Cloud Publications
International Journal of Advanced Remote Sensing and GIS
2019, Volume 8, Issue 1, pp. 2955-2962
ISSN 2320 – 0243, Crossref: 10.23953/cloud.ijarsg.404

Research Article

Change Detection Analysis of Vamsadhara - Nagavali River Fluvial System, using Multi-Temporal Remote Sensing Data and GIS Techniques

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Publication Date: 21 February 2019

DOI: https://doi.org/10.23953/cloud.ijarsg.404

Abstract Land use & Land cover change detection analysis has been carried out in the present study covering the Nagavali and Vamsadhara Fluvial system (18°40′N to 18°09′N latitude and 84°10′ E to 83°39′E longitude). Satellite images of Landsat-7 ETM+ (2000) Landsat ETM+ (2010) Landsat OLV-TIRS (2016) and 1975 SI Toposheets have been used to study the temporal changes in the land use and land cover by onscreen digitisation techniques in ARC GIS 10.1 software followed by image processing to obtain changes in various classes of land use during study period from 1975 to 2016. The classes include plantation, settlements, water bodies, coastal area, wetlands, agriculture land and area under river course of both rivers. The classes, which have shown an increased area from 1975 to 2016, include Agriculture (from 56.93 % to 63.95%) and Settlements (from 1.40% to 3.43%). The classes that have shown the decreasing trend of Land Use are Plantation (from 19.76% to 13.14%), water bodies (from 2.29% to 0.77%), Wetlands (from 0.72% to 0.57%). The area under river course of both the rivers has shown a decreasing trend. The analysis reveals that due to increased irrigation facility plantation, wetlands and water bodies have brought under agricultural use and this trend need to be arrested. The Plantation area for natural resource management furthermore declines the soil erosion in between the Vamsadhara and Nagavali river area.
Keywords *Change detection; Land cover; Land use; Rivers; Satellite imagery*

1. Introduction

The process of Land Use Land Cover Change is a dynamic phenomenon. Advances in observation and detection methods specially like remote sensing and geospatial techniques have led to the boost in Global, regional and local scale studies of LULC. The issue of land use / land cover changes has been given priority in many international and interdisciplinary researches such as remote sensing, political ecology and biogeography (Turner et al., 1995, Jensen, 2005; Turner et al., 2007). Knowledge of spatial land cover information is essential for proper management, planning and monitoring of natural resources (Zhu, 1997). It is considered necessary for many agricultural, Geological, Hydrological and Ecological models. Disaster management is another such discipline where its use is encountered. Land use and land cover analysis are important for many planning and management activities and considered as an essential element for physical modelling and understanding the earth as a system. Now-a-days land cover maps are prepared for planning and management purposes. Due

to synoptic view, map like format and repetitive coverage, satellite remote sensing imagery is a remarkable source for gathering quality data on land cover information on local, regional and global scale (Csaplovics, 1998; Foody, 2002). Multi-temporal satellite data are useful in assessing the relationship between natural and anthropogenic factors effect on land use / land cover change. To develop an action plan for land resource development, change detection analysis is very crucial in monitoring the changes.

Objective

The objective of the present study is to identify the temporal changes in the land use/land cover classes in the Vamsadhara and Nagavali fluvial system in the coastal tracts of the Srikakulam District, Andhra Pradesh for the period from 1975 to 2016.

Study Area

The region selected for the present study is Vamsadhara and Nagavali fluvial system in the coastal tracts of the Srikakulam District, Andhra Pradesh. It comprises an area of 2285 km^2 and lies between 18°40′N to 18°09′N latitude and 84°10′ E to 83°39′E longitude. The study area covers two major rivers of northern Andhra Pradesh namely Vamsadhara River and Nagavali River. Northern border of the study area is demarcated by Eastern Ghats and slope is decreasing from north to south. Vamsadhara and Nagavali rivers flow from North West to the South Eastern direction in Srikakulam district.

