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Land Use Land Cover Analysis for Godavari Basin in Maharashtra Using Geographical Information System and Remote Sensing

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Abstract

The dynamic transformation of land use and land cover has emerged as a crucial aspect in the effective management of natural resources and the continual monitoring of environmental shifts. This study focused on the land use and land cover (LULC) changes within the catchment area of the Godavari River, assessing the repercussions of land and water resource exploitation. Utilizing LANDSAT satellite images from 2009, 2014, and 2019, this research employed supervised classification through the Quantum Geographic Information System (QGIS) software's SCP plugin. Maximum likelihood classification algorithm was used for the assessment of supervised land use classification. Seven distinct LULC classes—forest, irrigated cropland, agricultural land (fallow), barren land, shrub land, water, and urban land—are delineated for classification purposes. The study revealed substantial changes in the Godavari basin's land use patterns over the ten-year period from 2009 to 2019. Spatial and temporal dynamics of land use/cover changes (2009-2019) were quantified using three Satellite/Landsat images, a supervised classification algorithm and the post classification change detection technique in GIS. The total study area of the Godavari basin in Maharashtra encompasses 5138175.48 hectares. Notably, the built-up area increased from 0.14% in 2009 to 1.94% in 2019. The proportion of irrigated cropland, which was 62.32% in 2009, declined to 41.52% in 2019. Shrub land witnessed a noteworthy increase from 0.05% to 2.05% over the last decade. The key findings underscored significant declines in barren land, agricultural land, and irrigated cropland, juxtaposed with an expansion in forest land, shrub land, and urban land. The classification methodology achieved an overall accuracy of 80%, with a Kappa Statistic of 71.9% for the satellite images. The overall classification accuracy along with the Kappa value for 2009, 2014 and 2019 supervised land use land cover classification was good enough to detect the changing scenarios of Godavari River basin under study. These findings provide valuable insights for discerning land utilization across various categories, facilitating the adoption of appropriate strategies for sustainable land use in the region.

Keywords

GIS, Remote Sensing, Land Use Land Cover Change, Change Detection, Supervised Classification

1. Introduction

Land use applications involve both baseline mapping and subsequent monitoring. Land use is generally inferred based on the land cover, yet both the terms land use and land cover being closely related are interchangeable [1]. Remote sensing and Geographic Information System (GIS) has been used for land use/land cover mapping, over the years. Remote sensing data made it possible to study the changes in land use land cover in less time and with good accuracy [2]. Remote Sensing (RS) data has been used to classify and map land cover and land use changes with different techniques and data sets. Landsat images have served a great deal in the classification of different landscape components at a larger scale [3]. Last three decades land satellite images have been used for this study. These satellite images further processed and analysed by GIS software. Geographic Information Systems (GIS) offer effective tools for the analysis of land use issues, as well as for land use planning and modeling, as highlighted many researchers. [4] [5] and [6] successfully utilized ERDAS Imagine software for mapping land use and land cover changes through both unsupervised and supervised classification methodologies. Asadi *et al.* (2010), created spatial digital database for Land Use/ Land Cover using ERDAS image processing software and analysis were done in Arc/Info and ArcView GIS software. GIS provides a flexible environment for collecting, storing, displaying, and analysing digital data necessary for change detection [7]. [8] applied the new version 2.3.2 of the Semi-Automatic Classification Plugin for QGIS for LULC classification. [9] used QGIS software for image classification. LULC mapping is very essential in finding out the soil erosion in any specific area, because the vegetation cover has significant impact on soil erosion. QGIS Open-source software has been used to evaluate and analyze LULC change between 2000 and 2010 and MOLUSCE plugin was used for producing the map of area change between study period and provide transition matrix [10]. Geographic Information Systems (GIS) and remote sensing are effective methods for obtaining precise and timely data on the spatial distribution of changes in land use and cover over huge areas [11]. The primary goal of this study is to employ Geographic Information System (QGIS) and Remote Sensing (RS) applications to assess the extent of changes in Land Use and Land Cover (LULC) categories and understanding the patterns of land use change in the in the Godavari River Basin under study over a span of 10 years from 2009 to 2019. The current study is an attempt for determining changes in LULC categories through spatial comparisons of the produced LULC maps by integrating QGIS and RS.

2. Methodology

2.1. Study Area

The Godavari River is India's second longest river after the Ganga. Its source is in Trambakeshwar, Nashik, Maharashtra. It flows east up to Nanded District in the state of Maharashtra. Study area covers the upper and middle part of the Godavari River from Trambakeshwar in Nashik district to Vishnupuri in Nanded district in Maharashtra as shown in Figure 1. It covers a length of 350 kilometers and basin area around 51381.75 km^2 for the study.

