International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

An Approach to Study the Change of Coastal Shoreline of Krishna District, Andhra Pradesh, India, using Remote Sensing and Geographic Information Systems

G.T. N. Veerendra, B.Kumarvel

Abstract*: The average global sea level rise has been rising from the past 30 years, the past tide gauge information shows, the rise was about 18 cm (7.1 in) above over a century from 1897-97. In most precise, data acquired from satellite radar shows the sea level rise was accelerated from 7.5cm (3 in) from the past 20 years. The speedup is due to many reasons, some of them like global warming, expansion of seawater, melting of polar ice sheets and glaciers. The current trend is expected to furthermore accelerate due to industrial revolutions, which led to the reduction of natural resources. In the present paper, a study area was chosen to evaluate the dynamics of the coast region, the location of the study area was across the sea coastline of Krishna district Andhra Pradesh, India, the process of evaluation undergo with available collateral data consists of top sheets and satellite data of Resourcesat and Landsat in comparison with sketch maps of delta of Krishna river prepared in the years 1897 and 1966. It was identified that the spread of erosion and deposition occurred in an average of above 10 sq.km. Which leads to the formation of both mangroves and settlements..

***Index Terms*: GIS - Geographical Information Systems, SOI- Survey of India, LISS- Linear Image Self Scanning Sensor.**

I. INTRODUCTION

The concern of human-induced global warming after the first industrial revolutions had made its mass exploration of people and resources from the coastline area, tends that perspective effects considerably high. It is projected that minimum 600 million population reside within the surroundings of 10m of present sea-level (SL) (McGranahan et al., 2007) on the other hand population are growing more rapidly, sea coast populated capitals are extremely threatened by rises in SL. Globally, small island nations are more vulnerable to the rise of sea level even for 1m. (Mimura N. et al, 2007). Hence, the 21st century is more concern about SL rise and its adverse threats. SL rise roots variation of impacts for seashore lands, which includes erosion, the salinity of the ecosystems, seawater intrusion, and submergence. In addition with the population rise, it is expected that a huge rise between 2100-2150 should possibly show severe threats, such as displacement of the outsized percentage of the seaside residents and economy (McGranahan, 2007). However, humans were adaptive to these changes with a wide choice of measures which can protect and planned accommodation, such adoptive nature can reduce possible impacts. In terms of protection, world's poorest countries, small islands are most affected and prone to massive displacement, the optimists assume, protection is unaffordable and may fail to lead to massive displacement of the population on an unpredictable scale (Nicholls.R, 2010). The pessimists believe that protection measures will be in widespread and were successful through the technological advancements like flood warning systems and monitoring of location with sensor assembly and IOT (Internet of Things) IOT. The study rise in sea level is most linear along by temperature, but the connection among temperature and SL is expected probably non- linear on past time scales.

This paper explores the areas that were undergone with erosion and deposition with the help of available maps which are developed during the 1890s and 1960s by the sophisticated engineers like Sir. Arthur cotton and so, supported with Survey of India (SOI) topographical maps of the study area (Krishna District, A.P, India) collectively geo-referenced and precisely merged/associated with INDIAN Remote Sensing Satellite Information in form of IRS- Resourcesat- LISS- IV, which has given the insight features and extraction of actual deposition / erosion of the area chosen for the paper. The results are mostly concern and were identified as vulnerable hotspots and newly formed sea beds with coastline villages/towns.

II. IPCC ASSESSMENT REPORT ON CLIMATE CHANGE

According to the Intergovernmental Panel on Climate Change (IPCC) Assessment report, the temperatures of earth surface could reach more than 40 C by the end of 21st century higher than the relative 1980 -99, also other models proposed by researchers and information by Special report on emission scenarios (SRES) were also confident that, the upper limits in temperatures will rise from 4.40 C to 6.40 C, therefore projected SL increase from 48 to 59 cm.

Revised Manuscript Received on 30 May 2019.
***** Correspondence Author
G.T.N.Veerendra, Research Scholar, Department of Civil Engineering, Annamalai University, Chidambaram, Tamil Nadu, India.
Dr. B. Kumarvel, Assistant Professor Department of Civil Engineering, Annamalai University, Chidambaram, India.

