

# HISTORICAL TREATISE OF SHORE DYNAMICS AND SPIT GROWTH NEAR KAKINADA COAST, GODAVARI DELTA, ANDHRA PRADESH

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**ABSTRACT:** India has 7517 km long coastline with major deltas on the east coast. Godavari delta is the 3rd largest, located in Andhra Pradesh, and it is familiar as rice bowl of the State. The presence of spit makes Kakinada a natural harbor. It is home for an anchorage port and a deep water port. Kakinada's deep-water port is the second largest in the state after Visakhapatnam port built in the year 1996. Hence its time sequential study is vital to understand the coastal processes and its environment. The study of multi-date remote sensing data and the historical maps revealed that during the period 1851-1893 the delta progradation is insignificant, but there was substantial growth from 1893-1957 to an extent of about 150 km<sup>2</sup> at the rate of 1.66 km<sup>2</sup> per year. For a period of 44 years i.e., from 1957-2001 the growth of the delta is marginal or almost stable. Again from 2001 onwards there is a steep growth in the delta development. There was a net increase of 178 km<sup>2</sup> area from 1851-2008. The Kakinada spit growth was initially noticed during 1864 and maintained its present form since 1914 to date and forms a semi-enclosed water body, popularly known as Kakinada Bay. The spatial and temporal pattern of the spit lies in the North South direction, with little bulging and re-curvature towards in the Northwestern sector.

## 1. INTRODUCTION

Andhra coastline is characterized by open beaches sand bars, sand spits and river mouths. Evans (1942) discussed on the origin of the spits, bars and other coastal landforms. The historical and functional approaches to study shoreline changes along with landforms help in deciphering the coastal processes operating in an area. The pressure to use the coastal zone for a variety of purposes is intense, and there is every reason to believe that this pressure will not diminish. The coastal zone is the site of many conflicts that arise because of large number of possible uses focused on a narrow strip of land and water. These conflicts include disputes about coastal erosion and its control; port and industrial influence. Any attempt to handle the coastal problems requires thorough understanding of processes in the geomorphological systems and anthropogenic activities indulged by population propulsion. Rivers appear as the major sources of sediment for the beach deposits on the Indian coast. Mani Murali et.al (2009) used multi-temporal satellite images of IRS-1D IRS-P6 for monitoring shoreline environment of Paradip, East Coast of India. Meijerink (1983) and Rao and Harikrishna (1989) studied the geomorphology of Mahanadi delta and problems of coastal dynamics and shoreline changes which arose after the construction of Paradip port. Chandra Mohan et.al (2001) envisaged that the rivers are major source for the littoral drift and the annual discharge of sediments along the Indian coast is 1.2x10<sup>12</sup> kg/year. The annual discharge of sediment from Godavari river is estimated as 38.389x10<sup>9</sup> kg. into the sea. Shoreline changes directly affect the economic development and land use management (Chen and Raju, 1998). Therefore shoreline changes have drawn a great attention worldwide to link environmental changes. Sastry et al (1991) discussed morphological changes of Godavari delta and suggested it is essential to assess qualitatively and quantitatively the changes in delta front with the available past data through systemic field studies and using satellite imagery. Hemamalini and Nageswara Rao (2004) analysed the coastal changes of south of Gowtami Godavari river from multi-date satellite data and maps. Several workers have studied geomorphological, environmental, oceanographic and industrialization and port development ([www.kakinadaseaports.in/html/masterlayout.htm](http://www.kakinadaseaports.in/html/masterlayout.htm)) aspects of spit and its environs (Sambasiva Rao and Vaidyanadhan, 1979a, Sambasiva Rao and Vaidyanadhan, 1979b, Vaidyanadhan, 1991, Ramasubramanian, et.al, 2006, Reddy and Prasad, 1982, and Mruthyunjaya Reddy 2008).

## 2. APPROACH

The Godavari basin is the largest in Andhra Pradesh covering an area of 312812 km<sup>2</sup>. The length of Godavari river is 1465 km and second largest river in the country. The area of study covers NE parts of Godavari delta shore line in East Godavari with an area of about 180 km<sup>2</sup> (Fig.1). Besides the study of historical data, the remote sensing data analysis is the best tool for monitoring changes in delta/shoreline. The steady growth of Kakinada spit and its morphological changes are monitored with the help of 15 data sets from 1851 to 2008 using published literature, Survey of India toposheets and satellite images. The images used are SPOT MLA (Feb. 1989); IRS 1B LISS-III (Feb. 1993); IRS 1C LISS-III (March 2001); IRS P6 LISS-III (Feb. 2006, March 2007 and March 2008). The growth of a sand bar in the form of a spit is a conspicuous feature in the vicinity of Kakinada. In the present study the delta progradation over last several decades is analyzed through temporal satellite data. The figures from 2a to 2g are taken from the published work of Mahadevan and Prasada Rao (1958). The figure 2i is used from the project report of Ramana Murty and Venugopal (1987).



