Estimation of Erosion and Deposition of Krishna River Bank using Remote Sensing & GIS

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Abstract*— *Krishna River is one of the longest rivers (1300 Km) in India characterised by frequent bank erosion leading to channel pattern modifications and shifting of bank line. This study is aimed toward quantifying the real bank erosion and deposition alongside of the Krishna River inside India in the course of 47 years (1970-2017). The supply of River Krishna is at Mahabaleshwar in Satara district, Maharashtra in west and meets in Bay of Bengal at Hamsaladeevi in Andhra Pradesh, on the east coast will be studied the usage of an incorporated technique of Remote sensing & Geographical statistics device (GIS).

Vulnerability & Morphological changes will be identified the usage of 1970-2017 data of LANDSAT Multispectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), Operational Land Imager (OLI) and settlement identified using topographical maps. ArcGIS used for accurate information about current river channel motion and bank erosion.

Index Terms*—*Erosion, Deposition, Krishna river, Remote sensing and GIS

I. INTRODUCTION

A river carries water, sediment and solute from the drainage area to the sea. This is important to engineers because water is used for a variety of purposes by humanity; water courses are used as navigation channels, and also erosion, transportation and deposition of sediment cause a number of problems in the river and in the catchment that must be solved pragmatically. The direct impact of transportation of sediment and water from the geologist's and geomorphologists' point of view is that the structure and form of the river and adjacent areas are continually changed due to erosion and sedimentation. The rates of this change are variable. these channel modifications can be within the form of size, shape, composition of bed material, slope and plan-form. The engineer's primary goal is to understand the basic mechanisms of erosion, transportation and deposition of sediment by flow inside the river and develop qualitative and quantitative strategies for prediction of river behavior. The approach followed by engineers is called Fluvial Hydraulics or river dynamics and this approach has been advanced throughout the past years.

Therefore, even though normal design and operation of river management consider making plans horizons of forty-seven years, the longer time perspective is fundamental to understanding the functioning of certain river channel procedures like platform change and floodplain evolution. for the reason that transport processes of interest to fluvial geomorphology have long timescales, this additionally results in expansion of the spatial scale of analysis, and a causal linking of the neighborhood to the catchment level of the river system. The behavior of river systems may be categorized on the basis in their equilibrium states, as determined by the balance between three kinds of parameters (Thorne 1997).

A. Stages of River

Stages of River: As the erosion cycle proceeds the morphology of streams also changes and the streams pass through the three stages of development as the earth' surface namely youth, maturity and old age. Although the stage reached by the stream usually corresponds to that of the surrounding topography, this is not necessarily the case. Usually the stream is less youthful in character near its mouth than in the vicinity of its head waters (Hack 1960). If one considers a newly uplifted land mass as the starting point and traces the successive changes, which occur with time, the first stage of the stream will be youth. Here streams have relatively steep slopes and they are engaged in cutting their channels downwards. Lateral erosion and valley widening is extremely small. The cross section of the stream will be V-shaped with no or little flood plain

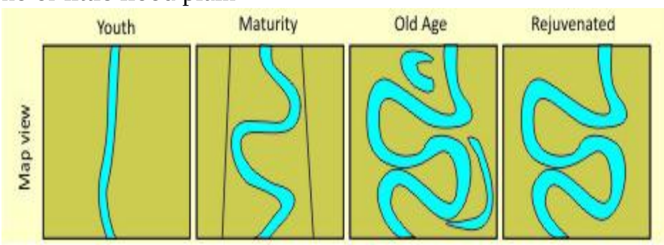

Figure 1 Stages of River

https://blogs.agu.org/mountainbeltway/2010/06/11/river-landscape-evolution/

B. Application Remote sensing and GIS in River Monitoring

There are direct and indirect methods for monitoring the river bank erosion. The direct method is taking measurements from the field in terms of linear rates of erosion, volumes of erosion and channel cross section. The indirect method is by analyzing the archival sources that exist at various timescales with the sediment records.

The archive sources can be conventional survey maps, aerial photos or satellite images. In the recent years, Satellite Remote Sensing (RS) and GIS technology has been successfully proven itself as a valuable information generator for carrying out river morphological/engineering studies and

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creating geospatial database for analysis. Using multi-temporal high-resolution satellite data, the latest river configuration, and shift in the river courses, formation of new channels/oxbow lakes, bank erosion/deposition, drainage-congested areas, etc. can be mapped at different scales. Since accurate river configuration is obtained, it can be used for laying models for conducting river behaviour studies. Information derived from remote sensing can be used for other river morphological application studies like monitoring the existing flood control works and identification of vulnerable reaches, planning bank protection works, and drainage improvement works etc.

