Unveiling the changing landscape of the Krishna Delta: a geospatial approach

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Abstract:

Land use / Land cover (LULC) change detection is a process that involves identifying and analyzing alterations in LULC patterns over time. It is a critical component of environmental monitoring, as it provides valuable information about the dynamics of the Earth's surface. The Indian coastline is a tapestry of diverse ecosystems, and the Andhra Pradesh coast, particularly the stretch between Bapatla and Machilipatnam. This area is a fascinating case for studying LULC change by employing remote sensing and Geographic Information Systems (GIS) techniques. An on-screen visual interpretation was carried out on Landsat 5 TM and sentinel 2B digital imageries for the years 2003 and 2023 respectively. The LULC is categorized into twelve classes i.e.,abandoned aqua ponds, Agri-based Industry, agriculture, aqua ponds, Built-up, Degraded Forest, Mangrove Forest, mudflats, saltpans, sandy area, Plantation, and water bodies. The observation shows a main change in the Mangrove Forest, an increase of 6.39%. As The Forest Department of Andhra Pradesh has taken up the mangrove afforestation. Their expansion helps combat climate change by reducing greenhouse gas levels. Increased mangrove cover supports fisheries and eco-tourism, providing a source of income for local communities. Additionally, healthy mangroves reduce the need for expensive seawalls and other coastal protection measures. Aqua ponds have an increase of 4.27%. This 4.27% increase, suggests a potential shift from abandoned aqua ponds to functional ones, and agricultural land has shown a decrease of 0.62% from 2003 to 2023.

Keywords: Krishna Delta, LULC, Remote Sensing, GIS, and visual interpretation.

1. Introduction:

The Krishna Delta is one of the major delta systems along the east coast of India covering an area of 7,278 km2 in the Krishna and Guntur districts of Andhra Pradesh, originating in the Western Ghats, this region forms a sprawling delta as it cumulates into the Bay of Bengal. It has a coastline of about 246 km. The area is served by the Krishna Canal system and other drains. The delta soils are the most fertile. In deltaic alluvium, two crops are harvested every year. Paddy

and sugarcane are extensively raised on these lands. The area experiences a dry, sub-humid, mega thermal climate with oppressive summer and good seasonal rainfall. The southwest monsoon sets in the second week of June and lasts till September end. October and November receive rainfall from northeast monsoon. The entire Krishna Delta covering an area of 4736 sq.km has brought to light a number of geomorphic features such as flood plains, ancient channels, natural leeves, ancient beach ridges and swales, mangrove swamps, and tidal flats. (K. Nageswara Rao and R. Viadyanadhan,1981.) The geographical features of the delta, including its flat terrain and regular water supply from the Krishna River, have made it one of the agriculturally productive regions in India.Geomorphic expression of the variety of landform units exposed in the Krishna Delta is a manifestation of complex interplay of riverine and marine processes in space and time. The dominance of fluvial processes is largely responsible for the progradation of the delta (M. Anand Rao et.al.,2006). It is observed that there is a net increase in the extent of mangroves, indicating a better protection to the town against tropical storms. The unplanned growth of aquaculture may be an amplifying factor for coastal flooding, particularly if it is interfering with the drainage system (M.V.Ramana Murty.et.al.,2023).

Land cover change is a dynamic phenomenon addressing environmental issues including natural calamities. Recent advancements in geospatial technology and availability of remote sensor data have fostered monitoring and mapping of land cover changes more precisely. Remote sensing is widely used where emerging research findings are focused mainly on coastal hazard studies(K. Nivedita Priyadarshini et al., 2019).Land is a natural resource in which all ecosystem depends on its productivity. The land-use and land cover pattern of a region is a tangible result of natural and socio-economic factors and their utilization by man in time and space. Land use and land cover statistics are important information to analyse the changes of land use and land cover(Dr. N. Victor Babu and G. Ashenafi Tolessa,2013).The growth of computer technology and the launch of Landsat satellites have made it easy to trace the changes and advances that have happened over the many previous decades. Remote sensing technology coupled with a GIS has been advantageously utilized in the detection of numerous environmental features, i.e., vegetation covering, urban sprawls, transition in forests, and specific variations in LULC changes over specified periods (Roy & Roy, 2010). It has been noted that remote sensing and GIS techniques give more accurate and cost-efficient data assessment compared to other traditional procedures and surveys.

The study of LULC in part of Krishna Delta has attempted to identify the change phenomenon of land use/land cover. The outputs of the present study help in understanding the spatial extent of various LULC categories and associated water systems in this region. Remote sensing and GIS technologies can be effectively used in mapping and creating an updated spatial database on LULC.