The mechanism that was applied to find the cause of the rise in SL was is the acceleration of ice-sheet melting vs the direct rate proposed by Meehl et al, 2007. On the other had several other alternate studies were also considered like kinetic constraints for the influence of ice glaciers and ice- tributaries to SL rise with the rate of potential glaciers (Pfeffer, et al, 2008) Also, the previous data related to ice core suggests that for the duration of the interglacial period, the mean temperature of the earth was 2-30 more than in the present, where the temperatures in a region-wide of Antarctica and Greenland was more than 50 (Jasen,E. et al., 2007). In the view of Kopp et al (Kopp, R. et al., 2009) the present day of melting process could contribute 0.92 m per century in SL rise. Alternatively, observations of temperature changes in the early start of the industrial era by Rahmstorf.S (2007) anticipated 0.5- 1.4m for SL rise from 1990 and gradually it may relatively high in 2100. The exploration of reasons behind the rise of the sea had given an opportunity to undertake some research studies to monitor the long term management of flood responses to sea. In connection, Delta commission of Netherlands (Delta Commission, 2008) had approached to explore the change possibility and impact scenarios in future of 2050, 2100 and 2200, through expert judgment and simulation model approaches. The authors had concluded that by 2100 the temperature rise will be by 60 C(31), however, Lenton, et al. (2008) had identified the difference of temperature variation in terms of local warming with a range of 5-80 C and 3-50 of global warming. Perhaps many studies conducted over uncertainty in SL rise globally, subject to the location, the global mean value could vary in terms of density of ocean and its spread to that area. A further local contribution of discharges from a freshwater lake to the ocean shall also show considerable level if the outflow was dominated, seawater intrusion to the flowing channels and canals. Also particularly in withdrawing of ground water and land filling are to be considered as severe threats.

III. DIVA MODEL

An integrated model like DIVA (Dynamic interactive vulnerability assessment model was a unified tool to evaluate the socio-economic and biophysical threats focussed by climate change and economic development. DIVA model is mostly attentive with flood rate, submergence, deposition, and erosion ratio of the target area also in connection with GDP and LULC (Land Use & Land Cover), in addition, the tool will act as a data information storage model with spatial reference of the location. The benefits of DIVA should not completely reliable, but the flood rate/submergence and erosion characteristics Dasgupta, et al. (2009). With reference to Bruun rule by Zhang, et al.,(2004), the coast erosion activity can be judged by both directly assessed by capturing the sediments and transferring to basins of tides and, an indirect method called ASMITA model by Zhang, K, et al. (2004). In the model over 200 of the large basins all over the world are measured, the process was to examine the progressive feed of seashore with waving action. According to Van Goor, et al. (2008). The impact in an area nearby sea coast zone was mostly affected by hurricanes, storms, high tides and an extreme increase of sea level and its intrusion as backwater effect to the rivers.

In the above view of mitigating strategies for SL rise, the planners have to assess about the action plans that are to be applied to mitigate the damage control of SL rise, either in the form of constructing dikes and its fixation of heights.

IV. GEOSPATIAL APPROACH FOR STUDYING COASTAL DYNAMICS

With reference to the previous studies on coastal change, areas like the Chukchi Sea, Alaska by Boad and Turner,2005 had undergone estimation for the position of sea shoreline using spatial - raster data sets. According to Chandrasekar, N., (2012) had identified that level was changed by >1m in response to the surges even with less range of tides consisting of 25 cm. Magesh et al. (2014), Sunil Kumar et al., (2006) further stated that change of landforms was a predominant action undergone due to hydro-dynamic pressure characteristics copping with tectonic plates and structured formation of continents in the southern region of India. The present study area was also had mostly undergone geo-morphological distortion occurred during Tsunami in 2004. (Chandra seaker et.al.,). The timeline features available with the help Geospatial technologies can give a real-time view of the coastland formations with required scales and accurate information in terms of shape, size and texture feature (Abermann et akl., 2010). Remote sensing and advanced surveying techniques can provide ground truth values which enable the user interface to explore larger areas in less time (Slaymaker, 2001). Also, techniques incorporated with computational algorithms can simplify the identification of geo-morphological landforms using raster data sets, pixel-based grouping and modeling techniques in GIS platform. (Dawson and Smithers, 2010). According to Mith & Clark (2005), the changes on land can be estimated and can be correlated with the help of datasets, also with field measurement can be helpful for monitoring the changes of coastal surface.