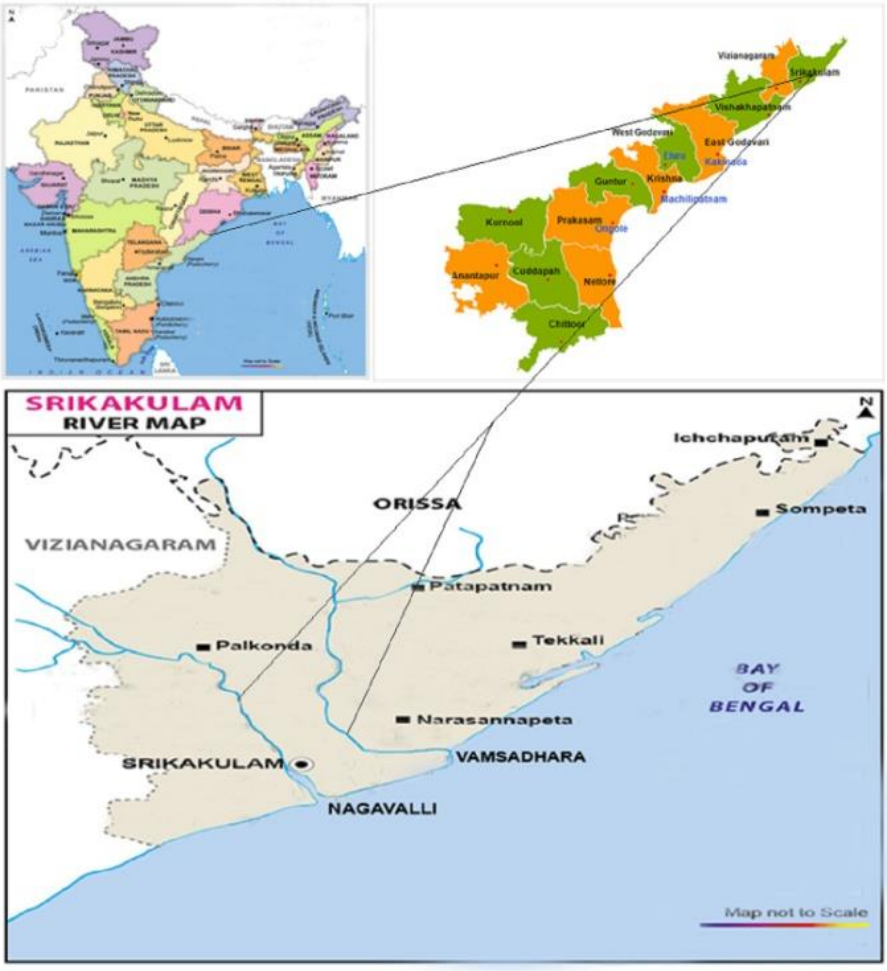

Figure 1: *Study area of Nagavali and Vamsadhara fluvial system*

Vamsadhara River originates in the border of Kalyansinghpur in Rayagada district and Thuamul Rampur in Kalahandi district of Odisha. Vamsadhara River flows for a length of 154 km in Orissa State and runs along the border of Orissa and Andhra Pradesh for a length of 29 km from Battili to Gotlabhadra and enters Andhra Pradesh at Gotlabhadra village. The river flows for a length of 82 km in Andhra Pradesh before emptying into the Bay of Bengal at Kalingapatnam in Srikakulam District of Andhra Pradesh. Vamsadhara is an important east flowing river between Mahanadi and Godavari. The river rises just south of the Belagad village in the undivided Phulbani district of Orissa at an elevation of about 600 m. The total length of the river is about 221 km, of which 125 km is in Orissa, 23 km is at the boundary between Orissa and Andhra Pradesh and 73 km is in Andhra Pradesh. Study area is shown in the following figure (Figure 1). The area between these two rivers forms present study area.