Figure 1 Location Map

## 3. RESULTS & DISCUSSION

The Godavari river mouth region has displayed enormous changes in space and time. Mahadevan and Prasada Rao (1958) mapped the spit growth from 1851 to 1957 and are shown in Fig. 2a to 2g. During 1851 the Gautami Godavari river was flowing in northward direction. At the mouth of this distributary there are number of islands (Fig. 2a) of varying size and shape. The eastern part of the coast which was projected as a triangular landmass in 1851 is bifurcated into two during 1864 (Fig. 2b). By the year 1864 there are five islands more or less circular in shape oriented in almost NS direction (Fig. 2b). Hence, the first appearance of spits in this region dates back to 1864. The lengths of these spits are about 3.75 km and 4.75 km separated by a distance of about 400 m. During this year there are two islands, circular in shape and are oriented in north-south direction from the eastern spit. By 1878 two isolated sand bars are observed (Fig. 2c). One (southern bar separated from 1b of Fig. 2b) is having a length of about 2 km (number 1c in Fig 2c) and other (northern bar) 3 km (number 1d in Fig 2c). These two are separated by a distance of 5.50 km. The Gautami Godavari river continues to flow in northward direction and the islands present during 1864 are further fragmented towards east of Patavala village and the size of the islands is also marginally increased. But there is erosion along the northern coast (between E1 and E2 of Fig.2c) of Kakinada during 1864 and 1878. By the year 1889, a full-fledged growth of spit having a length of 17 km is observed with a

discontinuity at the centre (about 8.50 km). The bigger island (Fig.2d) is further gained in size by merging a neighboring island.

The spit is developed further measuring 25 km during 1914 (Fig. 2e). The spit was broken at three locations. The development of creeks is observed across the river Gautami Godavari, because of large volumes of water that they drain. Creeks are markedly linear due to rapid sea ward progradation. For the first time the Kakinada spit appeared without any discontinuity in the year 1937-38 (Fig. 2f), showing the dominance of long-shore sediment deposition (growth) and cross shore sediment movement. The maximum width of the spit head is observed to be 1.25 km. The spit is found to be well connected to the main land. The southern part of the spit measuring 6.50 km in the year 1914 got merged into the main land. A number of islands present earlier are united and two major islands are formed separated by the distributaries of Gautami Godavari river. The northern flow of Gautami Godavari river which was predominant is now constricted by the development of two big islands in the east of I.Polavaram. Subsequently, the narrowed branch of Gautami is called as Gaderu river had developed. A small hook shaped spit is observed on southern distributary of Gautami Godavari river (S2 in Fig. 2f). During 1957 (Fig. 2g) the spit was breached at a length of 15 km from its head. The Gaderu River is bifurcated into several narrow branches dividing the two major islands into six. A new branch of river from Gautami Godavari river is flowing in northward direction close to Patavala village is known as Coringi river. A small narrow drain is developed south of Kakinada which is known as Bikkavolu drain. This drain is also used as a fishing harbour. In 1975-76 it is noticed that the spit is again attached to the main land. There is an increase in the length of the spit (Fig. 2h) to an extent of 1.6 km. The density of drainage network has increased as a result of development of several creeks along Gaderu river course. In between the two distributaries of Gautami Godavari river a number of creeks have formed resulting into several small islands. A narrow hook shaped spit noticed in 1937-38 consolidated and increased in its width (Fig. 2h). A small spit is also observed projecting into the bay in NE-SW direction. On the right bank of southern distributary of Gautami Godavari river, there is a small narrow linear "Y" shaped spit (Fig.2h) is also developed. The Bikkavolu drain at south of Kakinada is prominently seen.