2.2. Data Collection and Preprocessing

The LANDSAT 5 (TM) and LANDSAT 8 (OLI/TIRS) data has been used for the LU/LC classification of study area. For this study gets LANDSAT images of three years 2009, 2014 and 2019 from USGS Earth Explorer website. The spatial resolution of LANDSAT 5 and LANDSAT 8 is with 30 m resolution. LANDSAT images of the past three years have been considered for temporal changes of LULC. The details of collected LANDSAT images are shown in Table 1. The land use land cover classes from the different satellite images were generated by supervised Image Classification technique by using SCP plugin in QGIS software.

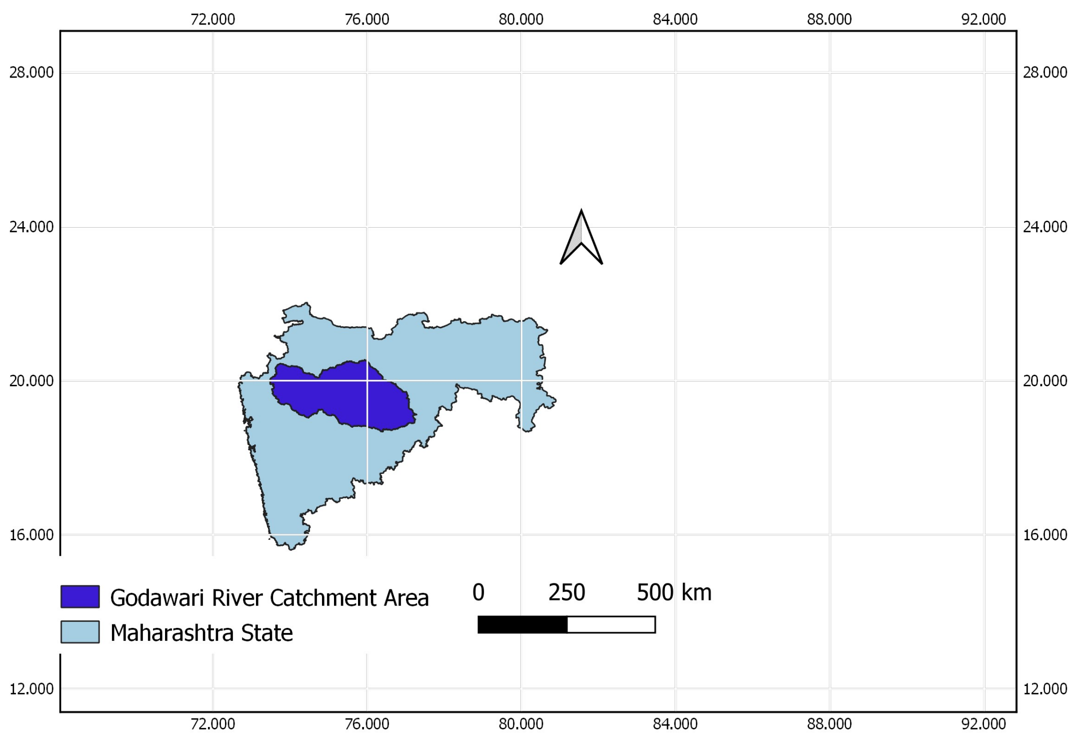

Figure 1. Location of study area.

Quantum GIS (QGIS) is a open-source desktop geographic information system application that provides data viewing, editing, and analysis of remote sensing data. QGIS 3.10.6 have been used to process the data. Semi-Automatic Classification Plugin was used for Image Classification and Change Detection. Figure 2 shows the LULC map for the study area for the year 2009. Similarly Figure 3 and Figure 4 represents the LULC map for the year 2014 and 2019 respectively.

The widely adopted approach for detecting alterations in Land Use and Land Cover (LULC) is the post-classification comparison technique, primarily relying on supervised maximum likelihood classification. Figure 2 represents the road map of the study. This technique involves the use of a supervised classification method to create the land use land cover map. In supervised classification, clusters are formed based on the comparable spectral characteristics found in the image. The algorithm categorizes pixels into spectral classes to generate a comprehensive understanding of the landscape. Supervised classification generates clusters based on similar spectral characteristics inherent in the image. The algorithm groups pixels into spectral classes. It is most often executed through

Table 1. Satellite images and their characteristics used in the study.