V. MIGRATION OF UPPUTERU RIVER MOUTH

The River Upputeru is the major channel flowing from the Kolleru Lake dividing twin deltas called Krishna and Godavari. The Upputeru channel was having length of approximately 49 km from the end point of Kolleru Lake to serve as a discharge path of water to the sea, the location was between 160 20' & 810 30' respectively, the area nearby the meeting of flooded water to the sea was previously enriched with huge number of coconut and Ttiky trees and etc. Mostly, the river mouth was served as flood out a passage for the water coming from the upstream side, infamous the Upputeru River was located at downstream side of Kolleru Lake. One of India's largest freshwater lake covered with two districts of Krishna and West Godavari.

The lake was a major tourist visited the place, on the other hand, many birds from other countries use to visit in winter seasons. According to statistics, the lake was a significant habitat for 20 million birds of home and travelers,With reference to the topographical data from Survey of India (SOI) from 1967, the main Upputeru channel has to flow nearby the villages of Pathapadu, Kalipatnam and should discharge at Yetiporu. The width of the channel was comparatively more at the end than the initial starting point, channel width was varying about 0.32 km at the diversion and was increased to 0.47 km at the final end discharge towards sea, the fig. 1 shows the old and actual mouth of Upputeru channel, later in the year 1989 as shown in the fig. 2 an artificial dredged channel was made by the local farmers for discharging more flood water occurred during heavy rains on the upstream side along with contributed percentage from Kolleru Lake, the satellite data of Indian Remote Sensing Satellite- Linear image Self Scanning Satellite(LISS)- II of the year 1989. The artificial dredged channel had managed to flood the surplus amount of water during monsoon season but had drastically changed the hydrodynamics of the old channel was completely changed, the variation difference can be seen in the fig.3 & 4 of IRS- LANDSAT TM & Linear Image Self Scanning Satellite (LISS) –III of the years 1999-2002.

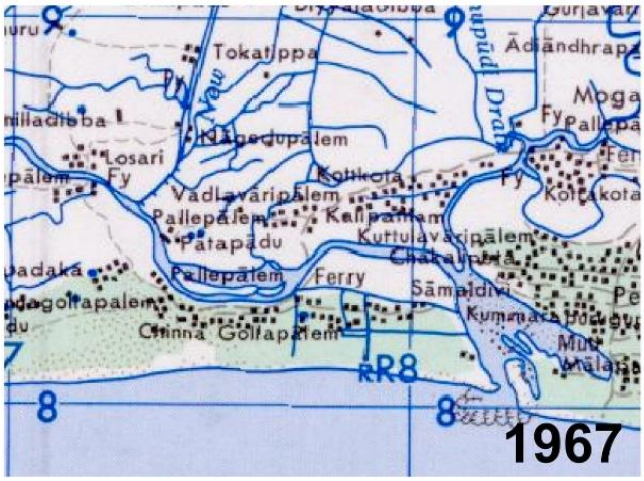


Fig: 1. A topographical sheet of the year 1967

The domination of sea currents on the outflow of the channel had managed to erode the tail end part, resulting in the submerging of land at the shoreline. On the other hand the artificial dredge of new channel had created an impact of diverting the surplus water occurred during the rainy season combined with actual flow of water to be discharged enrooted for sea, but the seasonal transform of the old mouth is due to lack of sufficient outflow had created intrusion of seawater and erosion of coastline land. In addition, the heavy diversion of water through the new channel had extended the width of the channel, because of change in seasonal outflow offshore exchange in the adjoining sea.

In fig. 5&6 the information from IRS-LISS- III&IV of 2002 and the recent years of 2015 also shown a drastic change of both straight cut and tail end part of the channel, by using spatial techniques it was identified that about 3.22 to 3.8 sq.km of area has been undergone erosion, soon it is expected to be a more change leads to more openings to the sea and more possibility for submerging the vegetation area.

