

Paleo-topographic Reconstruction of Cultural Landscapes using Remote Sensing and GIS: A case study of the ancient port of Tamralipti

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(Received: Dec 29, 2021; in final form Sep 13, 2022)

Abstract: Human interaction with the landscape they inhabit leaves imprints that are largely inconspicuous on the ground. Yet, these remain the most thought provoking among the sets of clues available to us in fuelling the quest to understand our past. Spatial view provided by satellite imagery plays a pivotal part in enabling us to identify these imprints in the form of patterns. In this study, a paleo-environmental reconstruction of a particular cultural landscape using geo-spatial tools has been attempted. A range of historical documents (textual records such as traveller's accounts dating to 5th and 7th centuries CE, maps of the Indian sub-continent published in the 18th and 19th centuries) and satellite imagery of the last 50 years (CORONA, Google Earth Digital Globe) are used to identify and analyse the distribution of cultural sites that are hitherto unexplored to understand the impact of past changes to the landscape of these ancient sites located along one of the most dynamic regions of the Indian subcontinent: the Gangetic Delta. The identification of numerous sites of a distinct pattern and their distribution, analysed along with the morphological signature of the landscape on which they remain almost undetected has led to certain inferences on the possible location and extents of the ancient port of Tamralipti. The study also reveals the coastal and deltaic changes in the vicinity of the ancient port.

Keywords: Geo-spatial analysis of Cultural Landscapes, Gangetic Delta, Tamralipti, Google Earth imagery, CORONA imagery.

1. Introduction

The delta of the Gangetic river system, where the river and its distributaries debouch into the Bay of Bengal is particularly interesting in a number of ways. Apart from being home to one of world's most intense ecosystems and largest fertile agrarian landscapes, it bears vestiges of an ancient legacy that is veiled in mysteries of a dynamic landscape and fleeting narratives of a bygone past.

According to archaeological and literary sources, Tamralipta/Tamralipti (henceforth, Tamralipti) is believed to have existed between 3rd century BCE and 8th century CE. The port of Tamralipti served as a major centre for the exchange of commerce and culture. Apart from maritime ties, Tamralipti was well-connected with major inland towns such as Pataliputra (currently identified with Patna). Based on the records left by visiting Chinese monks in the 5th and 7th centuries CE, it was also a major centre for learning, with strong links to Buddhism. Its significance as a major point of disembarkation on the East Indian coast linking the subcontinent to China, Ceylon and the South East Asia would have attracted a strong current of people and ideas from far and near making the region a melting pot for cultural exchanges.

The present study focuses on areas within the southern region of the Indian state of West Bengal and borderlands of Odisha to look for possible locations for the ancient port of Tamralipti. Although the larger historical, geo-political context would have been under the influence of this site and may have encompassed an even larger extent including parts of Bangladesh.

2. The Objective

The main objective of the paper is to explore the region with geospatial data and analysis to identify and locate the

ancient port of Tamralipti and its probable geo-political extents by correlating descriptions of it in historical literature and cartographic records along with archaeological and geomorphological signatures visible in satellite imagery.

3. The Methodology

3.1 Study of ancient literature

The study began with the analysis of the descriptions left by Chinese monks such as Faxian (5th century CE) and Xuanzang (7th century CE) of the ancient port town of Tamralipti. Based on excavations in the past decades, the city of Tamluk has been identified with this ancient port.

3.2 Analysis of satellite imagery for features suggestive of past settlements

The book *Patterns in Past Settlements: Geospatial Analysis of Imprints of Cultural Heritage on Landscapes* (Rajani, 2021) discusses how satellite imagery reveals clues of past occupations on particular landscapes. For identifying geomorphological features such as paleochannels and coastal strandlines (past coastlines) coarser resolution imagery offers better visibility in contrast to cases where one is looking for buried remains of built features which require higher resolution imagery. These are visible as cropmarks exhibited through a distinct variation of ground surface vegetation tone and texture (Rajani 2021). These are also highly dependent on the season during which the imagery was captured by the satellite.

Analysis of Google Earth imagery in the vicinity of the excavated sites revealed sites that followed a particular arrangement of square shaped concentric enclosures resembling forts and moats, predominantly aligned along cardinal directions. Most of them remain largely

inconspicuous following subsequent land cover developments, both anthropogenic and otherwise.

3.3 Study of historical maps and records and location of historical sites

Identification of numerous sites of a particular layout led us to study historical maps of the region and it was found that maps prepared and published in the 18th and 19th centuries by British cartographers such as James Rennell and Aaron Arrowsmith marked several sites in the region as forts.