S. No.	Satellite	Sensor	Spectral Bands	Month/Year of Acquisition
1	LANDSAT 5	TM	7	2009
2	LANDSAT 8	OLI/TIRS	11	2014
3	LANDSAT 8	OLI/TIRS	11	2019

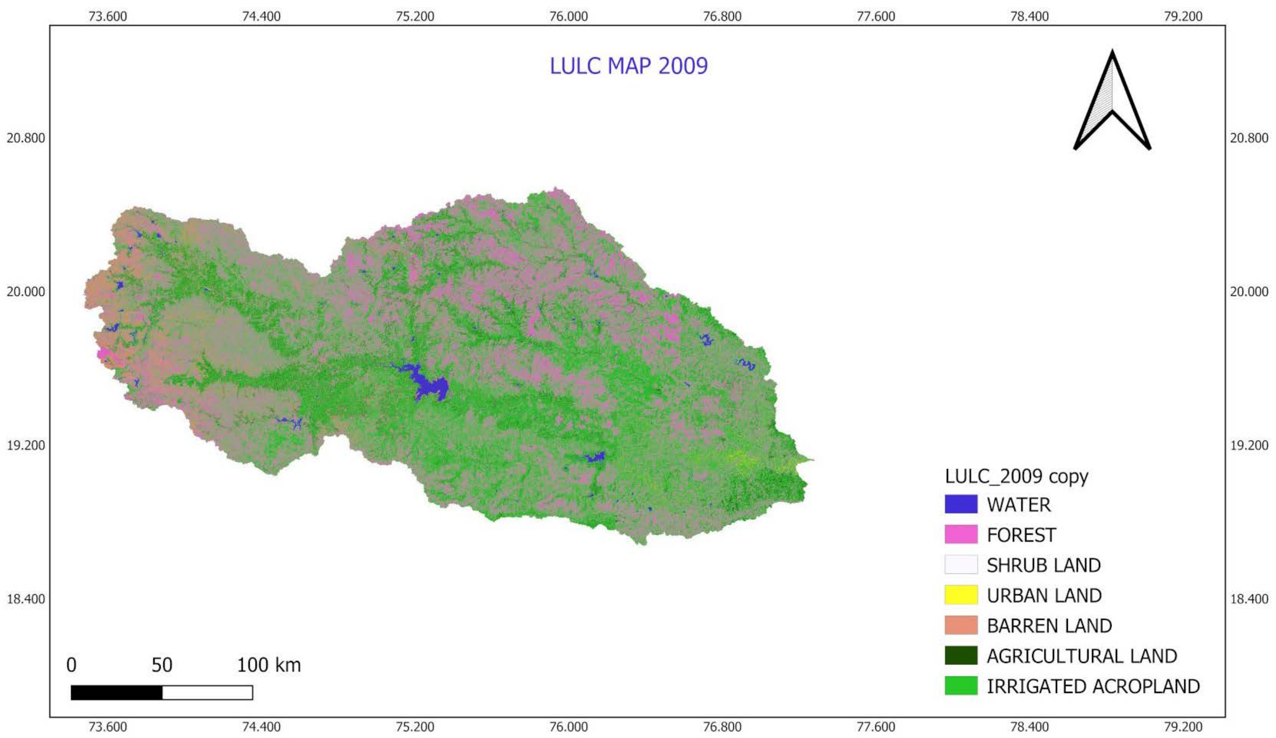

Figure 2. Land use land cover map (Year-2009).

