals from the Vice Chancellor, Andhra University for her outstanding performance in curriculum.

Mr. B. Sridhar is currentlypursuing Doctor of Philosophy in the Department of Geo-Engineering and Centre for Remote Sensing Andhra University College of Engineering, AP, India. He has over six years of experience in Remote Sensing, Land Use and Landcover planning, Urban GIS Applications, Environmental,Geological, Geo-physical, Natural Disasters and Hydrogeological studies. He is currently member in InternationalAssociation of Engineers (IAENG), The Society of DigitalInformation and Wireless Communications (SDIWC); AssociateMember in Institution of Engineers India (AMIE); Life Member,Indian Society Of Remote Sensing and International Society forResearch and Development (ISRD). He is also a life time member in Indian Red Cross Society.