2.Data Used:

Toposheets of 65 D/12, 15, 16, 65 H/03, 04,07,65 A/05, 09, 13, 14 and 66 E/01 of 1:50,000 collected from Survey of India (SOI). To study LULC changes two multispectral satellite images were acquired for 2003(LANDSAT 5), and 2023(SENTINEL 2B) were obtained from United States Geological Survey (USGS) and Copernicus.

3.Study Area:

The Study area is a part of the Krishna Delta covering an aerial extent of 3754 sq. km. It covers between 80˚20'00" to 81˚20'00" E longitude and 15˚40'00"to 16˚20' 00" N latitude (Figure.1)The area has a coastline of about 190 km.The Krishna Delta, a vast expanse of fertile land formed by the Krishna River's depositional processes, is a significant geographical and ecological region in India. Located primarily in Andhra Pradesh, it has been a cornerstone of the region's agriculture and economy for centuries. The delta is characterized by its flat terrain, intricate network of rivers and canals, and rich alluvial soil. Mangrove forests once thrived along the coast, providing crucial ecosystem services.The delta is home to a rich biodiversity, including various flora and fauna adapted to the wetland environment.

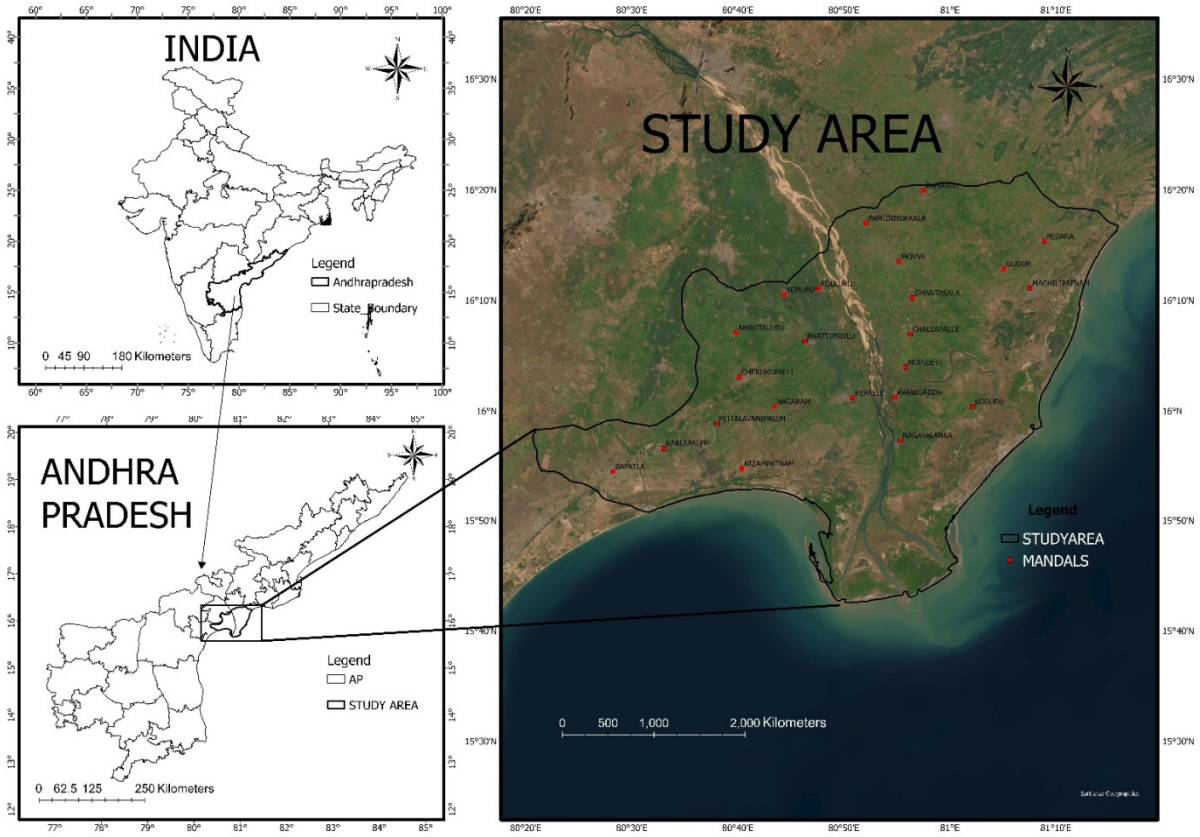

Figure.1: Location map of the study area

3.1 Geomorphology:

The area is basically occupied by deltaic and coastal plains. The landforms present in the area are mainly fluvial landforms and other forms are marine and Aeolian. Landforms derived from the streams are known as fluvial landforms, beach ridges, mangrove swamp shown in Figure. 2. These landforms can be due to erosional or depositional processes. The study area has common depositional landforms i.e. channel bars, Channel Islands, cut-off meanders, deltaic plains, meander scars, natural levees, oxbow lakes, and paleochannels.

