SANDHI

CHANDRAKETUGARH

– rediscovering a missing link in Indian history

(Project Codes AIB and GTC)

A synoptic collation of three research by the SandHI Group

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

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Foreword

The Department of Higher Education, Ministry of Human Resources Development, Government of India has steered a series of national and regional level workshops, for launching pilot projects, for creating centers of excellence based on a spirit of inter and intra-institutional convergence promoting research, development, innovation (RDI) initiatives. The idea is to pro-activate and augment a 'people-centric' course of India's future growth plans, strategies and development programs based on clusters of projects executed by IITs and other allied institutes.

Addressing the aforesaid course, the Indian Institute of Technology Kharagpur has made a distinctive and forerunning headway for creating and initiating a cluster of projects under the 'Science-Technology & Culture-Heritage Interface' schema of Government of India. Other IITS and Institutes of national importance have also followed.

The present report is one of many to represent the headway. As one of many, it represents the effort to forward the vision of IIT Kharagpur, which will serve both as an umbrella to plan, design and activate a 'people-centric' ground reality for a cluster of projects. The vision is based on the foundations of Indo-centric theme and an operational-cum-organizational structure of scientific exploration, at the same time. These projects represent inter and intra-institutional convergence of research, development, innovation (RDI) initiatives. The vision is called 'SANDHI'. 'SANDHI' literally means convergence and confluence. 'SandHI' is also the platform of inter-disciplinary and inter-institutional assimilation. SandHi is the acronym of 'Science-Heritage initiative''. Under 'SANDHI', there are four levels of activity:

- First, a deeper level of philosophical research based on scientific exploration;
- Secondly, an outward recovery of Indian heritage systems based on the epistemological domain of Indian science and technological traditions;
- Thirdly, a re-positioning of traditional community planning and engineering systems based on the Indian ethos; leading to a fourth and demonstrative level, i.e., a pro-active resurrection of traditional knowledge systems of India based on creative economy regeneration and marketing in various corners of reality – concerning the people, their economy, their folk and the all-round livability of the surrounding they belong to.

Exploration Through Cooperative Inquiry

Constituting Level three, there are a set of geo-exploration and geo-quest projects. One of them is Chandraketugarh.

Chandraketugarh, situated at Latitude 22°41'48.28"N and Longitude 88°41'19.38"E in the North 24 Parganas, West Bengal, exhibits remnants of an important port-city that apparently flourished from about 4th century B.C. to Post-Gupta age.

The more popular but limited excavated site is 'Khana Mihirer Dhipi' at Chandraketugarh. This it is believed to be early medieval age. The place was connected with the Bay of Bengal mainly through two rivers: Bidyadhari and Padma, flowing into Bangladesh. It is believed that the city had trade contacts with international frontiers or lands like countries in the South-east Asia and also in the Mediterranean and perhaps, indirectly with even the later Greco-Roman world in its formative and early days. The current inferences about the civilization history of Chandraketugarh are at large based on and limited to the antiquities found at the place, till date. But there are traces and findings that point out to an older tradition beyond 400 BCE, making and presenting something more powerful in the lineage of eastern Indian history and something comparable to the ancient Indus Valley findings in the west of India. It is a point that has been unfortunately marginalized and often neglected. Therefore, there is a need to initiate a fresh exploration in a deeper and wider framework of things. Hence, the present research.

The present research also attempts to shed light on degradation status of the ancient history and the ancient structures of Chandraketugarh and subsequently re-cast a more truthful history of the lower Indo-Gangetic plain. The task is attempted through inter-twined projects:

Project AIB

To rediscover the history of urban planning science and urban engineering in Eastern India through an archaeological exploration of Chandraketugrah, West Bengal on the prior foundations of:

Project GTS

A geo-quest of Chandraketugarh by:

- Reframing the evolutionary trend of urban settlement of Chandraketugarh primarily in relation to the early historic urban growth in Bengal and beyond, using geo-scientific knowledge; and
- Evaluating deterioration status and plausible preservation and/or restoration aspects of the ancient structures.

The Team

The present report is a wonderful work of a team, who have dedicated their handwork to the cause and need of a fresh exploration.

1. Oindrilla Bose (AIB) [Key Geo-exploration supports and Riparian research]
2. Tanima Bhattacharya (AIB) [Iconography and allied Historical research]

&

3. Arundhati Patnaik, Apala Sarkar Ghosh and Tushar Kanti Saha [SandHI Support Team]
4. Ananta Agarwal (GTS) – 2015 MS Thesis, IIT Kharagpur
5. Sandhi Summer Interns 2015 in the Geological and Geophysics Department (GTS)
6. Joint team of professors from the Departments of Architecture and Regional Planning and Geology and Geophysics
7. Sunny Bansal, Deepanjan Saha, Prerna Mondal, Arpan Paul and Vidhu Pandey [SandHI Research Scholars team]

The present report is a culmination of the tireless efforts of these bright, young and surging minds.

Joy Sen and Arindam Basu
Principal Investigators,
SandHI projects on Chandraketugarh

Supporting team of Professors:
Probal Sengupta and Abhijit Mukherjee

September 11, 2015

India of the ages is not dead nor has She spoken her last creative word; She lives and has still something to do for herself and the human peoples. And that which must seek now to awake is not an Anglicized oriental people, docile pupil of the West and doomed to repeat the cycle of the Occident's success and failure, but still the ancient immemorial Shakti recovering Her deepest self, lifting Her head higher toward the supreme source of light and strength and turning to discover the complete meaning and a vaster form of her Dharma.

Shri Aurobindo

Arya: A Philosophical Review
(January 1921)

'The Foundations of Indian Culture'

It may be debatable whether material history is the expression of an original idea; but it is an indubitable fact that spiritual history is always so. 'It is of the One existence that yearning hearts speak in diverse ways' - has said a Vedic seer (RV: 1.164.46); and this is true not only in an abstract way, but in a concrete form also.

Like the mystic Asswattha tree of the Upanishad, [the Bodhi Tree] 'with its roots above and the branches below', the Vedic tradition, in a broad sense, it stands at the very source of almost all forms of spiritual cults. And the interpretation of this tradition can be attempted with best results if we do not place the Vedas on the isolated heights of the past, but with a total (complete) vision of the present retrace our steps to the roots discovering, with a penetrating insight, the links at every steps.

Sri Anirvan

Vedic Exegesis

'The Cultural Heritage of India', Volume one,

RMIC, Kolkata (2001)

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PROJECT ONE

To rediscover and re-formulate the history of urban planning and engineering in India through archaeological exploration of Chandraketugrah, West Bengal

The Team

1. Oindrilla Bose (AIB) [Geo-exploration supports]
2. Tanima Bhattacharya (AIB) [Iconography and allied Historic research]
3. Arundhati Patnaik and Apala Sarkar Ghosh [SandHI Support Team]

&

4. Sunny Bansal, Deepanjan Saha, Prerna Mondal, Arpan Paul and Vidhu Pandey [SandHI Research Scholars team]

PROJECT ONE

To rediscover and re-formulate the history of urban planning and engineering in India through archaeological exploration of Chandraketugrah, West Bengal

Table of contents

1.0 Introduction

The present report deals with the re- exploration of geo- archaeological, architectural and iconographic study of Chandraketugarh, located in the North 24-parganas, (shown in Fig 1) district of West Bengal, India.

1.1 Preamble: Chandraketugarh is an urban centre of the ancient state of Gangaridai (as evident in Fig 6) belonging to the trans-Bengal region at the interface of West Bengal and Bangladesh. The description has been found from various travelogues from India and abroad. The position of Chandraketugarh has been acknowledged on the basis of Maritime-Land route memoirs and textual historic evidences obtained from within India and also from the eastern and western parts of Asia. The antiquity of the area dates back to eras as early as 4th century BCE, a period much prior to the Mauryan era and shows evidence in the continuity of subsequent Sunga, Kushana, Gupta, Pala and Sena dynasties.

1.2 Geographical Location: The location of Chandraketugarh (as shown in Fig 2) is 22□41′52″N and 88□41′8″E.It is an ancient city of Bengal situated along Bidyadhari River, at a distance of 10 km from the northern part of the river. It is nearly 35 Km from the northeastern part of Kolkata, in the North 24 parganas. Centuries ago Bidyadhari River was connected to the Adi Ganga and the river channels helped this region to enjoy an easy access to the sea.

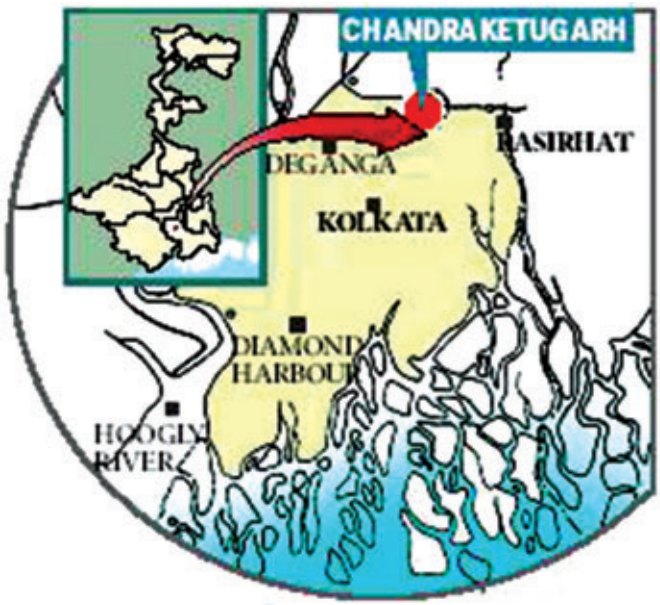

Fig 1 Map showing the position of Chandraketugarh

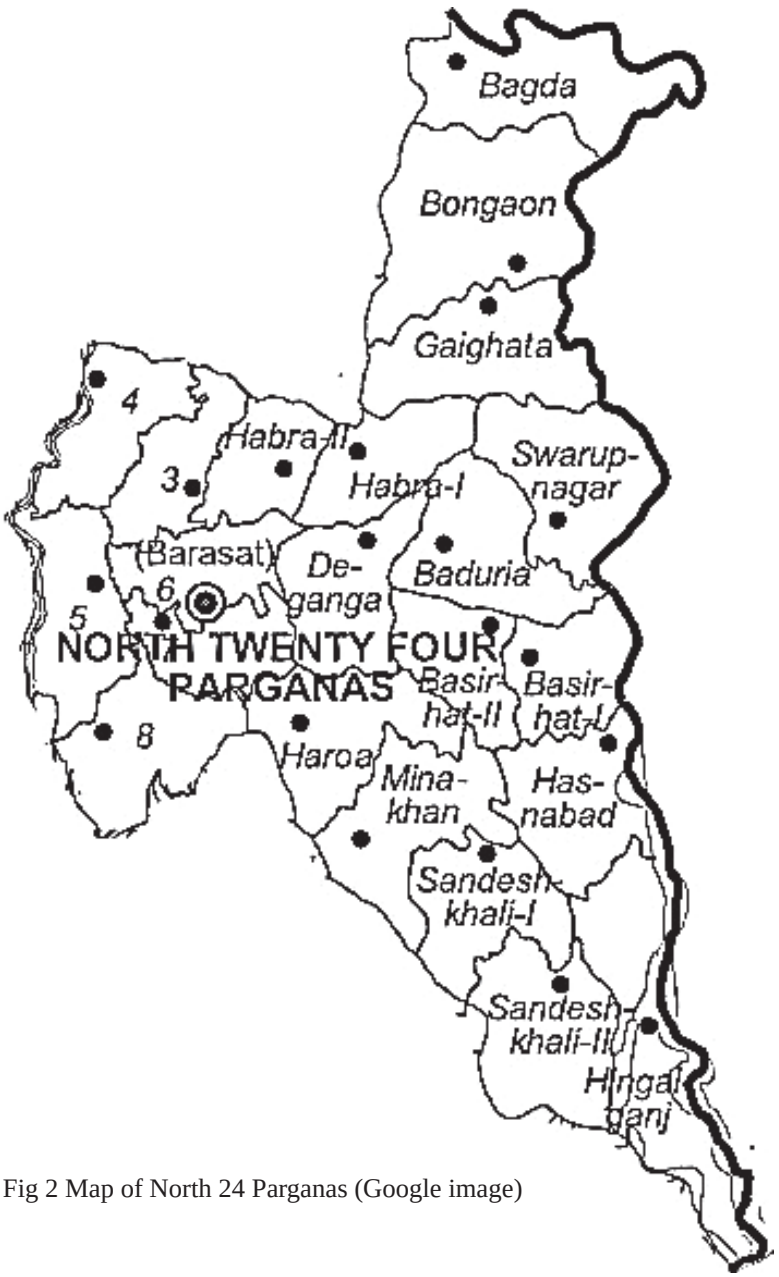

Fig 2 Map of North 24 Parganas (Google image)

1.3 Historic Evolution: Some Findings

The various descriptions regarding Gangaridai, documented by numerous travellers (both international and national) in their travelogues are as follows:

International Evidences

Various international travelers like Megasthenese, Ptolemy, Diodorus Siculus etc. have described Ganga and its surrounding region, then known as 'Gangaridai' in different ways in their respective travelogues. Portion of descriptions are mentioned below:

- The present Bengal was previously known as Gangaridai - indicated by the Greek traveler Megasthenes (350 BCE-290 BCE) in his work 'Indica'. The capital of Gangaridai was Kotalipara (present day Gopalganj district of Bangladesh). The name ;Sandrokrottos' in Indica bears an unexplained similarity with the name 'Chandraketu' –a fact yet to be explored
- According to Ptolemy (CE.90- CE.168) Gangaridai includes the entire region around the five mouths of the Ganges.
- During Alexander's invasion, Diodorus Siculus (c.90 BCE-c.30 BCE)obtained a description of the country beyond Indus from Phegeus, the king of Greece. The Greek sovereign described his journey across a desert which took twelve days to traverse and beyond it was the river Ganges, which was thirty-two stadia in width and was of greater depth than any other river. This river flowed from north to south and empties into the ocean forming the eastern boundary of Gangaridai
- In 'The Periplus of the Erythrean Sea' (1st – 3rd century CE) it was mentioned that Gangaridai was located adjacent to the Bay of Bengal which is north to the port city of Dosarene of Kalinga (ancient Orissa)
- In 'The Periplus of the Erythrean Sea' it was also mentioned that many Greek seamen maintained trade with the Muziris. They exported great quantities of fine pearls, silk cloth, and spikenard from the Ganges
- 'The Periplus of the Erythrean Sea' mentioned about 'Gangae', but Megasthenese in 'Indica' mentioned the same region as 'Gangahridi' present in the eastern part of India

National Evidences

Different eminent national historians have described location of present Bengal, its various rivers, economic life in their various documentations. Some of the important facts are mentioned below:

- Kautilya (370 BCE-283 BCE) being the minister of Chandragupta Maurya mentioned that he maintained foreign policy with external countries like Sri Lanka, Barbara, Burma, Pasa, Nepal, China, Afganisthan, Kamboja (also northwestern part of India. He preferred land routes to water routes and also southern routes to northern routes.
- According to Rakhaldas Bandyopadhyay (1909), during the rule of Chandragupta Maurya, Gangaridai was independent like Andhra kingdom and was joined with Kalinga.
- Dr. N.K. Sahu said that the Ganga dynasty of Orissa were the descendents of Gangaridai people who migrated to South India from Tamluk, South Bengal. He further said that Gangaridai people occupied the entire eastern coast of India stretching from Bengal to Kalinga and Madras.
- Excavation around Chandraketugarh proved that it was a part of the city'Gangae'. Historian Paresh Chandra Dasgupta said that most probably 'Gangae' was the port town of Chandraketugarh.

Various international and national travellers/historians during their voyages through India described Gangaridai and the different river courses flowing through that region in various ways. These are the important sources to locate Gangaridai and most importantly Chandraketugarh. These travelogues logically points out at the importance of the greater Chandraketugarh region in the international forum. The ancient Indian literary sources and the archaeological evidences of the present century also corroborate the trade and commercial transactions of South Bengal with foreign nations.

2.0 SandHI Perspective

Chandraketugarh, an important port city is believed to be of early medieval times. This site was once connected with Bay of Bengal mainly through two rivers, namely Bidyadhari and Padma. It is believed that the city maintained trade relation with foreign lands like South-east Asia, Mediterranean and indirectly with Greco-Roman world in the early days. The quality, diversity and the number of plaques and ivory objects unearthed points it out to be a sophisticated urban centre of India. But the origin of the city's name, verification about its location on the river bank, actual area of the site, actual date of its urbanization in relation to the early historic urban growth in Bengal or of a wider network etc. are still not proved by field evidences. The proposed research aims at resolving some of the issues and/or to check/ validate the existing inferences by adopting geo-scientific approaches. The research also needs to shed light on the degrading condition of the ancient structures and also on their probable preservation.

Objectives: Following are some of the objectives that are required to be fulfilled in the aforesaid project work.

- To reframe the evolutionary trend of urban settlement of Chandraketugarh primarily in relation to the early historic urban growth in Bengal and beyond using geo-scientific knowledge.
- To evaluate deterioration status and plausible preservation and/or restoration aspects of the ancient structures.

Deliverables

The concerned site being situated on the Ganga-Brahmaputra delta is packed with numerous signatures of palaeo-channels, marshes, palaeo-levee, palaeo-point bars etc., indicating heavy sediment load and low discharge capacity of the rivers. Earlier researches inferred that Chandraketugarh and other historic sites of the region are buried sites where early alluvial horizons are buried under thick alluvial depositions because of the influence of active flood plains. With a due need, geomorphological and hydrogeological studies, application of non-invasive and probable invasive geophysical techniques, engineering geological investigations, study of the sediment characters and sedimentary structures, geochemical analysis and sediment dating form the foundation of the proposed investigation in order to address the first outlined objective. Non-destructive index test needs to be employed in order to assess the status of degradation of the ancient structures which eventually would enable us to comment on plausible preservation and/or restoration aspects with reference to these structures. It should also be noted that depending on feasibility, a few other relevant cities in Bengal and even beyond it are proposed to be covered for some obvious reasons in this investigation.

2.1 Archaeology

Chandraketugarh, the old urban centre with thriving trade and commercial activities of the 4th Century BCE is a haven of archaeological antiquities ranging from coins, beads of semi-precious stones, terracotta, stone sculptures to gold coins and objects made of bone, ivory and wooden artifacts. The quality and artistic skill of the excavated artifacts indicate that Chandraketugarh was once a very elegant and refined urban centre of ancient India. A polygonal brick temple facing north, known as Khana Mihirer Dhipi was recovered from this site. Since this area in all probability was connected to the Bidyadhari River, it can be mentioned as a significant port city. This site was known as 'Gangaridai' to the ancient Greek and Roman writers. This 'Gangaridai' (Bengali: Gonggarriddhi meaning wealth of the Ganges. In Sanskrit: Ganga Rashtra meaning nation of the river Ganges) was an ancient state established around 300 BCE is described by the Greek traveler Megasthenes in his work 'Indica'. Again Ptolemy mentioned that Gangaridai occupied the entire region around the five mouths of the Ganges. In 'The Periplus of the Erythraean sea', the location of Gangaridai was mentioned to be close to the Bay of Bengal, north of the port city of Dosarene of Kalinga (ancient Orissa).

3.0 Geo-Quest

The formation of the Bengal basin and its geological features are of great importance. The concerned area lies within Bengal basin. Bidyadhari River, once connected to the Ganga River was the main source of communication of the concerned area. Thus the evolution of the said basin through geologic period and the shifting of the river courses through ages are described below.

3.1 Geomorphological Features

Chandraketugarh is situated within the Bengal basin, which is the largest deltaic sedimentary system. Here accumulation of sediments in the basin mainly contributed by the Ganges - Brahmaputra - Meghna (GBM) river system and is finally dispersed into the Bay Of Bengal, forming the largest submarine fan of the world. Geomorphology of the area is presently dominated by the Holocene GBM floodplain and delta. The mineralogy is dominated by detrital quartz, some feldspar, and minor amount of carbonates; illite and kaolinite are the major clay minerals. The heavy mineral assemblages include amphibole, pyrope and epidote. Difference in the sediment provenances are reflected from mineralogy and sedimentology of the area.

