

## **Applications of remote sensing and Geographic Information System (GIS) in Archaeology**

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### **Abstract**

The advancement of remote sensing technology and the analysing capability of Geographical Information System (GIS) can very well be used in the science of Archaeology. Though these subjects look apart, they can be studied in conjunction with each other. The applications of remote sensing are vast and the field of archeology need not be left out in that. These techniques contribute to explore and understand the past. The improvement in the spatial and radiometric resolution helps in demarcating the sites of archeological importance and GIS helps to analyze with utmost accurate quantitative information. Mapping of geomorphological features, palaeo-channels, shift of shorelines, changes in the topographical features, identifying the potential archeological site from the spectral signatures are promising to use the latest remote sensing technology for the historic subject. In addition to the image interpretation techniques, vegetation marks, anomalous landforms, shifting of river mouths, palaeo coastlines help the archeologists for supporting their hypothesis. Synoptic coverage of images provides an opportunity to link it with historic evidences in a larger scale. Earlier archeological studies at Dwarka, Poompuhar, Tranqubar, Hampi etc used remote sensing and GIS. In this study, the power of remote sensing and GIS at the archeological studies at Gujarat and Tamilnadu will be described. The possibility of linking of Gulf of Kutch and Gulf of Khambhat in the past is explained with the support of digital elevation model from remote sensing data. The historic Adam's bridge and the mapping of it through remote sensing are also explained. This paper introduces remote sensing capability to Archeologists which can be used for their archeological explorations.

### **Introduction**

Remote sensing is a method of obtaining information from distant objects without being in direct contact. This has become possible due to the latest sensing devices and the sensed object. There are many stages in the acquisition of the remote sensing data (Fig 1). Recent satellites with high resolution such as QUICKBIRD, SPOT, Cartosat, IRS etc. provide highly accurate imagery of the areas in different wavelengths (Fig 2). These imageries are highly suitable for the regions which are inaccessible. Owing to the credibility of geoinformatics technology, especially remote sensing and GIS, mapping and monitoring of spatial features has to be done both quantitatively and qualitatively. GIS in association with remote sensing is an effective tool in spatial analysis. This latest technologies can be very well applied in Archeology studies.

### **Geographic Information System (GIS)**

GIS is a system of computer software and procedures designed to support the capture, management, manipulation, analysis, and display of spatially referenced data (Fig 3) for solving complex planning and management problems. Maps, aerial photographs, satellite imagery, field observations etc. are given as input in the system. GIS analyses the data and gives the output in the form of maps, tables,

graphs etc. GPS, remote sensing, digital photogrammetry and GIS are able not only to produce printable maps, but to display raster and vector images on a computer screen and to analyse them in an inter disciplinary manner for the purposes of society. Components of GIS are

- Hardware

It consists of input devices like scanner, digitizer etc. and central processing unit.

- Software

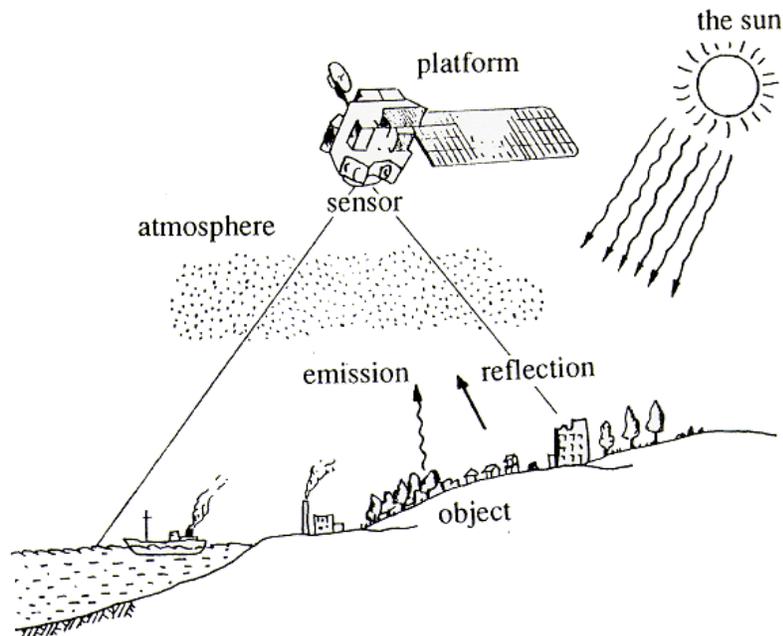
The GIS software includes the programs and the user interface for driving the hardware. Some important GIS Software are ArcGIS, Erdas Imagine, ENVI, ArcInfo etc. It can be divided into following category. Software's used for input, editing, maintenance and also for analysis of the datasets it is also used for processed data display and output