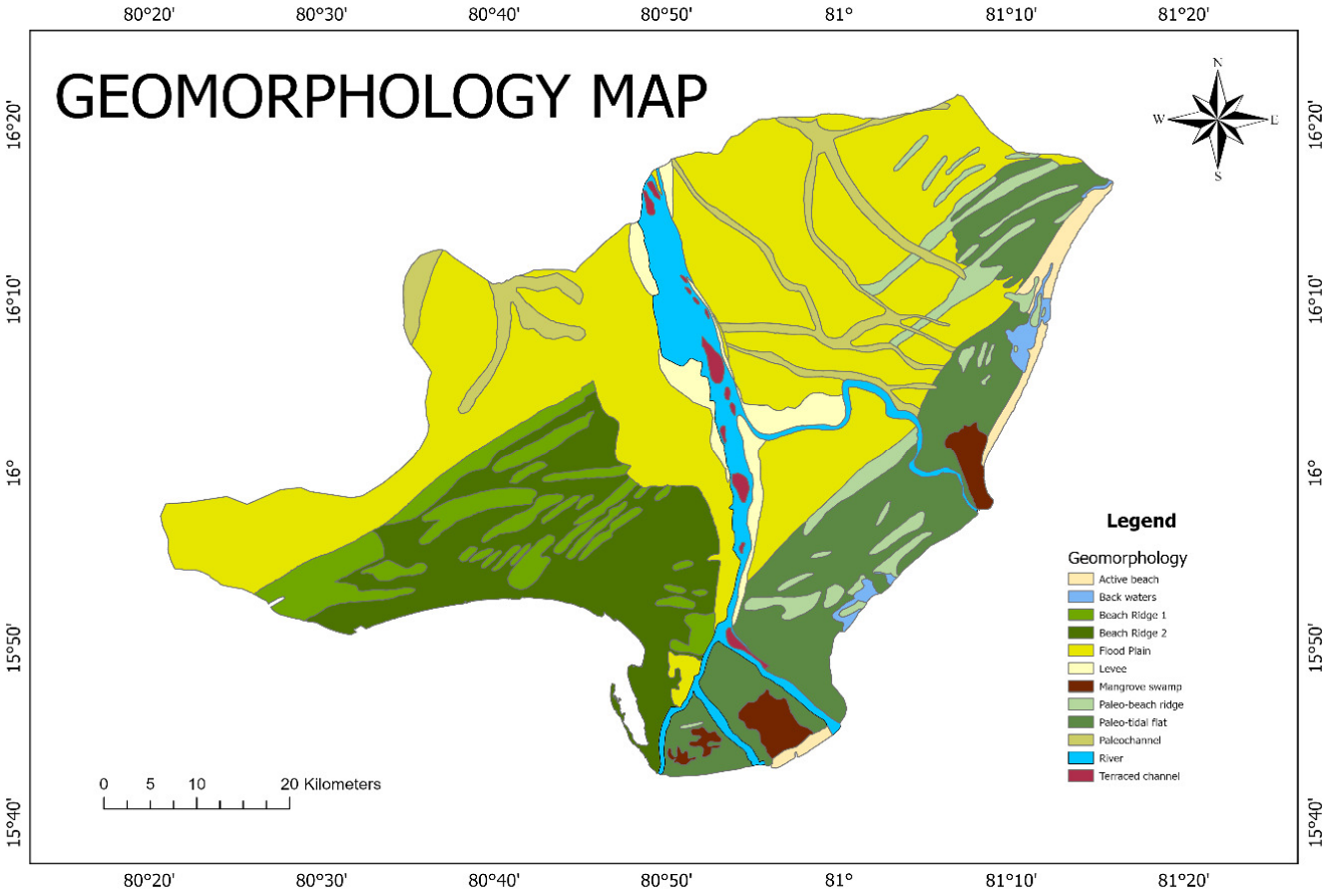

Figure. 2: Geomorphology map of the study area

4. Methodology:

The visual Interpretation technique has been adopted for the LULC classification followed by the guidelines of NRSC 1989. It is a fundamental method for detecting changes in LULC over time. It involves the human analysis of remotely sensed imagery to identify and map different land cover types and their changes. It offers unique advantages in terms of accuracy and detail. In this study, LULC features are categorized into twelve types namely, abandoned aqua ponds, Agri-based Industry, agriculture, aqua ponds, Built-up, Degraded Forest, Mangrove Forest, mudflats, saltpans, sandy area, waterbodies, and Plantation in the Figure-3. These twelve classes were identified based

on the visual interpretation of the satellite imagery coupled with field checks. These datasets were digitized and analyzed through ArcGIS ProSoftware to obtain LULC statistics for the areas under these categories for 2003 and 2023.