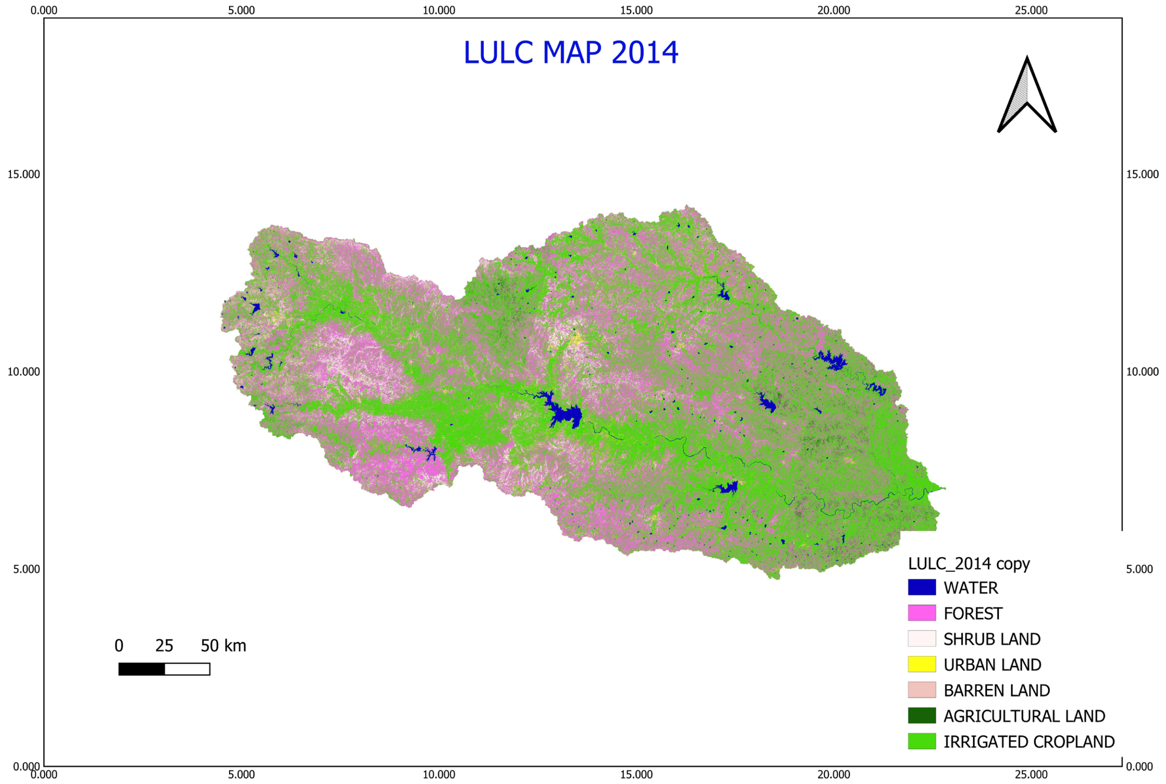

Figure 3. Land use land cover map (Year-2014).

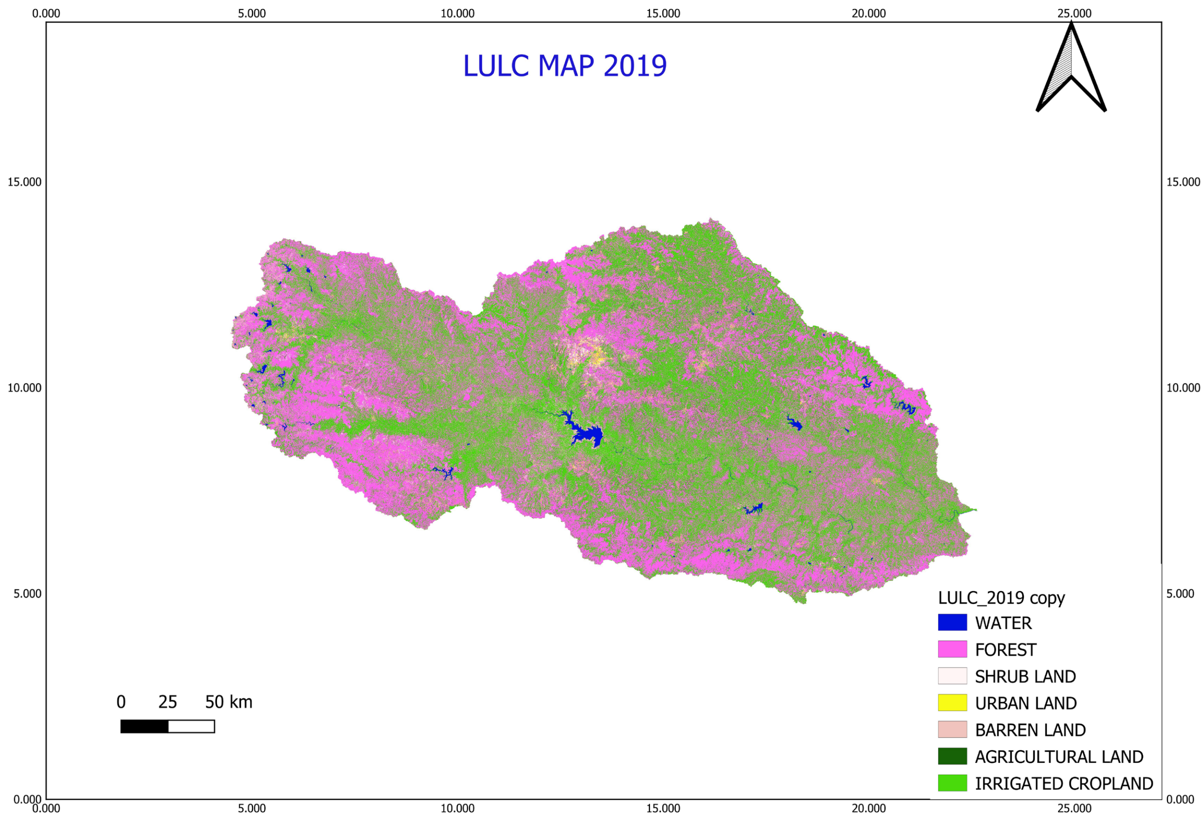

Figure 4. Land use land cover map (Year-2019).