- Data

Data is the most important component of a GIS. A GIS can integrate spatial data with other existing data resources, often stored in a DBMS. The integration of spatial and tabular data stored in a DBMS is a key functionality afforded by GIS.

- Liveware

It represents GIS users such as engineers, scientists, policy makers, monitoring and implementing agencies. These cross-sections of people use GIS to evolve a decision support system and solve real time problems.



**Fig 1: Remote Sensing Data Acquisition**

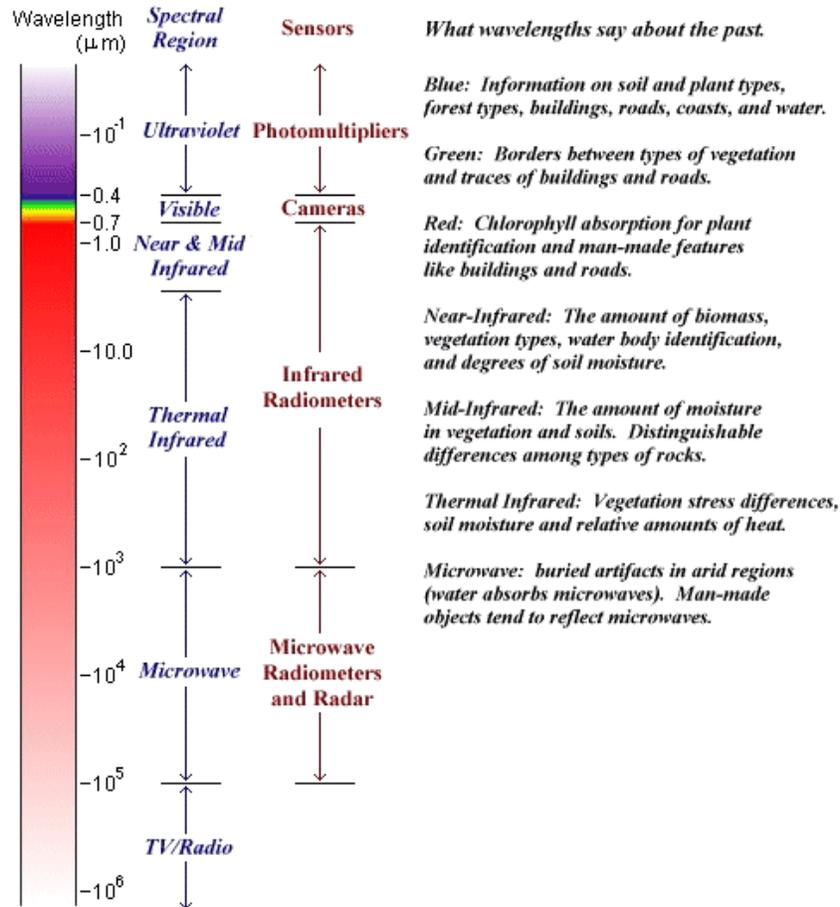


Fig 2. Spectral wavelengths used in remote sensing

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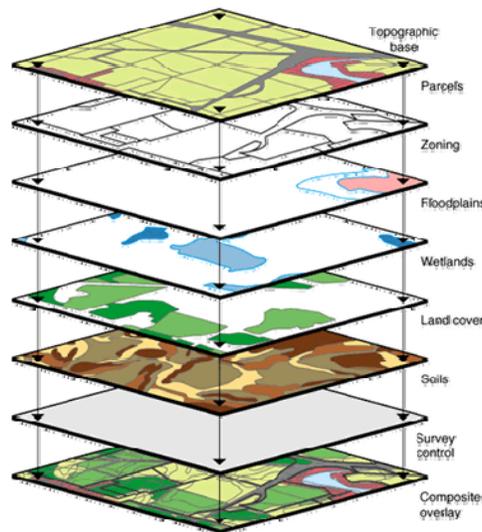
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*Fig 3: Geographic Information Systems*