2. Materials and Methods

Time series satellite imagery was used to map the temporal trends spread in between Vamsadhara and Nagavali fluvial system. For this purpose, Topographic sheet 74 B/3, 65 N/16, 65 N/15, 65 N/14, and 65 N/11 were collected for the year (1975-76); Landsat-7 ETM+ (2000); Landsat-7 ETM+ (2010); Landsat OLI_TIRS image (2016) have been used for the present study and they are depicted in the Table 1. Satellite data of TM, ETM+, and OLI_TIRS is obtained from online Global Land Cover Facility (GLCF) website of USGS, USA for years 2000, 2010 and 2016 respectively. All the FCC (false color composite) images were geo-referenced by co-registering the selected ground control points that are prominently identified from the images as well as the Survey of India topographic maps of the area that are later brought to a common geographic coordinate system, which helped in comparing them with one another for estimating the areas and temporal changes in the land use/land cover that is shown in the following figure (Figure 2). The images enhanced through ALR technique has aided mapping of various land use/land cover features such as Plantation, Settlement, Water bodies, Coastal Area, Wetlands and Agriculture land through Onscreen-digitization in Arc GIS 9.3 Software.

Table 1: *Satellite imagery and characteristics*

2016 Landsat-8 (30Meter Resolution)			
	Date Acquired	**TARGET-WRS-PATH**	**TARGET-WES-ROW**
Coast side	2016-02-21	140	47
Up-Land side	2016-02-12	140	47
2010 Landsat-5 (30Meter Resolution)			
	Date Acquired	**TARGET-WRS-PATH**	**TARGET-WES-ROW**
Coast side	2010-01-19	140	47
Up-Land side	2010-01-26	141	46
2000 Landsat-ETM (30Meter Resolution)			
	Date Acquired	**TARGET-WRS-PATH**	**TARGET-WES-ROW**
Coast side	2000-03-20	140	47
Up-Land side	2000-04-12	141	46
TOPO SHEETS (74B/3, 65N/15, 65N/14, 65N/11) OF 1975-76			

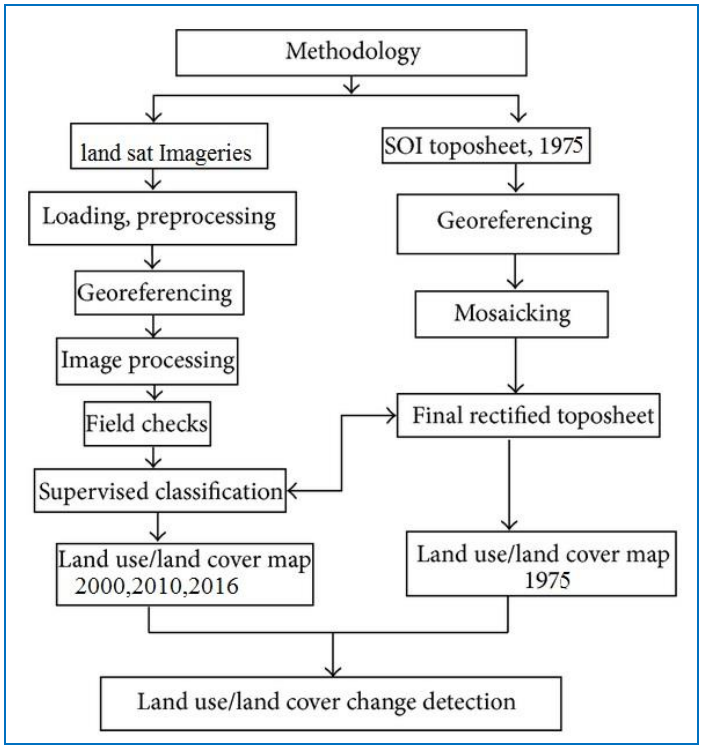

Figure 2: *Depicting the standard methodology for change detection studies*

3. Results and Discussion

Following Table 2, depict the land use / land cover changes from the year 1975 to 2016.