clustering method. The ISO data Clustering Algorithm is a well-known algorithm deployed in implementing Unsupervised Classification [12]. This type of classification is generated based on the computed algorithm embedded within the GIS software. In QGIS, supervised Classification was conducted using the Semi-Automatic Classification Plugin. The accuracy assessment has been carried out by applying random points in accuracy assessment window. In this study, accuracy assessment of the resultant classified images was carried out to determine the quality of information derived from the data which is collected by using GPS from ground truth and Google earth. The overall classification accuracy in this land use land cover classification, 80% and Kappa Statistic of 71.9%. Forest, Irrigated Cropland, Agricultural land, Barren Land, Shrub Land, Water, Urban Land were chosen as the 07 key LULC classes for mapping the entire study area. The agricultural land under irrigation had a comparable spectral response, hence the area under agricultural was classified into two categories as Irrigated Cropland and agricultural land showing Fallow Land only.

2.3. LULC Change Detection

A post-classification change detection approach was used to examine the changes. In recent decades, many change-detection methodologies have been developed, including image differencing, post classification change matrix, comparison methodology, and principal component analysis [10] [13]. A pixel-based comparison method was used to produce the changes in LULC using QGIS. A Comparison methodology was built from 2009-2014 to 2014-2019 to assess the overall changes in land-use classifications between 2009 to 2019. In the comparison methodology, the total increase or reduction of each class of land cover is assessed as a percentage of the original area and change in each class of land cover is determined quickly and accurately.

3. Result and Discussion

In this paper, changes in the land use and land cover of Godavari basin are assessed between 2009, 2014 and 2019 ten years of period (2009-2019). The findings of the present examination are displayed in **Table 2**. **Figure 5** indicates the total percentage area of the three respective years 2009-2014-2019 expressed in the form of Bar Chart.

Relative changes in land uses of the Godavari River Basin under study were assessed based on data presented in **Table 2** and **Table 3**. Trends of land use changes from 2009-2019 showed some negative changes; but land use changes pattern from 2014-2019 showed comparatively better changes than 2009-2014 time period (**Figure 6**).

Irrigated Cropland:

These are the areas with standing crop as on the date of Satellite overpass. Cropped areas appear in bright red to red in colour with varying shape and size in a contiguous to non-contiguous pattern. They are widely distributed indifferent terrains; prominently appear in the irrigated areas irrespective of the source