During the year 1983 (Fig. 2i), there is no notable change in the spit, except increase in the length of about 750 m. This map is extracted from the project report of Ramana Murty and Venugopal (1987). The two spits S2 & S4 are observed with change in width and shape. The orientation of the spit (S4) is also changed from EW to ENE-WSW direction. The spit (S2) from the northern bank is hanging in NS direction. In the year 1989 (Fig. 2j), the length of the spit (S1) is increased by about 500m. One more small spit is developed from the existing spit (S3) located on the northern distributary of Gautami Godavari river. The 1993 image (Fig. 2k) shows the width of the spit head is decreased by about 700m. There is a very narrow breach in the spit at a length of about 16 km from its head. On the southern part of the spit, Pillavarava kaluva (PK) which is previously flowing into the Kakinada bay has made a direct contact with the sea. The prime cause for the above activity is resulted from coastal erosion. One more small spit, developed from the existing spit (S3) located on the northern distributary of Gautami Godavari river during 1989, is widened and curved. Both the spits (S2 & S4) have increased in their width. The port activity in the form of jetty is observed to the north of Kakinada. A conspicuous growth of spit measuring 23 km in length trending in NS direction is noticed during 1983.

The geomorphic setup of image 2001 (Fig. 2l) shows the attachment of spit (S1) to the main land. The spit head has widened on the eastern margin by about 200m. One more small spit is developed from the existing spit (S3) which is widened further and curved. The northern spit (S2) is almost disappeared. In the process of erosion, five islands are formed at the estuary of the southern distributary of Gautami Godavari. A break water barrier is constructed in between the port and spit head during 1996-1998. The southern part of the spit has shifted westward by about 400m. The coastal configuration from image 2006 (Fig. 2m) indicates that there is a slight increase in the length of the spit (S1) by 100m and width by about 150m. There is a westward movement in southern part of the spit (S1) by about 400m. The development of small spit from the existing spit (S3) which is still widened and curved, while the spit just beneath is merged with the mainland. The five islands present during 2001 are united with the southern spit (S4). The northern spit (S2) which is insignificant during 2001 is almost eroded. In general, there is accretion along the coast south of Kakinada port and erosion near Kothapalle (Uppada village). The state of the spit (S1) during 2007 (Fig. 2n) is almost same to that of 2006. One more small spit is developed from the existing spit (S3), which is located on the northern distributary of Gautami Godavari river during 2007, is widened and curved.

Continued erosion along the coastal stretch between Kakinada and Kothapalle (Uppada village) is observed. The condition of the spit (S1) during the year 2008 is more or less same to that of 2007 (Fig. 2n). The spit (S3) bifurcated during 2007 is merged. Both the spits (S2 & S4) have decreased in their width. In addition, one more bar is seen parallel to the coast on the northern bank of the southern distributary of Gautami Godavari. In the north of southern distributary of Gautami Godavari river, erosion (E in Fig.2n) is observed for a length of 3.5km and a width of about 150m. Erosion along northern stretch of Kakinada coast continues causing severe damages to village

Uppada. The increased shipping activity and dredging at north of Hope island has resulted in stunted growth of the spit.

The shore line changes along Kakinada coast is shown by superimposing the historical map of 1851 over the latest satellite image based map of 2008 (Fig. 3a). During 1851 the Gautami Godavari river was flowing in northward direction with four major islands and three minor islands of different shapes at the confluence (presently Kakinada bay). During that time there are no traces of spit. The information on Corangi, Gaderu rivers and various creeks was not available. When compared to the map of 2008 it is broadly observed that there are enormous changes all along the coast with the development of several new landforms. The entire coast is divided into three segments based on the shape of the coastal setup. The coast between Patavala and Kottapalle including Kakinada which is concave in nature is considered as segment one. The coast in between Patavala and Corangi disused lighthouse which is almost flat is regarded as segment two. The third segment which is a convex coast covers Corangi disused lighthouse to Kandikuppa. The segment one and two envelops Kakinada bay, where as the third segment is abutting Bay of Bengal. The coastal length between Kottapalle in the north and Kandikuppa in the south is 110 km during 2008, whereas during 1851 it is only about 80 km. With the exception of erosion off Kottapalle coast, nowhere else such phenomenon is present. The extent of delta progradation is not uniform all along the coast. In case of segment one, on either sides of Kakinada the development of coast is 1.5km in the north and 2.5km in the south. The extension of the coast in the north of Bikkavolu drain is 3.75 km whereas in the south it is 2 km only. In segment two, maximum progradation of delta (6 km) is observed near Corangi. Four observations are made in segment three. About 1.25 km of growth is observed in the east of Corangi disused lighthouse. An increase in the deposition of sediments is found at east of Bhairavapalem, Masanitippa and Kandikuppa to an extent of 2 km, 2.8 km and 6 km respectively. Several new landforms in the form of shoals, creeks, marshy areas, mudflats, spits, channel bars, river islands, etc are observed along the coast. The spit with a length of about 17 km protruding more or less in NS direction is worth mentioning. The head of the spit is about 5 km in length and 1.6 km in width. The average width of rest of the arm is around 200 m. The islands appearing in 1851 are all united with the main land separated by narrow creeks. During 1851 the segment three is also concave in shape devoid of any conspicuous landforms. The development of new landforms in segment three is attributed to the change in the river course of Gautami Godavari river.