The basin is a peripheral foreland formed by continent- continent collision. It is a consequence of the subduction of the Indian plate below the Eurasian and Burmese plate. Formation of Bengal basin initiated with the break-up of Gondwanaland during the late Mesozoic period. Basin development process in the late Jurassic – early Cretaceous period initiated by the extrusion of basalt in both the Rajmahal, South Shillong plateau areas. It was followed by slow subsidence of Bengal shelf in the late cretaceous. In the middle of Eocene, basin wide subsidence was initiated by movement along the basin-margin fault. This led to marine transgression, resulting in deposition of Sylhet limestone. Probably the basement fault movement embossed the CMHZ on the limestone and that led to separate evolutionary history of both the eastern and western halves of the basin. Lagoonal argillaceous and areneceous sediments were deposited on the western part of the basin, whereas eastern and north-eastern halves were occupied by open neritic sea. Later on intense tectonic activity led to basin wide regression resulting to the development of modern Bengal basin, which is an alteration from marine-estuarine environment to fluvial- tidal dominated environment.

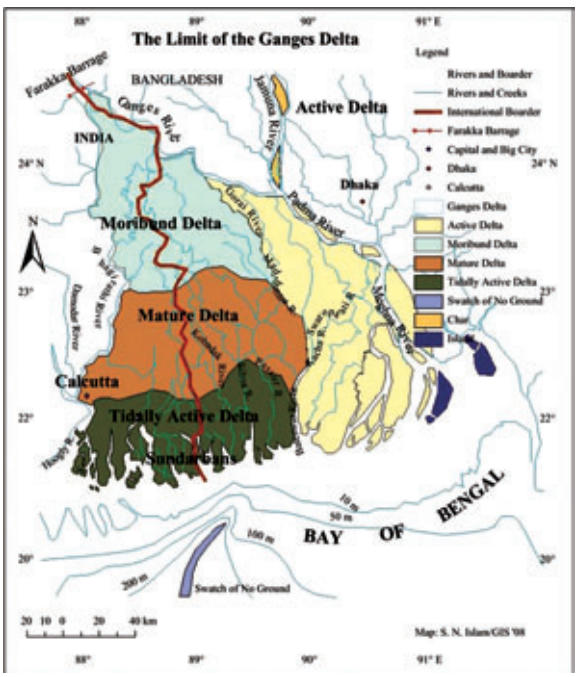

Fig 3 Ganga-Brahmaputra delta system (Islam et.al, 2008)

The concerned region is situated on the moribund delta of Ganga-Brahmaputra River system, (shown in Fig 3) and the rivers constantly alter their courses. This site is in a large measure riverine, hence criss-crossed by numerous drainage lines. Here the rivers are mainly rain water fed, which river of the northern part are fed by tide water or back water. The height of the region is less than 10mt. above the mean sea level.

The major drainage of this area is constituted by the Bidyadhari River flowing by the side of Haora, little south of the concerned area. This area was most probably linked with the Bidyadhari River in some way and the Ganga in some way was connected to the Bidyadhari River. Chandraketugarh was although not situated on the Adi Ganga, but in all possibility it was connected with the region further to the North and North-East. Some surface indications of these rivers have been found suggesting their flow through Deganga (located in Fig 1) connecting Bengal with Bangladesh. These rivers are lost today,

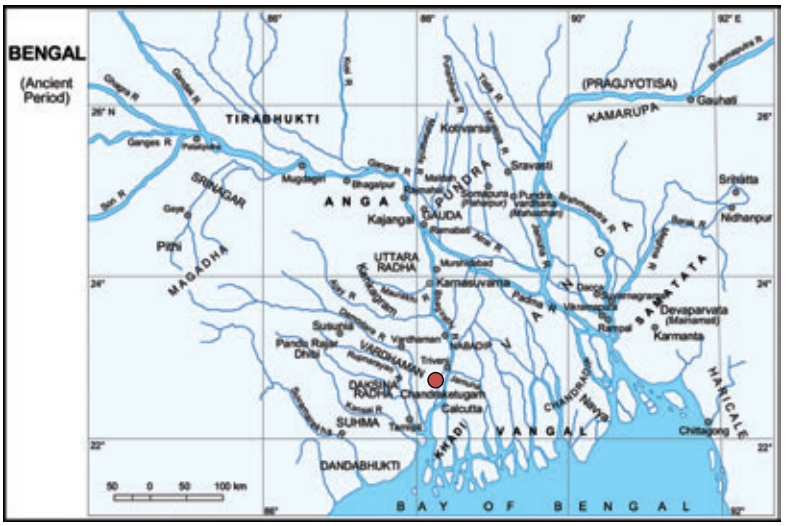

Fig 4 Drainage pattern and position of Chandraketugarh in ancient Bengal (Google Image on Ancient Bengal)

Fig 5 The position of Chandraketugarh lying on the Barasat–Basirhat connection with respect to Kolkata (Image from Google Earth)

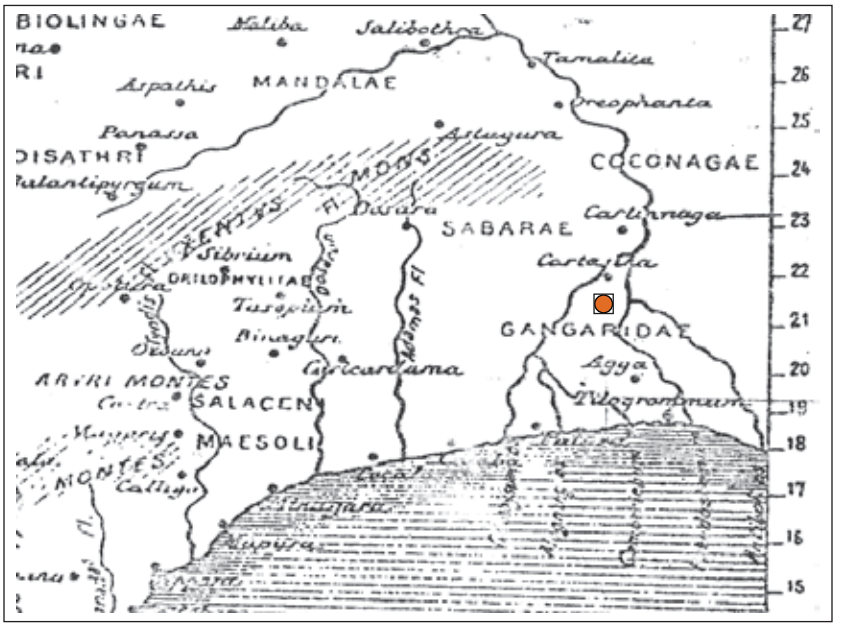

Fig 6 Ptolemy's Map (2nd century CE), the conjectural map on Chandraketugarh showing the location of Gangaridai, within greater Bengal, (accessed from Google maps)

days, hence the interconnection between Bengal and Bangladesh came to an end, leaving Chandraketugarh a dead place. According to a report of Geological Survey of India (GSI), the site shows various geomorphic features like palaeo-levees, palaeo-channel, and point bars etc. Their stratigraphic analysis showed lesser amount of sand and more than 80% of silt and clay revealing alluvial nature of the deposition.

The region of present Bengal, previously known as Gangaridai, had its capital at Kotalipara. Ptolemy also mentioned the location of the said region around the five mouths of the Ganges namely the Kambyson, the Mega, the Kamberikhon, the Pseudostomon and the Antibole. He further mentioned that the royal residence was in the city of Ganges.

During Alexander's invasion, Diodorus Siculus (c.90 BCE-c.30 BCE) described the country beyond Indus from Phegeus, king of Greece. He came across a desert after twelve days of traverse and beyond it was the river Ganges, thirty-two stadia in width, was of greater depth than any other river. This river flowed from north to south and emptie into the ocean forming the eastern boundary of Gangaridai. Excavation around Chandraketugarh proved that it was a part of the city 'Gangae'. Historian Paresh Chandra Dasgupta said that most probably 'Gangae' was the port town of Chandraketugarh.

Various description from different travellers are the important sources to locate Gangaridai and also in broader sense to locate Chandraketugarh. Thus in order to assess the position of Chandraketugarh against the chronology of Indian history and to identify the palaeo-channels and its impact on Geo-spatial shifting of the river courses affecting Chandraketugarh's history, various methodologies are suggested to meet up the above mentioned objectives.

Methodology Suggested

The following methodologies are suggested along with their respective purposes, which can be approached in future research work, in order to meet the above mentioned objectives.

Table 1

No.	Methods	Description	Purpose
1.	Geo-archaeological investigation	Deals with the study of various terracotta figurines, artifacts of early historic times dug out from the ground.	To understand the socio-economic condition of the place, dating may reveal the chronology of settlements occurred in the area.
2.	Hydrological investigation	Deals with the study of fluvial system.	To understand the shifting of the river courses.
3.	Geophysical investigation	Deals with the study of sub-surface features (presence of any structures ,conducting materials etc).Here it is carried out mainly with the help of a GPR.	To study the sub-surface layers and to delineate the presence of any such structures or bodies there.
4.	Sedimentary analysis	Deals with the study of different sedimentary layers(preparing lithologsupto certain depths at various locations), grain size variations,Sedimentary structures,etc.	To delineate the chronology in their sequence of depositions and also to understand the sedimentary environment.
5.	Remote sensing	Deals with the study of surface features from aerial photographs.	To trace the paleo-channels with the help of GIS in order to delineate the pattern of shifting of river courses.

3.2 Riparian Shifts and Historic Analysis

Adi Ganga is one of the oldest and most eminent river of West Bengal and also of India. Since it has been flowing from the ancient time, witnessed India's glorious past. From fifteenth to seventeenth century CE it was the main flow of the Hooghli River. It is a trans-boundary river of Asia which is flowing through the nations of India and Bangladesh (present times). Rising in the western Himalayas in the Indian state of Uttarkhand, flows south and east through the Gangetic plain of North India into Bangladesh and finally empties into the Bay of Bengal, forming the third largest river by discharge. (as observed in Fig 7). After entering into Bangladesh, the main branch of Ganga is known as the Padma. It is further joined by the Jamuna river forming the largest distributary of Brahmaputra (as seen in Fig 8). However the Ganga begins its flow at the confluence of Bhagirathi and Alakananda rivers at Devprayag.

Fig 7 Map showing course of the Ganges

The Indian supercontinent overlies Indian tectonic plate which is a minor plate within the Indo-Australian plate. The southern super continent Gondwana began its north-eastward drift until it collided with the Eurasian plate and subducted underneath it giving rise to the Himalayas. South of the Himalayas, vast trough is created due to plate movement which is gradually filled up by sediments borne by Indus and its tributaries and also Ganges and its tributaries, forming the Indo-Gangetic plain.

Fig 8 Map showing combined drainage of Brahmaputra, Ganga and Meghna River

The Late Harappan period (1900 BCE-1300 BCE) saw the spread of Harappan civilization towards the eastern part of Indus river basin to the Ganges-Yamuna doab. But no settlements were found on the eastern bank of the Ganges. But after the decline of Harappan civilization at around 2nd millennium BCE, Indian civilization shifted from the Indus valley basin to the Ganges basin. Thus the Gangetic plain became the main center of powerful settlements successively from Mauryan Empire to the Mughal Empire. Megasthenese, an European traveller was the first to mention about Ganges in his work titled 'Indica'. He mentioned 'India, again, possesses many rivers both large and navigable, which, having their sources in the mountains which stretch along the northern frontier, traverse the level country, and not a few of these, after uniting with each other, fall into the river called the Ganges. Now this river, which at its source is 30 stadia broad, flows from north to south, and empties its waters into the ocean forming the eastern boundary of the Gangaridai, a nation which possesses a vast force of the largest-sized elephants.'

Fig 9 River showing its meandering course (aerial view)

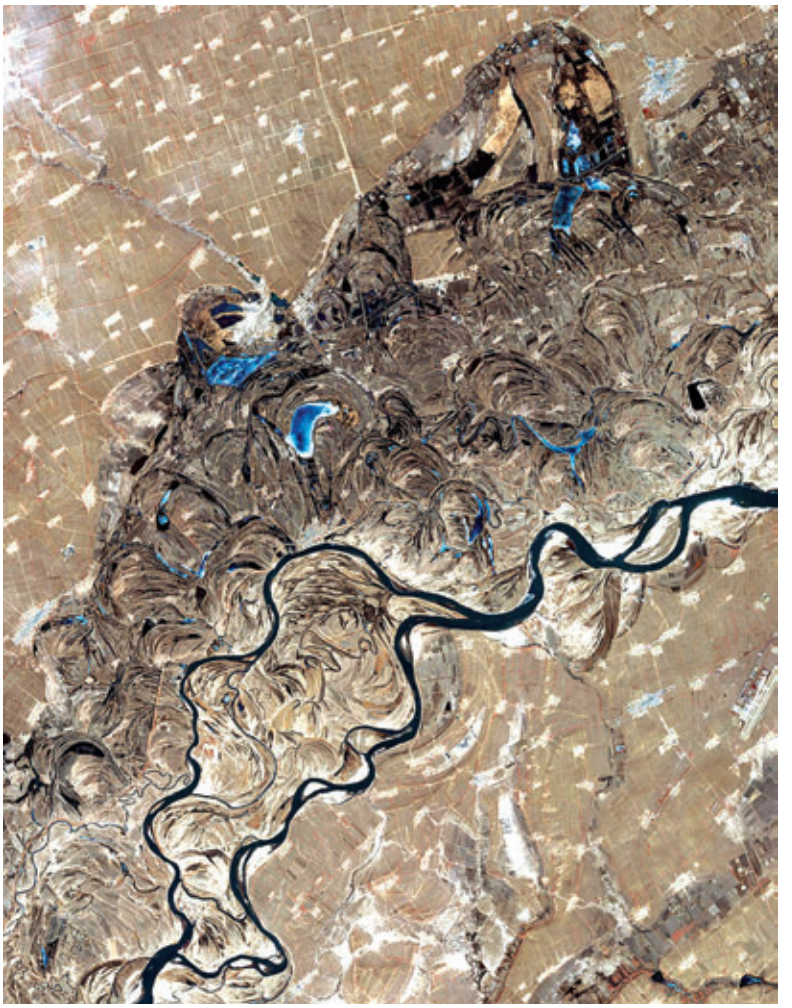

Fig 10 River with its meandering course and formation of ox-bow Lake (Aerial view)

The course of Adi Ganga also shows that it eminates from the Hoogli in the southern part of Kolkata and goes over to join the Bidyadhari river. This river is an important river in the Indian state of West Bengal. It originates near Haringhata in Nadia district and then flows through Deganga, Habra and Barasat areas of North 24 parganas before joining the Raimangal River in Sunderban area. It is a significant river in Berachampa area (Chandraketugarh). It has formed a major navigation route for earlier civilizations. The river port of Chandraketugarh in the third century BCE was on the banks of this river. This river has been the major drainage system of North 24 Parganas and Kolkata. Centuries ago this river was connected to the Adi Ganga and aside of this route that Chandraketugarh enjoyed an easy access through the sea. The fertile alluvial deltaic region formed by these rivers led to various settlements on the bank of these rivers. Various relics unearthed from this region concluded that it has seen settlement of diverse inhabitants from pre-Mauryan times to the Pala-Sena age. Due to this sea route, people of this region maintained foreign policy with external countries like Sri Lanka, Barbara, Burma, Pasa, Nepal, China, Afganisthan, Kamboja (northwest of India).

Studies have seen that sufficient energy is required for bank erosion and that may lead to active meandering process. Meandering (as evident in Fig 9, 10) is a general river tendency where it flows with a sinuous curve leading to erosion of sediments from the outer part of the bend and depositing them on the inner part of the bend. When a meander gets cut off from the main stream, an ox-bow lake (as seen in Fig 10) is formed and then the river starts flowing in a straight path. Thus this event leads to shifting of river course. Neotectonic activity is another important factor for the shifting of the river course, though its effect on the alluvium cover is difficult to observe on field. However distortion of meanders, presence of escarpments, development of asymmetric terraces etc may lead to show neotectonic activity in such areas. Since previously described rivers are not found to flow through the concerned area these days, the above mentioned reasons may add up as a cause for shifting of the river courses. More research works are required to be carried out in order to find out the exact reason behind its shifting.

4.0 Iconography and Community Life in Chandraketugarh

West Bengal, rather the undivided Bengal since antiquity presents an array of visual documentation of the styles and proclivity of the period. Regional, geographical specification of the terrain and lack of availability of stones in the sub-terrain of greater Bengal has triggered the creativity to attribute shapes modeled to pliable terracotta. Elasticity of the material enables the artist to form the desired shape only by touch of finger tips. The easy availability of clay in the riverine plains of Bengal might be one of the reasons for its enriched terracotta tradition (Mukherjee 2002). Another plausible reason was the easy-molding nature of clay and the scarcity of stone in Bengal .

Bengal is a lucrative region for studying terracotta as it has a long, rich and a continuous presence of terracotta art from ancient times to present day. Though the terracotta repertoire of Bengal was overshadowed with the terracotta specimens from Mathura, Amaravati in the larger regime, but the surprising and overwhelming presence of the terracotta figurines and its continued addition has marked Chandraketugarh as one of the most crucial site.

Literature Review

Artifacts unearthed during a recent excavation at the famous Dum Dum mound, takes the city's history back to the 2nd Century BC. Traces of urban settlement found during the excavation shows a close resemblance with those found in an urban settlement at Chandraketugarh, said by an ASI regional director (east) P K Mishra. The raised ground at the north of Clive House has yielded remains of an urban settlement that dates back to 2nd Century BC. The third to seventh layers of soil marked as Period I belong to early historic period 2nd-1st Century BC to 11th Century AD. Various antiquities are excavated including exquisite terracotta plaques and figures from the 2nd - 1st Century BC to 8th-9th Century AD.

This excavation showed that even the peripheral zone of Calcutta had an urban settlement. The discovery of various objects bear close resemblance with those found at Chandraketugarh may indicate that Dum Dum was an extended part of that settlement (Times of India dated 23/11/14).

Opinions of contemporary pedagogues on the concerned area are evident from media. Of many, two has been mentioned, one of which includes that of Nobel laureate economist Dr. Amartya Sen and the other one of Harvard University professor Dr. Sugata Basu.

- Dr. Amartya Sen recently mentioned that since a large number of civilizations developed centering Chandraketugarh,so excavation in and around this area is essential to reconstruct the history of Bengal.
- Dr. Sugata Basu also said that Chandraketugarh definitely belongs to pre-Mauryan era but it may also belong to a time much before than it. He further said that if research can be carried on this site then it can be established whether there was any relation between Bengal and East Asia in terms of trade and commerce.

Fig 11 Map showing the important excavation sites from Bengal

Interpretion and analysis of the exquisitely carved terracotta figurines from Bengal, was first documented by Gurudas Basak in the year 1888. Along with the scholars from India the mapping of the field of art and craft was thoroughly documented and measured by European scholars like Alexander Cunningham, A.H. Longhurst. A.H. Longhurst had failed to recognize the possibilities of Chandraketugarh in establishing the early historic horizon in 1908. But R.D. Banerjee deciphered the brilliance of the figurine of mother Goddess excavated from Chandraketugarh. In the essay on Early Indian Terracotta published in the year 1927, A.K. Coomaraswamy indulged the stylistic parameters and chronological scheme of Indian terracotta without even referring any specimens from Bengal, '…a considerable group of Mauryan and Sunga terracottas of which examples have been found in the lower, or nearly the lowest levels at several widely separated sites, extending from Pataliputra to Taxila' (HIIA, DaverEdm. 1965). Terracottas of Bengal always remain marginal in the arena of Indian art. Even in the Study of Stella

Kramrische 'Indian Terracotta' published in the year 1940, she mentions Bangarh as the only site from Bengal. Early terracotta of Bengal has been studied in terms of relation of Kushana-Mathura stylist genres. There was an inclination that prevailed to club the figurines with the contemporary civilizations in terms of styles, technique, postures, objects and compositions. As Niharranjan Ray opined, 'Evolution of Bengal School towards the common Gupta idioms of Art'.

Approach towards Bengal terracotta had received a thrust during the early twentieth century when a chain of sites in the region of lower Gangetic delta was excavated in Bengal under the supervision of K.N. Dikshit. The remnants of Chandraketugarh, earlier known as Berachampa, unearthed extremely prolific terracottas acquiescent but remains unnoticeable in the inception report of K.N. Dikshit. It was Kalidas Dutta, the landlord of village Jaynagar and Majilpur, that the site of Chandraketugarh receives reasonable attention. In 1956 under the supervision of Kunja Gobinda Goswami excavation was retrieved. But his views on the terracotta figures from the Chandraketugarh were enigmatic. Scholars like P.C. Dasgupta for the first time attempted to justify the found terracotta objects from Chandraketugarh.