II. STUDY AREA

The Krishna River is the fourth-biggest river in terms of water inflows and river basin area in India, after the Ganga, Godavari and Brahmaputra. The river is almost 1,300 kilometres (810 mi) long. The river is also called Krishnaveni. It is a major source of irrigation for Maharashtra, Karnataka, Telangana and Andhra Pradesh.The Krishna river rises in the Western Ghats, at an elevation of about 1,337 m (4,386 ft) just north of Mahabaleshwar, about 64 km (40 mi) from the Arabian Sea. It flows for about 1,400 km (870 mi) and outfalls into the Bay of Bengal. The principal tributaries joining Krishna are the Ghataprabha River, Malaprabha River, Bhima River, Tungabhadra River and Musi River.

The Krishna river originates in the western ghats near Mahabaleshwar at an elevation of about 1,300 metres, in the state of Maharashtra in central India. It is one of the longest rivers in India. The Krishna river is around 1,300 km in length. The Krishna river's source is at Mahabaleswar near the Jor village in the extreme north of Wai Taluka, Satara District, Maharashtra in the west and empties into the Bay of Bengal at Hamasaladeevi (near Koduru) in Andhra Pradesh, on the east coast. It flows through the state of Karnataka before entering Telangana State.

The delta of this river is one of the most fertile regions in India and was the home to ancient Satavahana and Ikshvaku Sun Dynasty kings. Vijayawada is the largest city on the River Krishna. It causes heavy soil erosion during the monsoon floods. It flows fast and furious, often reaching depths of over 75 feet (23 m) (Figure 2)

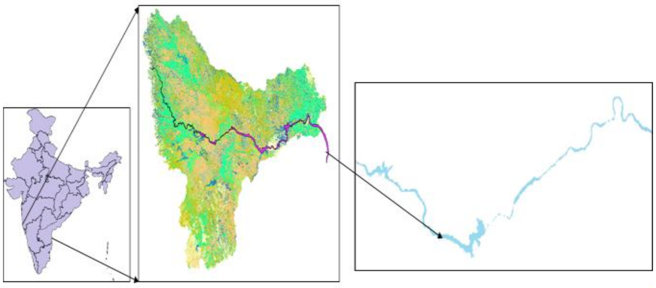

Figure 2 Study Area of Krishna River

III. DATA USED

Based on satellite image quality and availability the primary data were used MMS, TM, ETM+ and OLI/TRIS (Table 1) sensor of Landsat satellite for different years from 1970 to 2017 and data is collected from the for-River Morphology (Figure 3) (https://landsat.usgs.gov/tools_wrs_shapefile.php)

Table 1 List of Satellite Imagery

Satellite	Sensor	Path/Row	Date&year
Landsat-1,2&3	MSS	(153-158)/ (47-49)	26/02/73 to 19/01/76
Landsat-4&5	TM	(142-147)/ (48-49)	19/11/89 to 06/10/93
Landsat-7	ETM+	(142-147)/ (48-49)	14/11/99 to 29/10/01
Landsat-8	OLI	(142-147)/ (48-49)	28/03/17 to 14/04/17

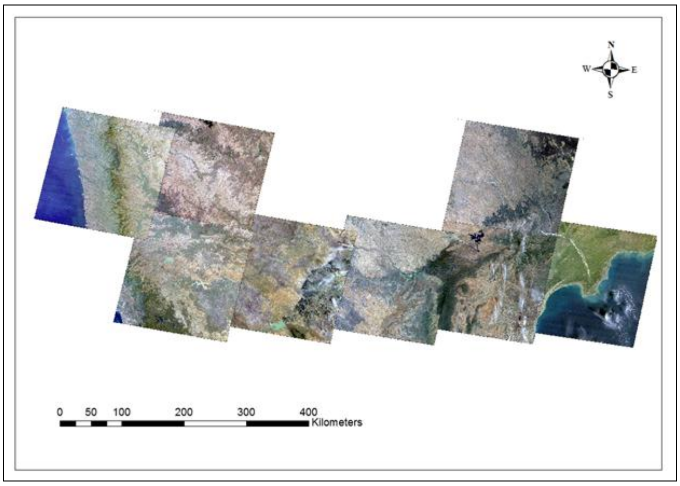

Figure 3 Landsat Satellite Image of Krishna River

III. METHODOLOGY

The Krishna River from Mahabaleswar near the Jor village in the extreme north of Wai Taluka, Satara District, Maharashtra to Bay of Bengal at Hamasaladeevi (near Koduru) in Andhra Pradesh is digitized in the scale of 1:50,000 for all the satellite image mosaics from the 1970 to 2017 years . The stretch of river has been divided into 24 reaches by using vector line operations by ArcGIS Tools.