Further, time series analysis on the growth of the delta for a period of 157 years is carried out (Fig.3b). Based on the data analysis, it was observed that there is marginal increase in delta area during the period 1851-1893. From 1893-1957 there was substantial delta growth to the extent of about 150 sq km at the rate of 1.66 sq km per year. For a period of 44 years i.e., from 1957-2001 the growth of the delta is marginal or almost stable i.e., at the rate of 0.77 sq km per year. Again from 1993 onwards there is a steep growth in the delta development. At the outset there is a net increase of 178 sq km area from 1851-2008 with an average growth rate of 1.14 sq km per year.

#### **4. SUMMARY & CONCLUSION**

Spit forms an important geomorphological feature of the Godavari Delta. The shore line changes along Kakinada coast is studied by superimposing the historical map of 1851 over the latest satellite image based map of 2008. When compared to the map of 2008, it is broadly observed that there are enormous changes all along the coast with the development of several new landforms. It is observed that there is marginal increase in delta area during the period 1851-1893. Abundant sediment supply from hinterland has supported the process of delta progradation. From 1893-1957 there is substantial delta growth to the extent of about 150 sq km at the rate of 1.66 sq km per year. For a period of 44 years i.e., from 1957-2001 the growth of the delta is marginal or almost stable i.e., at the rate of 0.77 sq km per year. Again from 1993 onwards there is a steep growth in the delta development. At the outset there is a net increase of 178 sq km area from 1851-2008 with an average growth rate of 1.14 sq km per year. The spit is acting as natural break water protecting the entire eastern portion from the fury of the sea and providing tranquility and shelter to ships which are berthed at anchor in the Kakinada bay. Coastline changes deciphered from time sequential remote sensing data and integrating with historical data in GIS environment gave fruitful results to understand the coastal processes and delta environment.