Fig: 2. Indian Remote Sensing Satellite LISS-II of the year 1989

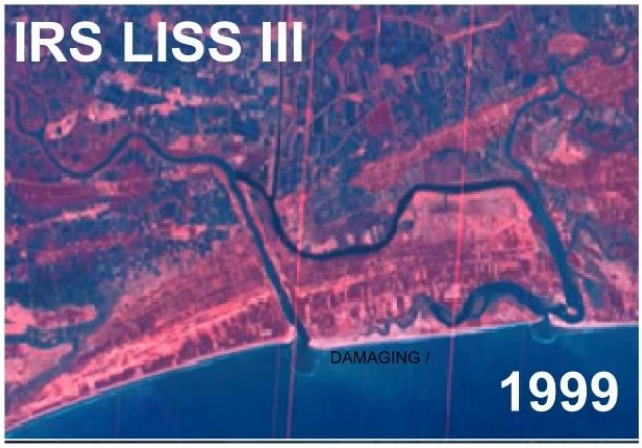


Fig: 3. Indian Remote Sensing Satellite- LANDSAT TM of the year 1999

Fig: 4. Indian Remote Sensing Satellite LISS-III of the year 1994

Fig: 6. Indian Remote Sensing Satellite LISS -IV of the year 2015

VI. GEOMORPHIC FEATURES STUDY OF KRISHNA DISTRICT, ANDHRA PRADESH, INDIA

The digitization techniques include identification of shape, size, and pattern and also based on the extraction of the desired feature of the proposed study area. The preparation of geomorphological map information of the area was combined extraction of the data from various topographical sheets and the available satellite data of Linear Image Self Scanning (LISS) - IV satellite information and Cartosat -2A. The classification of the features had given an opportunity to explore the morphological changes in terms of deposition or erosion and response of coastal process. The distribution of Geomorphological units are shown in the fig.7, the map was generated using toposheets of Survey of India (SOI), Geological Survey of India (GSI) maps of the entire district clubbed with Linear Image Self Scanning Sensor (LISS- IV) of the period 2015 satellite images were used to deliberate the distributed units within the coast area to understand coastal landforms and their changes

The coastal plain is nearly flat and gently sloped surface distributed long side of the seashore region, consists of sand, silt and clay, geomorphological terms such as vegetation, salt extracting ponds and creeks, which results in deposition of sand mounds. The length of the coastal plain of the study area was covered approximately 118 km. The occurrence of wave action, wind storms, and coastal currents results in the splashing and backwashing of inland deposits. (Ahmad, 1972). The spread of coastline was between the villages of Nachugunta, Gullalamoda, Sorlagondi, Nali, Ramakrishna Puram, Palakayatippa also with Machilipatnam Mandal, kanuru, Interu, Kruthivennu, all the identified villages, and Mandal Headquarters Machimipatnam was only away of < 8.2 km from the sea shoreline. Table 1. Addressed about the distribution of geomorphological units across the coast line and was identified that most of the formation was taken plan for Alluvium (AL) family.

VII. IDENTIFICATION OF MIGRATED COAST LINE OF KRISHNA DISTRICT, ANDHRA PRADESH, INDIA.

S.No	Soil Type	Complex	Percentage %
1.	Alluvium	SP- Spit	< 2
2.		PBSC- Paleo Beach Swale Complex	4 to 5
3.		ABR- Active Beach Ridge	8 to 9
4.		TF- Tidal Flat	18 to 20
5.		PBR- Paleo Beach Ridge	<4
6.		B- Beach	<4
7.		PTF- Paleo Tidal Flat	50 to 60
8.		MF- Mud Flat	<8

Table 1. Distribution of geomorphological units across the coast line of Krishna District, A.P, India

The change in the topography of a region indicates the difference between the sediment load of the area delineate towards the morphological distribution, which leads to modification of coastal line over time (Gyasi-Agei et al., 1995; Pavlopoules et al., 2009; James et al.,2012). As explained earlier, the present study area was carried out using the geomorphological distribution of units maps combined with updated satellite images of LISS-III, IV and the sketch maps of Delta prepared in 1897 and 1966 respectively. According to G.T.N.Veerendra (2018), Geographic information system (GIS) is an automated tool and a database to outline and extract the features of the earth and to store the enormous data types according to the point, polygon and attributes that can be visualized certainly as an information system. The thematic map addressing the deposition/erosion of the present study area –Krishna District was undergone with the help of Satellite information acquired from NRSC, the data consists of LISS IV MX multispectral ortho-rectified images covering the study area as shown in the fig.8.