Among the descriptive studies one of the earliest studies was done by G. S. Dutt in 1938. He gave an exhaustive description of temple terracottas in Bengal and argued that one can divide terracotta art into two divisions,

1) Figure sculpture and

2) Sculpture in relation to temple architecture

The first chronological development of the early terracottas of Bengal was explored in the hands of S.K Saraswati. In his 'Sculptures of Bengal' he wrote, 'The various ancient sites of Bengal… have yielded a very large number of terracottas…, and in this general studies of early Bengal sculpture, it is not possible to refer even to the principal ones among the various types that have been recovered till now' and that 'the abundance of material and the varieties in types and forms call for a separate and independent treatment…' (Page: 90). Like Kramrische, S.K. Saraswati believed that the gradual progression and the stylistic orientation was an integral part of pan-Indian tradition.

Subsequent pedagogues from Bengal devoted to constitute the chronological stylistic schema to continue the legacy. Nihar Ranjan Ray first explored the social dimension of the terracotta tradition. In his book 'Chandraketugarh, A port City in Ancient Bengal' of 1980 arouses questions about the social, religious implications of these terracotta figurers, "What purpose in contemporary society was served by and through terracotta plaques…? Did they serve any cult purpose? If so, which cult it was, what (was) its nature and character? In which level of society did it have currency? Or was it a manifestation of an urban phenomenon brought about by migratory traders and sailors from different countries, a phenomenon that penetrated the local society as well? If so, how were these plaques used? ..."

A more critical bending towards discerning the evolution of early Bengal terracotta takes shape in the book called Early Bengal Terracotta by Joachim Karl Bautze. He dissects North Indian terracotta on the basis of three major sites which are Mathura, Kausambi and Chandraketugarh. He had classified the figures in terms of its iconographic attributes, such as hair pins, mirrors, beads and marks, Jewelleries, amulets etc. Based on the analysis, he attributed specific time and date to the terracotta figurines started from 2nd century BCE to 1st century CE.

In contemporary times Sima Roy Chowdhury has discussed the terracotta figurines specifically unearthed from Chandraketugarh in her essays entitled 'Some interesting terracottas from Chandraketugarh in private collections' and 'Terracottas from Chandraketugarh: A study in theme and motifs' published successively in the years of 1995-1996 and 1997-1999. Besides identifying the general features she tried to identify the unique qualities attributed to Chandraketugarh only. According to most recent scholarships 'Chandraketugarh: A treasure house of Bengal Terracotta' by Emanuel Haque, published in the year 2001 presents a well charted linear progression of stylistic evolution of the terracotta sculptures from pre-Mauryan to Gupta period. Later on Asok K. Bhattacharya, Gautam Sengupta and Sharmi Chakraborty have done a calculative yet commanding analysis.

Methodology

To propagate both linear and dynamic progression of the art and culture prevailed in the area of Chandraketugarh since antiquity, scholars applied different analytical methods that emerged from their primary and secondary observations.

With an exhaustive description of some of the important figures from the area of Bengal, P.C. Dasgupta argued for the analogies in art forms of the site with other terracotta yielding sites of Bengal. He also noted the relationship of Sunga style with stone depictions of Bharut, Sanchi, Bodh Gaya and Bhaja. Greco-Roman influences on terracotta art forms were also clearly noted. Similar kind of work on terracotta materials of Chandraketugarh was done by the same scholar in 1959. He illustrated several early historic terracotta forms from Chandraketugarh and also compared certain forms with corresponding north Indian terracotta art forms (Das Gupta 1959). Several scholars have attempted to describe the terracotta forms found from different sites. Toy-carts, being an important finding from Chandraketugarh, Bautze (1989) focused on various seated figurines in the toy-cart and argued that it is difficult to correlate with exact gods and goddesses of Hindu mythology. With a descriptive study of such toy-carts he argued that the paucity of archaeological records made it difficult to identify the actual use of such carts. Mukherji (1991) gave a detailed description of 18 terracotta forms found from different important terracotta yielding sites of West Bengal, housed in State Archaeological Museum, West Bengal. Gautam Sengupta (1992) reported the presence of Pala period terracotta plaques from two sites viz. Bairhatta in South Dinajpur and Jagjivanpur in Malda districts of West Bengal. Enamul Haque (2001) provided a detailed illustrative description of 963 terracotta specimens from Chandraketugarh. Jana (2002) gave a description of terracotta specimens from the site of Mangalkot .

Table 2

NO	Methods	Description	Purpose
1.	Carbon dating	Carbon-14 dating, also called radiocarbon dating, method of age determination that depends upon the decay to nitrogen of radiocarbon (carbon-14). Carbon-14 is continually formed in nature by the interaction of neutrons with nitrogen-14 in the Earth's atmosphere; the neutrons required for this reaction are produced by cosmic rays interacting with the atmosphere.	Determination of the exact timeline and the exact dates of the terracotta figurines, other found objects like pottery, beads, coins, ivory objects etc. to establish the chronological framework.
2.	Compare with the contemporary parameters	Comparing the style, technique, iconographical attributes to decipher the approx timeline of the terracotta figurines and other found objects with prevalent contemporaries in the rest f India.	Because of the absence of proper timeline and to establish a typological chronology of the objects unearthed.
3.	Process of Cross-dating	As the objects found in the refused pits than the regular layers of earth, the principle that a diagnostic artifact dated at one archaeological site will be of the same approximate age when found elsewhere. This is a process where found item that is indicative of a particular time or cultural group; a computer would be a diagnostic artifact of our time and culture concerned with space.	interpret archaeological strata using the law of superposition; Apply cross-dating to determine the age of other artifacts.

Styles and Techniques

The clay used in terracotta craft is generally a blend of two or more types of clays, found in river beds, pits and drains. They are blended together and then given beautiful shapes and patterns. The folk theme is used in the craft most of the times. The pattern is beautifully highlighted with traditional expertise and precise artwork. The items are between 700 and 800BCE. Most of the times local fuel like twigs, dry leaves or fire wood are used in the kiln. The iron content, reacting with oxygen during firing, gives the fired body a reddish color, though the overall color varies widely across shades of yellow, orange, buff, red, "terracotta", pink, grey or brown. In some contexts, such as Roman figurines, white-colored terracotta is known as pipe clay, as such clays were later preferred for tobacco pipes, normally made of clay until the 19th century.

Features (According to different phases of Bengal)

The terracotta sculptures, figurines and other objects excavated from the area of Chandraketugarh are divided into subgroups depending on its social, religious, economic implications. Relying on the religious inculcation the terracotta sculptures can be identified in different diversification that demands specific attention of the scholars. And rest of the objects can be grouped as,

1. **Mother Goddess:** Figures portraying the cult of mother worship are generally having broad hips, heavy breasts and narrow waists as evident in the figure no 12. Mother Goddess figurines are mostly of 'timeless' type with simplistic features. Mother Goddess figurines are historically associated with fertility cult. In present research the contemporary mother figure of Natai-Chandi explicates an alternative interpretation. The myth related to Natai Chandi reflects the mother figure as a symbol of a tortured woman in a male-chauvinist society who does not challenge but finds way to survive in the existing social orders by performing Nataibrata. Sometimes the mother figure is associated with gender rather than fertility cult .

The mother figure unearthed from Chandraketugarh reveals sameness with the mother figure of contemporary Sunga period.

Fig 12 Mother Goddess from Chandraketugarh

Fig 13 Mother Goddess from Sunga period

2. **Votive Figures:** Votive figures are usually minimalistically moulded forms of human beings and animals submitted to the God for the purpose of wish and wish fulfillment.
3. **Female Figures:** There are evidences of plaques portraying single female figure, with attendants posed in different postures; as for example female figure carrying a child in her arms called mother and child etc.
4. **Dolls and Toys:** Dolls and toys were used as play thing for the children. Thus we can find fully finished kind of toys and even toys made by the children themselves, which are primitive and amateurish in nature. A large number of animal and bird and other figures served as toys including toy carts as wheeled figurines, animals including ram, horse, elephant, etc. These figurines have two holes at the bottom, providing space to attach wheels.
5. **Mithuna Sculptures:** The variety of Mithuna pose indicates that systematic body of erotic knowledge was prevalent in lower Ganga valley which is an important socio-historical issue. The similarity in art forms between Khajuraho reliefs as depicted in fig 15 and Bengal terracotta (fig no 14) signifies continuity of Indian erotic iconography. The continuity of erotic art forms demand causation, which requires iconographic data to relocate the connection between the Eastern Gangetic doab and the laterite plain of Madhya Pradesh.

Fig 14 The above terracotta plaques showing amorous couples from Chandraketugarh

Fig 15 Amorous couples from Khajuraho, Chandella dynasty

6. Animal Figures: A wide variety of animal figures are represented which include horse, elephant, humped bull, goat, cow, deer, etc. and different species of unidentified birds.

Fig 16 A contemporary horse figure from Harinarayanpur, timeless variety

Fig 17. An elephant figure from Chandraketugarh, 1st to 3rd century CE

7. Numismatics (Coins and beads)**:** A series of coins belonging to different periods have been found in Chandraketugarh. They are mainly cast and punch marked copper and silver coins of early period. Silver coins of Mauryan period, a gold coin of Kushana age, several gold coins of Gupta age and a silver coin of Skandagupta have been excavated from the site.

8. Potteries: Potteries and its broken parts found from the archaeological sites of Chandraketugarh can be generally divided into two parts–A. Sun baked and B. Fired potteries. Few of the specimen of the potteries, definitely belonged to its culminating phases are intricately carved as is evident in figure no 18.

Fig 18. Potteries from Chandraketugarh (matured phase)

Based on the stylistic evolution of the found objects and by applied methodology of comparing objects with the contemporary practice of rest of India it can be easily bifurcated. Thus, the found chronological strata of linear progression is as follows,

Period I: Pre-Maurya (c. 600BCE – 300 BCE)

Period II: Maurya (c. 300BCE – 200 BCE)

Period III: Sunga (c. 200 BCE – 50 CE)

Period IV: Kushana (c. 50 CE – 300 CE)

Period V: Gupta (c. 300 CE – 500 CE)

Period VI: Post-Gupta (c. 500 CE – 750 CE)

Period VII: Pala-Chandra-Sena (c. 750 CE – 1250 CE)

From the material evidences of different excavated sites as Mauryan, Sunga, Kushana and Gupta periods can be defined. The material culture revealed from these Early Historic sites though varies but has certain general attributes. Ceramic assemblage generally includes Northen Black Polished Ware, Black Slipped Ware, and Rouletted Ware etc. Punch marked and cast copper coins are important findings. Bone and ivory objects, terracotta seals, beads of semi precious stones, copper and iron objects, terracotta figurines and plaques etc. comprise a rich material culture in this phase (Roychoudhury 2009). The material culture revealed from various sites indicates their close resemblance with the corresponding north Indian sites. The contact with Roman world can be attributed from the findings like Rouletted ware, gold-foil beads, double handled amphora, terracotta and other materials (Chakraborty 2000). One of the important aspects of ancient Bengal's material culture was its terracotta art.

A parametric observation over different phases of local history has been tabulated below. The various significant features observed across time frame are documented in the following table 3.

Table 3

<table>
<tr><th>Time series
Observations</th><th>Pre Mauryan</th><th>Mauryan</th><th>Sunga</th><th>Gupta</th><th>Kushana</th><th>Pala-Sena</th></tr>
<tr><td rowspan="2">Archaeology</td><td colspan="6">Various coins, beads of semi-precious stones, terracotta, stone sculptures, ivories, objects made of bones, wooden artefacts etc. are recovered consistently from pre Mauryan to Pala-Senaperiod .</td></tr>
<tr><td>A 45 sq. Km sized prayer hall (700-600 BCE) locally known as Khana Mihirer Dhipi(temple ruin) was found.(Fig 32,33)</td><td colspan="5"></td></tr>
<tr><td>Epigraphy</td><td colspan="6">Brahmi-Kharosti language was mainly used in the inscriptions.(Fig 39)</td></tr>
</table>

Table 3 (Contd...)

Time series Observations	Pre Mauryan	Mauryan	Sunga	Gupta	Kushana	Pala-Sena
Iconography	1. Significant motifs and symbols of Vedic culture like swastika, lotus, conch, umbrella, alter, wheel, sun, thunder bolt, the tree of life, the bull, vase, large number of clay toy carts of winged elephants, ram and horses etc. are found 2.Torso of a Tirthankara - the oldest figure of Buddha of Bengal was recovered.(Fig 28)	A unique terracotta of female figurine (3rd Century BCE) - well clad with typical Mauryan head dress with hanging ribbons,fillets and discs have been unearthed.(Fig 27)	1. A terracotta figurine of a divine couple riding on a tiger is a remarkable specimen introduced as early as Sunga period. 2. Various terracotta figurines of Yaksi or a woman with different kinds of birds are found. (Fig 29,30)	A small bronze female image with a mirror in her left hand and an indistinct animal (lion) on the pedestal was found- image dated to late Gupta period - probably represents Parvati were found.	Terracotta figurine of headless warrior – indicating Kushana age was also recovered.	
Numismatics	Cast and punch marked copper and silver coins.	Mainly silver punch marked coins (Fig 34).	Copper cast coins found.(Fig 35)	Several gold coins (Fig 36) and a silver coin of Skandagupta were found. Copper cast coins were also found.	A gold coin was found. Copper cast coins also found.	
Trade and Commerce	Coins with wheel and ship motifs indicate that they maintained trade and commerce via sea route (Fig 38) have been recovered consistently from pre Mauryan to Pala-Sena period.					
		Chandragupta Maurya maintained foreign policy with external countries like Sri Lanka, Barbara, Burma, Pasa, Nepal, China, Afganisthan, Kamboja(also northwest of India)- preferred land routes to water routes, southern routes to northern routes.				

4.1. Iconography Over the Ages

Applied methodology of carbon dating, cross dating and the stylistic comparison between the contemporary parameters of art and visual representation aided to bifurcate the found objects into different historic periods that can be analyzed as follows.

Maurayan period

Besides being famous for the polish of the monolithic shaft of Ashokan period terracotta is a group of no less importance, which have been found at several Mauryan sites during archaeological excavations. These are usually made from moulds. The tradition of making mother-goddess in clay, which goes back to the pre-historic period, is revealed by the discovery of these objects at Mauryan levels at Ahichchhatra. Terracotta was also used for making toys and these consist mainly of wheeled animals, a favorite being the elephant.

We have remains of high quality sculpture from Mauryan period. Of the several stone sculptures the Yakshi and Yaksha (from Didarganj, Patna) bearing the distinctive polish of the Mauryan School are examples of extraordinary craftsmanship and are most attractive. Terracotta sculptures from Chandraketugarh of the contemporary times of Mauryan period shares the sameness in the basic visual representation. As in the case of female figurines of Mother Goddesses and the Cauri bearer from Mauryan era manifests the iconography of Indian beauty with full breasts, high hips and narrow waist. Even we can locate the common features in the case of depiction of the jewelleries and elaborate headgear as can be seen while comparing the figure no 19 from Chandraketugarh and 20 from Maurayan era.

Fig 19 Broken plaque of a female figure from Chandraketugarh 300BCE – 200 BCE

Fig 20 The Cauri bearer from Maurayan period 300 BCE – 200 BCE

Sunga Empire

The Sunga Empire is a Magadha dynasty that controlled North-central and Eastern India as well as parts of the northwest (now Pakistan) from around 185 BCE to 73 CE. The Sunga period saw a noticeable advancement in the Indian form of sculpture and ornamentation emphasizing the belief in folk deities like yakshas, yakshis and shalabhanjikas. The artifacts lack the polish of the Mauryas and are mostly set in low relief .

Fig 21: Terracotta from Chandraketugarh, Sunga period, 200 BCE – 50 CE

Fig 22: Terracotta from Mathura, Sunga period, 200 BCE – 50 CE

Major centres of Sunga terracotta artifacts were Chandraketugarh and Tamluk in Bengal, and Mathura, Kaushambi and Bhita in Uttar Pradesh. It appears that terracotta objects were made at these centres and then exported. Sunga terracottas are found all over North and Eastern India. The sudden increase in fashioning of terracotta objects is credited to the technique of using a single mould to make the entire figure. These are pale red or orange in colour, uniformly baked and of extremely fine fabric. Chandraketugarh terracotta of the period are finely bake, mostly in terracotta color as appeared in figure no 21. The stylistic connection between the Sunga and the Chandraketugarh terracotta lies in the representation of elaborate head dresses and comparatively elongated bodies presented in low-relief. Posture, anatomical detail through incised lines is the stylistic thread that connects the art of both areas and also the stress on surface detail and nudity continued as before.

Kushana Period

During Kushana Empire many images from Gandhara reveal similarities to the features of Greek, Syrian, Persian and Indian figures. Kushanas introduced a mixed culture that is best illustrated by the variety of deities produced under Greco-Roman, Iranian, and Indian influence. Two major stylistic divisions can be made among artifacts of the period:

a. Imperial art of Iranian derivation and

b. Buddhist art of mixed Greco-Roman and Indian sources

The style of Kushan artworks is stiff, hieratic, and frontal. It emphasizes the power and wealth of the individual. Here we find development in style and technique of carving figures. New methods of narrating long and continuous stories were invented by an effective combination of old and new styles. There is a keen interest in rendering of anatomy or drapery.

Rita Dutta (1991) gave a descriptive account of certain male figures which are housed in State Archaeological Museum, Kolkata. She concluded that these figures with vertical scratches were typical to that of Kushana period and the associated finds from the habitational deposit also confirmed a Kushana affiliation.

Fig 23: Male torso from Chandraketugarh, Kushana period, 50 CE – 300 CE

Fig 24: Statue of Kanishka, Mathura, 2nd century CE; now in the Mathura Museum, 50 CE – 300 CE

Stylistic interpretation of both of the statues, figure 23 from Chandraketugarh and figure 24 from Mathura clearly indicates the pan-Indian concept of linear progression. Robustness of the figures, incised lines to show the folds of the drapery, delineation of the geometric shapes while depicting the structure of the body, predominance of two dimensionality or quality of ba-relief are the prime features that have the potentiality to establish the close association between the two.

Greco-Roman Influence on Gandhara Art

With the Greco-Roman Influence on Gandhara Art, the focus shifted from depiction of narratives of mundane reality to acquire vivid detailing. The region attained its peak of prosperity in the Kushana period (1st to 3rd centuries CE), when it became one of the strongholds of Buddhism, and developed an advanced urban life where the Gandhāra art flourished (Foucher, 1902, pp. 3-50; Deydera, 1950, pp. 1-5). In the 1st century CE, Parthian and Roman merchants brought in the art and culture of their respective lands and local Hellenistic art tradition and Buddhist missionaries the elements of Buddhist art. This last factor was developed (in Amaravati, Mathura, and Gandhāra) into a synthesis combining eastern Hellenistic and Bactrian styles with the Indian art of anthropomorphic representations of the Buddhist personages.

Fig 25: Development of portraiture from Chandraketugarh, Gandhara period, 50 CE – 300 CE

Fig 26: Large terracotta head of Bodhisattava, Gandhara period, 50 CE – 300 CE

The above portraiture (fig no 25) manifests a much developed style in round having a close affinity with terracotta head from Gandharan region, in terms of the modulation, carving of the ornaments, flowing of the hairs through the bare shoulders, especially portraying the eyes and the eyebrows.

In the first half of the 20th century, A. Foucher, 'the father of Gandhāra studies', argued that the Greeks had exerted a primary impact on the making of the Gandhāra art, and connected it with the rise of the Greco-Bactrian state and, following its fall, the influx of Greek population into northwest India. Later he expressed the view that the Hellenistic art had penetrated across Iran in Greco-Iranian form. Daniel Schlumberger developed similar ideas. Other scholars, such as B. Rowland and H. Inholt, while admitting the initial Greek influence, emphasized the influences from the west, namely, Roman, Palmyran and Parthian[7] .

Sculptures and Coins from Chandraketugarh

Chandraketugarh is a treasure house of Bengal terracotta. Numerous terracotta figurines subsequently belonging to different periods of Bengal's history, reflecting their socio-economic and cultural aspects have been unearthed. Various motifs and symbols have also been recovered.

- The significant motifs and symbols of Vedic culture are swastika, lotus, conch, umbrella, alter, wheel, sun, thunder bolt, the tree of life, the bull, vase etc. A large number of clay toy carts of winged elephants, ram and horses have been recovered. D.P Ghosh thinks that these motifs symbolize Vedic trinity, Indra, Agni and Surya. A winged male holding the stalks of lotus in his two hands have been recovered. Probably symbolizes the early variety of icon of lotus in the hands of Surya, representing source of energy required for vegetation. Various forms of horses are found on clay pots, seals, terracotta plaques and coins.
- A unique terracotta of female figurine which been recovered from this site measuring about 14.7 cms, dated to be about 3rd Century BCE, is well clad with typical Mauryan head dress with hanging ribbons, fillets and discs (as observed in Fig 27). It links with the figure from Harappa. It establishes the antiquity of the area and also links Mauryan India with ancient Persia and Greece.