5. Results and Discussion:

Change detection analysis highlights the dynamism of land use categories within the study area. The Krishna Delta, situated at the confluence of the Krishna River and the Bay of Bengal, is a dynamic coastal ecosystem facing rapid environmental transformations.

Results from classified maps indicated that there is a decrease from 257.69 to 43.432 sq.km, an increase in Agri-based industry from 4.05 to 5.18 sq.km, a decrease in agriculture has been identified from 2251.64 to 2230.94 sq.km, an increase in aqua ponds from 281.85 to 441.95 sq.km, followed by built up from 238.54 to 286.73 sq.km, mangrove forest 58.51 to 298.27 sq.km, mudflats from 54.80 to 114.71sq.km,and a decrease in plantation from 151.65 to 126.26 sq.km, followed by saltpans from 45.62 to 38.28 sq.km, an increase in water bodies from 127.73 to 139.58 sq.km has been identified from 2003 and 2023 respectively.

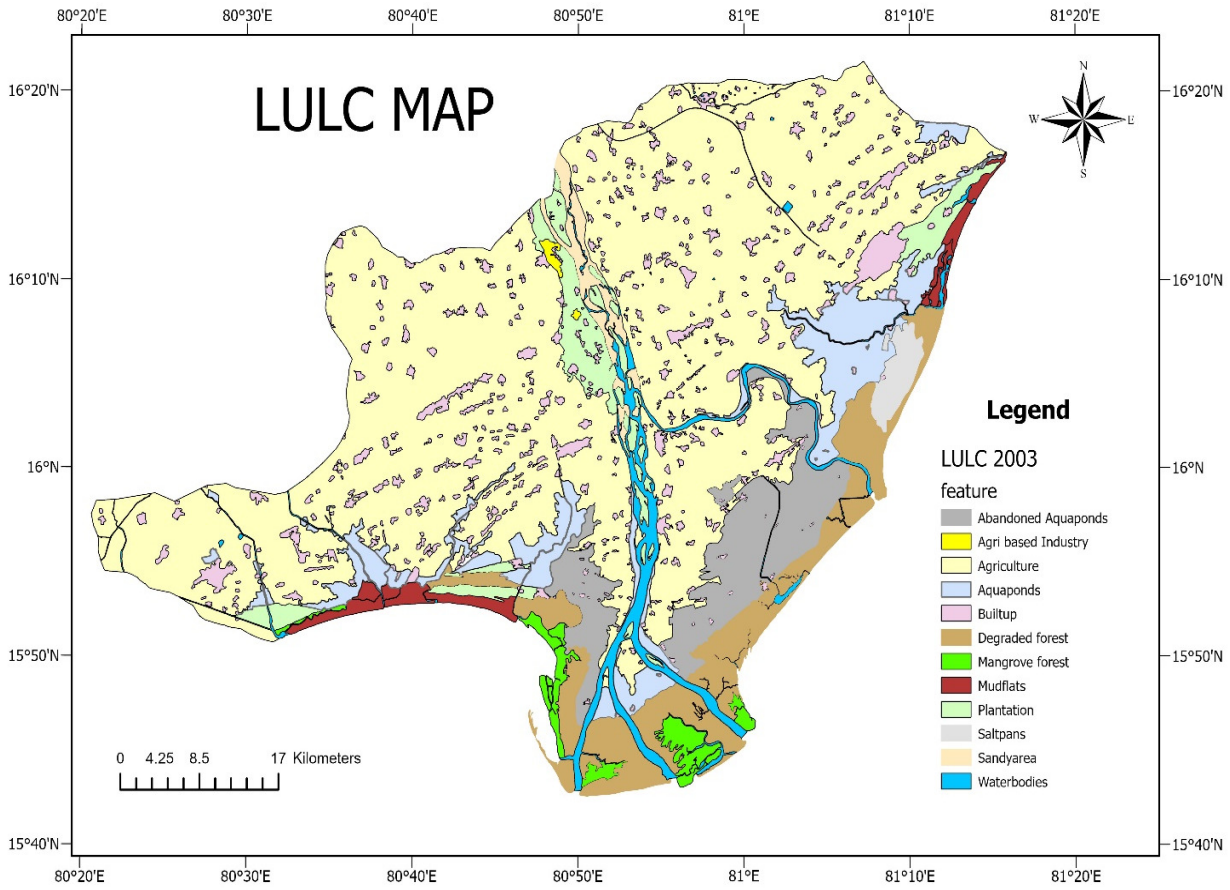

Figure.3:LULC map for the year 2003

The spatial distribution of land cover types within the study area is quantitatively presented in Table .1. And the graphical representation of the LULC classes for the year 2003 are in the Figure.4.