In order to estimate the erosion and deposition that has been taken place, initially the union of reference river layer and delineated OLI layer is done after splitting into 24 different reaches and then non over lapping portion of the union layer and OLI is returned as output layer by using symmetrical difference tool whose output is Erosion layer. The erosion layer is erased from the union layer (reference river layer and OLI layer) named as Erase-1.Then the reference river layer is erased from the Erase-1, which is named as Deposition layer. The same procedure is done for all remaining River banks. The eroded and deposited layers are clipped at each reaches. At each reaches the River has been clipped with ArcGIS tools (Figure 4).

Erosion and deposition area has been estimated through area estimation using GIS software tools for polygon areas with the shifting bank-lines in study period. From there erosion and deposition maps, statistics are prepared.

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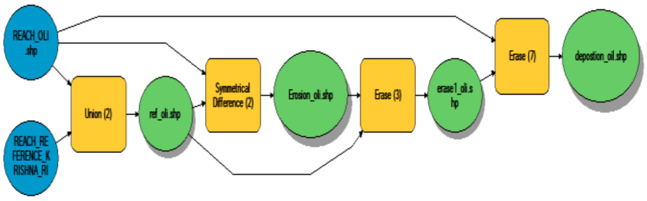

Figure 4 Erosion and Deposition Model Using Arc GIS Model Builder

IV. RESULTS

According to observation of MSS image (1972-1983) is with minimum erosion in reach7 (0.012174ha) and maximum erosion in reach 4(42122.91739ha). Deposition minimum in reach 22 (0.511552ha) and maximum in reach 18 (426.964001ha) is observed. The MSS Deposition and Erosion graphically shown in Figure 5 and Images show in Figure 10,11,12

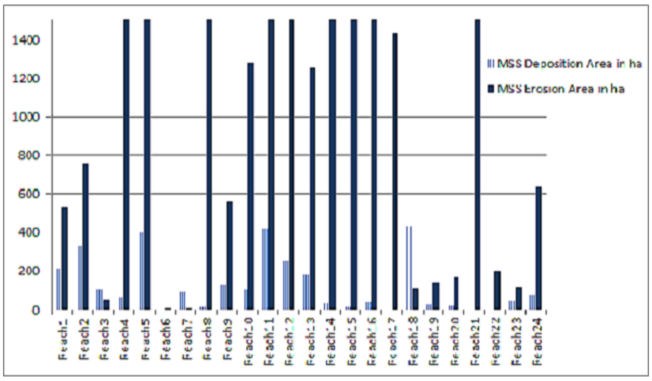

Figure 5 Deposition and Erosion During 1972-1983(MSS)

According to observation of TM image (1982-2013) is with minimum erosion in reach6 (1.342165ha) and maximum erosion in reach 15(17799.63057ha). Deposition minimum in reach 4 (3.807436ha) and maximum in reach 12 (1553.875882ha) is observed. The TM Deposition and Erosion graphically shown in Figure 6.

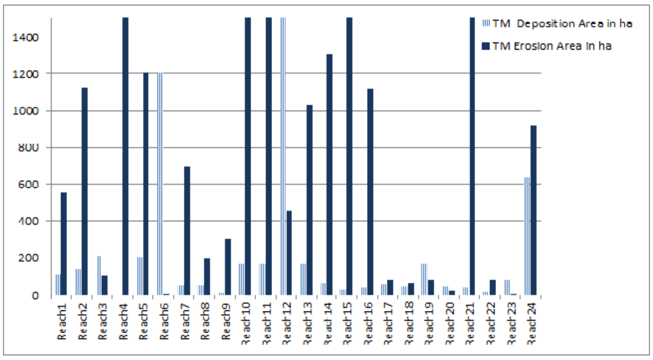

Figure 6 Deposition and Erosion During 1982-2013(TM)

According to observation of ETM+ image (1993-1999) is with minimum erosion in reach22 (13.20728ha) and maximum erosion in reach 13(19072.18281ha). Deposition minimum in reach22 (7.819662ha) and maximum in reach 12(934.875152ha) is observed. The ETM+ Deposition and Erosion graphically shown in Figure 7