Fig: 7. Geomorphological Units of Krishna District

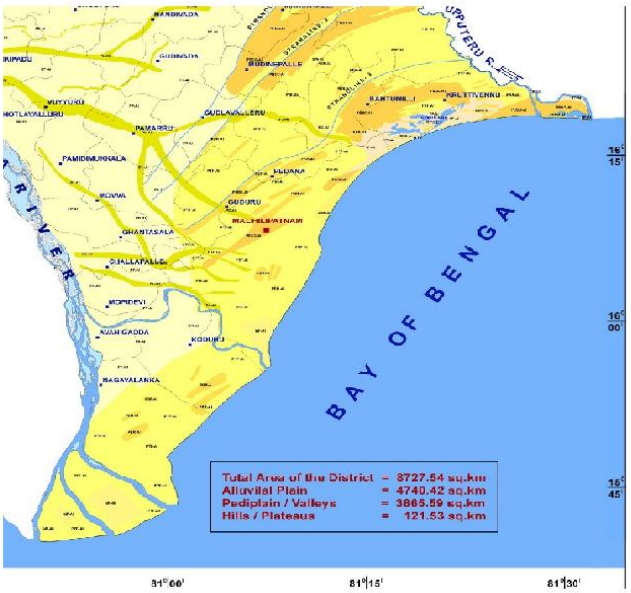


Fig: 9. Sketch Map of Krishna District as prepared in1897 by Sir. Arthur Thomas Cotton

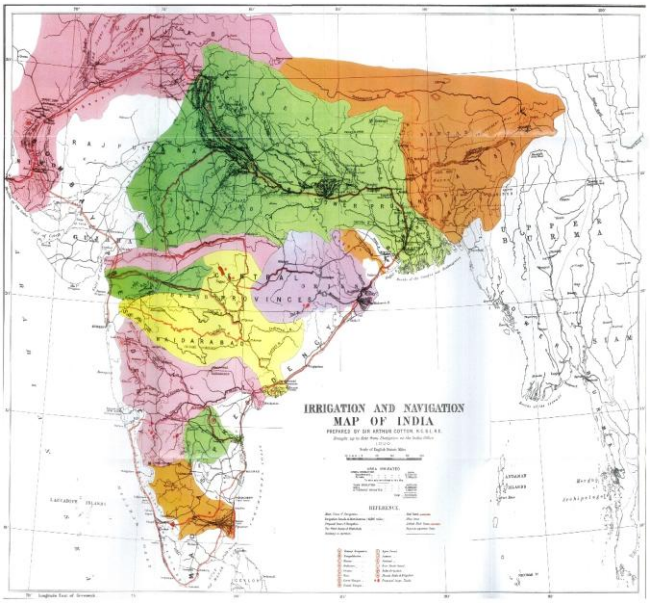
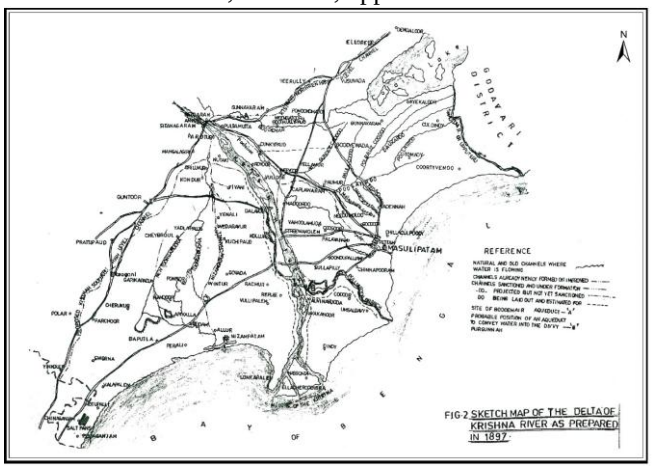
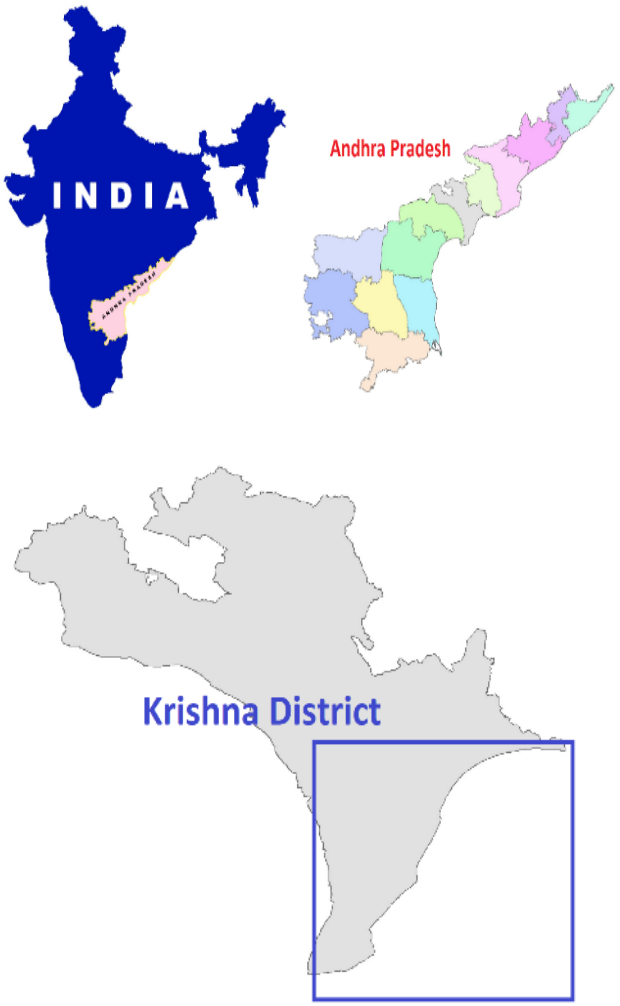