Table.1: LULC Distribution by Area (sq.km) in 2003

S.no	LULC feature	Area (sq.km)
1	Abandonedaqua ponds	257.69
2	Agri-based Industry	4.05
3	Agriculture	2251.64
4	Aquaponds	281.85
5	Built-up	238.54
6	Degraded forest	249.46
7	Mangrove forest	58.51
8	Mudflats	54.80
9	Plantation	151.65
10	Saltpans	33.24
11	Sandy area	45.62
12	Waterbodies	127.73

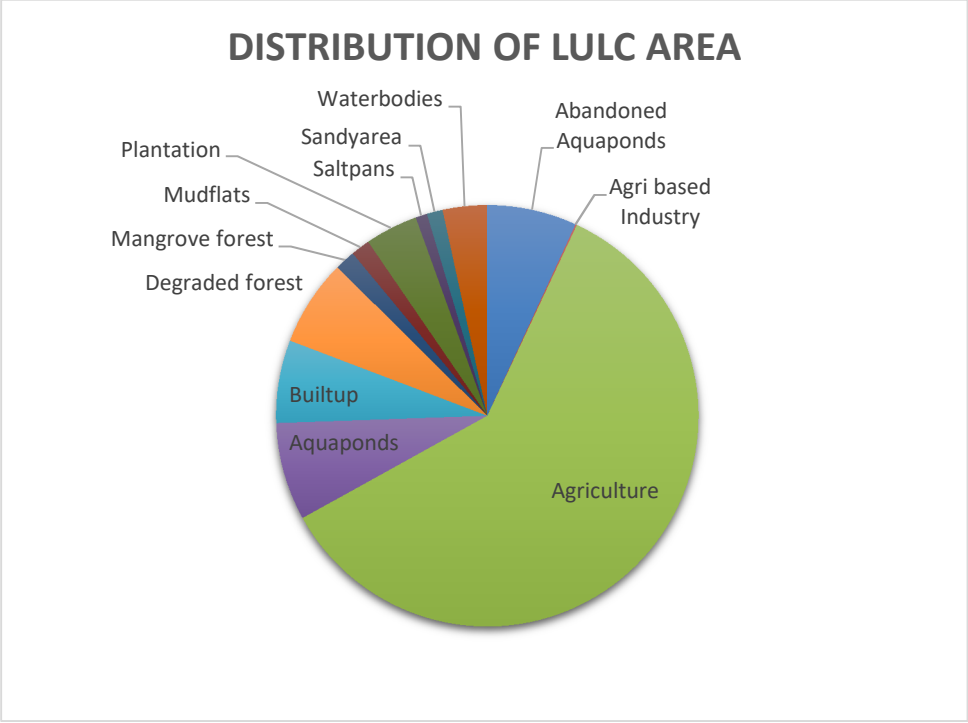

Figure.4: Graphical representation of the LULC classesarea (2003)