Attempts were made to identify these sites (mostly spelt using old British names in the aforementioned maps) based on the closeness in the names provided in these maps and current place names along with their geographic location and with reference to other physiographic features. Subsequently, Google Earth imagery and CORONA satellite imagery was analysed and we observed the same concentric arrangements (both square and rectangular) in the vicinity of the identified locations, some intact, others altered to varying degrees of transformation. This has been elucidated in the respective section later in this paper.

3.4 Linking the distribution of sites and the geomorphological signature of the study region

Finally, these sites were plotted and analysed against the geographical character and physiography of the region to derive certain conclusions about the possible location and extents of the ancient port of Tamralipti.

This involved identifying the geographic coordinates of the sites from multiple sources (such as place descriptions in historical records, web portal of protected monuments and sites at both national and state levels) and plotted on Google Earth. These points were then transferred as vector data to Q-GIS to be analysed with multiple imagery such as CORONA, DEM etc.

Further, the pattern of site distribution was analysed with respect to the geographic arrangement (such as proximity to active or paleo water features, ancient shorelines, site elevation etc.). Based on this, inferences were formulated. This has been explained further in the section on Observation and Inferences. The following flow chart (Figure 1) elucidates the methodology.

4. Results and discussions

The geographic arrangement of the region has a unique composition. It is edged by the Bay of Bengal to the south, the east is bordered by the river Hooghly and its western fringe is occupied by the river Subarnarekha beyond which are rocky outcrops. The presence of numerous paleo-channels suggests that the rivers channels have changed their course several times in the past. The shoreline has also undergone changes as we observe paleo-strandlines running almost parallel to the current coastal edge.

It is beyond doubt that inland navigation was one of the most common means of transport and commerce in the region by observing the character of its landscape. Apart from natural features like the active and inactive water channels and strandlines, a cultural feature that is the most curious of all in this region is the presence of numerous square and rectangular layouts of similar proportions and alignment. A detailed study of the region using Google Earth and CORONA satellite imagery led us to identify several such layouts forming certain recurrent patterns. In the following sections, the observations and doubts are discussed.

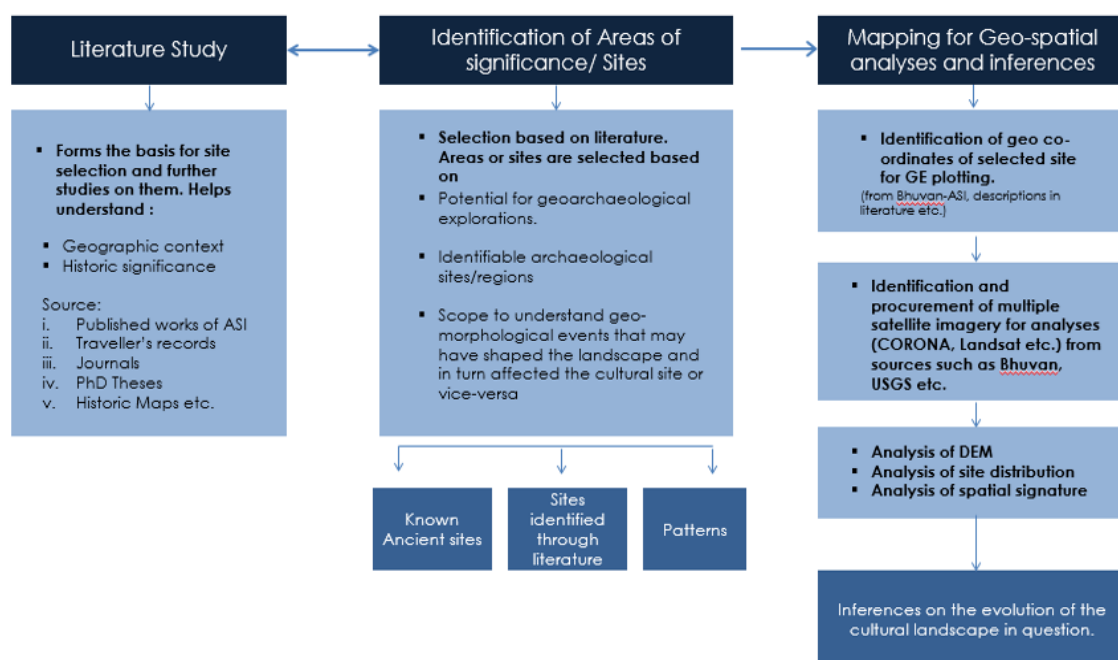


Figure 1. Flow chart explaining the sequence and inter-relation of methods adopted in this study.