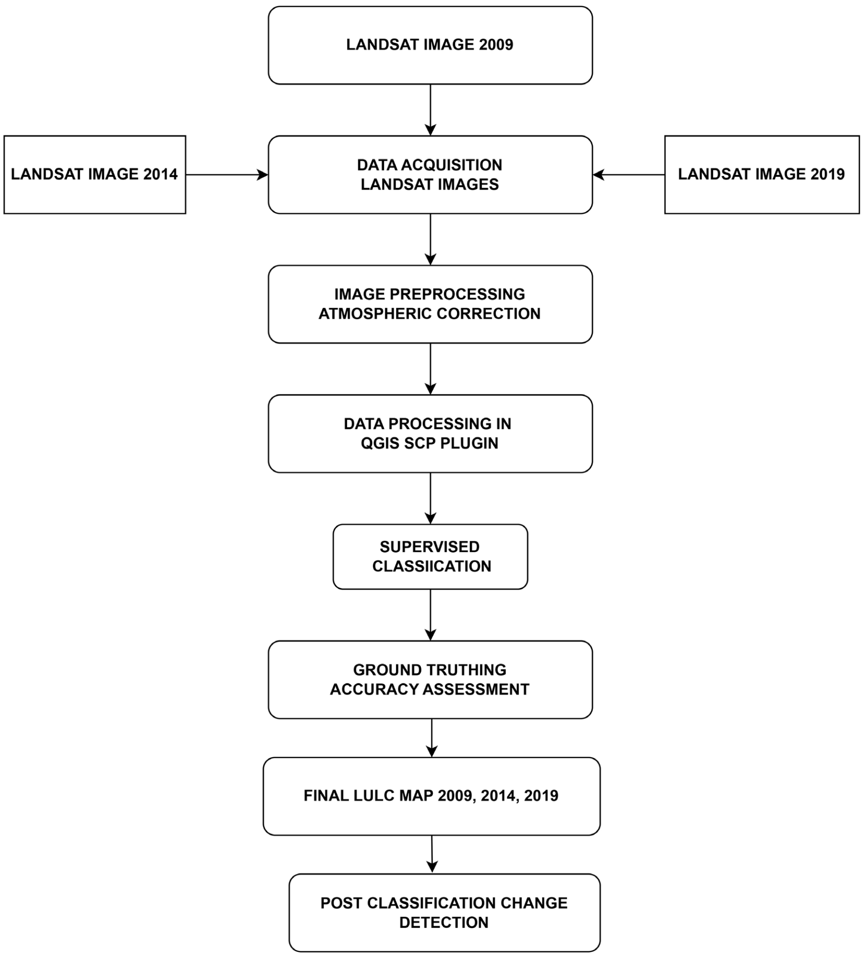

Figure 5. Road map of study.

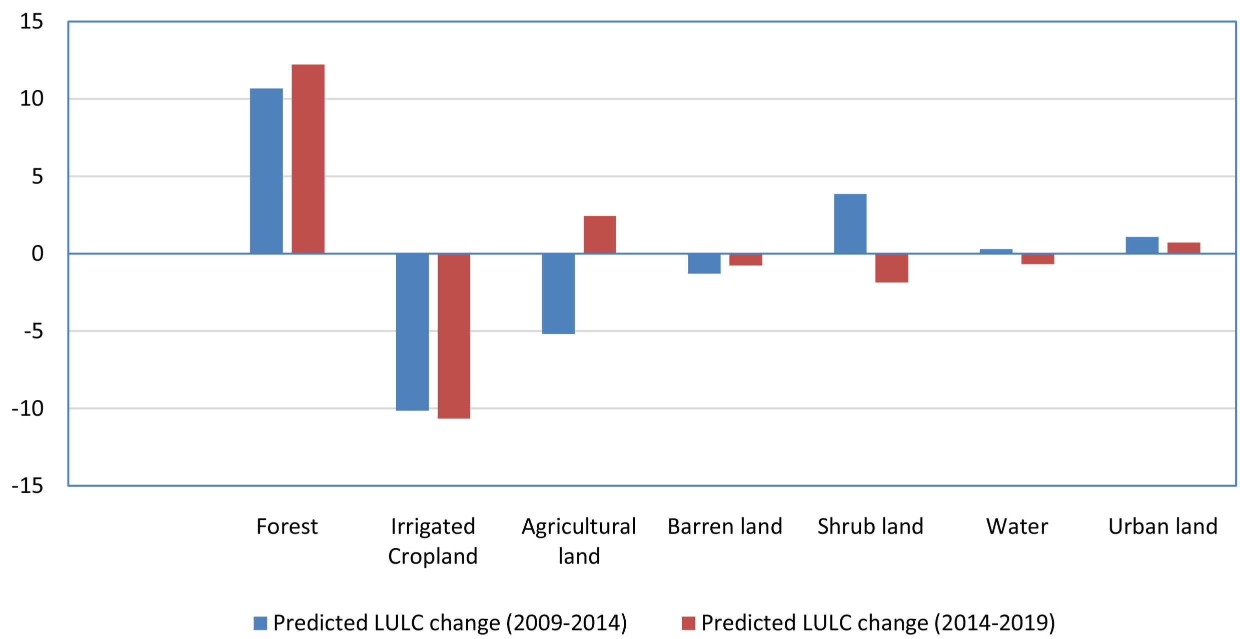

Figure 6. Predicted land use land cover change for three respective years of 2009-2014-2019.

Table 2. Land use land cover change analysis of the Godavari River basin 2009-2014-2019.

Land use Land Cover	2009 Scenario		2014 Scenario		2019 Scenario	
	Area [ha]	% Watershed	Area [ha]	% Watershed	Area [ha]	% Watershed
Forest	1354702.93	26.37	1902982.75	37.04	2525748.96	49.27
Irrigated Cropland	3202254.61	62.32	2680822.07	52.17	2128297.49	41.52
Agricultural land	315176.31	6.13	48148.85	0.94	173396.78	3.38
Barren land	201105.73	3.91	134728.02	2.62	95112.73	1.86
Shrub land	2400.79	0.05	201088.15	3.91	104850.75	2.05
Water	55277.84	1.08	70723.85	1.38	35626.33	0.70
Urban land	7257.27	0.14	63030.14	1.23	99666.88	1.94

Table 3. Predicted LULC change (2009-2014) and (2014-2019) of the Godavari River Basin under study.