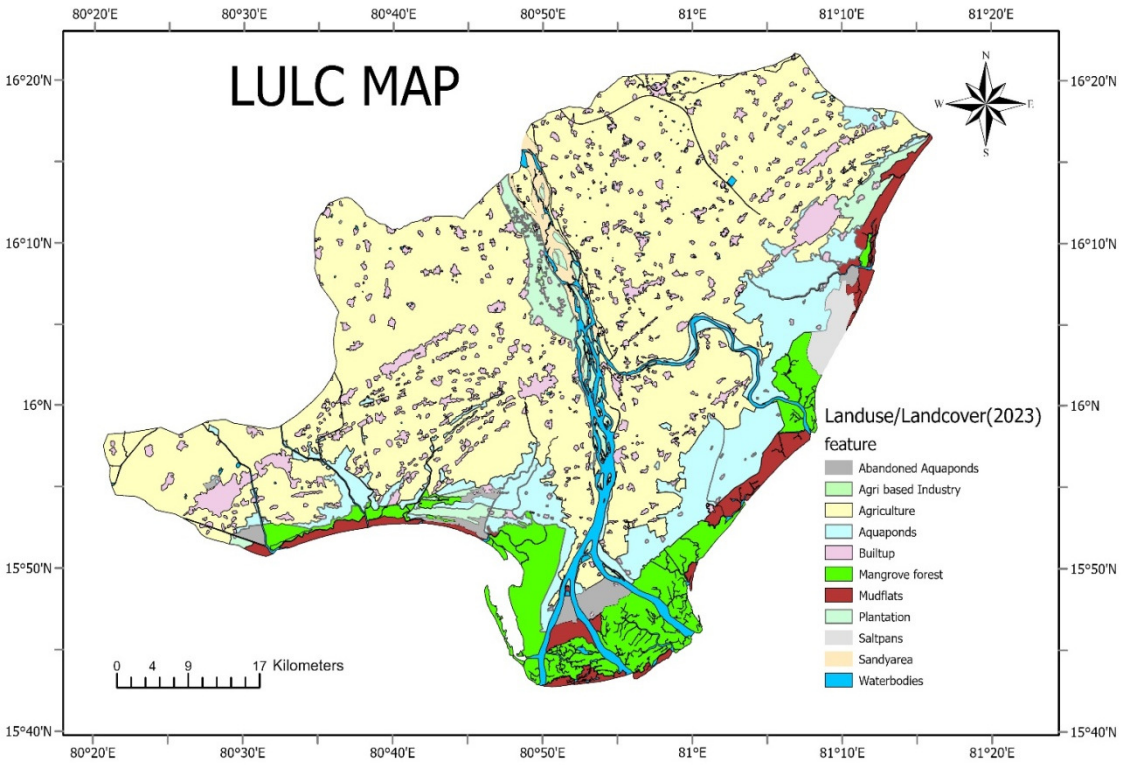

Figure.5: LULC map for the year 2023

The spatial distribution of land cover types within the study area is quantitatively presented in Table .2. And the graphical representation of the LULC classes for the year 2023are in the Figure.6.

Table .2: LULC Distribution Area (sq.km) in 2023

S.no	LULC feature	Area (sq.km)
1	Abandoned Aqua ponds	43.42
2	Agri based Industry	5.18
3	Agriculture	2230.94
4	Aqua ponds	441.95
5	Built-up	286.73
6	Mangrove forest	298.27
7	Mudflats	114.71
8	Plantation	126.26
9	Saltpans	29.56
10	Sandy area	38.28
11	Waterbodies	139.58

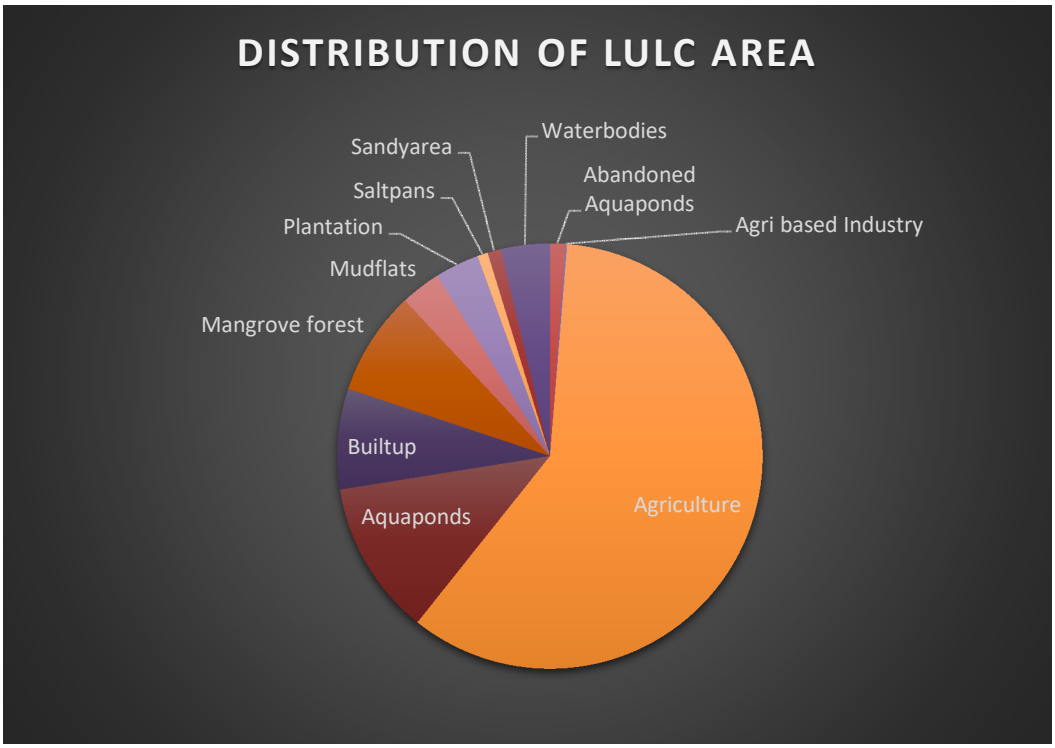

Figure.6: Graphical representation of LULC classes area (2023)

The Land use land cover changes in the study area for the years 2003 and 2023 given in Table .3. It quantifies the extent of increase or decrease for each category, allowing for a clear understanding of how the landscape has transformed over the past two decades.