### **Application of Remote sensing and GIS technology in Archaeology:**

#### **1) Tranqubar coast, Tamil Nadu :**

Tranquebar, which is known as Tarangampadi, is located in Nagapattinam District, on Southern Tamilnadu Coast along the mouth of Uppanaru River. It holds the habitation of late Chola period till date. It was the main port for Dutch people and Danish period. In 14th Century inscription itself, this place was mentioned as Tarangampadi. It was a commercial port attracting traders from different countries, including overseas. The Masilamani temple situated in this location was built by Maravarman Kulasekhara in the year 1305 AD (Nagasamy, 1987). Geologically the coast is aligned almost north-south without any prominent bays and hills and is covered with recent alluvium. The coastline consists of long narrow and low sandy beaches. Many small rivers join the Bay of Bengal near Tranquebar region. The shelf region of Tranquebar is gentle topographic variation with fairly smooth ocean bottom. The shelf gradient is slightly more up to 10m water depth, remaining fairly gentle from 10 to 50 m depth and again becomes steeper up to shelf edge. The width of the shelf is about 32 km. The seafloor comprises of medium to fine sand up to 5 m depth, between 5- 10m silty clays, and 10-15 m silty clay and clays beyond (Rao and Rao, 1991).

Topographic sheets and satellite imagery were used for detecting the shoreline changes at Tranquebar at different years. Topographic sheets of 1932, 1972 were scanned and geometrically registered in image processing software with RMS error less than 1.0. Then shorelines of these years

were digitized in GIS environment and displayed over the satellite imagery of Google Earth to know the shoreline shift for the period of last 74 years.

In this method, it is possible to detect the shoreline shift over the decades. The shift of shoreline from 1932 to 1972 is detected as 32 m and 200 m shift is observed from 1972 to 2006 towards the landward. The overall net shift towards the landward is 232 m from the years 1932 to 2006 (Fig 4). The observations of the narrow strip of beaches confirm the eroding activity at that region. The historic Tranquebar fort is just 35 m away from the present shoreline. It is evident that erosion is high in that region from the big boulders put as barriers by local authorities. The study reveals the truth that the shoreline at Tranquebar is migrating rapidly towards landward. After 2004 tsunami, it is reported that wave action and erosion has become very high in east coast. Necessary steps have been taken to save the Danish archeological monument in Tranquebar( Fig 5). Evidences in the intertidal zone, topographic charts and the map of 17th Century at Tranquebar confirm the shoreline recession. This suggests that about 232 m recession takes place in 75 years. The relative sea level rise has undoubtedly been taking place on coasts where the land margin is subsiding (Sundaresh et al., 2007).



*Fig 4 Shoreline recession map of Tranquebar in 1932 (red line),1972( green line) in 2006 image*