4.1. The port of Tamralipti in Ancient Literature

The only literary references so far commonly adopted for its identification with the city of Tamruk in West Bengal, India, are from Chinese records dated to the 4th and 7th centuries CE (the translations of which have been used for this study).

i. Faxian (visited India in early 5th century)

An excerpt from '*A Record of Buddhist Kingdoms*' as translated by James Legge. (Legge, 1877)

"...Continuing his journey east for nearly 50 yojanas (from the ancient kingdom of Champa), he came to the country of Tamralipti (the capital of which is) a seaport. In the country there are twenty-two monasteries at all of which there are monks residing."

ii. Xuanzang (visited India in 7th century)

An excerpt from '*Si-Yu-Ki, Buddhist Records of the Western World*', as translated by Samuel Beal (Beal, 1884).

"...From Samatat going west 900li (A Chinese unit of distance, equal to about 0.5 km) or so, we reach the country of Tan-mo-li-ti (Tamralipti). This country is 1400 or 1500li in circuit, the capital about 10li. It borders the sea. There are about ten sangharamas (A Buddhist monastery) with about 1000 priests. **The coast of the country is formed by a recess by (or in) the sea, water and land embracing each other.** By the side of the city is a stupa built by Asoka Raja."

iii. Alexander Cunningham

An excerpt from *Ancient Geography of India* (Cunningham, 1871) (based on *Histoire de la vie de Hiouen Tshang et de ses Voyage dans l'Inde* by Stanislas Julien) (Julien, 1853)

"The kingdom of Tan-mo-li-ti or Tamralipti is described as 1400 or 1500 li, about 250 miles, in circuit. It was situated on the shoreline, and the surface of the country was low and wet. **The capital was in a bay and was accessible from both land and water.**"

Apart from this, in the original French translation, Julien mentions the presence of a stupa about 200ft high near the capital.

4.2. The geo-spatial Analysis of the Deltaic region: The concentric layouts

Most of these layouts resemble tiers of embankments and may have been part of ancient fortifications and/or part of a larger network of traditional water systems. The architectural character and nature of usage will only be understood through detailed investigations. In order to trace the origins of these recurring layouts, a study of historical maps of the region was done which revealed some interesting information.

While studying the region, a recurrent pattern of concentric layouts, mostly square or rectangular was observed. It is curious to note that some sites of the Archaeological Survey of India (ASI) and a few sites where excavations have been made in the past also form a part of such a concentric arrangement of squares and rectangles (Figure 2).



Figure 2. a. The example of Moynagur in West Bengal where the concentric tiers are visible in Google Earth imagery of 1/2010; b. CORONA declassified imagery from USGS portal; c. Two tiered arrangement in site within the study region in Google earth 1/2011

4.3 Information in 18th and 19th century British Maps

Aaron Arrowsmith's Map (1816/21)

A map compiled by Aaron Arrowsmith, an English cartographer and published in the early 19th century identifies about 9 sites marked as 'forts' within the deltaic region (see Figure 3). An excerpt from the description provided for the map in David Rumsey's online portal:

"Rare (unrecorded?) 1821 state of Aaron Arrowsmith's massive nine-sheet map of India first published in London in 1816. Arrowsmith's improved Map of India was the greatest map of India published from information

predating the Great Trigonometrical survey (1802-1921)."

Though the names of most sites have been rendered with old British spellings, an attempt was made to identify the places with reference to known places and the comparison of natural features in the vicinity as marked in Arrowsmith's map of 1816. A table including place names as given in the 1816 map of Arrowsmith and their current names, as identified in this study (Table 1.), have been listed below. The accuracy of this identification requires further substantiation.

Table 1. Place names from Arrowsmith's map and their current identification

Sl. No	Name in Arrowsmith's Map (sites in the vicinity of which concentric layouts have been observed are marked in <i>bold-italics</i>)	Current name (conclusion based on similarity in names and identification w.r.t to natural features shown in map)	Co-ordinates (Latitude, Longitude)
1	<i>Tamlook</i>	TAMLUK	22.292145°, 87.921833°
2	<i>Myrahgur</i>	MOYNAGUR/ MOYNACHOURA	22.249307°, 87.793615°
3	<i>Markondeah</i>	MARKUNDA	22.175130°, 87.297317°
4	Buckerabad	BAKHRABAD	22.146032°, 87.387620°
5	Narangur	NARAYANGARH	22.163204°, 87.388194°
6	Turkoah	TUTRANGA	22.043784°, 87.385028°
7	Belarry	BELDA	22.076320°, 87.339798°
8	Balleah	BORAH/BAHALIA	21.732685°, 87.515875°
9	<i>Depah</i>	DIPA	21.732685°, 87.515875°
10	Ammersee	AMARSAI	22.058949°, 87.602871°
11	Palaspoor	PATASHPUR	22.019910°, 87.540672°
12	<i>Kolander</i>	KOLANDA	22.092006°, 87.526535°
13	Badercally	BHADRAKALI	22.223808°, 87.427629°
14	Sillee	SALUA	22.266595°, 87.285232°
15	<i>Adjudagur</i>	AJODHYAGAR	22.283195°, 87.324880°
16	Bansah	BANSAPATRI	22.641392°, 86.654635°
17	<i>Doudpoor</i>	DAUDPUR	22.274042°, 88.830951°
18	Taujepoor	TAJPUR	21.657832°, 87.626387°
19	Bazdebpoor	BASUDEBPUR	21.824053°, 87.622215°
20	Jargong	JHARGRAM/JAARGO	22.455122°, 86.997770°