Fig 27: Terracotta of female figurine with typical Mauryan head dress

- Torso of a Tirthankara (as seen in Fig 28) was found from the remnants of Chandraketugarh. It is the oldest figure related to Jainism of ancient Bengal excavated and is a significant treasure as very few of the early relics related to Jainism are now extant.

Fig 28 Image of torso of a Tirthankara

- Among various terracotta figurines, Yaksi or a woman with different kinds of birds are found (as seen in Fig 29). Even male figurines holding a parrot have also been found. A metal image of Parvati and several terracotta plaques showing woman with mirror (as evident in Fig 29) have been yielded. At Khana-Mihirer Dhipi a small bronze female image with a mirror in the left hand and an indistinct animal (lion) on the pedestal was found. The image was dated to be of late Gupta period, probably represents Parvati.

Fig 29 Female terracotta figurines holding a parrot or a mirror

- Various terracotta plaques of yaksha or yakshi (as observed in Fig 30) have been recovered from this area.

Fig 30 Terracotta plaques of yaksha or yakshi

- Panchchuda (as seen in Fig 31) is a goddess with five hair-pins in shape of ayudhas like sword, arrow, battle-axe, trident and the god is famous terracotta found from Chandraketugarh. It is described later in details.

Fig 31 Terracotta figurines showing panchchuda

- A terracotta figurine of a divine couple riding on a tiger is a remarkable specimen found in this area. This bears a male deity wearing a ridged cap with sword and shield in two hands, riding a tiger in motion and a female deity sitting behind the male god. This shows a folk trend that was introduced as early as Sunga period.
- Chandraketugarh has yielded a number of terracotta showing a man playing on a harp and a woman engaged in dancing . Hence it adds a new dimension to art and music and also throws a light on their social life.
- A 45 sq. Km sized prayer hall was discovered that dates back to 700-600 BCE. This site comprises the remains of a temple and a palace, northern black polished ware and other wares were also discovered. The ruin of this massive temple structure is locally called Khana-Mihirer Dhipi (as seen in Fig 32, 33) which was uncovered after the excavation in 1950's.

Fig 32 A close look at the brick structure at Chandraketugarh (Khana Mihirer Dhipi)

Fig 33 Khana Mihirer Dhipi and place where terracotta plaques used to remain stuck are shown respectively

Numismatics: A series of coins belonging to different periods have been found in Chandraketugarh. They are mainly cast and punch marked copper and silver coins of early period, silver coins of Mauryan period, a gold coin of Kushana age, several gold coins of Gupta age and a silver coin of Skandagupta.

- Coins of early period: Silver-punched-marked coins: They belong to 4th-3rd century BCE. Its shape varies from round, nearly round, oval, square or rectangular (as evident in Fig 34). Size range from. 5-.9 inch (round), .62*.47-.97*.52 inch (rectangular). Its weight ranges from 1.7-3.48 gms.

Fig 34: Silver punch marked coin

- Punch-marked bullion coins: Three ship type punch-marked bullion coins have been discovered. There the ship is single decked; rear part is dolphin like with snout in front and is archaic in shape. Coins with ship motif indicate that they maintained sea and riverine commerce with India and abroad in pre-Christian days. Round or square in shape with 11-51.75 grains in weight.
- Copper cast coins: Numerous copper coins of Sunga and Kushana period and few of early Gupta periods have been collected. These bear various motifs and symbols like hollow cross, bull on a mountain, arrow-heads within frame, elephant, tree, flower, human figures etc. Copper cast coins with wheel motif are also very common (as seen in Fig 35).

Fig 35 Copper cast coin with boat motif

- A rare punched marked coin: A silver coin of half an inch size, circular, 52 grains in weight has been recently discovered. Its obverse side consists of three human figures, probably a branch of a tree at the corner of a four-squared railing and a spider. Reverse side depicts a peacock with its expandable tail on a five-arched hill.
- A unique copper cast coin: Animals of different species particularly elephant appear prominently on copper coins. It is thin square shaped, half an inch in size and 50-52 grains in weight.
- Fish symbol on punch marked coins: Depiction of fish on the punch marked silver coins were obtained, suggests the cult of fertility and also the worship of water.
- Kushana coin: A Kushana gold coin was recovered from Dewan Ati, a village few miles from Chandraketugarh. Obverse side of it shows bust of a king, and reverse side has goddess standing right, holding in right hand a scepter, 120 grains in weight and is 6 and a half cm in diameter. Gold amulets bearing Kushana coins were used as ornaments.
- Gupta coins: Some significant Gupta coins have been yielded from this site. A gold coin of Chandragupta 1(320-326 CE) has been recovered where he was commemorating his marriage with the Licchavis, a powerful clan of the Nepalese. (as evident in Fig 36)

Fig 36 Marriage type gold coin (Obverse and reverse side)

- Archer type coin of Samudragupta: Its size varies from 8″-9″ and 110-120 grains in weight. The obverse side consists of a king with a bow in his left hand and an arrow in his right hand. (as seen in Fig 37b)

Fig 37a Obverse and Reverse side of a Gold coin of Huviska

Fig 37b Obverse and Reverse side of an archer type coin of Chandrgupta 2

- Copper punch marked coin with decked ship, boat, wheel, four armed motif (as evident in Fig 38). Thus these coins collected from the study area indicate it to be an important port city that had maritime trade and commerce with various parts of the country and abroad.

Fig 38 Copper punch marked coin with decked ship, wheel and four armed motif

Epigraphy:

Ancient Chandraketugarh was mainly dominated by Brahmanical faith. Inscriptions on clay seals refer to Dwijas (men of Brahmanical caste). The performances of Vedic sacrifices are seen in several seal inscriptions. Brahmi-Kharosti language was mainly used in the inscriptions (as seen in Fig 39). In one of the inscriptions it was written that during a famine the king supplied grains to the people which they have to return after the condition gets normalized through cowries (virtual money). Hence it showed that they had a very organized government that supported the people by giving loans.

Fig 39 Brahmi script inscribed on a seal found from Chandraketugarh

4.2 Community Life

Sun baked, hand modeled minimalistically represented basic shaped figurines found from almost every region of historic and pre-historic civilizations. Therefore these kinds of figurines can be regarded as the 'Ageless type'. Among the terracotta figures unearthed from Chandraketugarh, Statuettes of mother goddesses formed the major group. Mother goddesses are the great symbol of the earth's fertility, motherhood and creation. She was worshiped under many names and attributes. Similar figures have been known in every part of the world. Essentially she was represented as the creative force in all nature, the mother of all things, responsible particularly for the periodic renewal of life.

Mother Goddesses

Hand modeled, primitive form of mother goddesses with archaic appearance is common since the proto historic time to the present. The fragmented figure is a depiction of the mother goddess with pinched face. The figure was made using the most common methods prevailed all through the world i.e.

1. Additive process in which people used fingertips to add pellets to the sculpture,
2. Subtractive process in which people used to etch out few portions of the clay to depict figural parts.

The face resembles a bird and eyes, etched out boldly. The rectangular head dress too has been decorated with lines. Similar mother goddess figurines have been recovered from nearly all archaeological sites in India and continued to be produced even today.

Fig 40 Figurines of Mother Goddesses unearthed from Chandraketugarh

In another type Mother Goddess portrait with animal faces are also frequently encountered in early terracotta art of India. Mother goddess with goat's head has generally been identified as 'naigamesi', or a female counterpart of 'Harinaigamesa' figures. Harinaigamesa as a turtlery deity of child birth has been mentioned in the Mahabharata, the Kalpasutra and early medical treaties. It is believed the figurines were associated with well being of the children and acted as their protectors. In the present instance we come across a depiction of a female figure with an animal head, probably that of a goat.

The second illustration of figure no 40 is of a goddess, rendered in the round and decorated with an appliquéd necklace. The necklace has intricate floral motifs etched out on it and decoration hanging from it. The figurine possibly represents a Mother Goddess figurine. The figure bears marked resemblance to stone sculpture in delineation of human torso which can be consciously compared with full blown female sculptures of Maurayan period, vibrant with life.

The figures of mother goddesses sometimes flanked with the figure of a child on her lap, symbolizing the motherhood, sustenance of life and creation.

A fragmented plaque from Chandraketugarhhas can be seen in fig 41, showing a female figure holding a child in her arms and the child is clinging to her body as if it feels to be most secured on her mother's lap. The plaque perhaps stands for the protection of the children or the devotees. The drapery is indicated by a series of string like lines perhaps to show the folds. Both the figures are bejeweled, which are intricately carved. Though the female figure is headless but the child wears a double layered headgear along with a huge earring on the earlobe. Both features are common to the terracotta of Chandraketugarh.

Fig 41 Terracotta figurines of Mother and child excavated from Chandraketugarh

A close look to these terracotta figures reveal different layers and aspects of the society, its fashion, religious rituals and practices, cross-cultural influences, economic, business and political statement etc. We can identify a group of male and female figures which presented the fashion statement of the contemporary period.

There are very few figures which are sculpted in round. The female figure is bejeweled with detailed carved necklace, headband with a round medallion fixed on the forehead, bangles and a waist band with eight spiked wheel formation. The stylistic feature lies on the hair dressing which is simply parted on both the sides flowing down to the neck. Her hands are bent from the elbow and placed on the chest which is typical feature of mother Goddesses from Kausambi.

In another figure we can see mother and child both having elaborated turban placed on the left side of her head, wearing a triple stand necklace, huge earring and bangles. It proves that there was a trend of wearing turban amongst the females besides male members of the society.

Fashion Statement of Female

Delineating the fashion statement of the particular time period, there is a bunch of sculpture of females with an elaborated hair dressing with hairpins, probably having some esoteric value.

Fig 42 Female figurines depicting the huge hairdo with ten auspicious hairpins

These are example of sacred female figures in figure no 42, with exclusively depicted enlarged headgear and ten hairpins. Clad in a diaphanous drapery, the diagonal lines represented the folds of the garments. The figure is fully ornamented with string of gems, bangles, waistbands, heavy earrings and elongated ends of the drapery. These kind of divine figures can be associated with the Goddesses like Devi Maya, Sri, and semi-divine yakshis or with apsaras.

The trend of wearing elaborate auspicious headgear along with hairpins can be regarded as the ten weapons of war. These ten weapons can be equated with ten weapons of Goddess Durga. These are the symbolical allusion of the later association with Brahmanical pantheon. For example, the Vajra is associated with Indra, Parasu or axe with Ganesha and Trishula with lord Shiva. These Figures can also be associated with the later development of Saptamatrikas. Emphasis on the reproductive organs in representation reiterates the association with fertility cults.

The second (in figure no 42) plaque with bicornate headgear and emblematic hairpins styled as the stack of weapons. The figure clad in transparent drapery gives prominence to the volumes and contours of the body. Rounded earrings, multi stringed girdle heavy bangles and the central rosette. The central rosette is one of the prime features that can be equated to the 'Hridayachakra'. It is the place of the chakra important in the diagram of tantra. The figure symbolically pronounced the interaction and assimilation into the pantheon of formal tradition. Few of these plaques have floral border and probably to hang these plaques perforated on the top.

Figures of Sri or Goddess Lakhsmi

Amongst the figures of the Matrikas, there are few plaques which can be identified as the mother Goddess called Sri devi or Lakhsmi devi. In the group of Figure no 43, the figures and surroundings are portrayed with opulence. Sri is the Goddess of prosperity and abundance. Thus the plaques are modeled intricately. She is posed amidst blooming garden and fluttering birds. She is holding a lotus in her left hand which is an iconographic representation of devi Lakhsmi. She is adorned with heavy jewelleries as bangles, triple strand girdle, earrings, anklets etc. Here we find a decorative border rounded through the ends of the plaques that attributes a sense of completeness to the whole composition.

Fig 43 Representation of Goddess Sri or Goddess Lakhsmi as the symbol of prosperity

In few plaques, the goddess is found standing on the lotus and flanked with her attendants. Sometimes she is surrounded by buds and blooming lotuses, probably in order to depict her as 'Padmalaya'. In a plaque Sri devi is adorned with an elaborate asymmetrical headgear. Her diaphanous robe stresses on her apparent nudity and the hieratic frontal pose reiterates her divine status.

Semi Divine Winged Male Figures: Initiation of Sacred Iconography

There is a group of male figures with wings which demands concentration of the perceiver, as is evident from figure no 44. It is difficult to ascertain the exact identity of these figures. The statuette of a winged male divinity is widely distributed in early sites of northern India. This kind of semi divine figures attributed the name Naimisharan by Sri Anandamoyee Maa. According to her explanation:

Suchinamsrimatamgehe yogabhrashtoabhijayate

Athavayoginameva kulebhavatidhimatam

Etaddhidurlabhataram lokejanmayadidrisam (Gita 6/41-42)

A person who has not been able to pursue his yogasadhana due to his untimely demise is born in a holy and noble household or in the family of realized yogis. Such births are scarce.

Fig 44 Semi-divine winged male figures with turban

Here the man wears the characteristic asymmetrical headgear frequently encountered in the representation of male figures from Chandraketugarh. Besides the headgear, the man is adorned with a heavy necklace and a waistband of beads attached to it.

Archaic Representation of the Sun God or Surya

This is a fragment (figure no 45) of a plaque portraying a male winged figure standing on a lotus and holding lotus stalks in his hand. The figure is adorned with channavira, circular earrings, armlets and a decorated waistband with beads and pearls hanging from it. Similar winged male figures with lotus flowers have been generally identified as the nascent form of Surya, the Sun God in Indian iconography. It has been suggested that the Surya image of North Indian tradition has evolved from this form. Compared with the figure no 46 of the Sun God from Konark, the iconographic attribute evinced the resemblance between the two.

Fig 45 Terracotta plaque from Chandraketugarh reveals the early iconographic attributes of the Sun God

Fig 46 Stone sculpture of the Sun God from Konark Sun temple, Odissa

In another fragment from a large plaque (figure no 47) we find portrayals of a male figure with wings flying above something, which is now lost. Such figures have generally been named Gandharvas and Kinnaras in Indian art. This can be associated with the Greek God Bacchus and his ivy leaves (figure no 48).

Fig 47 Figures of winged gandharvas with corns and stupas at the background

One can surmise from other extant pieces that this flying figure probably accompanied an enshrined divinity. The most interesting part of it remains the stupa like sections created consequently at the back of the figure. This can be the testimonial of the presence of the religion Buddhism at this geographical territory.

Fig 48 Greek God of wine, Bacchus (painting by Caravaggio)

Another plaque portrays a winged female standing on a lotus in a lotus pond. An object resembling ear of corn adorns her ear and frames her face. The plaque in high relief has been envisaged in great detail. Accompanied with corn motif the goddess undoubtedly is associated with vegetation and fertility. Such winged divines of early Indian art have been found from early historical sites such as Vaisali, Kausambi and Tamluk. Opulence and the flowery corn at the backdrop can be associated with the idea of cornucopia in Western philosophy.

Fig 49 Woman adorned with a large headgear and cornucopia

Fig 50 Symbol of Cornucopia used as an element of architectural decoration in the West

The cornucopia (from Latin cornucopiae) or horn of plenty is a symbol of abundance and nourishment as is visible in is figure no 50, commonly a large horn-shaped container overflowing with fruits, flowers or nuts. The horn originates from classical antiquity which manifests an uncanny similarity with the horn of the Unicorn of Indus valley.

Fig 51 A male holding a peacock in his hands from Chandraketugarh

Fig 52 A peacock from Indus Valley civilization

A female figure is preserved up to the bust (figure no 51). She wears a headgear with peacock feathers, ear ornaments of corncobs, torque and necklace with a circular pendant. She holds a stick in her left hand on which a peacock is perched. Peacock is a recurring subject in Indian art panorama since Indus Valley civilization as is perceptible in figure no 52.

Fig 53 Mithuna couple from Chandraketugarh

Fig 54 Stone sculpture of Shiva Parvati from Ellora caves

The plaque depicts a couple or a dampati (figure no 53) reminds us of the figure of Shiva and Parvati in the Ellora caves, where Goddess Parvati is sitting on the lap of Lord Shiva and he is consoling her after being threatened by demon Ravana, who tried to shake the Mount Kailasha found in the figure no 54. The male figure is adorned with the asymmetrical headgear typical of Chandraketugarh. The theme appears to be popular in early historical art of India as evident from such couples represented on terracotta at the sites of northern and eastern India and on stones on the façade of western Indian caves such as Karle.

Position of Animals in Socio-Cultural Life:

Chandraketugarh terracotta plaques offer a great variation which is really astonishing. Here many a times we get the delineation of animal figures juxtaposed with humans as can be seen in the figure no 55. An illustration of a narrative theme depicted on a small circular plaque which shows a turbaned man riding on a pony. Few other plaques show depiction of elephant, horse, tiger, swan and unidentified birds. If compared to the full blown figure of the elephant from Mamallapuram found in the figure no 56 it shows the linear progression of stylistic evolution through the passage of time.

Fig 55 Elephants in terracotta from Chandraketugarh

Fig 56 Stone sculpture of Elephant from Mamallapuram

Architectural Evolution

A toy cart featuring a divine couple riding on an animal, probably a tiger with a canopy like architectural section at the top. The figures are arranged below a two tired temple like structure supported by what appears to be wooden posts. The backslab is covered with dense foliage. The iconography of the composition raises a number of problems. But the architectural background is indicative of the cultic importance of the figure. The most interesting feature of this plaque remains in the incorporation of the architectural part which has sameness with typical Bangla Chal. The same kind of architectural elements are generally used as the top of the Chajjas in Rajasthani architecture.

Fig 57 A toy cart from Chandraketugarah

Fig 58 Chajjas in Rajasthani architecture

Fig 59 Terracotta temples from Amadpur and Diknagar showing typical Bangla chal

Glimpses of Social Life

There is a plaque (figure 60) showing the process of reaping off the corn, which is the only documentation of their social lives. This is a fragment of a plaque depicting a harvesting scene. The plaque portrays three men kneeling and harvesting the grain with large sickles. Terracottas portraying narratives with similar harvesting themes have been found also at Tamluk in southern Bengal. This is the testimonial of their social activities as a group as we find in the paintings on the papyrus from Egypt (figure no 61) which clearly shows their social life and group activity.

Fig 60 A fragmented terracotta plaque shows people are reaping corns from the field

Fig 61 Paintings denoted a scene of social life from Egyptian period.

Cultural Life of Chandraketugarh

There is a group of plaques depicting musicians playing different types of musical instruments, dancers, presenting a panorama of the cultural life of the community. Figure no 62 depicts a male figure playing lyre. He wears a turban, earrings, torque, bracelets and lower garment with a thick sash. His left leg is folded and right leg is on a foot stool. He is holding the lyre in his left hand. A female figure can be seen dancing on his left. Her hair is probably done in trefoil coiffure the right part of which is damaged. She wears a torque, necklace and earrings, bracelets, girdle. Between these figures is a low stool probably with a dish and some objects on them. There is a hut like structure behind her. To the extreme right of the plaque are two monkeys. One is possibly holding the parasol over the man's head. The other is seated at the feet of the man and probably pressing his leg.

Fig 62 Terracotta plaques from Chandraketugarh presenting the glimpses of cultural life and practices

In the second plaque, two female figures with two attendants holding two fans in the background. The female figure to the right is leaning on the shoulder of the other and her left arm is around her shoulder. The figure to the left is fiddling with her ear ornament with her left hand. The figure on the right wears a flowing headscarf and fringes of hair are visible under it. She also wears ear ornaments, thick torque and necklace. The other has her hair tied to a knot on left side, wears a necklace and a beaded string across her chest, bracelets and armlet. The lower part of the plaque is broken.

Thus, we can conclude essentially that, "art" is, such as the inscription of a cave man usually of symbolic meaning and emblem representing the power of man and the power of those "supernatural" entities. It is the mirror of the immediate surroundings and reaction of the society. It is inclined to existentialism to "reflect society" thus, shouldn't be measured, rather deciphered alike scripts. Art is an expressive form which should be embraced in the various ways it has been presented to us. "It" is a shape shifter that shouldn't and couldn't be tamed.

"Conscious art highly explores, details, and unfolds several vices that make human lives unbearable in the societies that have bred us. It's amazing how versatile and diverse art can be; it explores events in the real world as well as the imaginary world, and this is principally brought about by artists themselves—which is brilliant…"by Lutakome 'FELIX' Fidelis.