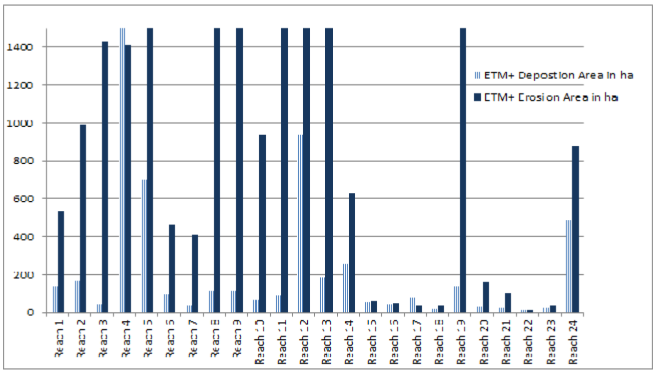

Figure 7 Deposition and Erosion During 1993-1999(ETM+)

According to observation of OLI image (2013) is with minimum erosion in reach7 (1.342165ha) and maximum erosion in reach 5(42230.81994ha). Deposition minimum in reach22 (3.858876ha) and maximum in reach 9 (1408.623988ha) is observed. The OLI Deposition and Erosion graphically shown in Figure 8.

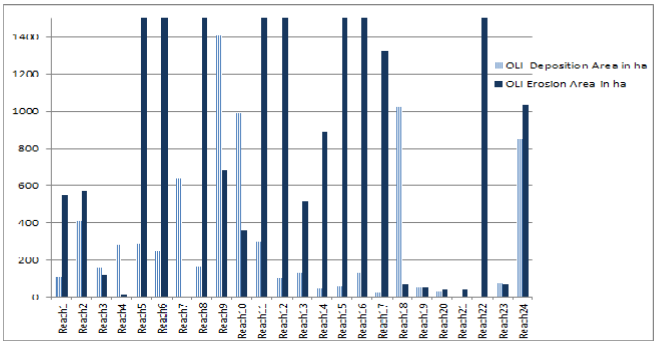

Figure 8 Deposition and Erosion During 2013(OLI)

From the above statistics we observe MSS with highest erosion and least deposition i.e., during the period 1972-1983.From 1972 to 1983 we observe a drastic change in erosion value and with a slight change in deposition (i.e., from MSS to TM).

Table 2 Total Deposition & Erosion Statistics

LANDSAT	Total Deposition Area in ha	Total Erosion Area in ha
MSS	2989.805384	110400.257
TM	5274.265171	57167.42845
ETM+	5701.215308	43788.02578
OLI	7545.061244	93834.06753

From 1993 to 1999 we observe a minute change in deposition and fall in erosion (i.e., from TM to ETM+). But

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from 1999 to 2017 we observe a drastic change in erosion and deposition. (i.e., from ETM+ to OLI). The results shown in Table 2 and Figure 9.

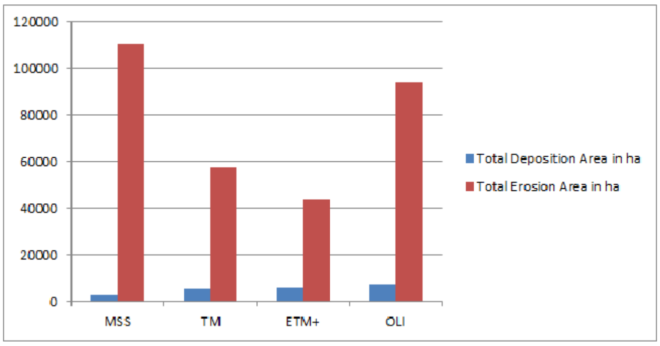

Figure 9 Deposition & Erosion during (1972 -2017)

V.CONCLUSION

This study demonstrates efficient way to determine river channel and understanding river erosion and siltation and how it has trended on settlement alongside the Krishna River banks using remote sensing and GIS from medium resolution Landsat images and topographic maps. This type of study is obliging for further planning of river and river adjacent to settlement management in an effective manner as it could be incorporated the long-time changes of the river morphology. GIS analysis result shown 1972 to 2017 typical changes occurred in Krishna River. Erosion and deposition due to meandering of the bank line is regular process and but the large area of Krishna River is effected by this. Different amount water area identified from satellite images may have different month of imagery

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