Geo-Archaeology of

GANGETIC DELTA

Fortification

From Aron Arrowsmith's Map published in 1821

Figure 3. Arrowsmith's map marking forts within the study area. The map is a part of a larger 1816 map of India from David Rumsey's portal.⁷

It is interesting that out of the patterns identified in this study, some are in close proximity to the sites of Arrowsmith's Map. It will not be possible to ascertain the character or condition of these sites in the 19th century, i.e., if they were physically intact, or were present as ruins or mounds, as the map was a compilation of several documents present before the Great Trigonometrical Survey was carried out. We are not certain if ground validation was made for any of these in the 19th century. It is crucial to identify historical documents of the region that could have recorded these sites.

The Journals of Major James Rennell during the surveys of the Ganges and Brahmaputra between 1764 and 1767 as compiled by T.H.D La Touche for the Geological Survey of India (1910) (Touche, 1910)

"Major James Rennell was first employed on the survey of the Ganges delta with the special object in view of finding a shorter passage suitable for large vessels from the Ganges to Calcutta, than that through the Sunderbans and the [river] Meghna. The Journal gives a detailed account of this voyage and of three subsequent expeditions, during which he surveyed a great part of Northern and Eastern Bengal. "

Though a lot of disparities will occur with the course of the rivers and water features as these underwent tremendous changes over the centuries that have passed, Rennell's volume is an irreplaceable resource for the data on the region's historical landscape. He identifies several historical and cultural landmarks of the period; some of these have been marked on his final maps, others in his description. It is of interest, that while trying to identify the buildings or landmarks that he describes in his journal, we came across certain sites, (some of which are identified by him, others in the vicinity of important places that he mentions) follow the patterns that have been observed in the lower reaches of the deltaic region (Figure 4).

The sites within the larger deltaic landscape

The distribution of the sites (ASI, other excavated sites, sites from Arrowsmith's and Rennell's Maps and sites identified in this study) and the geomorphological character of the deltaic region render the possibility of the identification of the ancient port of Tamralipti and/or its larger geo-political extents. The following Table 2 and the associated Figure 3 has been used to elucidate the observations.

Table 2. Details of sites that are identified in this study

SITE No	Current Name	Latitude	Longitude	Tiers visible / Condition in most recent imagery	Other features (all units in km)	Cardinal alignment
T01	Mahishadal	22.183597°	87.986284°	2 / fragmented	0.5 x 0.8	Clock-wise tilt
T01 A	Ranthala Bagan	22.181453°	88.005363°	1/ fragmented moat like feature	0.2 x 0.4	Clock-wise tilt
T02	Noorpur	22.212509°	88.071201°	1 / fragmented	0.24 x 0.24	Clock-wise tilt
T03	Tamluk hospital	22.287071°	87.919830°	1/ fragmented	0.34 x 0.5	Near perfect N-S alignment
T04_a	Gurudasapur	21.841645°	87.215358°	1/ vegetation cover reveals a square profile with a mound till 2015.	0.4 x 0.4	Clock-wise tilt
T04_b	Chaulia				Linear arrangement of water tanks	Clock-wise tilt
T06	Jallabhaj	22.238978°	88.021936°	1/ rectangular crop mark	0.22 x 0.32	Clock-wise tilt
T09	Falta fort	22.290197°	88.105429°	1/ oval in profile		NA
T12	Bhaua	22.389651°	87.054830°	1/ negative cropmark reveals a square profile with a mound	0.2 x 0.24	Clock-wise tilt
T27	Chandrarekhagarh	21.963867°	87.058937°	1/ moat clearly visible in the form of cropmark	0.88 x 0.6	N-S
T28	Dhobani sol	21.915828°	87.061476°	1/ square moat clearly distinguishable from cropmark	0.5 x 0.5	N-S
T29	Bedjharia	21.964430°	87.081665°	1/square profile visible from soil mark	0.35 x 0.35	Clock-wise tilt
T30	Unknown	21.946710°	87.072255°		Cropmark with significant elevation in close proximity to an inactive tributary	
T31	Changaul	22.316865°	87.383286°	2/ the configuration is largely altered but connections can be deciphered from the presence and arrangement of linear water features that form the edges	1 x 1.17	N-S
T 33	Kasba Narayngarh	22.156125°	87.390461°	Multiple tiers visible but have been cut across by roads		Near perfect N-S alignment
T 34	Gar Arara	22.623466°	87.372342°	Very significant in terms of the layout which is a single tier square with protrusions on all sides except the eastern end.	0.18 x 0.2 excluding protrusions	N-S
T35	Payrachali	22.049072°	87.603924°	2/ positive cropmark reveals the outer square where the inner	0.24 x 0.24	N-S