Fig: 10. Irrigation and Navigation Map of India in 1966

According to Mihai Valentin (2010), the process of georeferencing a scanned map can be done by know co-ordinates and the projection system has undergone like projected coordinate system (PCS) & Geographic coordinate system (GCS) with the tools like GIS or Eradas software. The map acquired from irrigation department records was gathered from Irrigation & water supply department of Krishna district, Andhra Pradesh, India is undergone with georeferencing by the process of pick points. Later the scale of 1:10,000 or better scale can be selected to have an accurate pick point for the scanned image. Davis.D, (1999) suggests a process of referencing geographically for a scanned map can be done by picking the series of points that are having a similar shape and point feature that could match the latitude and longitude of the location, in most precise rectangular coordinates. The map shown in the fig.9 & 10 were taken into account and had picked the accurate points representing the similar pixel information within the map, the points picked were of about 20 to have the precise and accurate match of each location to the satellite information. Most of the points were on the Krishna river and the subordinate channels of the river like Budamerru, Gunderu, upputeru and etc.





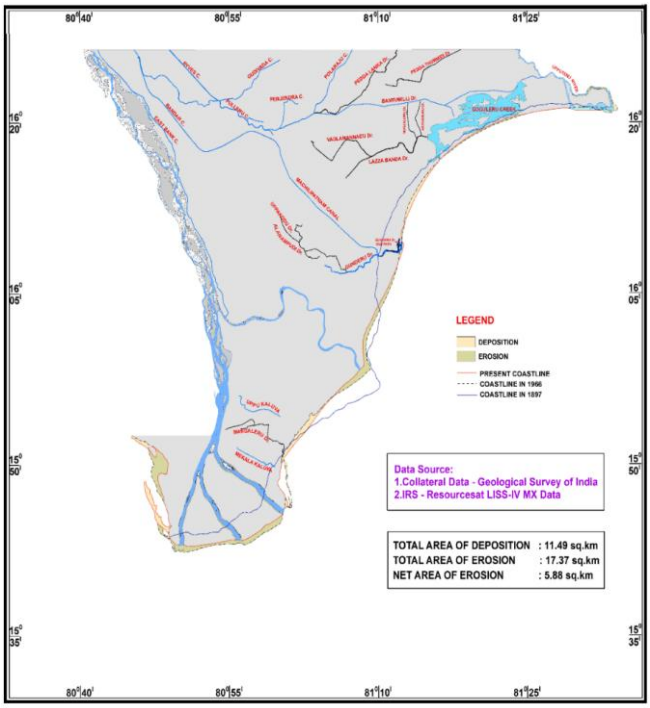


Fig: 11. Coastal Erosion / Deposition process during 1897-2015 in Krishna District, A.P, India

After completion of referencing of maps in the ARC GIS 10.2 and Eradas 9 software's, the reference maps were in layers on the GIS window, further step is to create shapefiles and digitizing the features of the layers and assigning the attribute value. It was identified, the overall cost of the district had undergone both deposition and erosion because of many factors discussed in the literature, the blue line in the fig.11 shows the spread of coastline during the year 1897 and the dotted line represents the coastline in 1966, followed by the present coastline of the district in red. The analysis of the shapefiles had identified that over an area of 11.49sq.km., was undergone with deposition, settlements like Machilipatnam Mandal, Nagayalanka and etc were evolved over the due course of time. On the other hand erosion of 17.37sq.km., was happening from the past 100 years. Altogether the net area of erosion was calculated as 5.88 sq.km.