Table .3: Land use/land cover changes for 2003 to 2023

S.no	LULC feature	Area (sq.km)		Percentage		Change %
		2003	2023	2003	2023	
1	Abandoned Aquaponds	257.69	43.42	6.68%	1.15%	-5.53
2	Agri-based Industry	4.05	5.18	0.10%	0.13%	0.03
3	Agriculture	2251.64	2230.94	59.96%	59.38%	-0.62
4	Aquaponds	281.85	441.95	7.50%	11.77%	4.27
5	Built-up	238.54	286.73	6.35%	7.63%	1.28
6	Degraded forest	249.46	-	6.64%	0.00%	-
7	Mangrove forest	58.51	298.27	1.55%	7.94%	6.39

8	Mudflats	54.80	114.71	1.45%	3.05%	1.6
9	Plantation	151.65	126.26	4.03%	3.36%	-0.67
10	Saltpans	33.24	29.56	1.08%	0.78%	-0.3
11	Sandy Area	45.62	38.28	1.21%	1.01%	-0.2
12	Waterbodies	127.73	139.58	3.40%	3.71%	0.31
13	TOTAL	3754.00	3754.00	100.00%	100.00%	

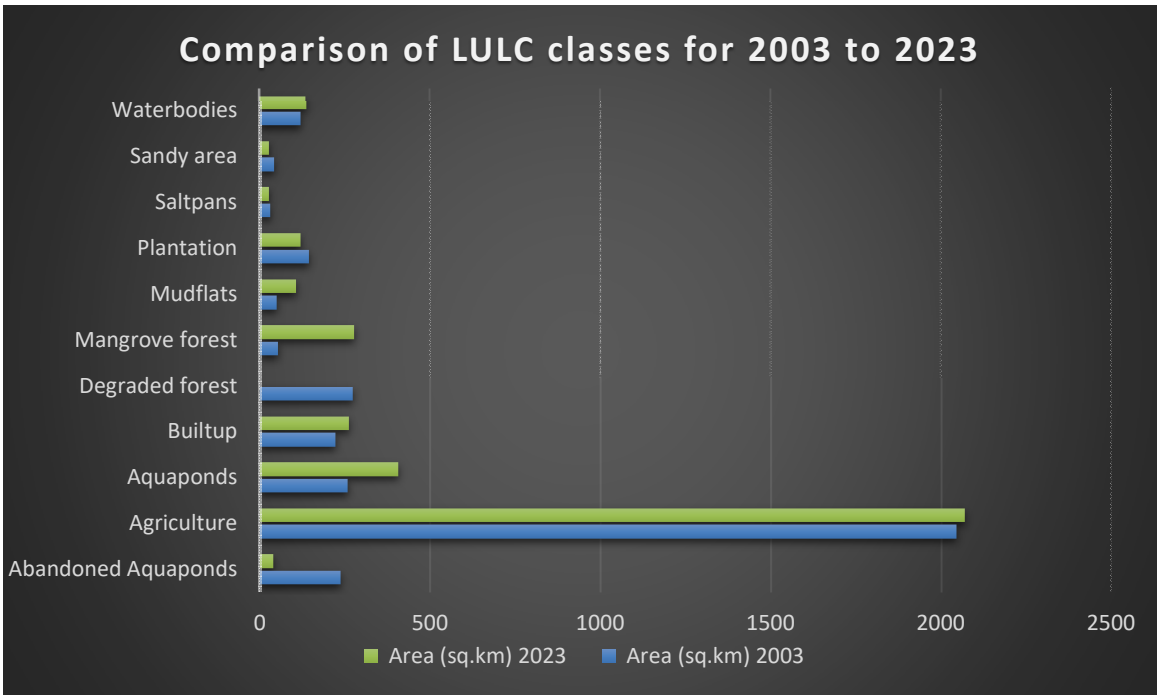

Figure.7: Comparison of LULC classes for 2003 to 2023

6. Conclusion:

The study showed that abandoned aqua ponds decreased in area by 214.27 sq.km i.e. 5.53% this change suggests that the abandoned aqua ponds are shifted into aqua ponds in usage. Agri-based Industry has shown an increase of 1.13 sq.km i.e.0.03%. A decrease in the agriculture area by 20.7 sq. km i.e. 0.62% has been identified due to the conversion of agriculture into aqua ponds.In coastal regions, land competition between aquaculture ponds and agricultural fields might exist. This could lead to a marginal decrease in agricultural land. Aqua ponds have increased in area by 160.1 sq.km i.e.5.53%, suggesting an intensification of aquaculture practices. Aquaculture, especially fresh water fish farming, requires a substantial amount of water. Increased aquaculture can put pressure on freshwater resources, impacting irrigation for agriculture. In coastal areas, excessive water extraction for aquaculture can contribute to saline water intrusion, affecting soil quality and