5 Conclusion and Interpretation

It may be said that the study area is thus an ancient city of Bengal, as old as 4th century BCE, located in North 24 Parganas of West Bengal. The area, as mentioned by various travelers in their piece of work, is situated within 'Gangaridai', an ancient state present at the current position of Bangladesh and West Bengal. Since numerous rivers drain this area, it is mainly a fertile deltaic land. The area was mainly drained by Bidyadhari River, and since it was connected with the Adi Ganga, the people of Chandraketugarh enjoyed an easy access through this route. But these days due to the shifting of the Bidyadhari River course, the easy communication between Chandraketugarh and other parts of India and outside came to an end leaving it as a dead place. Various relics uncovered from the study area reveal the settlements of Mauryas, Kushanas, Guptas and eventually Pala-Senas. Hence these discoveries prove that this site is archaeologically very important to decipher the socio-cultural, economic aspects since antiquity.

The site has demonstrated an array of terracotta works depicting the subjects started from Mother Goddesses, figures of mother and child, female figurine showing auspicious head gear along with hair pins to the specimens showing cultural, social and architectural evolution. Thus, reflects the fashion statement of a particular time period. Many plaques show harvesting scene replicating their social life. Plaques showing musicians playing various instruments and dancers performing, reflects their cultural life. Plaques of goddesses like Parvati, Laxmi etc. are found. Different coins with wheel and boat motif have been unearthed. It shows that the people of Chandraketugarh used to maintain a trade relation with various countries through the sea route.

Through various methodologies like Geo-archaeological investigation, Hydrological investigation, Geophysical investigation, Sedimentary analysis, and Remote sensing methods attempts are made to relocate Chandraketugarh not only in Bengal but also in greater Asia and hence lies the importance of its location. Efforts are also to be made to trace back the palaeo-channels of the once flowing river courses and also the causes behind the shifting of their courses which left a huge impact on the settlements which were made centering those river courses.

Among the five different methodologies suggested above, hydrological investigations and sedimentary analysis of the study area are of greater importance. Since the area is a deltaic flat land, detailed studies regarding the type of delta; whether wave dominated or tide dominated, pattern of delta formation, etc. are required to be known through sedimentary analysis. A comprehensive study of the sedimentary structures and its various layers demarcating grain size variations (normal grading / reverse grading), dating is an important tool to denote the chronology of the deposited beds etc. are required to be done, which may lead to a better understanding on the sedimentary environment of the concerned area. The above study may help to delineate the drainage pattern of the area and also the causes for the shifting of the river courses which is evident from the existing surface indications.

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Fig58. Retrieved from https://lh3.googleusercontent.com/sxdaC5CHSBcyS5kxdHc9dsVetp9s4n 4ysMsQtYVfgotuwA9C7cOagD7ryZe4Exu-loEW=s134

Fig 59. Retrieved from http://chitrolekha.com/wp-content/uploads/2013/03/pic5.jpg

Fig 60. Retrieved from Eloquent Earth; GoutamSengupta, Sima Roy Chowdhuri, SharmiChakraborty

Fig 61. Retrieved from http://sffiction.blogspot.in/2013/10/also-there-is-no-beer.html

Fig 62. Retrieved from Eloquent Earth; GoutamSengupta, Sima Roy Chowdhuri, SharmiChakraborty

2

PROJECT TWO

Geo-Quest of Chandraketugrah, West Bengal by:

Reframing the evolutionary trend of urban settlement of Chandraketugarh primarily in relation to the early historic urban growth in Bengal and beyond using geo-scientific knowledge; and evaluating deterioration status and plausible preservation and/or restoration aspects of the ancient structures

The Team

1. Sandhi Summer Interns Report 2015, Geological and Geophysics Department (GTS)
   (under the guidance of Prof. Arindam Basu)
2. A Thesis by Anant Agarwal (GTS), MS (GG) IIT Kharagpur Thesis 2015
   (under the guidance of Prof. Abhijeet Mukherjee)

GEO - QUEST OF CHANDRAKETUGARH

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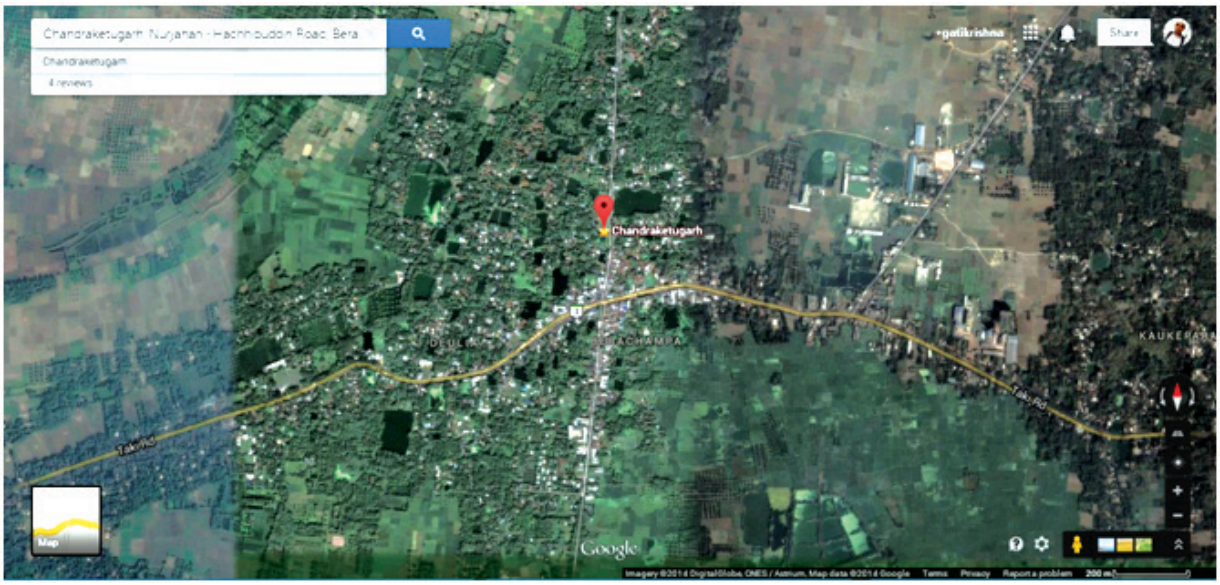
Content

1. Chandraketugarh-The Buried Heritage of Bengal

About 35kms north-east of Kolkata,India in the district of north 24-Parganas is the archeological site named Chandraketugarh (88°41'N,22°42'E),located on the banks of Vidyadhari river. Chandraketugarh lies on the road to Haroa, at a distance of 1 kilometer from Berachampa. The site is situated onMoribund delta of the Ganga-Brahmaputra river system. The two main waterline of this area are Vidyadhari and the Padma Nala,which is a part of the Ichhamati river. They are now both disconnected from the main Bhagirathi channel.



Location Of Chandraketugarh (Google Earth)

Chandraketugarh showcases one of the richest cultural heritages in Bengal but is yet to reveal all of it due to the temporary preclusion of the archeological excavation. Though the chronological classification is yet to be done but years of excavation have revealed relics mostly dated between 300B.C-100B.C. The time period corresponds to a span from early Maurya period to the more recent Kushanas and Guptas and Pala periods. According to a school of thought,Chandraketugarh was actually a port city that had come up on the rich, alluvial Ganga-Vidyadhari delta, and had eventually merged into the mainland.

No wonder there is no hard fact about the period of Chandraketugarh. Lack of evidence and excavation still keeps us in dark about various aspects of this civilization. There is no written record of this civilization. More mysterious is the fact that it vanished leaving no social memory in the surrounding areas other than some local mythologies. Yet, there is no doubt that the civilization reached a level of sophistication evidenced by the enormous amount of artifacts, which is not possible in a short span of time. Then what exactly could have been the reason which led to the abolishment of such a mighty civilization?

2. Mythology-The Folklore

Chandraketugarh is named after the chieftain or so called king figuring in local and medieval legends currently in Basirhat area. Apart from the popular stories relayed by the old folks about king Chandraketugarh,there are no authentic historical document confirming its existence. Even if he did exist,the rule of such a petty ruler cannot explain the existence of such an extensive archeological site with high ramparts and temple complex. Though we are not in light about the political history of the place,but from some royal seals inscribed with the head of rulers,it can be demonstrated that the early government was democratic while it was followed by monarchy. (Chandraketugarh a lost civilization, Gourishankar De, Subhradip De)

Chandraketugarh terracotta was produced through many centuries, approximately from the 4th BC to the 5th A.D.,particularly rich is the variety of pieces going back to the Shunga era, a dynasty that reigned in north India from about 185 to 73 BC. It is in this chronological and stylistic setting that we can situate the two plaques and the pot particularly important owing to the complexity of the depictions. Comparable in its subject theme with other finds from Chandraketugarh and Kaushambi, the plaque most likely depicts the highlight of a celebrated event: Udayana's flight with Vasavadatta from her father's palace. The romantic and magical story of Udayana, king of Vatsa, who would beget a son who would be king of the celestial Vidyadharas, and of his lover and later spouse Vasavadatta, the daughter of the king of Ujjayini, is no doubt one of the most popular in the Indian narrative repertoire (Figure 1a). The two runaways sit on a speedy and almost unbeatable female elephant from the royal stables. As in similar plaques, a servant sits behind them and hands out money from a bag in order to turn away the pursuers, while a woman holds a large parasol to protect the threesome. The elephant and her load are preceded by two horsemen, they too shaded by a parasol, and many other personages, both male and female, fill the scene. Two men sit and watch from the branches of a tall tree, and another tree with garish flowers and some delicate shrubs and grass at its base complete the sylvan setting(Figure:1b). Considering its subject, it is not unreasonable to surmise that such a plaque was intended for private use. It probably graced the house of a well-to-do family, and it is possible that it was received as a wedding present. Besides being pleasantly evocative of a very popular event, this type of depiction no doubt had an auspicious significance: the two protagonists' love would be transferred, as in a sort of protective rite, on to the married couple.

To a ritual or at least celebrative context also belongs the pot(Figure 1c), as testified by its preciousness and by the theme of its decoration. For objects in this category too, the hypothesis of wedding presents applies; the persons depicted would thus be a bridal procession. We are thus again in an evocative context auguring joy and prosperity. Water is also referred to in the pot, where two boats are shown on a background of wavy ripples conveying the movement of flowing water. These are sweet waters, as indicated by the swimming ducks, probably one of the river arms which make the usual landscape of the Ganges delta. The larger boat is vigorously pushed by rowers; on the other one a man holds a drum above him. Next to him, on firm ground, a man opens a basket from which a small bird comes out; and the relief continues with dancing figures among which a winged nymph lifts in flight. Dancing figures can also be seen: two men fight with swords near a Ficus indica with falling aerial roots, others wield long sticks, clearly the performances at a big feast. Some people hold sunshades or fly-whisks, men and women mix in joy and freedom.

Figure 1 Terracotta Plaques And Pottery From Chandraketugarh

More complex is the interpretation of the composition on the second plaque. A crouching man keeps a reluctant monkey tied by the neck, while another monkey behind him holds a sort of vessel, and this seems to be the center of the scene. It is not evident whether or not at least some of the men and women grouped around them are actively taking part in the scene.

(http://www.asianart.com/exhibitions/freschi2/intro.html#1c)

Apart from the myths spoken by the terracotta art, there is another popular name engraved on the ruin,whose origin still arouses controversies between the historians and the mythologists.(Figure 2)" Khona "lives on as a mystery in folktales and legends of eastern India and in the curious brick structure that bears her name. She remains a household name in eastern India and Bangladesh; verses composed by her are compiled and fondly remembered. And then, there is a curious ruin in West Bengal that goes by her name. Yet, no one knows if she was a historical figure or not. There are many versions of her legend. The common theme is that the famous scholar Varahamihira from Ujjain had a son, and he was horrified by the horoscope he had cast for the newborn. He thought his son would die within a year, and abandoned the child inside a vessel and let it flow with the river. The child was rescued and brought up in a distant land by demons, and named Mihir. He later married a brilliant woman, and they travelled together to Ujjain to face his fath0er. In the royal court, Mihir's wife defeated Varaha in a debate. She exposed and ridiculed his mistakes in public. Unable to bear the shame, Varaha ordered his son to cut his wife's tongue. In the version of the legend from Orissa, she came to be known after this bloody incident as "Khona" which means "dumb" in Oriya. In the Bengali version, she was given the name "Khona" by her father as he had thought she was born at an auspicious moment, a good "Kshana". Although the Bengali version says that she was brought up by "demons" in Sri Lanka, it is possible that the "demon-land" was the then Bengal itself. Some medieval works like Kalhan's Rajtarangini referred to Gauda, the then Bengal, as the kingdom of demons. One really wonders how Khona's name has come to be tagged to this site. Her fame in folklore has nothing to do with this particular ruin, but is linked to some verses she is thought to have coined. These verses (popularly known as "Khona's sayings") are mainly to do with weather forecasts and agricultural advice: what sort of weather is good for crops and when should a certain crop be sowed, and so on. There are also some verses dealing with astrology, which taunt Khona's father-in-law, Varahamihira, for his ignorance.

Figure-2 The Mound of Khona-Mihir

(http://www.hindu.com/mag/2008/01/20/stories/2008012050230700.htm)

The bewildering mix of these folk verses, the peculiar legend of her rivalry with Varahamihira and the torture, and the curious ruin in Berachampa (Figure 3) makes one wonder about it all. Was she simply an astrologer who had different ideas about horoscopes, or is there more to the story? Was the structure in Barasat something other than just a "temple" — an observatory, perhaps? (Traditional observatories are built along the north-south direction.) Did she find something unpalatable to the medieval scholars like Varahamihira who lived in the last years of the Gupta age?

Figure-3 The ruins of the ancient civilization at Berachampa

(http://www.hindu.com/mag/2008/01/20/stories/2008012050230700.htm)

The Ramayana,one of the oldest Indian mythology got its present form probably around 400 B.C. It was introduced in the realm of Indian art by the artists of Kausambi,where the terracotta art had reached its zenith during the Sunga period. It depicted the story of Sita's abduction by Ravana. Though the terracotta plaques of Chandraketugarh negate the claim of Kausambi as an introducer of Ramayana in Indian art,Chandraketugarh can call for a co-sharer of this claim. In Chandraketugarh also intact plaque depicts king Ravana wearing turban and ear rings and holding Sita in his arms who is strangling to free herself in vain. The scene of two monkeys wrestling in the background of palmyra tree is the clue for identification of figures of Bali and Sugriva. (Chandraketugarh a lost civilization,Gourishankar De,Subhradip De)

3. History and Archeology

The twin mounds, the Khana Mihir and Chandraketugarh are located in Berachampa near Barasat which is about 50kms from Kolkata. The Khana Mihir mound is found to preserve a Pala temple, while the Chandraketugarh mound is awaiting an extensive excavation. (https://rangandatta.wordpress.com/tag/chandraketugarh/).

The Archaeological significance of the Chandraketugarh area came to the attention in the early years of the last century when road-building activities exposed a brick structure.A. H. Longhurst first visited the site in 1907 on the urging of Tarak Nath Ghosh, a local resident Longhurst but declared "the ruins were of little or no interest".K.N. Dikshit, Superintendent of the Eastern Circle of the Archaeological Survey of India (ASI), first published a report on the site in 1922-23.The site was excavated by the Asutosh Museum of the Indian Art of the Calcutta University through 1955 to 1967and historians think that the story of the place dates back to as early as the third century BC, judging from the Roman and Mediterranean coins found here. In 2000, there was a minor excavation at the site by ASI under Bimal Banerjee; however this effort has come to an abrupt stop.

http://subhaditya-infoworld.blogspot.in/2012/10/chandraketugarh-may-be-ancient-port.html

History says that this place in the delta of the Ganga River is the site of one of the oldest cities in Bengal and belonged to the kingdom of a mighty ruler. It is believed that the place was an important urban center, a bustling town during the tenure of King Ashoka and most probably a port city. It had a high encircled wall with a rampart and a moat. To know more about the cultural sequence of the site, city planning, settlement pattern and rampart,the eastern rampart area of Chandraketugarh was selected in the first instance for excavation. A vertical trench was laid across the rampart towards its eastern edge in east-west orientation. At a depth of about 2.75m from surface brick soling and traces of wooden logs have also been noticed on the section.

(http://asi.nic.in/asi_exca_2005_westbengal.asp).

Not much is known about the socio-religious background of the civilization; little is revealed by the inscriptions in Kharoshti and Brahmi scripts which have been found in the potteries unearthed here.A 45 sq. kilometers prayer hall dated to 700-600 B.C could have been a place for community prayer. The remains of Chandraketugarh comprises of a palace and a temple; which almost confirms the acceptance of Hinduism as the dominant religious belief.Chandraketugarh was a minor center of Buddhism and was reigned by brahmanical and vedic faith. This is the reason why the royal missionaries Fa-hien, Heun-Tsang never visited this port city and thus the name of this city doesn't occur in their accounts. Only the poetic description of Kalidasa in Raghuvansham gives a little description of Chandraketugarh.

Artifacts suggests that the site was continuously inhabited and flourished through the Sunga-Kushana period,then the Gupta period and finally the Pala-Sena period. Chandraketugarh boasts of some of the magnificent instances of the art of terracotta. What is unusual about the Chandraketugarh terracotta sculptures is their very large numbers, their great variety, and the fact that many of them are extremely well-made and very beautiful.Numerous fragmentary terracotta plaques were excavated among which the mithuna plaqueis noteworthy. The ceramic type includes grey ware, dull red ware and red ware. The main shapes are vases, bowls, miniature pots, handis etc. having decorations in the form of parallel incisions, chequered pattern criss-cross designs etc.The plaques bear resemblance to those discovered in Ahichhatra and Kaushambi. This points to an established communication link and common cultural heritage among these sites.The terracotta figurines(Figure 4) dates back to the period of Maurya, Sunga and Gupta as well a Kushana Dynasty. Northern Black Polished Wares have also been discovered in this site(Figure 5).These wares developed around 700 B.C. and reached its peak with the rise of Mauryan Empire. This distinctive pottery with lustrous black surface establishes links with earlier Harappan culture.

(http://www.indianetzone.com/55/northern_black_polished_ware.htm)

Figure 4 earthen pottery of chandraketugarhfigure 5: terracotta figure

Gold and silver punched coins,semi-precious beads, minted copper coins, objects made of bone and ivory,wooden artifacts with sculpture are the other antiquities recovered from the excavation site which are indicative of craft and mercantile activities. A gold coin of Chandragupta-Kumardevi has attracted our attention. The discoveries in Chandraketugarh site reflects the key era in civilization when agrarian life acquired an urban face where trade and commercial activities flourished in full swing.

(http://www.indianetzone.com/55/chandraketugarh.html)

In his book Geographia, Claudius Ptolemy mentions a river port called Ganges in southwest Bengal. Plutarch wrote about a powerful tribe called Gangaridae living near a prosperous port Gange in the Gangetic delta. An anonymous Greek sailor mentions in his book Periplus of the Erythraean Sea (first century A.D.), a port at the mouth of the Ganga from which Roman ships sailed out with exotic goods. According to the historian Paresh Chandra Dasgupta, Gange most probably was the port town of Chandraketugarh a fact that is corroborated by the large number of ship seals found during the excavation.

(http://www.studymode.com/essays/Chandraketugarh-Unfolding-The-History-Of-Bengal-539671.html).

The Kharosthi script,more or less contemporary with the Brahmi script appeared around 3rd century B.C and was enormously utilized by the Gandhara ethnicity of present day Pakistan lying in the north west of Asian subcontinent to pen down Gandhari and Sanskrit languages. This was used by the Kushanas, by an ancient Iranian civilization and also along the Silk Route which represents the far reaching interlinked chain of trade routes spanning the Asian subcontinent.(www.ancientscripts.com/kharosthi.html

The rivers commonly change their courses near the mouth and due to new alluvium deposition the ancient cities, situated at the delta region migrates more towards the mainland. Chandraketugarh being one such coastal town of Ganga River, makes it difficult for us to obtain hard facts about the ancient civilization. Although not adjacent to any major navigable sea-bound water channel at present, Chandraketugarh lies only ten kilometers north of the dying stream of Vidyadhari river. Vidyadhari once used to be a strong navigable river opening up to the Adi Ganga, the ancient course of the Ganges. Through this route, the Chandraketugarh site probably had easy access to the sea.

(http://www.indianetzone.com/55/chandraketugarh.html)

Advances so far in archaeology of Chandraketugarh

The archaeological study generally used the settlement pattern studies to understand the nature of sites or group of sites and their relationship with the environment to explain the subsistence and organization. It helps to trace the past human activities and their status of living through recovery and analysis of material culture and data they left behind which includes artifacts,architecture,biofacts etc.