				one is seen as a depression.		
T 38	Alisagar	22.385031°	87.555805°	3 / Moat like arrangements are clearly discernible through ground texture differences in satellite imagery	2.28 x 2.28 (outer tier), 1.1 x 1.1 (second tier)	Counter-clockwise tilt
T41	Panchetgarh rajbari	21.955891°	87.560057°	1/ square moat like feature visible	0.45 x 0.45	N-S
T42	IIM	22.444718°	88.299799°	Site records prior to construction of the institution needs to be verified to check if the square water body surrounding it is part of an older site.		Counter-clockwise tilt
T44	Unknown	21.988670°	87.514896°	Linear water feature	1.15 km long	
T 45	Unknown	22.042487°	87.549214°	Linear water feature	0.8 km long	
T 47	Khagra beri	22.118078°	87.455913°		Positive cropmarks, presence of moat like arrangements and elevation profile are significant	
T 49	Unknown	21.797193°	87.323349°	Outer edge of the square profile is raised with settlement on them, the inner tier is presently a tank	0.2 x 0.2	Counter clock-wise
T54	Unknown	22.352393°	87.849107°	Comprises of an outer enclosure within which are seen a pair of sites with concentric profile with bastion like features visible in 2007 imagery.	Each site is 0.4 x 0.4	clockwise tilt
T 55	Unknown	22.376802°	87.846778°	A smaller fort which is rectangular with basitons	0.17 x 0.24	N-S