Table 2: *Land Use/ Land Cover data from 1975 to 2016 in Vamsadhara and Nagavali fluvial system*

Land Use/Land Cover Type	Area (km^2)			
	1975	**2000**	**2010**	**2016**
Agriculture	1301 (56.93)	1389.4 (60.80)	1414.31 (61.89)	1459.02 (63.85)
Settlement	32 (1.40)	60.20 (2.63)	63.20 (2.76)	78.56 (3.43)
Plantation	451.6 (19.76)	363.21 (15.89)	341.3 (14.93)	300.25 (13.14)
Water Bodies	52.48 (2.29)	30.39 (1.32)	27.15 (1.18)	17.56 (0.77)
Nagavali River	30.83 (1.34)	28.69 (1.25)	26.69 (1.16)	23.83 (1.04)
Vamsadhara River	33.0 (1.44)	31.15 (1.36)	30.15 (1.31)	26.17 (1.14)
Coastal Area	367.41 (16.07)	367.9 (16.10)	367.90 (16.10)	366.44 (16.03)
Wetlands	16.68 (0.72)	14.06 (0.61)	14.30 (0.62)	13.08 (0.57)
Total	**2285.0**	**2285.0**	**2285.0**	**2285.0**

This study has been undertaken to understand the land use and land cover changes in different land use classes namely agriculture, settlements, plantation, water bodies, Nagavali River, Vamsadhara River, coastal area and wetlands. The analysis results of the above process have been shown in Table 2. The data indicates that there are significant changes in the land use pattern among the classes studied. The classes such as agriculture and settlements have indicated an increased land usage whereas all the other classes have indicated the declining trend of land utilization. Details are discussed below. To have a better comprehension the output maps for all the four years namely 1975, 2000, 2010 and 2016 are presented (Figure 3 and Figure 4)

The land use and agriculture have shown an increasing trend where an area of 1301 sq km (56.93%) was under agriculture in the year 1975 which has increased to 1389.4 sq km (60.80%) during the year 2000. The area was further increased to 1414.31 sq km (61.89%) in the year 2010 and it recorded an area 1459.02 sq km (63.85%) in 2016. Thus, the class agriculture has shown a significant increase.

The area under settlements has shown an increasing trend, where an area of 32 sq km (1.40%) was under settlements in the year 1975 which has increased to 60.20 sq km (2.63%) during the year 2000. The area was further increased to 63.20 sq km (2.76%) in the year 2010 and it recorded an area of 78.56 sq km (3.43%) in 2016. In this way the class settlements have also shown a significant and consistent increase.

The area under plantation has shown a decreasing trend where an area of 451.6 sq km (19.76%) was under plantation in the year 1975 which has decreased to 363.21 sq km (15.89%) during the year 2000. The area has further decreased to 341.3 sq km (14.93%) in the year 2010 and it recorded an area of 300.25 sq km (13.14%) in 2016. Thus, the area under plantation indicated a decreasing trend.
The area under Water Bodies has shown a decreasing trend where Water bodies occupied an area of 52.48 sq km (2.29%) in the year 1975, which has decreased to 30.39 sq km (1.32%) during the year 2000. The area has further decreased to 27.15 sq km (1.18%) in the year 2010 and it recorded an area of 17.56 sq km (0.77%) in 2016. The trend indicated the area under water bodies are in decrease in the study area.

The area under Nagavali River has shown a decreasing trend where an area of 30.83 sq km (1.34%) was occupied by Nagavali River in the year 1975 which has decreased to 28.69 sq km (1.25%) during the year 2000. The area has further decreased to 26.69 sq km (1.16%) in the year 2010 and it recorded an area of 23.83 sq km (1.04%) in 2016. The results strongly suggest the area occupied by the Nagavali River course has been reduced significantly.

The area under Vamsadhara River has shown a decreasing trend where an area of 33.0 sq km (1.44%) was occupied by Vamsadhara River in the year 1975 which has decreased to 31.15 sq km (1.36%) during the year 2000. The area was further decreased to 30.15 sq km (1.31%) in the year 2010 and it recorded an area of 26.17 sq km (1.14%) in 2016. The area under Vamsadhara River has decreased significantly.