Chandraketugarh is an ancient city of Kolkata situated alongside of Vidyadhari river, at a distance of 35 km from north eastern portion of Kolkata. Exactly 108 years back Chandraketugarh was first discovered. The archaeological significance this area came to the attention at early years of last century when road building activities exposed a brick structure. A.H. Longhurst first visited the site in 1906 on the urging of Tarak nath ghosh, a local resident. Again in 1909 Rakhaldas Bandopadhyaya visited the site and collected some artifacts. K.N. dixit superintendent of eastern archaeological survey of India first published a report on the site in 1922-1923.

A next step towards excavation carried out by university of Kolkata in the year 1955-56. The archaeological findings also proved that the area around Chandraketugarh was the center civilization right from fifth-fourth century B.C. to the medieval period. As the excavation carried out by University was in small scale, very little could be known about the city planning, architecture, rampart etc. Calcutta university ashutosh museum did unearth the remains of a temple. In their reports published in annual ASI reviews.

In 1956-57 university of Kolkata under shri K.G. Goswami carried out excavation at the mounds of Chandraketugarh. The excavation revealed the five successive periods of township from pre mauryan to gupta period with its distinctive potteries. At that time the structures had been of mud, bamboo and timber with tiles for the roof. In 1957-58 Shri P. Shome collected some terracotta seal which shows foreign affinities and some figurines of royal warriors of kushana periods. There were a large no of antiquities also found in 1960 which revealed the period of maurya and gupta. Among them were some punch marked coin of dolphin type exhibiting a ship. Terracotta toy carts and figurines of Indra and Kubera seated on a winged elephant. Agni riding a chariot drawn by pair of rams, a ram rider of Sunga period and another terracotta chariot driven by a pair of bulls with a royal personage or a vedic deity of the kushana period were found. In1961-62 they tried to correlate the strata which is necessary to understand the sequence. *(http://www.historyofbengal.com/from_asi_reports.html)*

To more about this there was an excavation conducted in field season 2001-02. They found some brick soling, wooden logs at a depth. Some antiquities like red sand stone, dice, terracotta ball, fragments of terracotta plaques also noticed. The consecutive field trip on 2000-01, 2001-02, 2002 -03 has yielded material of two cultural period viz. 2nd century B.C. to 11th-12th A.D. and 15th-16th A.D. and continued till modern era. The antiquities like terracotta objects mainly of human and animal figurines of Kushana and Gupta period. A stone plaque depicting Mahisamardini was an important finding of 11thA.D. Some excavation near to this area unearthed the history of Sultans period in 17th A.D. Some copper coins and structural complexities were encountered structural complexities showing a huge brick enclosure wall of almost 54m in length and width.

(http://www.historyofbengal.com/chandraketugarh_p1.html#history)

4. Geoscientific and Geomophological Studies

Chandraketugarh and river pattern of west Bengal (google maps)

Chandraketugarh is situated on the moribund delta of Ganga-Brahmaputra river system. Bidyadhari, Padma, Padda revers are flowing in this area. These are general fed by rain water and the north part river fed by tide or back water. Some marshy places and beds i.e. the swallow lakes are present in this region which are developed by the tide or back water. This region is at height less than 10 meters above the mean sea level.

This site contain many region n remain of ancient rivers on paleo-channel. Padma is the main stream of Ganges in the lower part of delta and there is another river Padma slept Padda was also flowing in this region. This is an offshoot of Yamuna River. Now a days, Padma is almost died up. There are some heaps of sands deep bands which are present along the trend of the river which give evidence about the strong ancient current of the river. Padma steel pulsates in the lower reaches from Chourasi to Tibi where we can still see ebbs and tides. In the Deganga area there is another river flows called Dev Ganga. (De and De)

The site situated on Katwa Surface confined within paleochannel in the eastern bank and southern bank by two paleo channel. According to Geological Survey of India the site is situated on varied geomorphic features paleolevees, paleo backwater, paleo channel, point bars etc. the stratigraphic analysis also shows the less percentage of sand in the strata and more than 80% of silt and clay. This data revealed the alluvial nature of deposition with some amount of phosphorous content in that layer. The last layer is the clayey lense which seems a stagnant type of water deposition. In the section around the sites were studied especially nearer to brick factory where a pit is dug in the soil to get the mud. The stratigraphy in this region showing similar pattern. At Bermanmara the top layer consisted of yellow brown sandy silt with gastropod shells, at Bermanmara the silty layer of 30cm thickness was followed by asandylayer. The stratigraphy of this region is very similar to Shanpukur where 5cm grey silt similar to the top layer which is followed by sandy layer of light grey color of 1cm thick, below this layer a dark grey layer for which early historic pottery were found.

Diamond Harbor, an another historic site survive up to medieval period contain alternating layer is concerned greyish mottled silt and coarse to medium grained sediment. Chandraketugarh and other nearby sites are the buried sites because no such mound are found. The structural mounds of Chandraketugarh are early medieval. So far the exposed sections it is concluded that the early historic alluvial horizon is at present buried under the alluvial deposition of later times. These exposures developed due to some human intervention and channel erosion. The buried sites are generally features of active flood plain. In this region the rate of sedimentation is more than the rate at which habitation build up. Hence the site get buried and flood deposit. The rapid aggradation data is brought out by Sunil Chandra who revealed that in 7000 B.P. to 3000 B.P., the surface had risen by 15m and in the next 2000 years the rate of aggradation was much slower that is 2 to 3m.

The unoxidized dark grey silt I the early historic pottery suggested the regular and low energy followed. In the Ghazital section the burnt brick and structure of Gupta period appear only after the partial oxidation of silt which suggests less frequent flood. It also shows the levee building process had already started in the early historic period.

The settlement pattern shows a linear pattern in this region. This seems to be placed on the bank of river and river might have also suffered lateral movement. The less percentage of alluvium in this region suggests that the region experienced a low energy flood. The ancient landscape shows there was a large vegetation cover and river system without large dams. The channel depth and velocity of water was low as expected an anastomosing river in the delta. Therefore the devastation was minimum.

(Chandraketugarh- a site in lower delta by Sharmi Chakraborty)

5. Connection of Chandraketugarh with the Rest of the World

In archeology, the techniques of pottery has been an important aspect of analysis of provenance throughout the world. Distribution of major elements in fired pottery, identification of different phases, finding of probable firing temperature, changing of properties of clay minerals due to firing, are the main aspects related to the study of provenance. But can we determine whether stylistically similar pottery was manufactured at one site or at several sites simultaneously? Were they produced in a location with one type of clay and then traded to other sites or the technical knowledge was spread to other sites by cultural diffusion? The answers will throw light on the organization of production and the nature of socio-economic activities of the particular area.

The cultural pattern of Chandraketugarh all along the Ganga plain shows how the rivers served as an important means of communication. In that region the development of trade and commerce along the river to ports and destined the commodities to different places by means of river. They supply the commodities to its hinterland and their route of trade was developed by regular exchange of products. Here the location and size of the settlement become important indicator of economy.

According to Ptolemy there were five mouths of Ganges, western coast Kambyson, Mega, Kamberikhon, Pseudostomon and Antibole. He also says that, "all the country about the mouth of river Ganga is occupied by the Gangaredai with the city-Ganga the Royal residence." Historian B.N. Mukherjee has equated Ganges with Chandraketugarh because of the largest settlement in the delta. However sediment deposited in the Chandraketugarh is strictly alluvial in nature. In that case we should consider all the country on the mouth of Ganges. The five mouths of river Ganga might be the estuaries of Ganga or the other five used by traders. That must have been in relation to trade either with other parts of India or Rome.

The settlement pattern of this region shows that a linear pattern was followed that must have been along the bank of the river. As the water table in this region is very high, there is no scarcity of water. The region is thickly forested and carbon rich alluvial horizon found throughout the region. The river shows an important means of communication. This pattern well matched with Ptolemy's five mouths of Ganga which are used by traders to go upstream. The settlement also developed along the trade route. Therefore the linear pattern might also be a product of trade. This was not only just for Roman trade but also coastal trade along the coast of Bengal.

The Kushana—the nomads of Central Asia, reigned from beyond the Pamir and the Oxus region and extended their territory to the Indian subcontinent by capturing Pataliputa of Bihar. The most remarkable achievement of the Kushana period was the proliferation of trade and craft. Though Bengal was a never a part of the regal Kushana rule, but it had a profound influence on the socio-economic lifestyle of the people of Bengal. The economy of Bengal flourished collaterally with the growth of international trade relations with India. Bengal, by the virtue of its locale, contributed to the growing maritime activities in Bengal. The position of Bay of Bengal, presence of large rivers, all favour growth. Chandraketugarh and Tamralipta, the two most prosperous international port cities of ancient Bengal, played the most crucial and significant role. The most significant aspect of Chandraketugarh is the maritime activities it had with Southeast Asia during the early Christian era. This port was the only outlet for the landlocked north and northeast of India, at least for the first two hundred years of the Christian era. Archaeological investigation has revealed a large number of objects of Indian origin from different parts of Southeast Asia, which emphasizes the significance of the maritime trade network of the Bengal coast with Southeast Asian countries. The recent analysis of fragments of roulette pottery found in different parts of Southeast Asia and Eastern India, shows that they originated at Chandraketugarh. Gogte said, they were dispersed to south India and South-East Asia by the Buddhist monks and traders of North-East India. Not only pottery, but beads, terracotta objects, grains, textiles, horses, etc. were involved in the trade. The discovery of mixed Kharosthi-Brahmi inscriptions from the sites of lower Bengal and from Southeast Asian sites is indicative of strong trade relations.

(http://euraseaa14.sharpsands.com/live/session_display/display_session_detail.php?thisID=127)

(Archeology of Eastern India: Pottery technology and provenance studies from the site of Chandraketugarh in lower Bengal. Anjan Kumar Das, Sheena Panja, Tapas Kumar Mukhopadhyay, Sachchidananda Chakrabarti)

The excavations at Chandraketugarh and Tamralipta in West Bengal, and in some places of Andhra Pradesh, and Tamil Nadu have brought to focus the evidence of Rouletted Ware which is datable to 2nd century B.C. Begley (1983) suggesting that Arikamedu in Andhra Pradesh was the main hub for the production of the Rouletted pottery in large quantity for trade and domestic purposes. It is believed that the Rouletted Ware is an evidence of Indo-Roman trade, and was imported from the Roman Empire.

Preliminary analysis reveals that Chandraketugarh might not have been the center of pottery production. The clays distributed within a radius of 10kms are of same nature but not responsible for these type of pottery making. This is contrary to the view of Gogte who suggested that the pottery was produced at this site and then carried to other regions. The X-ray studies revealed that the firing temperature was about 500˚C. The ancient potters did not use such low firing temperatures to produce such hardy materials but also used some fine quality clay admixed with some flux material to yield a lustre and shape to last nearly 3000 years.

(Archeology of Eastern India: Pottery technology and provenance studies from the site of Chandraketugarh in lower Bengal. Anjan Kumar Das, Sheena Panja, Tapas Kumar Mukhopadhyay, Sachchidananda Chakrabarti)

Similarly, the knobbed vessels have been reported from coastal Bengal and it was emphasized that this pottery was used for the Buddhist rituals. The Northern Black Polished Ware at the port cities were the evidences of coastal trade on the eastern Indian littoral.

The numismatic evidence along with other archaeological artifacts indicate trade relations between two geographically separated areas. A unique type of punch-marked coins with ship symbol are found from Chandraketugarh in West Bengal which are similar to boat symbol coins issued by the Satavahana kings. Such coins were also found on the Andhra coast. In Northern Sri Lanka a single mast boat coin in conjunction with a donatory inscription of 1st century B.C. is found. The potteries unearthed from the coastal regions bear the symbol of ship in the terracotta sealing and graffiti on potteries.

The excavations at Chandraketugarh, have yielded Kharosthi inscriptions on seals, plaques and pots. The terracotta seals from Chandraketugarh depict aquatic vessels containing corn flanked by symbols like conch and taurine. Such vessel types are known as Sasyadidhrta Sthali, a bowl shaped vessel. Another such vessel has legend in Kharosthi-Brahmi script referring to Tridesayatra, meaning a voyage to three countries or in triple directions. Another seal from Chandraketugarh reveals a type of vessel called Trapyaka belonging to the wealthy Tasvadaja family. It may be noted that Trapyaka is a type of ship mentioned also in the Periplus. The above vessel types as well as flanking symbols recall the Satavahana ships. It appears that the Kharosthi script was used by Bengal trades settled in the lower during the third to first centuries B.C. and was mixed up with the Brahmi, which was used by local merchants, developing a mixed type Kharosthi-Brahmi writings.

(http://drs.nio.org/drs/bitstream/2264/127/3/Man_Environ_27_117.pdf)

The archaeological treasure, Nabagraha slabs has been discovered from Mathurapur (Diamond Harbor sub division) and all the images are found standing side by side. Hindus generally worship them together and placed on the doorways as the architrave. In the Orissa temples, Nabagraha slabs are seen placed on the doorways as architraves. In South Indian temples there are also such images carved in the slabs. Hence there must have been a correlation between eastern and southern part of India with Chandraketugarh.

The Buddha images has been collected from Khana Mihirer Dhipi at Berachampa in the environs of Chandraketugarh. These images show all the characteristics of Kushana period. Such images were also found in sites as Sarnath, Kausambhi, Mathura etc, This image was either imported from Mathura, a great manu-factory of Kushana period or was created by local artists working under the inspiration of Mathura school.

Several terracotta figurines of Chandraketugarh show the Greek and Roman affinity. This based on the ancient dresses of Greek and Roman women. The female figure is the representation of that of a Roman heads wear, a diadem like head dress clearly indicating Hellenistic influence. These may be compared with similar terracotta and stone figures of Taxila and Pal Khera. (De and De)

6. Summary

Chandraketugarh is riddled with problem of buried sites and shifting channels. So it is important to understand the hydrological regimes of the period. It need to have some soil profile and date the different sedimentary rock. Dating is most important thing to relate the artifacts like beads and pottery in a chronological sequence. Geophysical tools like borehole data and subsurface imaging is also important to understand the subsurface features of this area. To study the geomorphological feature like paleo-channel, aerial photography and GIS study is also required.

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IDENTIFICATION AND MAPPING OF PALEOFLUVIAL CHANNELS OBSERVED IN CHANDRAKETUGARH AREA USING REMOTE SENSING TECHNIQUES

A thesis
submitted in partial fulfillment of the requirement
for the award of degree of

Master of Science
in
Applied Geology
by

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Contents

Abstract

Chandraketugarh is a buried site with only few structural remains partly visible on the ground. The landscape around remains partly visible on the ground and the remnants of old landscapes are present in the form of paleo-channels, paleo-levees and paleo-point bars. And in the present study, a new approach is being discussed to identify those remnants of old landscapes. Several satellite images such as SRTM DEM, LANDSAT ETM+ as well as LISS-III are used for analyzing the vegetation, soil moisture content as well as for mapping the paleofluvial channels in the area. Remote sensing techniques such as changing the band combinations for enhancing certain features, as well as creation of indices like Normalized Difference Water Index (NDWI) aid in the study and delineation of the paleochannels. Also, Google Earth imagery was used for marking the paleochannels manually, and then correlation was done with the corresponding DEM, slope, aspect and watershed images in ArcGIS (version 10.3). The generations of the paleochannels were subsequently estimated, and several other observations were also made such as the anastomosing nature of the paleofluvial channels.

Chapter - 1

Introduction

1.1 General

Remote sensing is now-a-days a widely used technique for analyzing the morphological features of an area. This technique enhances the quality of research as well as it provides the efficient way to look upon the geomorphological features of an area. In the current article this technique is used to delineate the morphological features which are helpful in identifying the paleochannels or abandoned rivers of the Ganga-Bhagirathi-Hugli river system. The area of survey lies between latitude 22.5°-23° N and longitude 88.5°-88.75° E. Chandraketugarh is one of the site which lies in the south of this section of the area and has both archaeological as well as geological importance and it is also most studied site in this area. It is situated in North 24 Parganas district, West Bengal, with its latitude 22.6978° N and longitude 88.6883° E in the western part of the compound of Ganga-Brahmaputra delta. It is about 38 km north east of Kolkata. It is situated between two major distributaries of the Ganga – the Bhagirathi-Hugli River to the west and the Mathabhanga-Ichamati (known as Padma in Bangladesh) to the east. Both distributaries flow into the Bay of Bengal. A derelict but broadly meandering distributary, locally known as the Padma, flows north of the site to join the Ichamati. Another derelict and broadly meandering distributary, locally known as the Jamuna, originating from the river Bhagirathi near Kalyani, and flowing from west to east, also joins the Ichamati river further north of the confluence with the river Padma. A north-south flowing distributary, Bidyadhari, flows 2km west of the Chandraketugarh and meets the Bay of Bengal.

1.2 Regional Geology and Geomorphology (Literature survey)

Geomorphologically the area around Chandraketugarh is a part of the Quarternary landscape and falls in the western part of the Ganga-Brahmaputra delta. It is located in the river-dominated upper delta plain near its transition with the tide-dominated lower delta plain. The first stratigraphic information of the area came from the drilling of a well at Berachampa, which revealed a thick succession (about 180m) of unconsolidated coarse clastic sediments, often gravel-bearing, down to a depth of about 180 m, overlying upper Miocene soft black sticky clay of over 100 m thickness (Deshmukh et al. 1973). This late Quaternary coarse gravel-bearing succession is a part of a sub-surface north-south trending belt, stretching from Murshidabad district in the North to N-24 Parganas district in the south (Biswas and Roy 1976). Spatially distributed and successive cross-cutting Holocene meander belts seem to be the dominant geomorphic features in the upper delta plain of the Ganga-Brahmaputra delta with the channels currently carrying more than 1 billion tons per year of sediment with a very high discharge of about 1 million cumec (Coleman 1969). Regionally the area around Chandraketugarh is characterized by the Proto-Padma, Bhagirathi and Padma meander belts. The area extending south of Chandraketugarh up to the sea does not show any trace of meander belts. The valley trenching and later in-filling is restricted along traces of major meander belts; and thus sub-surface Pleistocene deposits in these areas are preserved (Stanley and Hait 2000). Pleistocene beds are overlain by relatively thin fine-grounded Holocene deposits with an increasing thickness ranging from 11.3 m (Salt Lake), 43.5 m (Canning) to Pakhiralaya (greater than 50 m).

1.3 Objective of the Problem

Chandraketugarh is a buried site with only few structural remains partly visible on the ground. The landscape around remains partly visible on the ground and the remnants of old landscapes are present in the form of paleo-channels, paleo-levees and paleo-point bars. In the present study, a new approach is being discussed to identify those remnants of old landscapes.

The word paleochannel is formed from the words “paleo” or “old,” and channel; i.e., a paleo-channel is an old channel. It is synonymous with paleo-river, paleo-drainage, lost river, buried river, buried channel, or buried valley which are deposits

of unconsolidated sediments or semi-consolidated sedimentary rocks deposited in ancient, currently inactive river and stream channel systems. When the active channel is abandoned from the river system due to tectonic, geomorphologic, anthropogenic process/activities, as well as climatic changes, it becomes a paleochannel. The ages of the paleochannels vary from perhaps tens to hundreds of years which may include the recent meander cut-off to an abandoned channel system. However paleochannels have long attracted scientific and practical interest as they may preserve the sedimentary records (useful for understanding the climatic condition) including isotopic indicators of past rainfall, temperature and climates and also fossils (useful for understanding the anthropogenic development). Amongst other things, these abandoned channels are economically important because they often contain deposits of Tin, Tungsten, Uranium, Lignite, Gold, Platinum, Silver, and Diamonds besides permeable fills which form excellent aquifers. The presence of paleo-channel can pose serious threats to engineering projects within the region.

1.4 Identification of Paleochannels

The paleohannels can be traced over long distances. Typically the channels can be divided into primary and secondary channels (secondary channels are those drained by the primary channels). There are basically two different approaches for identification of paleochannels. The one is through field observation and the other is through satellite imagery investigation. For identification of a paleo-channel through field observation can be more time taking as it will take lot of time to investigate a large area. However it will be one of the most accurate ways to characterize the distinct features of the overbank deposits of currently active river channels, including ephemeral water courses which do not regularly flow and a paleochannel. The different features include the sedimentary deposit as they vary distinctly for different geomorphological features, as paleochannels are of highly porous gravel, in the alluvial fan area coarse-medium sand, medium fine sand are present, fine silt in the river channel zones, and silt in the delta.

In the present study the paleochannels of the river Ganga have been identified with the help of satellite images. Oxbow lakes, Natural levees, Channel fills, Point bars etc. are key morphological features to predict the presence of paleochannels and these features are very easy to identify with the help of satellite images. Oxbow lakes provide the information about the paleoflow direction of the river. Natural levees show the occurrence of flood and therefore provide information about flood plains. Channel fills provide the deposition pattern of the sediment flux. Point bars are easy to identify and can be located in the abandoned channels too.