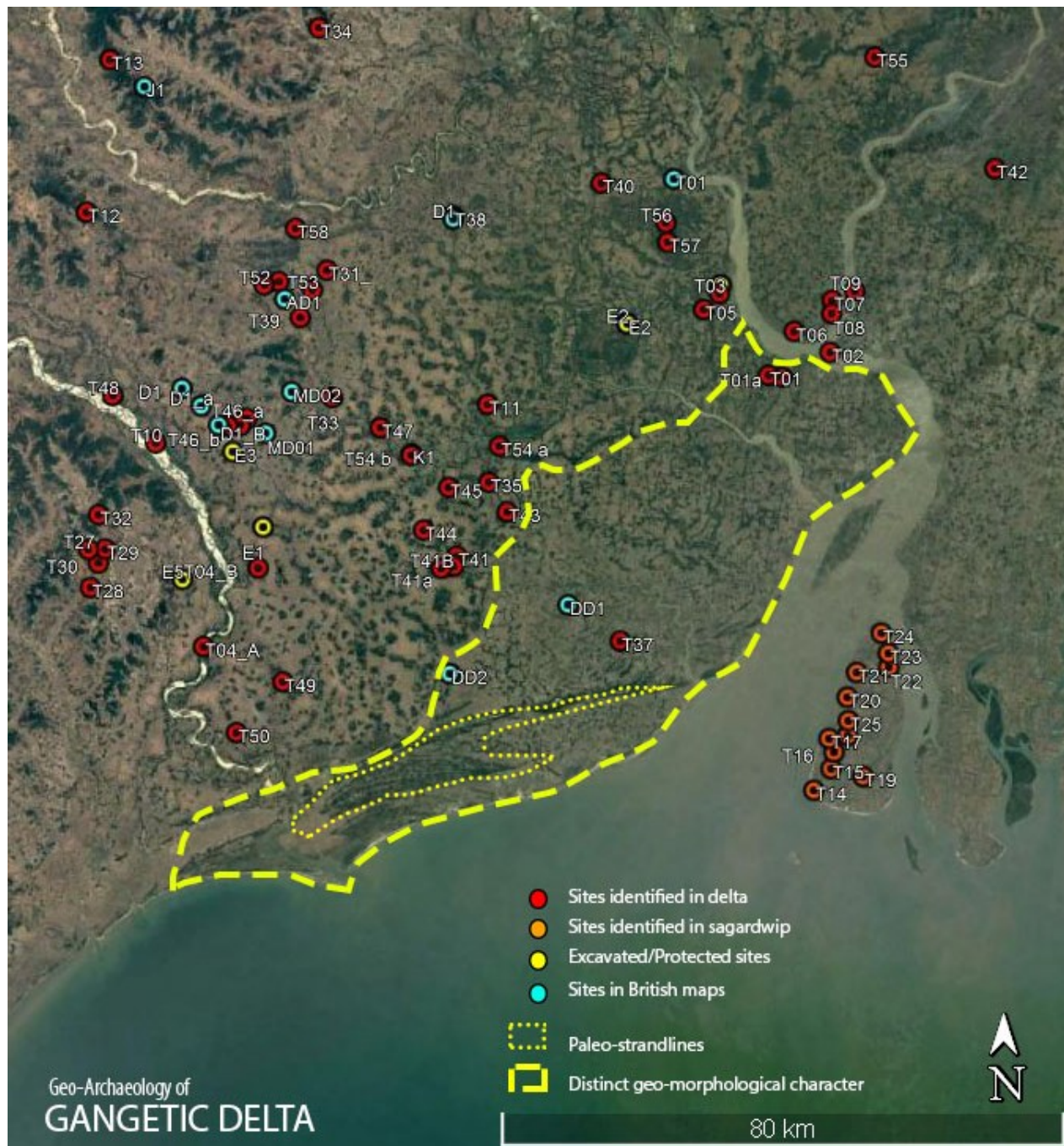


Figure 4. The study area showing the distribution of sites and the geomorphological character of the landscape. Google Earth image 12/1984

5. Observations and inferences

With the exception of two, the sites are restricted to the areas north of the region highlighted in yellow in Figure 3. Geological literature also identifies a few strandlines in the region, with the youngest one forming the current shoreline (Pravin 2005). Closer observation of Google Earth imagery reveals a distinct texture in this highlighted region when compared to the areas to its vicinity. The arrangement of paleo-strandlines (Figure 5), paleo and active channels within the highlighted region brings forward several questions on its possible historical character.

5.1 Presence of strandlines

The strandlines could be indicative of ancient coastlines that were much inland as compared to the present coast. These however, are not entirely parallel to the current coastline.

5.2 Network of paleo-channels and active river channels

A map published in 1740 (Figure 6) (although the information depicted could be much earlier) represents the current deltaic region as several smaller landmasses. Closer observation of Arrowsmith's map also reveals to us water channels that encircle several regions within the delta. It could well be possible that over time, the fragmented land masses under combined actions of sedimentation from the river and sea coast dynamics

transformed into what is observed at present. Also, from the historical descriptions mentioned in the earlier section of this paper, the capital, Tamralipti, is said to have been located along the bay, accessible by means of land and water.

Thus, this arrangement of paleo-channels and active channels could mean that historically, the region consisted of several smaller islands or fragmented landforms as we

observe in the present day Sundarban. Had this been the case, by observing the arrangement of the strandlines and the concentration of the identified sites, the port of Tamralipti could have been situated in the region that is immediately north to the highlighted region (Figure 3) (which may have been the bay in the historical descriptions along which the capital was situated) as this part could have been easily navigable by water and also accessible through land transport



Figure 5. The arrangement of strandlines is indicative that the coast was much inland in the past. Google Earth image 12/1984



Figure 6. a. The current deltaic region being fragmented by water channels, from the 1740 Seutter Map of India. b. Deltaic region with water channels encircling those (blue dotted lines) as shown in Arrowsmith's Map

A curvilinear feature (Figure 7 inset) at the edge separating the two contrasting geomorphological signatures at some point could either have been a major water channel or the coastal fringe. Had the ancient coastal edge been where the yellow highlight begins, then it is possible that the port of Tamralipti was located within one of the three highlighted regions as we observe vegetation patterns that are typical patterns of archaeological interest and a distinct landscape signature (encircled in red in the Figure 6).

5.3 Analysis of digital elevation model and multispectral imagery

Analysis of Digital Elevation Model (Figure 8) for the region strengthens the observations made on the basis of

signatures observed in satellite imageries of various dates. We observed that the three possible locations (highlighted in dashed rectangle in black) are worthy of detailed investigations as they are at a significantly lower elevation compared to areas to its north and south which indicate that this stretch may have been submerged or was separated from the land to its south at some point in history.

Similarly, a distinct vegetation texture is observed along the region which we conclude to have been a former shoreline (refer to Figure 6b.) in LANDSAT imagery of 1973 (Figure 8.b).