Land use Land Cover	Predicted LULC change (2009-2014)		Predicted LULC change (2014-2019)	
	Area [ha]	%Watershed	Area [ha]	%Watershed
Forest	548279.82	10.67	622766.21	12.23
Irrigated Cropland	−521432.54	−10.15	−552524.58	−10.65
Agricultural land	−267027.46	−5.19	125247.93	2.44
Barren land	−66377.71	−1.29	−39615.29	−0.76
Shrub land	198687.36	3.86	−96237.4	−1.86
Water	15446.01	0.3	−35097.52	−0.68
Urban land	55772.87	1.09	36636.74	0.71

of irrigation showing variation from 62.32% of watershed area in2009 to 41.52% of watershed area in 2019.

Agricultural Land:

An agricultural system with an alternation between a cropping period of several years and a fallow period. In other terms these are the fallow lands, which are taken up for cultivation but are temporarily allowed to rest, un-cropped for one or more season, but not less than one year. The agricultural fallow land is showing considerable variation from 6.13% of watershed area in 2009 to 0.94% of watershed area in 2014 and come down upto3.38% of watershed area in 2019.

Shrub Land:

These areas possess shallow and skeletal soils, at times chemically degraded extremes of slopes, severely eroded or subjected to excessive aridity with shrubs dominating the landscape. It increased from 0.05% of watershed area in 2009 to 3.91% of watershed area in 2014 and afterwords decreased to 2.05% of watershed area in 2019.

Water Bodies:

This category comprises areas with surface water in the form of ponds, lakes, tanks and reservoirs. Water bodies seem dim on satellite symbolism because of absorption of approaching IR radiation. Water bodies showing decreasing trend from 2009 about 1.08% of watershed area to 0.70% of watershed area in the year 2019.

Forest Land:

Forest land contributed the overwhelming area increasing spread category in the examination from 26.37% of watershed area for year 2009 to 49.27% of watershed area in the year 2019. Forest land has been partitioned into various categories like Deciduous, Forest Manor, Clean Forest and Vegetated Zone.

Barren Land:

This category includes areas such as Salt affected land, Shrub Land-Dense shrub, and Shrub Land-Open shrub. It is identified with light tone and smooth to coarse texture on image. These are geographical extent of 3.91% of watershed area for year 2009. Showing decreasing trend in 2019 from about 2.62% of watershed area in 2014 to 1.86% of watershed area.

Urban Land:

The urban land is showing rising trend respectively from the year 2009 to 2019. Urban areas are non-linear built-up areas covered by impervious stakeholders for the decision-making process. This study can provide significant input for spatial planning and environmental structures adjacent to or connected by streets. This cover is related to centers of population. This class usually occurs in combination with, vegetated areas that are connected to buildings that show a regular pattern, such as vegetated areas, gardens etc. and industrial and/or other areas [14] [15].

4. Conclusions

During this study, we took a close look at how the way land is used and covered in the Godavari Basin of Maharashtra changed between 2009, 2014, and 2019. The analysis showed big shifts in important areas like farming land, shrub-covered areas, water bodies, and urban spaces. These findings tell us a lot about how the region's landscape changed during this time.

Having accurate information about how land is classified is really important, especially when it comes to protecting the environment and planning for the future. The data we gathered in this study is a valuable tool for making smart decisions and planning ahead, which helps in ensuring the Godavari Basin can develop in a way that is sustainable and preserves the environment.

The specific reasons behind the observed changes in land use and cover in the Godavari Basin of Maharashtra between 2009, 2014, and 2019 can be complex and multifaceted. Several factors may contribute to these shifts, and a comprehensive understanding often requires more detailed research. However, here are some common reasons that could influence changes in the mentioned areas.

Population growth and rubanization, agricultural practices and technology, changes in farming methods, crop patterns, and the adoption of new agricultural technologies impact the changes in land use land cover.

Alterations in water management and irrigation practices can affect the distribution of water bodies and impact surrounding land.

It's important to note that these reasons are interconnected, and changes in one aspect can have cascading effects on others. Additionally, site-specific conditions and local dynamics play a crucial role in determining the factors influencing land use changes in a particular region.

A key part of our research was using a software called Quantum Geographic Information System (QGIS), which is a popular open-source tool in the field of geospatial analysis. QGIS played a central role in looking at satellite images comprehensively, making it easier to analyze and visualize complex spatial data. Its user-friendly nature makes it an essential tool for researchers and professionals to gain meaningful insights from intricate spatial information.

The satellite data we used in this study had a special ability to quickly and accurately show us changes in how land is used. This is crucial for keeping an eye on how the environment is changing in real-time. Being able to identify changes promptly in farming areas, shrub-covered areas, water bodies, and urban spaces provides important information for managing land, allocating resources, and creating policies.