VIII. CONCLUSION.

The Upputeru Channel Straight changes at the tail end part was identified with the help of satellite images from National Remote Sensing Centre (NRSC) over a period of 40 years was first attempt to have the overall information and position of the channel, the effect of straight cut to the original mouth had motivated the tidal waves to get injected into the channel contouring the outflow. The aggression of sea currents and water had already made major environmental damage that had influenced the surroundings and also to the Kolleru Lake, during the field visits the ground truth value collected with the help of a hand-held Global Positioning System (GPS) was accurate to match the satellite information. It was identified that major erosion and deposition of sediments were undertaken during the last 50 years had evidenced that the seasonal outflows in to the sea and rise of global temperatures collectively shown their influence towards the coastline changes, on the other hand the Machilipatnam town was identified for seaport development area by the state government to enhance the water transport.. Also, the Mean Sea Level (M.S.L) is also a major concern about the developmental activities, because the M.S.L was just 14m altitude to the sea level, which is vulnerable to earthquakes and Tsunamis. So Environmental Impact Assessment (EIA) is much needed for development projects in that area.

XI. DATA AVAILABILITY

The collateral and satellite images that were used for this paper were procured from SOI (Survey of India), Hyderabad, India, the shapefiles and attribute code data generated and related information can be provided with restrictions.

X. CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Abermann, J., Fischer, A., Lambrecht, A., Geist, T., 2010. On the potential of very high-resolution repeat DEMs in glacial and periglacial environments. Cryosphere 4,53–65. (doi.org/10.5194/tc-4-53-2010)
2. Mc Granahan, G., Balk, D.& Anderson, B.2007, the rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environ. Urbanisation 19,17-37. (doi.org/10.1177/0956247807076960)
3. Nicholls, R. J., Wong, P. P., Burkett, V. R., Codignotto, J. O., Hay, J. E., McLean, R. F., Ragoonaden, S. & Woodroffe, C. D. 2007 Coastal systems and low-lying areas. In Climate change 2007: impacts, adaptation, and vulnerability. The contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden & C. E. Hanson), pp. 315–357. Cambridge, UK: CambridgeUniversityPress. (Retrieved from https://dl.sciencesocieties.org/publications/jeq/abstracts/37/6/2407
4. Mimura, N., Nurse, L., McLean, R. F., Agard, J., Briguglio, L., Lefale, P., Payet, R. & Sem, G. 2007 Small islands. In Climate change 2007: impacts, adaptation, and vulnerability. The contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden & C. E. Hanson), pp. 687–716. Cambridge, UK: Cambridge University Press (doi.org/10.2134/jeq2008.0015br)
5. Nicholls, R. J. & Cazenave, A. 2010 Sea-level rise and its impact on coastal zones. Science 328, 1517–1520. (doi:10.1126/science.1185782)
6. Meehl, G. A. et al. 2007 Global climate projections. In Climate change 2007: the physical science basis. The contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor & H. L. Miller), pp. 433–497. Cambridge, UK: Cambridge University Press. (doi.org/10.1017/cbo9781107415324.029)
7. Pfeffer, W., Harper, J. & O'Neel, S. 2008 Kinematic constraints on glacier contributions to 21st-century sea-level rise. Science 321, 1340–1343. (doi:10.1126/science.1159099)
8. Jansen, E. et al. 2007 Palaeoclimate. In Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor & H. L. Miller), pp. 433–497. Cambridge, UK: Cambridge University Press (doi.org/10.1017/cbo9781107415324.023)
9. Kopp, R., Simons, F., Mitrovica, J., Maloof, A. & Oppenheimer, M. 2009 Probabilistic assessment of sea level during the last