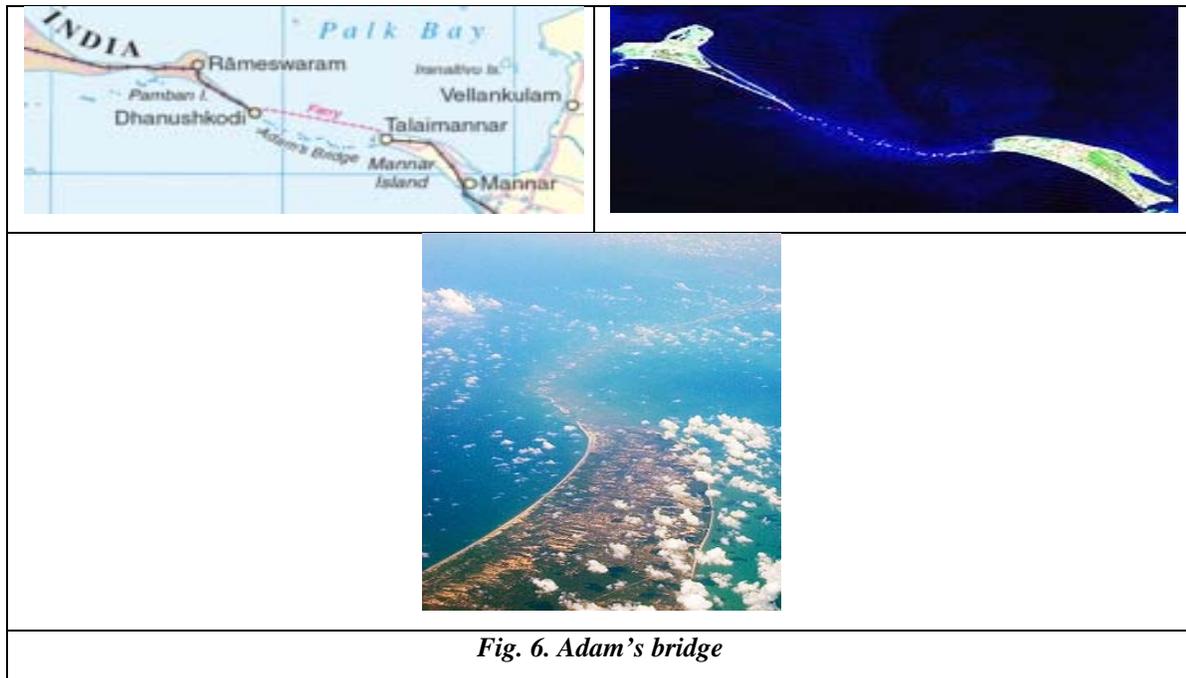
*Fig 5 Big boulders placed along the coastline near to Danish archeological monument, Tranquebar*

## **2. Adam's bridge:**

Adam's bridge which is located in the south Tamilnadu coast is a continuous chain of shoals, reef, sand banks, etc (Fig 6). It is believed that it was formed by the breaking away of Sri Lanka from the Indian mainland. The bridge consists of calcareous material mostly, sandstone and conglomerates. The rise in mean sea level in the past must have exposed or buried the ridges. Based on satellite remote sensing data, Indian Space Research Organisation (ISRO) states that Adam's Bridge comprises 103 small patch reefs lying in a linear pattern with reef crest (flattened, emergent – especially during low tides – or nearly emergent segment of a reef), sand cays (accumulations of loose coral sands and beach rock) and intermittent deep channels. The coral reefs are designated by the different studies variously as ribbon and atoll reefs.

One theory affirms that the origin and linearity of the Adam's bridge may be due to the old shoreline – implying that the two landmasses of India and Sri Lanka were once connected – from where coral reefs evolved. During the periods of low sea level, Adam's Bridge has provided an intermittent land connection between India and Sri Lanka. Geological Survey of India (GSI) carried out a special programme. In this study, it was suggested that the domain between Rameswaram and Talaimannar may have thus been exposed around 18,000 years ago. Thermoluminescence dating by GSI concludes that the sand dunes of Dhanushkodi to Adam's bridge started forming only about 500–600

years ago. Hence, the sea level variations in the past must have controlled the formation of Adam's bridge. GIS analysis would also confirm this as in the case of Rann of Kachchh.