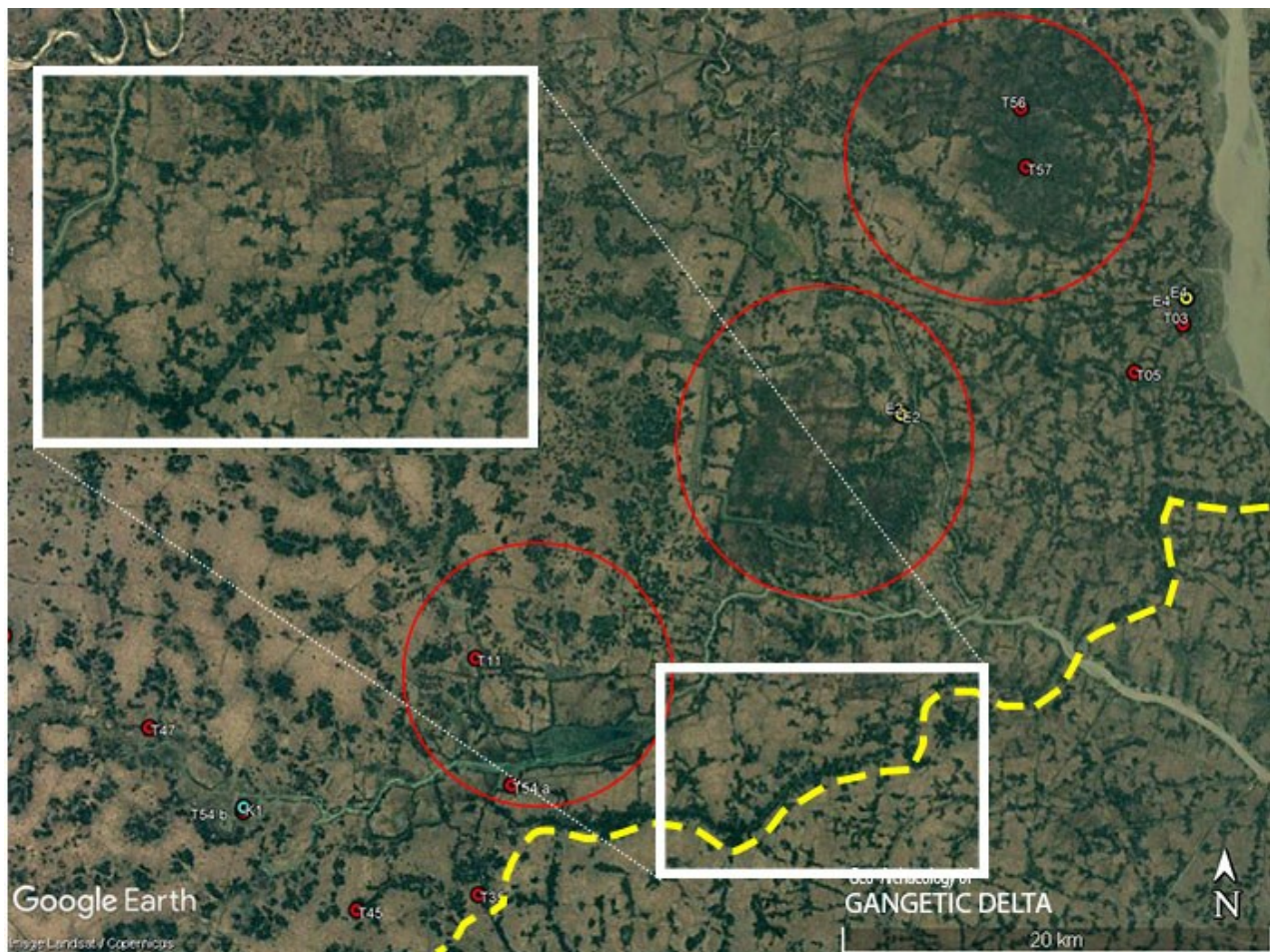


Figure 7. Areas with a conspicuous distinction in texture located along the probable edge of the ancient coastline. The concentric layouts are also observed within the three areas highlighted in red. Google Earth image 12/1984