Another distinctive feature of the paleochannel systems is that they are dominated by sinuous, single-thread channel courses. It seems particularly significant, however, that the older generations tend to be highly sinuous, with maximum sinuosity exceeding values of 1.7, while the younger generations tend to exhibit low sinuosity courses (values < 1.1). With the help of satellite images and their photogrammetric analysis the sinuosity of the meanders can be attributed. But in the case of the Ganga-Brahmaputra River the slope of the area is approximately 2-3 degrees and in such a case it is quite obvious to have much more meanders and therefore the different features associated with it are quite evident in the satellite imagery (Fig. 1&4). The earlier work of river engineers, geologists shows that the dynamicity of the river is enhanced in such a condition where there are fewer slopes and large sediment flux is dumped at the end of the river. So it is most likely to have such a nice meandering pattern at the Ganga-Bhagirathi-Hugali river delta. The geomorphological signatures of paleo-landscapes have been discussed before (Chakraborty 2000). However they are not integrated with the archaeological importance of the area and also they are discussed for a small area.

Chapter - 2

Data Acquisition

2.1 Satellite Imagery

Ancient geomorphologic features in the Ganga-Bhagirathi-Hugli river system are commonly not so prominent and well preserved due to dynamicity of the system however the preserved ones are easy to be distinguished using satellite data. In this study, such data were acquired from three different remote sensing platforms, i.e., SRTM, Landsat ETM+ and LISS III.

2.1.1 Shuttle Radar Topography Mission (SRTM)

Publicly available SRTM data (http://srtm.csi.cgiar.org/) at ~90 m spatial resolution with 16 m vertical accuracy was the first data set analyzed for this study. The SRTM uses the C-band wavelength to penetrate dry sand and portray the near-surface topography (Robinson et al., 2006; Ghoneim and El-Baz, 2007a; Ghoneim et al., 2007). The SRTM data were principally used in topographic analysis of the study area, to delineate the complete drainage network and watershed area of the Ganga-Bhagirathi-Hugli River system. The SRTM data was used to make the digital elevation model (DEM) (Fig. 2) which helps in delineating the main channels as well as at least second order channel. The reliability of the SRTM-derived drainage network was validated against the Google earth imagery for a small part of the Hugli watershed (Fig. 2 & 3). At this scale, there is excellent agreement between the SRTM-derived drainage network and the channels revealed by some of the earlier work of the geologists.

2.1.2 Lands at ETM+

Multispectral Landsat ETM+ data from the U.S. Geological Survey (http://earthexplorer.usgs.gov/) were employed for visual interpretation of surface features and depositional environments (e.g., fluvial and lacustrine deposits) in the study area. All the data used in this study (SRTM and Landsat ETM+) were projected to the Universal Transverse Mercator (UTM) and WGS84 datum and were saved in a Geographic Information System (GIS) to allow overlaying and correlation of surface/subsurface features. Each data source added significant information, which assisted in the exploration of the region under study. Passive satellite imagery, such as Landsat ETM+, enables us to distinguish whether features of the radar imagery are surface or sub-surface.

2.1.3 LISS-III

The study has mainly utilised remote sensing data from Indian Remote Sensing (IRS) satellite mission acquired from National Remote Sensing Center (NRSC), Hyderabad, India. The IRS uses pushbroom scanning system based on Charge-Coupled Device (CCD), the sensors being called Linear Imaging Self Scanner (LISS-III). This data is received from Linear Imaging and Self Scanning Sensor (LISS) which operates in three spectral bands in VNIR and one band in SWIR with 24 metre spatial resolution and a swath of 141 km. The obtained data is already ortho-rectified data. LISS-III (www.nrsa.gov.in) data has been used for extracting information on geomorphology, vegetation cover, lineaments and paleochannel mapping in the research study. For delineating such regional features, we have used LISS-III data (edge-enhanced with Laplacian isotropic filter) as good quality image data was available from this sensor. Several remote sensing image data sets of different dates were acquired, processed and studied. In view of partial haze, cloud and other radiometric problems in image data sets, the image data set dates vary for different tiles of the study area to give the best results for landform mapping, land-use land-cover mapping and paleochannel delineation. Selected sensors specifications of this scene (LISS-III) are given in Table 1.

2.2 Processing of Remote Sensing Data

The remote sensing data comprises of small equal-sized areas called pixels that form the ground resolution cell and contain values of spectral reflectance of the scene. The digital images are ortho-rectified and geometrically corrected to overcome the distortions of the satellite imagery. The distortions may be due to radiometry and geometry, or of panoramic distortion. The rectified image is then subjected to a number of image processing operations, such as contrast enhancement, image rationing, classification, etc. for extracting useful information related to the geomorphology of the area.

Geo-referencing is commonly performed using the method of rubber-sheet stretching that has been explained in many standard texts (e.g., Mather, 1999; Gupta, 2003). A number of ground control points (GCPs) distributed uniformly over the entire area are collected such that they can be easily located on both the image to be rectified and the reference map, such as a toposheet. The nearest-neighbour resampling method has been adopted to generate the final geo-referenced LISS-III image, as this preserves the original brightness values in the output image.

Chapter - 3

Methodology

3.1 Paleochannel Mapping

The study area is a part of the Ganga-Bhagirathi-Hugli River system and is a large fluvial system, which develops very complex meander belts of major distributaries in the upper delta plain of the Ganga-Brahmaputra River. The meander geometry is appropriate to the corresponding hydraulic parameters of the distributary system, like the slope of the channel, its water and sediment discharge and the texture of the sediment load of the system. Each meander belt builds up an alluvial ridge over a given period of time in upper delta plain. The various major physiographic/landform units are – (a) vast stretches of alluvial plains, (b) dry streams, (c) paleochannels, and (d) marshy land (Kumar et al., 1996; Sammdder et al., 2007). The river paleochannel deposits are significantly different from the vast alluvial deposits being composed of coarse sand with pebbles, boulder, cobbles etc. and have been came from well-developed regionally extensive earlier river systems. The land-cover types are closely related to the landform units. Therefore, as a first step, land-cover/landform mapping has been carried out using remote sensing data. Due to synoptic view, map like format and repetitive coverage, satellite remote sensing imagery is a viable source of gathering quality LULC information at local, regional and global scales (Csaplovics, 1998; Foody, 2002; Gupta, 2003). In this study, four LULC classes have been identified (Figure 1&4). These are – agricultural land, dry streams/ point bars, water body/marshy land and built-up area. Detailed characteristics of all the classes along with their interpretative characteristics on each band as well as on the colour infrared composite (CIR) of LISS-III image are given in the following table (Table 1). However the broad classification of the CIR image is shown in figure 4. The classification is done by using the iso-cluster classification tool on the ARCGIS 10 platform. The Google Earth image (fig. 3) shows approximately the same features but they are a little bit hazy and it is also unlikely to capture a large area with good distinction of the features as in CIR images or the other remote sensing images.

3.2 Remote Sensing Techniques

3.2.1 Band Combinations

The standard "false color" composite is a combination of 432 color bands in the same order. In this vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. In this composite generally, deep red hues indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas.

The composite image of 543 created in the ARCGIS 10 software provides a great amount of information and color contrast. This combination is useful for vegetation studies, and is widely used in the areas of timber management and pest infestation. Healthy vegetation is bright green and soils are mauve.

The composite image of 453 in the same order (near-IR (Band 4), mid-IR (Band 5) and red (Band 3)) is created in the ARCGIS 10 software which offers added definition of land-water boundaries and highlights subtle details not readily apparent in the visible bands alone. The inland lakes and streams are located with greater precision as more infrared bands are used in this composite. The 453 combination demonstrates moisture differences and is useful for analysis of soil and vegetation conditions because the wetter the soil, the darker it appears, because of the infrared absorption capabilities of water.

Table 1: Geomorphological features with their distinct colour in different satellite imagery

Land cover classes	Description	Blue Component Green Band	Green Component Red band	Red Component NIR band	CIR composite
Agricultural Land	Sparse vegetation, agricultural activity	Dark	Very dark	Medium to dark	Dull red
Water body	River, Ponds etc.	Light	Light	dark	Cyanish blue to Blue
Paleochannel	Very low vegetation density, agricultural activity, fallow land	Grey	Light	light	Yallowish-white
Marshy land	Low lying land with stagnant shallow depth water throughout the year	Very dark	Very dark	Medium to dark	Black
Built-up area	Town and villages; block like appearance	Light grey	Grey	Darker	Bluish grey
Dry stream/ flood plains	Dry sand appear in the bank of river	Dark gray	Dark	Dark	Cyanish-white

3.2.2 Normalized Difference Water Index (NDWI)

The Normalized Difference Water Index (NDWI) (Gao, 1996) is a satellite-derived index from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) channels. The SWIR reflectance reflects changes in both the vegetation water content and the spongy mesophyll structure in vegetation canopies, while the NIR reflectance is affected by leaf internal structure and leaf dry matter content but not by water content. The combination of the NIR with the SWIR removes variations induced by leaf internal structure and leaf dry matter content, improving the accuracy in retrieving the vegetation water content (Ceccato et al. 2001). The amount of water available in the internal leaf structure largely controls the spectral reflectance in the SWIR interval of the electromagnetic spectrum. SWIR reflectance is therefore negatively related to leaf water content (Tucker 1980).

$$NDWI_t = \frac{NIR_t - SWIR_t}{NIR_t + SWIR_t}$$

3.3 Geographic Information System (GIS)

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.

Esri's ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. In this study, the majority of the work was done on ArcGIS (version 10.3).

3.3.1 Slope (Spatial Analyst)

For each cell, the Slope tool calculates the maximum rate of change in value from that cell to its neighbors. Basically, the maximum change in elevation over the distance between the cell and its eight neighbors identifies the steepest downhill descent from the cell.

Conceptually, the tool fits a plane to the z-values of a 3 x 3 cell neighborhood around the processing or center cell. The slope value of this plane is calculated using the average maximum technique (see References). The direction the plane faces is the aspect for the processing cell. The lower the slope value, the flatter the terrain; the higher the slope value, the steeper the terrain.

3.3.2 Aspect (Spatial Analyst)

Aspect identifies the downs lope direction of the maximum rate of change in value from each cell to its neighbors. It can be thought of as the slope direction. The values of each cell in the output raster indicate the compass direction that the surface faces at that location. It is measured clockwise in degrees from 0 (due north) to 360 (again due north), coming full circle. Flat areas having no downs lope direction are given a value of -1.

The value of each cell in an aspect data set indicates the direction the cell's slope faces.

3.3.3 Watershed (Spatial Analyst)

A watershed is the upper lope area that contributes flow—generally water—to a common outlet as concentrated drainage. It can be part of a larger watershed and can also contain smaller watersheds, called sub-basins. The boundaries between watersheds are termed drainage divides. The outlet, or pour point, is the point on the surface at which water flows out of an area. It is the lowest point along the boundary of a watershed.

Watersheds can be delineated from a DEM by computing the flow direction and using it in the Watershed tool. To determine the contributing area, a raster representing the direction of flow must first be created with the Flow Direction tool.

Chapter - 4

Image Analysis

4.1 Mapping

Finally, integrating information from CIR composites, LULC map, and previous work of other geologists, paleochannels have been traced and a paleochannel map has been generated. In the study area, three major paleochannels exhibiting broadly successive shifting and meandering pattern have been deciphered. Scant agricultural activity and mostly devoid of vegetation on the paleochannels are indicative of high permeable, porous, coarse grained materials possessing high infiltration rate. The SRTM data was orthorectified and geoprocessed for characterizing the low relief areas. This data was used to make the contour profile, slope profile and aspect profile of in and around Chandraketugarh for the detailed analysis of the area. The LANDSAT 7 data was also preprocessed properly and georeferenced for its correct orientation. This data set was used to make the different composite images like false colour image (432) (Fig. 2), natural color imagery (321) and 757, 453(Fig. 3), 543(Fig. 4) colour composite for analysis of the different tone and texture of the different geomorphological features of the area. The spatial and statistical analysis of the LANDSAT (90m resolution) and LISS III imagery was done using the ARCGIS 10 software and its packages. This region is full of human settlements and also it is very dynamic in nature. The composite images are also cross-referenced with the LISS-III imagery (higher resolution of 23.5m).

Also, the area was marked in Google Earth, and the paleochannels as well as the current Ichamati river were demarcated using the "Create Polygon" tool. These files were saved in the "Kml" format and then were imported into ArcGIS using the Conversion tool "KML to Layer". The paleochannels created from Google Earth were then correlated with the Digital Elevation Model (DEM) image.

4.2 Images Generated

4.2.1 Google Earth image

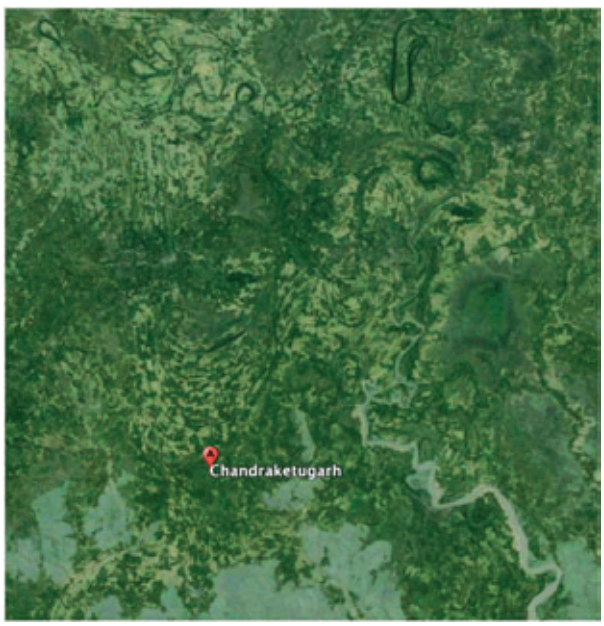

Figure 1 The Google earth image of the broader area around Chandraketugarh.

4.2.2 Band combinations

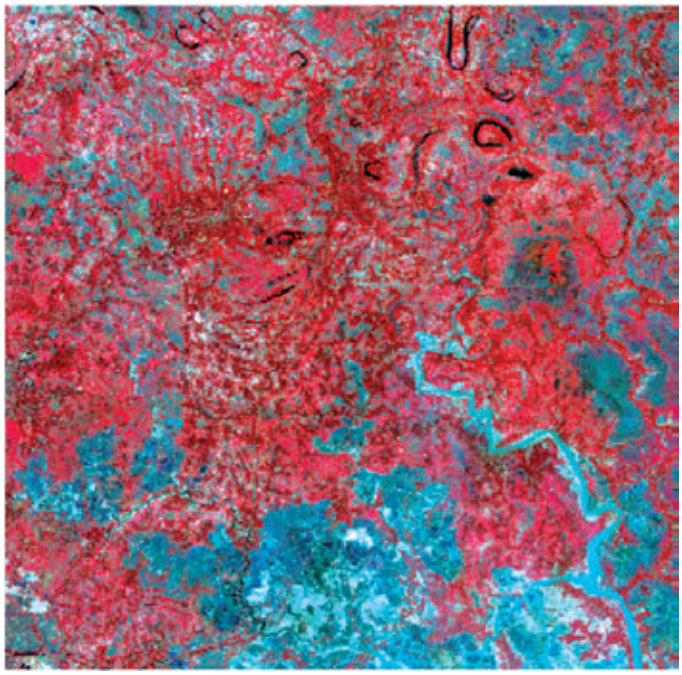

Figure 2 The composite image (432) of the study area.

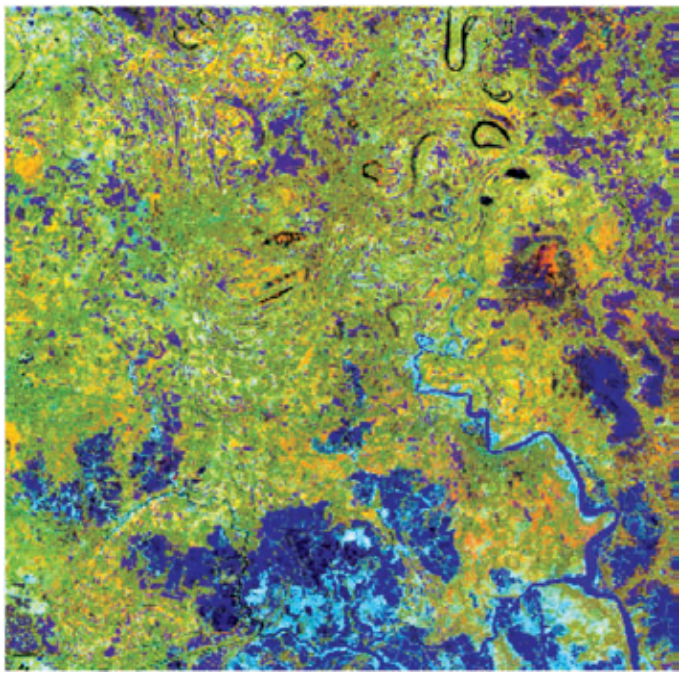

Figure 3 The composite image of combination of 453 bands.

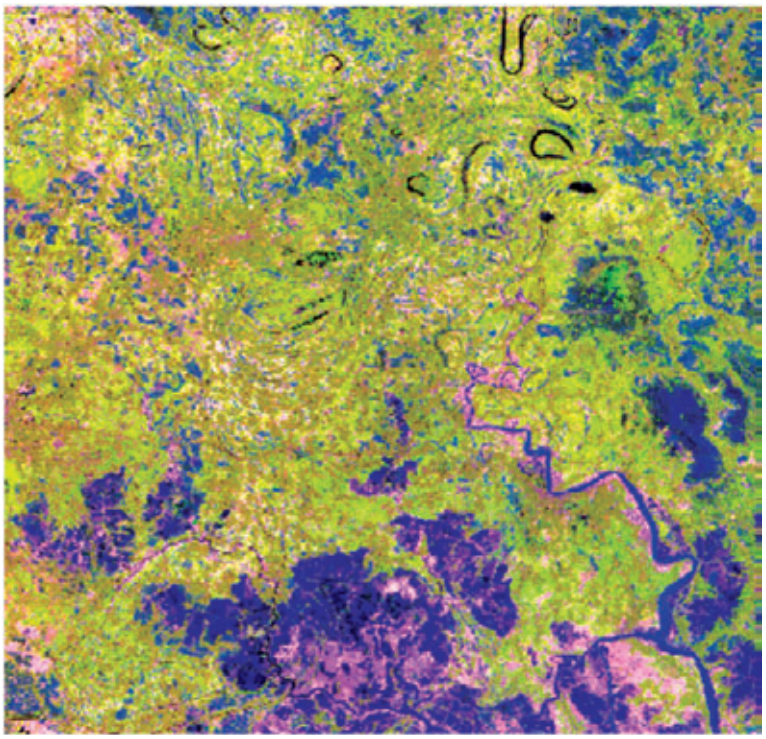

Figure 4 The composite image of combination of 543 bands.