Combining advanced satellite technology, open-source tools like QGIS, and dedicated research, we've learned a lot about how land is being used in the Godavari Basin. The knowledge gained from this study not only helps us understand how the environment is changing in the region but also sets the groundwork for managing land in a sustainable way. Using satellite-based methods and working together will continue to be crucial for keeping track of future changes and making smart decisions for the conservation and development of the Godavari Basin.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Chaudhary, B.S., Saroha, G.P. and Yadav, M. (2018) Human Induced Land Use/Land Cover Changes in Northern Part of Guragon District, Haryana, India. *Journal of Human Ecology*, **23**, 243-252. https://doi.org/10.1080/09709274.2008.11906077

[2] Halimi, M., Sedighifar, Z. and Mohammadi, C. (2018) Analyzing Spatiotemporal Land Use/Cover Dynamic Using Remote SensGIS Techniques Case: Kan Basin of Iran. *GeoJournal*, **83**, 1067-1077. https://doi.org/10.1007/s10708-017-9819-2

[3] Ozesmi, S. and Bauer, M.E. (2002) Satellite Remote Sensing of Wetlands. *Wetlands Ecology and Management*, **10**, 381-402. https://doi.org/10.1023/A:1020908432489

[4] Zsuzsanna, D., Bartholy, J., Pongracz, R. and Barcza, Z. (2005) Analysis of Land-

Use/Land-Cover Change in the Carpathian Region Based on Remote Sensing Techniques. *Physics and Chemistry of Earth*, **30**, 109-115. https://doi.org/10.1016/j.pce.2004.08.017

[5] Appiah Mensah, A., Akoto Sarfo, D. and Partey, S. (2018) Assessment of Vegetation Dynamics Using Remote Sensing and GIS: A Case of Bosomtwe Range Forest Reserve, Ghana. *The Egyptian Journal of Remote Sensing and Space Science*, **22**, 145-154. https://doi.org/10.1016/j.ejrs.2018.04.004

[6] Harshada, K. and Ingle, S. (2012) Land Use Land Cover Classification and Change Detection Using High Resolution Temporal Satellite Data. *The Journal of Environment*, **1**, 146-152.

[7] Wu, Q., Li, H.Q., Wang, R.S., Paulussen, J., He, H., Wang M., Wang, B.H. and Wang, Z. (2006) Monitoring and Predicting Land Use Change in Beijing Using Remote Sensing and GIS. *Landscape and Urban Planning*, **78**, 322-333. https://doi.org/10.1016/j.landurbplan.2005.10.002

[8] Congedo, L. and Munafò, M. (2014) Urban Sprawl as a Factor of Vulnerability to Climate Change: Monitoring Land Cover Change in Dar es Salaam. In: Macchi, S., Tiepolo, M., Eds., *Climate Change Vulnerability in Southern African Cities*. Springer, Cham, 73-88. https://doi.org/10.1007/978-3-319-00672-7_5

[9] Alawamy, J.S., *et al.* (2020) Detecting and Analyzing Land Use and Land Cover Changes in the Region of Al-Jabal Al-Akhdar, Libya Using Time-Series Landsat Data from 1985 to 2017. *Sustainability*, **12**, 4490.

[10] Al-Rubkhin, A.N.M., Talal, A. and Mohammed, A. (2017) Land Use Change Analysis and Modeling Using Open Source (QGIS) Case Study: Boasher Willayat. Dissertation Report. Sultan Qaboos University, Muscat.

[11] Guerschman, J.P., Paruelo, J.M., Bela, C.D., Giallorenzi, M.C. and Pacin, F. (2003) Land Cover Classification in the Argentine Pampas Using Multi-Temporal Landsat TM Data. *International Journal of Remote Sensing*, **24**, 3381-3402. https://doi.org/10.1080/0143116021000021288

[12] Dwivedi, R. and Ramana, K.V. (2005) Land-Use/Land-Cover Change Analysis in Part of Ethiopia Using Landsat Thematic Mapper Data. *International Journal of Remote Sensing*, **26**, 1285-1287. https://doi.org/10.1080/01431160512331337763

[13] Al-Doski, J. and Mansor, S.B. (2013) Change Detection Process and Techniques. *Civil and Environmental Research*, **3**, 37-45.

[14] NBSS & LUP Annual Report (2016) National Bureau of Soil Survey and Land Use Planning (I.C.A.R.). Nagpur.

[15] ISRO, NRSC. (2012) Manual of National Land Use/Land Cover Mapping (Second Cycle) Using Multi-temporal Satellite Data. Department of Space, Hyderabad.