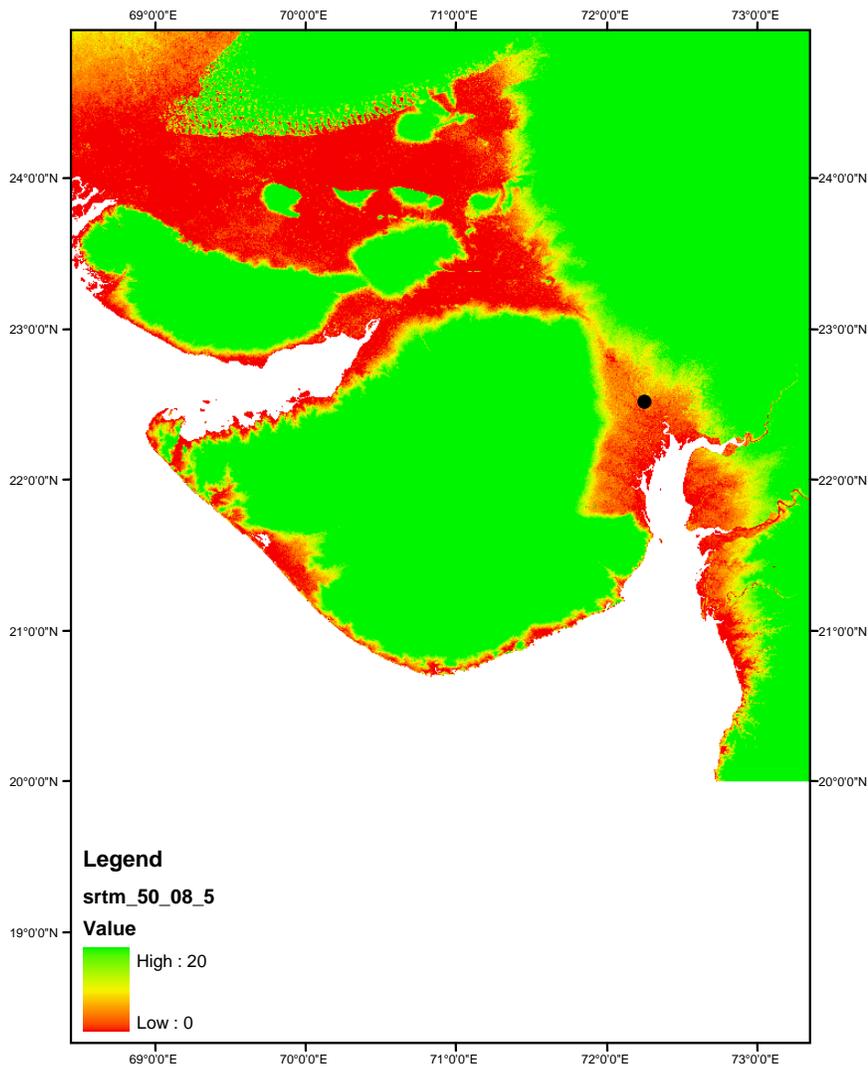
*Fig. 6. Adam's bridge*

### **Gujarat coast:**

Present day Gujarat state of India was the land of Indus civilization, alternatively known as Harappan civilization spread across the part of Kachchh and Saurashtra. This region is unique for its geologic features like the Rann of Kachchh. The Rann of Kachchh is a vast marshy salt plain, rising barely above the sea level. It extends about 300 km from east to west and at a few places about 150 km from north to south. It is divided by the highland of Kachchh into two parts: the Great Rann (about 18000 sq. km) in the north and the Little Rann (about 5000 sq. km) in the southeast. The Great Rann connects with the Arabian Sea through Kori Creek in the west and the Little Rann is connected with the Gulf of Kachchh in the southwest. During monsoon, major part of the Rann remains under water and from November to May the Rann often remains dry. Many hypotheses are there about the evolution of the Rann region, in that three prominent hypotheses regarding the palaeomorphological condition, especially during the Harappan times, namely: (a) formerly an arm of sea which had been raised due to a series of tectonic activities, (b) similar conditions are prevailing at least since the 3rd millennium BC (ref. 10) and (c) the Rann as a delta region of the Indus and other rivers and present change in morphology is due to tectonic disturbance of 1819 (Gaur A.S, 2013).

It was attempted to find out the possible connection of the great Rann with little Rann. Digital Elevation Model (DEM) for areas in and around the Gulf of Kachchh is used to find the possibility of any connectivity in the land area between the Gulf of Kachchh and the Gulf of Cambay in the past. DEM is a raster image consisting of regularly spaced height values. DEM was generated using the ARCGIS software and variations of the topography were colour-coded. Maps were generated with the normal current DEM values, 5 m reduced than the current DEM, and the areas within 0–20 m

were also extracted. The study and analysis of digital elevation map suggest that in case of rise in sea level of about 3 m, both Ranns have a water depth of 3–5 m and both Ranns form part of the Arabian Sea (Fig 7). These areas are highly sensitive to tectonic activities and the concern of rise and depression of land is suspected in the past. Based on archaeological evidence, it may be postulated that both Ranns were navigable in the past. DEM analysis generated from the remote sensing data makes it possible supports the same.



*Figure 7 DEM of the Rann of Kutch area*

### **Conclusion:**

Remote sensing and GIS can be used as a methodological procedure for detecting, inventorying, and prioritizing surface and shallow-depth archaeological information in a rapid, accurate, and quantified manner. Understanding how ancient man successfully managed Earth is important for the success of current and future societies.

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