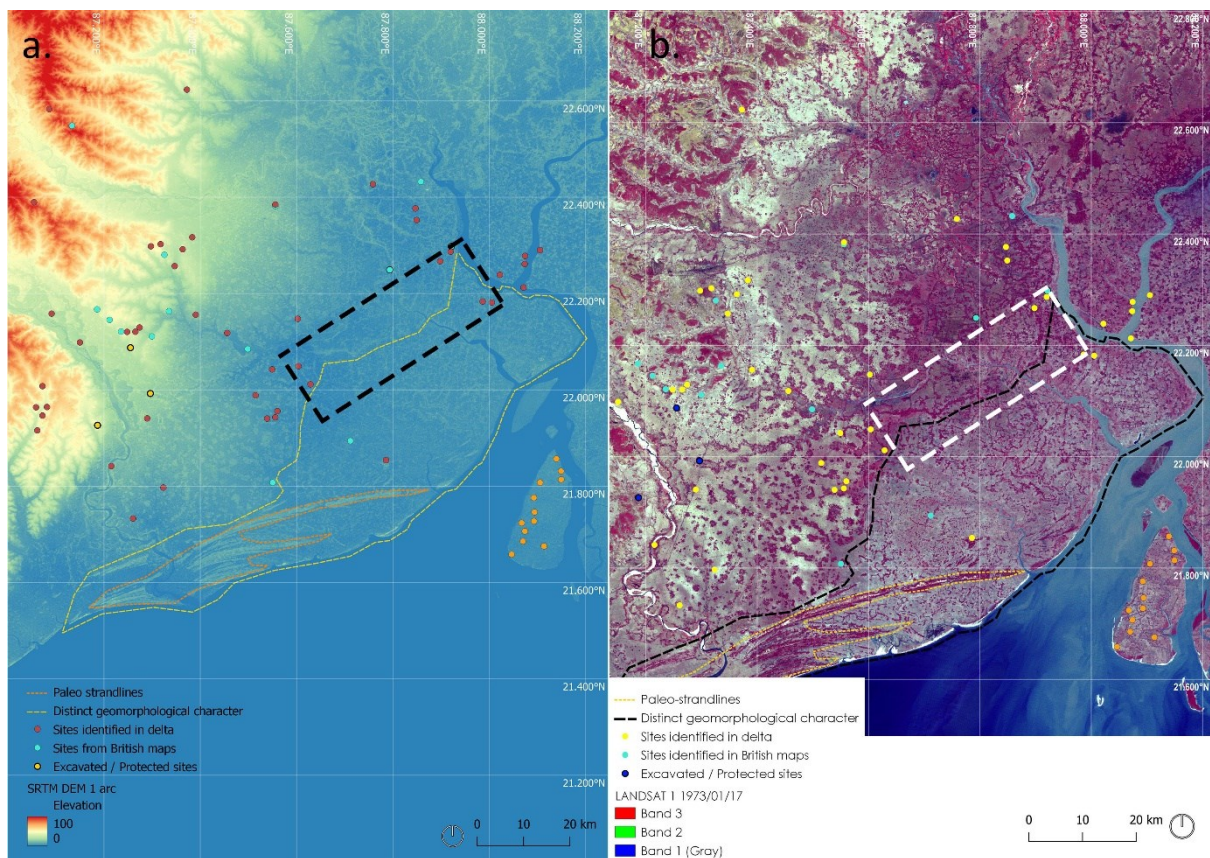


Figure 8. a. The sites overlaid on SRTM DEM 1 arc data stretched in single band pseudo-colour between 0 and 100 and b. overlaid on LANDSAT 1 imagery dated 1973/01/17.

6. Concluding remarks and future directions

The region that included Bengal and its neighbouring areas were historically under the political and economic control of numerous dynasties. However, despite the identification of potential locations, the current stage of this study does not grant the liberty to place our observations (the concentric layouts in particular) within any chronological framework as this would require intensive research and field investigations. As our primary references are of traveller's records between the 5th and 7th centuries and European maps published in the 18th and 19th centuries, the time-frame under consideration spans a few centuries. The geo-spatial patterns observed in the sites that have so far been identified within this region suggest that it was of immense significance in the past. Having been located in a very dynamic landscape, the sites underwent certain degrees of transformation, yet there are strong clues in the form of spatial layouts and other patterns that provide clues to the region's historical character, both architectural and geomorphological. Based on the character of the layouts that have been observed in all the sites that have been identified in this study, it is assumed that their inception would not have been widely separated and that they must have been products of the same socio-cultural context. What constituted this socio-cultural context and what were the regional and cross-cultural contributions that established them would be an interesting research problem to explore as this might shed more light into the illustrious yet eclipsed past of the ancient port in question.

The observations in this paper are based on spatial patterns and can be explored further with field investigations and calls for the need of a multi-disciplinary approach.

Identification of cultural heritage resources are a key component in sustainable city planning. This holds importance in multiple ways, the foremost of which is to empower communities to embrace their cultural heritage through well thought out strategies of city planning by acknowledging these diminishing cultural vestiges. Traditional knowledge systems embodied by these historic built resources, if incorporated appropriately to meet the demands of modern times, will help resolve a majority of the issues arising from human-environment interactions in ecologically sensitive areas such as the study region. Thus, the role played by remote sensing and GIS is vital in the on-going efforts for the conservation of cultural heritage resources.

Acknowledgements

The work reported in this paper forms a part of the Geo-archaeology project funded by the Space Applications Centre (SAC), Ahmedabad, under the GAP scheme. We thank SAC for supporting and collaborating in this work. We thank Geographicus Rare Antique Maps and Mr David Rumsey Collection for permissions to use the maps from their collection in this work. We thank the anonymous reviewers for their feedback.

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