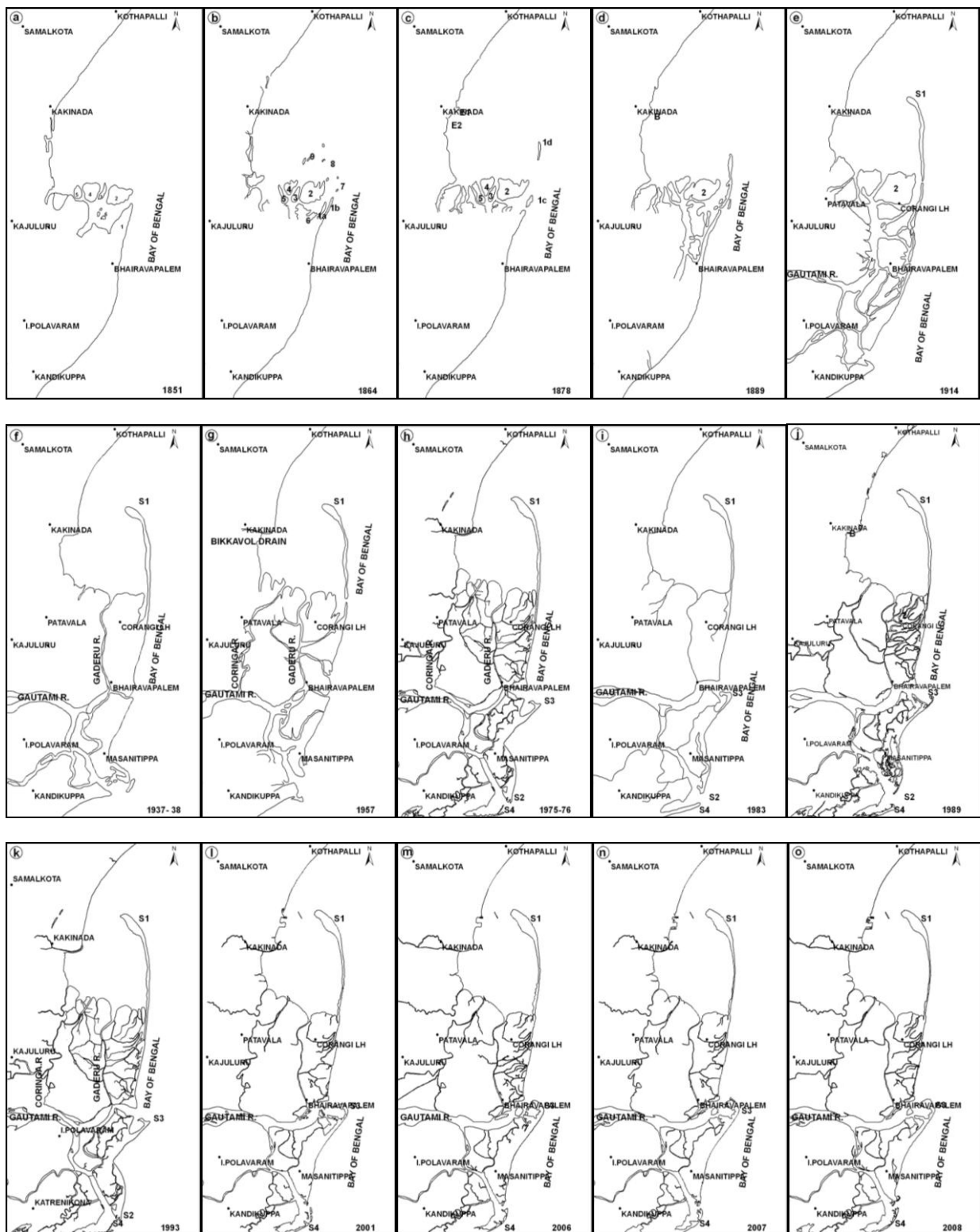


Figure 2 Shore Line Configuration (1851-2008) around Kakinada

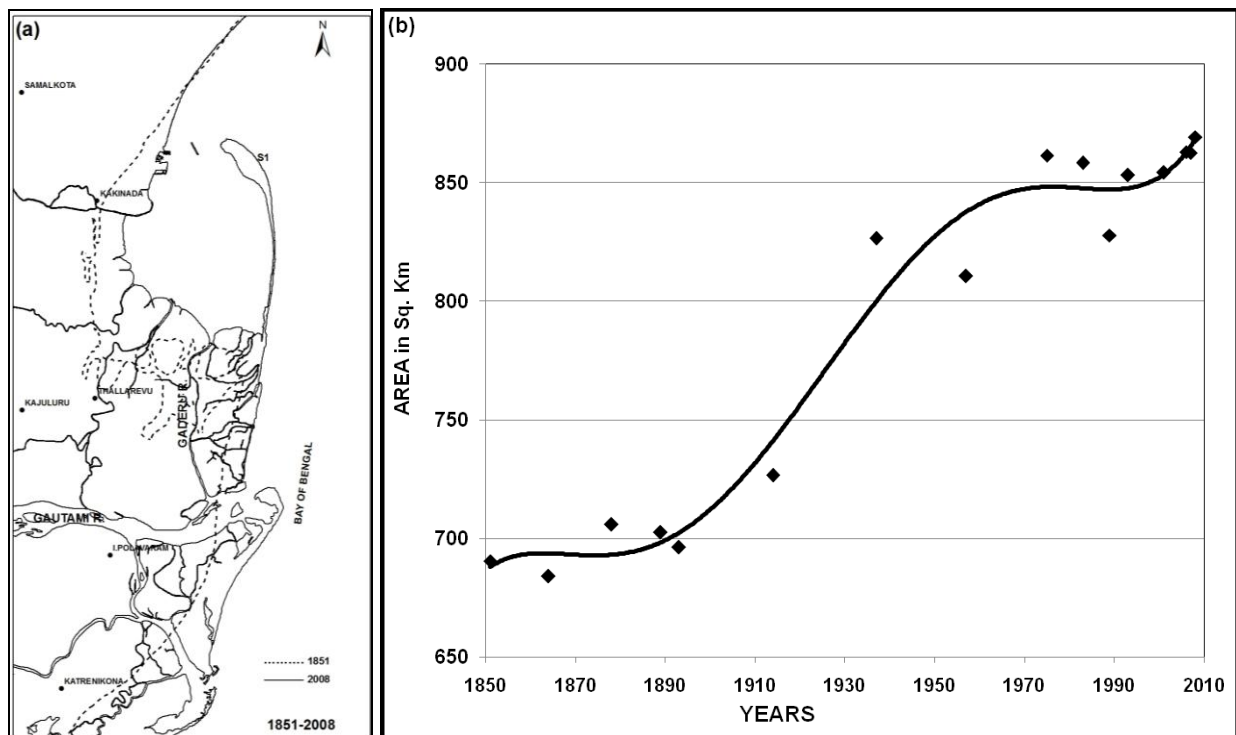


Figure 3 (a) Shore Line Configuration in 1851 and 2008 and (b) Delta Progradation (1851-2008) around Kakinada

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