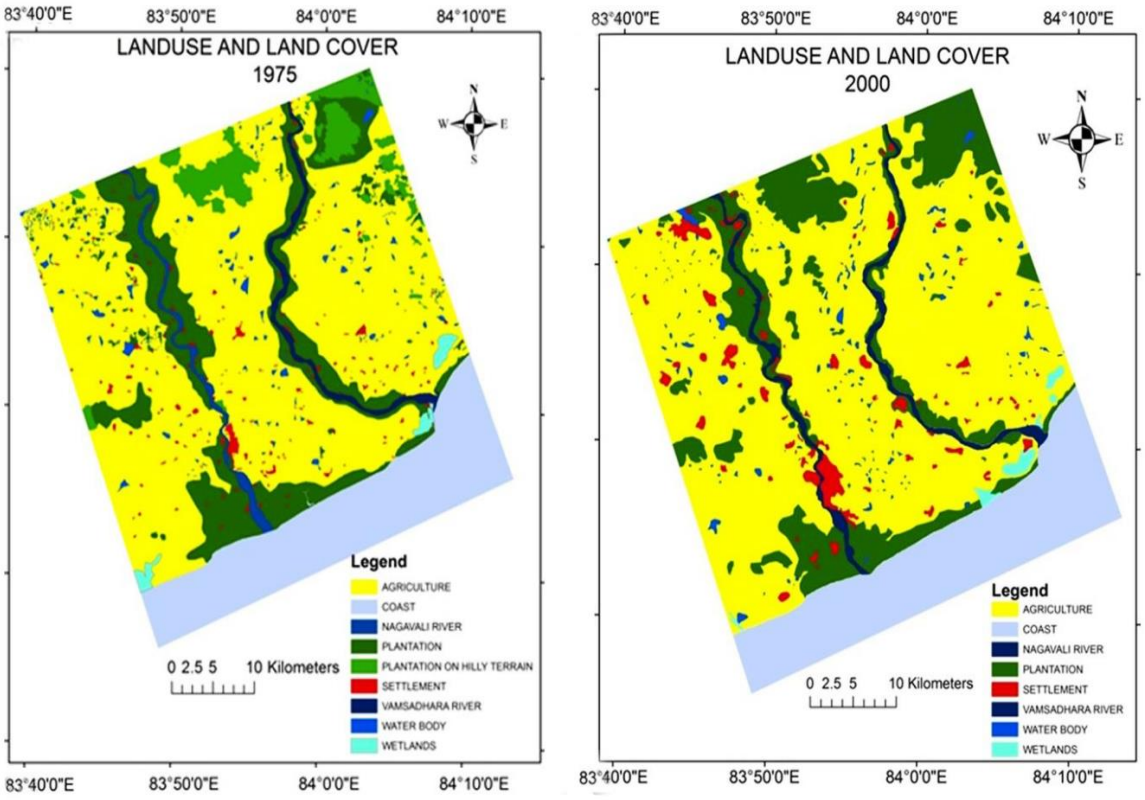

Figure 3: *The LULC changes during the years 1975 and 2000*

The area under Coastal area has shown a decreasing trend where an area of 367.41 sq km (16.07%) was occupied by Coastal area in the year 1975 which has decreased to 367.9 sq km (16.10%) during the year 2000. The area was stable and maintained 367.9 sq km (16.10%) in the year 2010 and it recorded an area of 366.44 sq km (16.03 %) in 2016. The area under coastal environment has come down slightly.

The area under wetlands has shown a decreasing trend where an area of 16.68 sq km (0.72%) was occupied by Coastal area in the year 1975 which has decreased to 14.06 sq km (0.61%) during the year 2000. The area was stable and maintained 14.30 sq km (0.62%) in the year 2010 and it recorded an area of 13.08 sq km (0.57%) in 2016. Thus, the class wet lands have registered a marginal decrease in the study period.