crop yields. Inefficient aquaculture practices can lead to water pollution through the release of nutrients, antibiotics, and other contaminants. This can affect soil quality and water availability.To minimize the negative impacts of aquaculture on agriculture, it's essential to adopt sustainable practices. An increase of 48.19 sq.km i.e.1.28% has been identified in Built-up, reflecting urban sprawl or development.The region has experienced rapid industrialization, attracting investments and labour, leading to increased urbanization. Improved transportation, communication, and public utilities have made the region more attractive for residential and commercial development. A degraded forest of area 249.46 sq.km i.e.6.64% has been identified in 2003, topographic maps indicate a significant decline in mangrove coverage within the Krishna Delta, suggesting a substantial degradation of its once vibrant ecosystem. The conversion of mangrove forests into aquaculture ponds, and saltpans has led to a significant loss of forest cover. Their wood has been used traditionally for firewood and charcoal production in coastal communities. However, The Forest Department of Andhra Pradesh has taken up the mangrove afforestation, and non-governmental organizations (NGO) also participated in the restoration of the mangrove forest in the region. A notable positive trend observed in the data is the increase in mangrove forest area by 239.76 sq.km which is 6.39% between 2003 to 2023. This growth from 53.83 sq.km in 2003 to 263.09 sq.km in 2023 highlights its successful conservation or restoration in the region. Mudflats have increased by 59.91 sq.km i.e.1.6%, which could be due to natural processes or sedimentation. Plantations have decreased by 25.39 sq.km i.e. 0.67% due to the increase in the Agri-based industries in the area. Sandy areas have shrunk by 0.2%, representing a loss of 7.34 sq. Km. The extraction of sand mining from riverbeds for construction purposes is a direct and significant contributor to the depletion of sand deposits. This practice not only removes sand directly but also disrupts the natural flow of the river, impacting sediment transport and deposition processes. Sand mining often occurs illegally and without proper regulation, exacerbating the problem. And an increase in the area of waterbodies by 11.85 sq.km i.e.0.31% has been identified in the study of LULC for the years 2003 to 2023 respectively.

References:

1. M.V. Ramana Murty, Ch. Ravi Kumar, K. Srinivasu, R. Kannan, B. Sundar,2023. “Monitoring of Coastal Geo-Environment for Hazard Mitigation: A Case Study of Machilipatnam Region, Andhra Pradesh, India.”American Journal of Geospatial Technology (AJGT),Vol1,Issue 2, pp 27-38,ISSN: 2833-8006.
2. Dr. v s r. Krishna (2021)“aquifer mapping and management plan of krishna deltaic area (parts of krishna and guntur districts), andhrapradesh”
3. K. Nivedita Priyadarshini, V. Sivashankari, and S. Shekhar,2019.“An assessment of land cover change dynamics of gaja cyclone in coastal tamilnadu, india using sentinel 1 sar dataset”The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,vol.42 ,pp:323-329.
4. Kubo Sumiko, K. Ch. V. Naga Kumar, Gajji Demudu, B. Hema Malini, K. Nageswara Rao, Ritesh Agrawal, Ratheesh Ramakrishnan, A. S. Rajawat,2017. “Monitoring of Eco-

Restoration of Mangrove Wetlands through Time Series Satellite Images: A Study on Krishna-Godavari Delta Region, East Coast of India",Geographical Review of Japan Series B 90(2), pp: 66–75.

5. Dr. N. Victor Babu and Ashenafi Tolessa, 2013. "Urbanization Trend Analysis of Greater Visakhapatnam Municipal Corporation (GVMC)", International Journal of Civil and Environmental Engineering, vol.35, issue.2 pp:147-1150 ISSN:1701-8285.
6. Roy, P. S., & Roy, A. (2010). "Land use and land cover change in India: Aremote sensing & GIS prespective". Journal of the Indian Institute of Science, 90(4), pp:489–502.
7. D. RamprasadNaik, T. Venkateswara Rao, B.S.Prakasa Rao and N. Venkateswarlu, 2009."Spatio -Temporal change study on Wetlands of Krishna delta using Remote Sensing Techniques"The Journal of Indian Geophysical Union,Vol.13, No.1, pp:25-32.
8. M. Anand Rao, S. Ramamurthy, B.M. Shah, V. Hanumantha Rao,2006 "Recent morphological changes along the Krishna delta shoreline",Journal of the Geological Society of India 67(5),pp:629-635.
9. K. Nageswara Rao and R. Vaidyanadhan, 1981. "Land-use capability studies from aerial photo interpretation – A case study from Krishna delta, India."Geographical review of India,Vol.43,no.3,pp:226-238.
10. United States Geological Survey (USGS) (http://glovis.usgs.gov).