interglacial stage. Nature 462, 863–867. (doi:10.1038/nature08686)
10. Rahmstorf, S. 2007 A semi-empirical approach to projecting future sea-level rise. Science 315, 368–370. (doi:10.1126/science.1135456)
11. Delta Commission. 2008 Working together with water. A living land builds for its future. Findings of the Deltacommissie 2008. See http://www.deltacommissie.com/doc/deltareport_full.pdf.
12. Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S. & Schellnhuber, H. J. 2008 Tipping elements in the Earth's climate system. Proc. Natl Acad. Sci. USA 105, z1786–1793. (doi.org/10.1073/pnas.0705414105)
13. Dasgupta, S., Laplante, B., Meisner, C. Wheeler, D. & Yan, J. 2009 The impact of sea level rise on developing countries: a comparative analysis. Clim. Change 93, 379–388. (doi:10.1007/s10584-008-9499-5)
14. Zhang, K., Douglas, B. C. & Leatherman, S. P. 2004 Global warming and coastal erosion. Clim. Change 64, 41–58. (doi:10.1023/B:CLIM.0000024690.32682.48)
15. van Koningsveld, M., Mulder, J. P. M., Stive, M. J. F., van der Valk, L. & van der Weck, L. W. 2008 Living with sea-level rise and climate change: a case study of The Netherlands. J. Coastal Res. 24, 367–379. (doi.org/10.2112/07a-0010.1)
16. Sanil Kumar, V., Pathakm, K.C., Pednekar, P., Raju, N.S.N., Gowthaman, R., 2006. Coastal Processes along the Indian Coastline. Curr. Sci. 91 (4), 530–536 (doi.org/10.1016/j.oceaneng.2010.11.009)
17. Chandrasekar, N., Saravanan, S., Rajamanickam, M., Hentry, C., Rajamanickam, G.V., 2012. Correlation between coastal geomorphology and Tsunami inundation along the coast of Kanyakumari, India. J. Ocean Univ. China, 1–6 (doi.org/10.1007/s11802-012-1794-0)
18. Kaliraj, S., Chandrasekar, N., Magesh, N.S., 2013. Evaluation of coastal erosion and accretion process along the South-West coast of Kanyakumari, Tamil Nadu using geospatial techniques. Arab. J. Geosci. (doi.org/10.1007/s12517- 013-1216-7)
19. Slaymaker, O., 2001. The role of remote sensing in geomorphology and terrain analysis in the Canadian Cordillera. Int. J. Appl. Earth Obs. Geoinf. 3, 11–17 (doi.org/10.1016/s0303-2434(01)85016-9)
20. Dawson, J.L., Smithers, S.G., 2010. Shoreline and beach volume change between 1967 and 2007 at Raine Island, Great Barrier Reef, Australia. Global Planet. Change 72, 141–154. (doi.org/10.1016/j.gloplacha.2010.01.026)
21. Mith, M.J., Clark, C.D., 2005. Methods for the visualization of digital elevation models for landform mapping. Earth. Surf. Proc. Land. 30, 885–900. (doi.org/10.1002/esp.1210)
22. G.T.N.Veerendra, A.Phani Manoj, Adari Satish Kumar & P. Urmila. (2018). Evaluation of Drainage and Surface water Resources of Brahmayyalingam lake in Agiripalli Mandal, Krishna district, INDIA using Geo-Spatial Technologies. International Conference on Recent Advances in Civil and Mechanical Engineering Practices (ICRACMEP-2018)
23. Gyasi-Agyei, Y., Willgoose, G., De Troch, F., 1995. Effects of vertical resolution and map scale of Digital Elevation Models on geomorphological parameters used in hydrology. Hydrol. Process. 9, 363–382. (doi.org/10.1002/hyp.3360090310)
24. James, L.A., Hodgson, M.E., Ghoshal, S., Latiolais, M.M., 2012. Geomorphic change detection using historic maps and DEM differencing: the temporal dimension of geospatial analysis. Geomorphology 137, 181–198. (doi.org/10.1016/j.geomorph.2010.10.039)

AUTHORS PROFILE

G.T.N.Veerendra, Research Scholar of Annamalai Unversity Chidambaram**,** Tamil Nadu, India, had published 9 research journals in various national and international journals. His Area of Interest in Research includes, Remote Sensing & GIS, Construction Management, Building Information Modelling and Structural Health Monitoring.

Dr. B. Kumaravel, Ph.D., is an Assistant Professor in the department of Civil Engineering, Annamalai University. His area specialization is water resources engineering & management and Air pollution dispersion modeling. He has published 10 papers in international journals and 11 papers in the proceedings of National seminar and Conferences. He has 18 years in teaching experience and 10 years in the field of construction works.