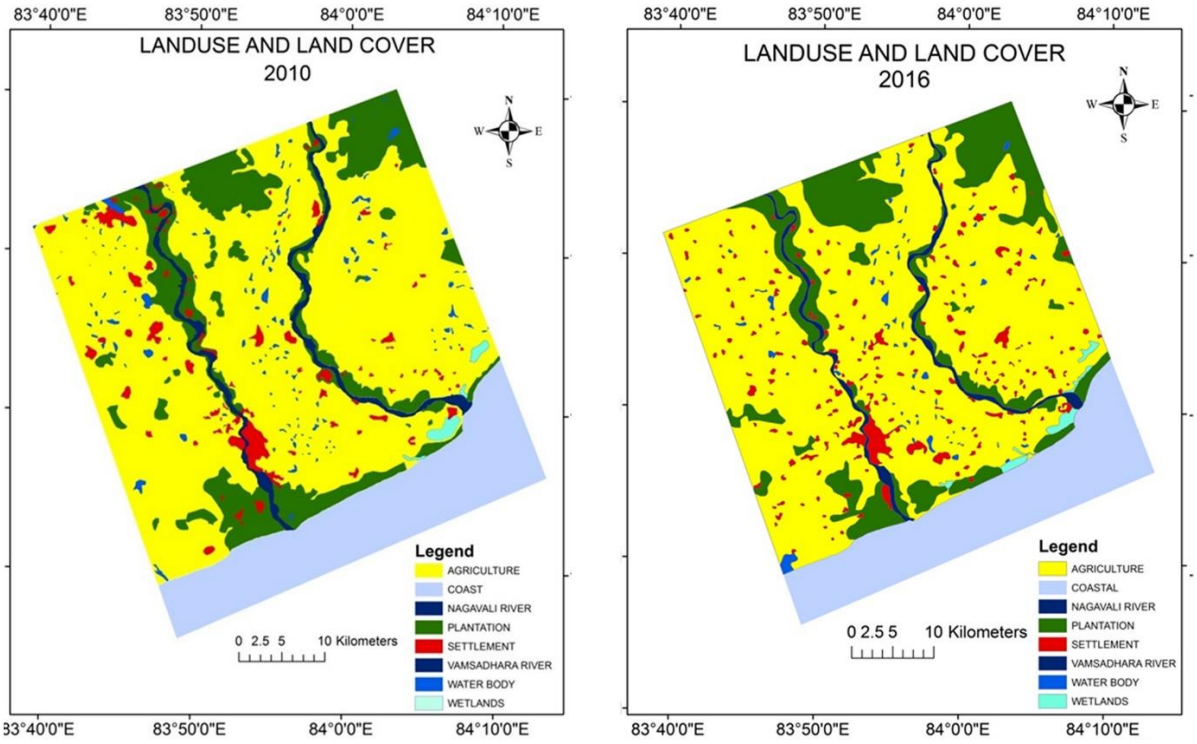

Figure 4: *The LULC changes during the years 2010 and 2016*

4. Conclusion

The present analysis reveals that due to deforestation and agricultural practices, forest area has rapidly declined in the study area, area under settlements has increased whereas the area under water bodies has decreased during the study period 1975 to 2016. It is estimated that almost all the decrease in dense forest area is because forestlands have been utilized for settlement, agriculture and related activities and the decrease may be due to human pressure on forests for firewood as well as grazing of cattle in the forested area, and urbanization. These activities also resulted; the risk of soil erosion.

According to the study of morphometric analysis (Panhalkar et al., 2012), it is recommended that in upper sub-basin of the two river systems, river needs to be given higher priority for soil conservation practices. In this study, Land use and Land cover changes from the year 1975-2016 are investigated for both the river systems together. The other parameters studies under land use and land cover changes namely river course, coastal area, and plantation also indicated a significant change and indicated a decreasing trend. This can be attributed to both the natural environmental changes as well as anthropogenic activities.

The results strongly suggest the study area is under increased human pressure on the natural environment and resources. Proper steps need to be taken under the environmental management to arrest further degradation of the land and water resources in the study area.

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