4.2.3 Maximum Likelihood Classification

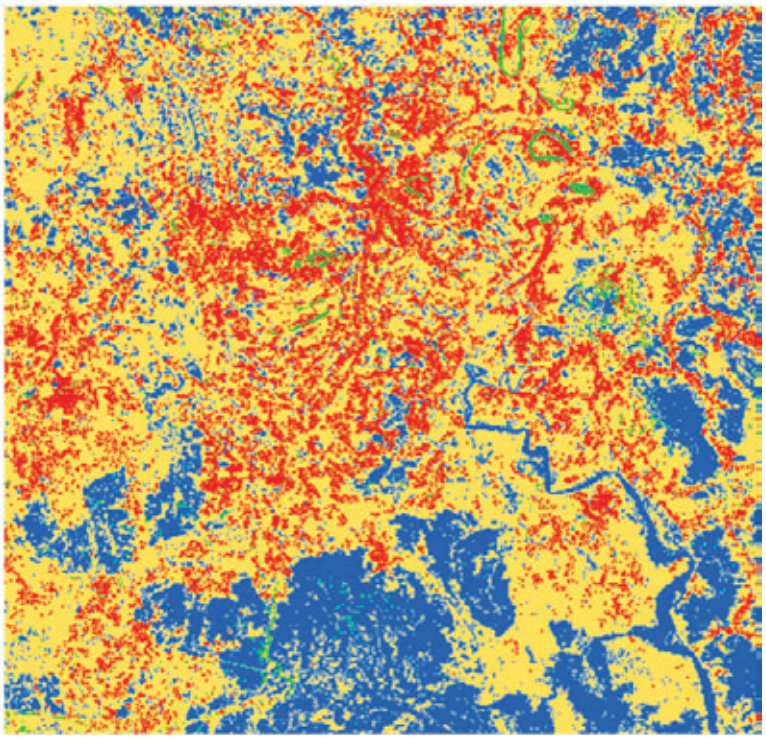

Figure 5 The classified image of land cover of the study area (Maximum Likelihood Classification)

4.2.4 Normalized difference water index (NDWI)

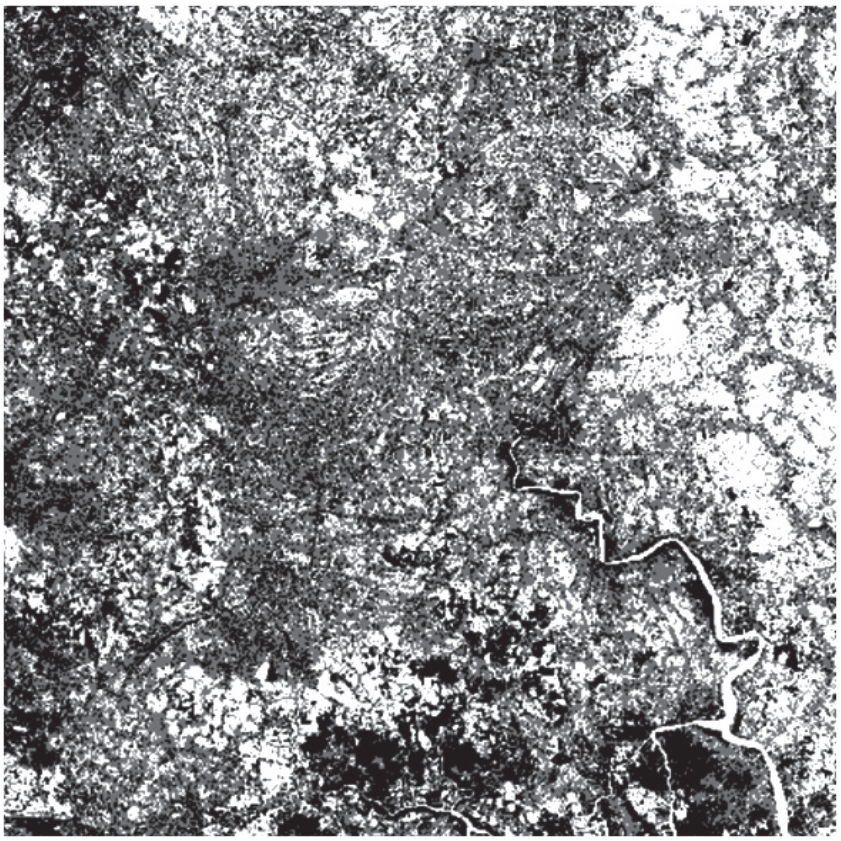

Figure 6 The NDWI (Normalized Difference Water Index) image of the area

Symbol	Range	Label
	-0.237209305 - 0.083799858	-0.237209305 - 0.083799858
	0.083799858 - 0.202230423	0.083799858 - 0.202230423
	0.202230423 - 0.557522118	0.202230423 - 0.557522118

Figure 7 Colour index of NDWI image

4.2.5 Paleochannels mapped in Google Earth

Figure 8 Paleochannels and Ichamati River mapped in Google Earth imagery

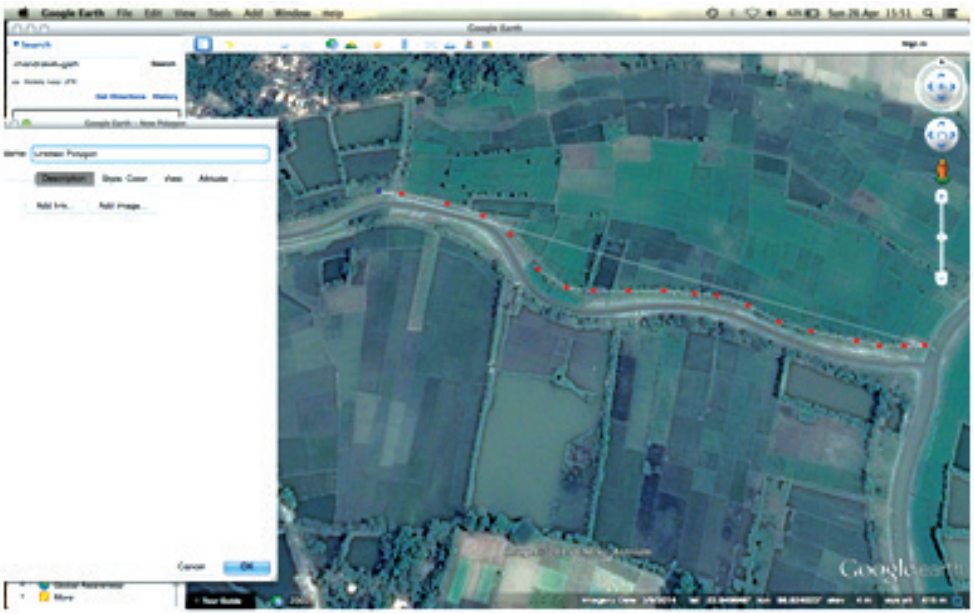

Figure 9 Create Polygon tool used for making the above image

4.2.6 Paleochannels imported in ArcGIS (onto DEM data)

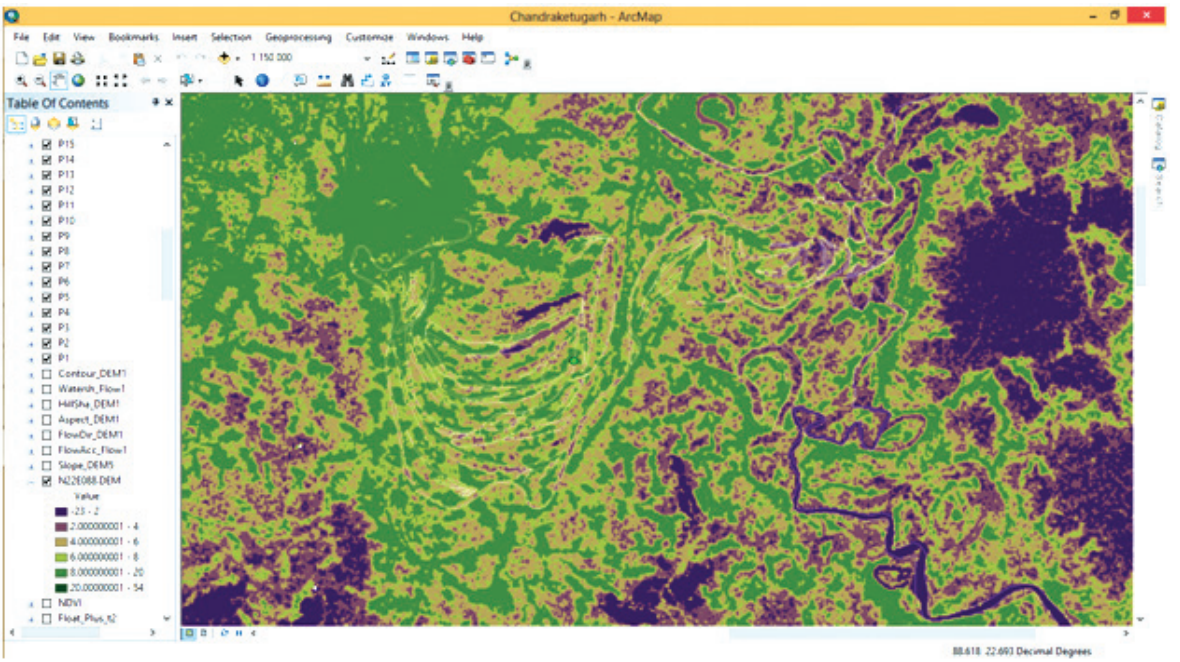

Figure 10 Paleochannels imported into ArcGIS onto the SRTM DEM data

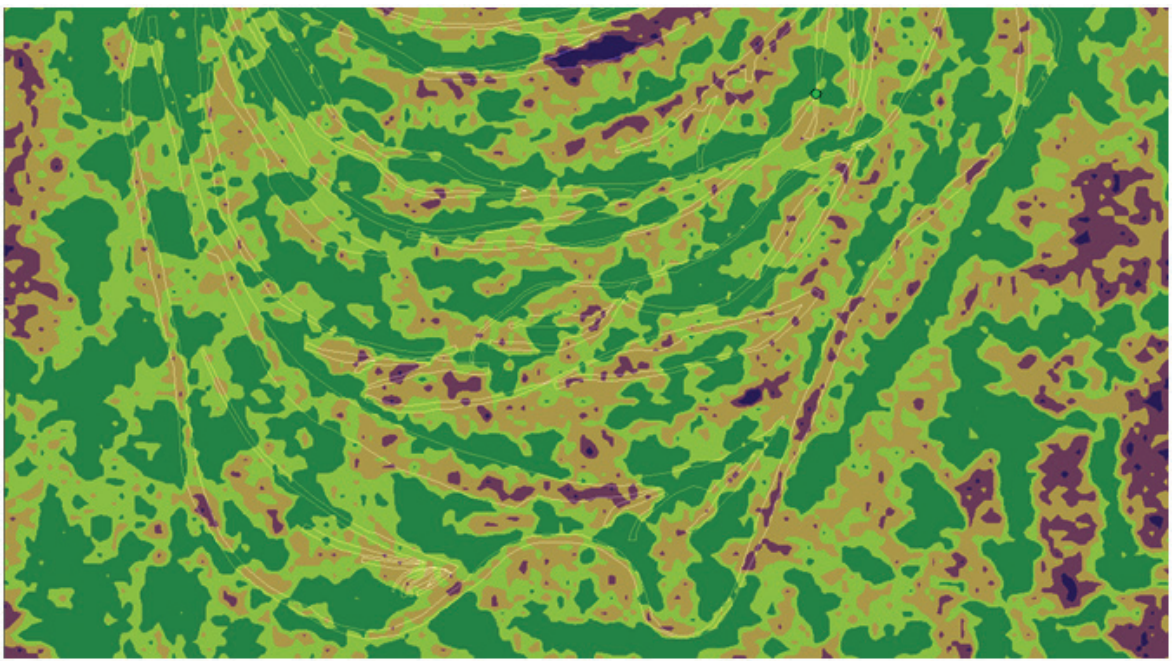

Figure 11 Magnified image of the paleochannels

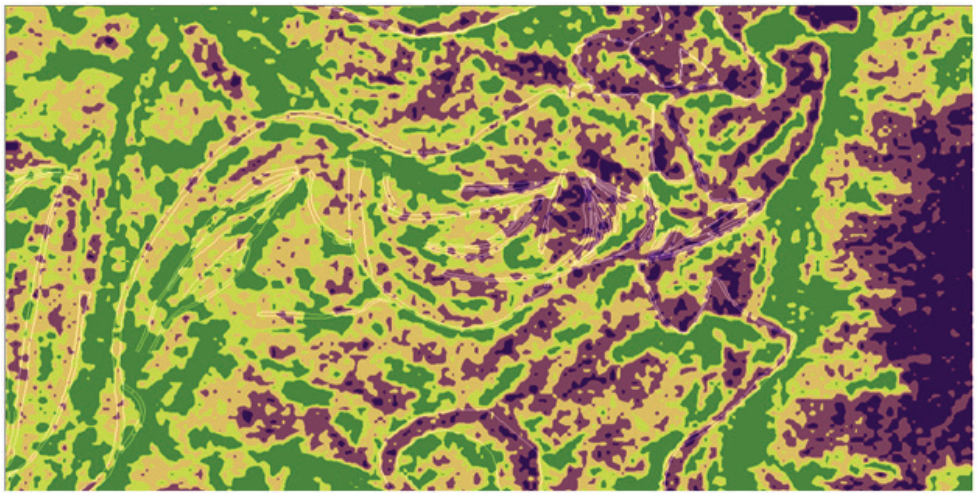

Figure 12 Magnified image of the paleochannels (cutting the Ichamati river)

Symbol	Range	Label
	-23-2	-23-2
	2-4	2.000000001-4
	4-6	4.000000001-6
	6-8	6.000000001-8
	8-20	8.000000001-20
	20-54	20.00000001-54

Figure 13 Colour index of the SRTM imagery

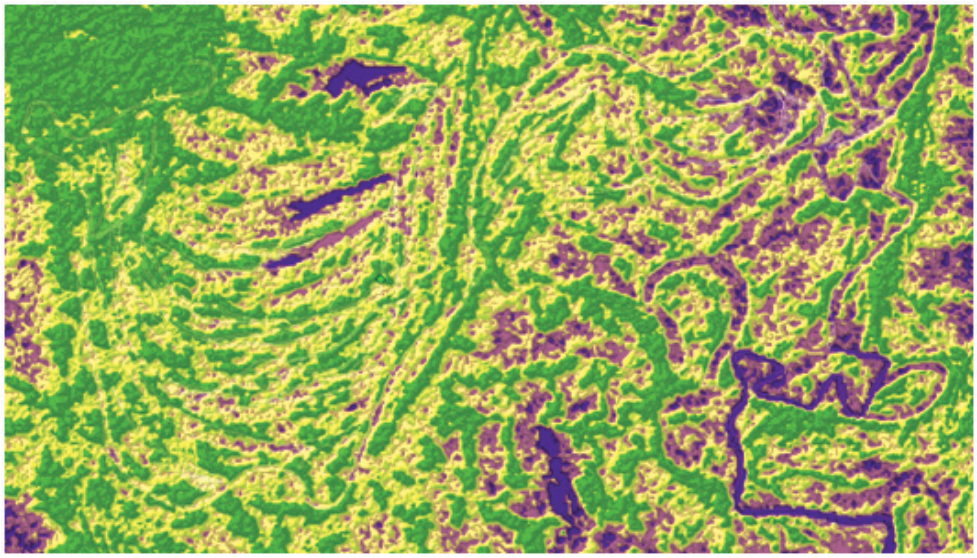

Figure 13 DEM image with hillshade effect

4.2.7 Slope

Figure 14 Slope of the area (which is very little in magnitude)

4.2.8 Aspect

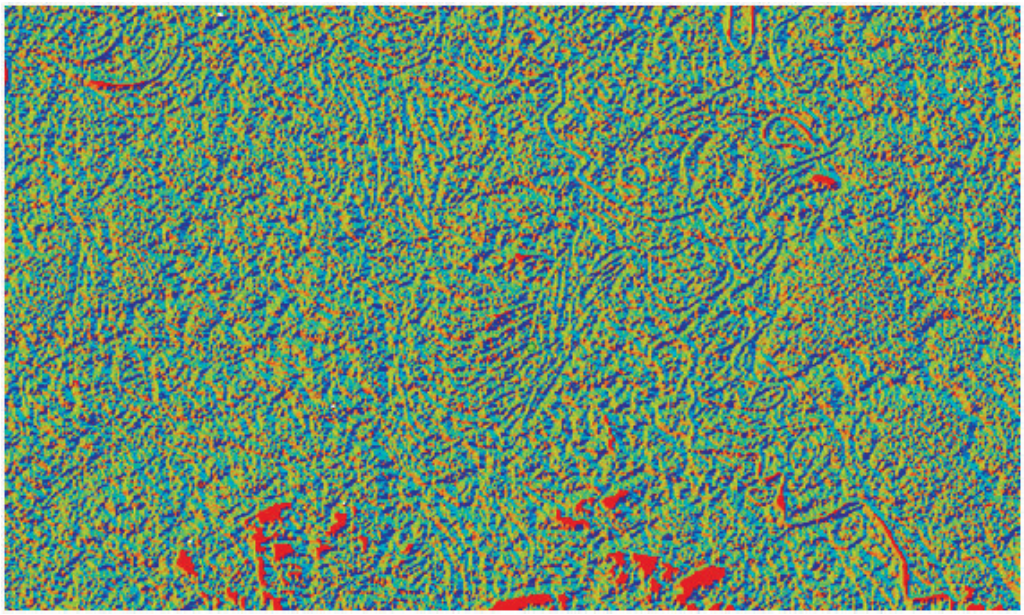

Figure 14 Aspect of the Chandraketugarh area

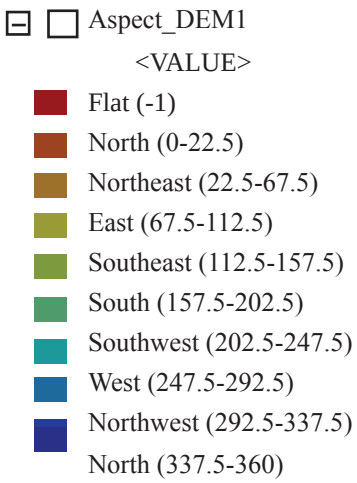

Figure 15 Colour index of the Aspect image

4.2.9 Watershed

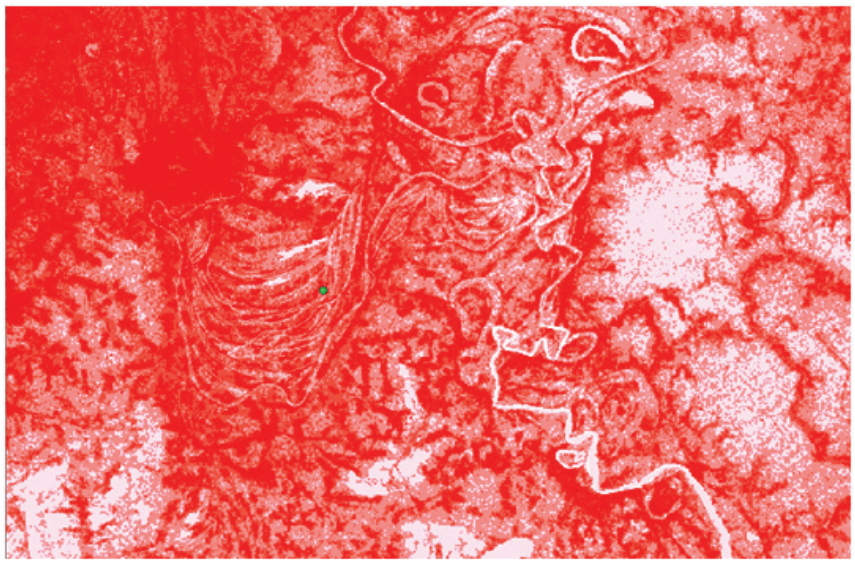

Figure 16 "Watershed" image of the Chandraketugarh area

Symbol	Range	Label
	-23-2	-23-2
	2-5	2.000000001-5
	5-8	5.000000001-8
	8-12	8.000000001-12
	12-54	12.000000001-54

Figure 17 Colour index of the Watershed image

Chapter - 5

Results and Discussion

5.1 Observations

There were several observations made while mapping the paleochannels:

1. It was observed that the paleochannels flow through the areas of low elevation, as is evident from the magnified images (Figures 11 and 12). The surrounding area of high elevation is the reason why the bottom-most paleofluvial channel meanders and changes its course.
2. The river pattern observed in the Chandraketugarh area is anastomosing in naure. This further supports the conclusion that there is low gradient in the area, which was deduced by creating the "Slope" image using ArcGIS functions (Figure 14).
3. Since Ichamati river is intermittent or seasonal in nature, it is possible that the paleofluvial channels were also seasonal in nature. This also explains the fact that the streams are discontinuous.
4. It cannot be said for sure through analysis of soil moisture content that some areas are paleofluvial channels. However, paleofluvial channels may be distinguished from paleo-floodplains – the former has silty sand and the latter has silt deposits. Also, in paleofluvial channels, there exist unconfined aquifers and in paleo-floodplains, there exist confined aquifers. Due to the presence of unconfined aquifers, the vegetation above paleofluvial channels is more exposed to groundwater.
5. The generations of the paleofluvial channels may also be determined using a simple concept – as rivers flow, they erode sediments on their outer side, and thus avulsion takes place in that direction. Thus, we can say that the paleochannels observed in Chandraketugarh are younger on the downward side.
6. Also, the paleochannel that connects to the present-day Ichamati river makes a large angle with the river. We can infer from this that this paleochannel is the oldest in the relative chronological order of paleochannels observed in that area. This concept is based on the fact that as the angle between paleochannels and present-day river becomes smaller, the paleochannels prove to be younger.

5.2 Future Perspective

The dynamicity of the river is such that it varies with the slope inversely, though the elevation of the study area is nowhere more than 10m and due to the enormous amount of sediment flux deposition the meandering pattern always vary accordingly. So there is a need to model the depositional pattern of the river systems to understand the paleo-river distribution pattern and therefore predict the same. The need of extensive borehole survey will also justify the above cause.

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