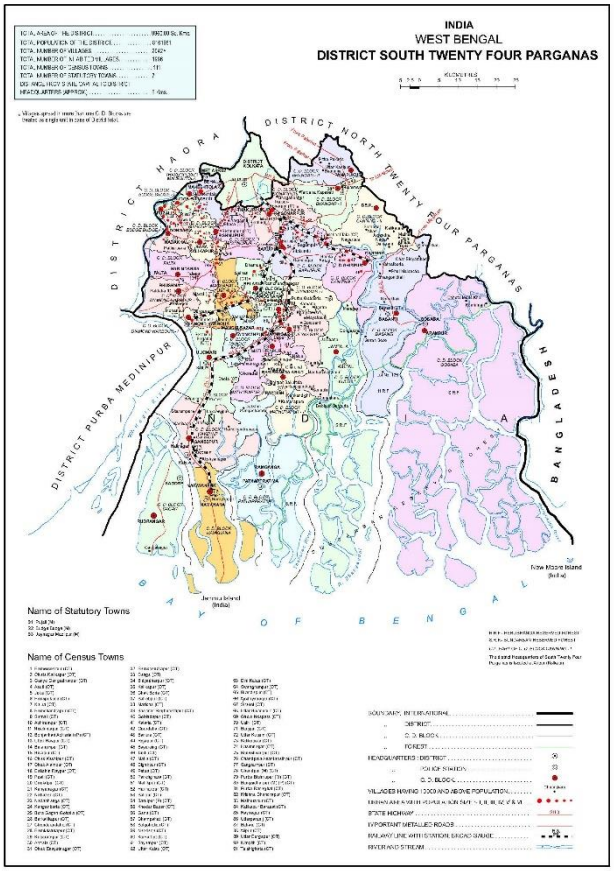
DISTRICT SURVEY REPORT

South 24-Parganas District

Prepared As Per Ministry of Environment, Forest And Climate Change Notification S. O. 3611 (E), Dated 25th July 2018



PREPARED BY:

Sathi Planners Private Limited

QCI-NABET Accredited And ISO 9001:2015 Certified Company
Address – Lake Avenue, Kanke Road, Ranchi - 834008, Jharkhand
Email – info@sathiplanners.com, Ph. – 7604035778
Website – www.sathiplanners.com

UNDER THE GUIDANCE OF:

West Bengal Mineral Development And Trading Corporation Limited
A Govt. of West Bengal Undertaking
Regd. Office: 13, Nellie Sengupta Sarani (Lindsay Street), 2nd Floor
Kolkata – 700 087, West Bengal

Content

PREAMBLE

Keeping in view of experience gained in period of one decade, the MOEF&CC came out with Environmental Impact Assessment Notification S.O.-1533(E) dated 14th Sept.2006. It has been made mandatory to obtain environmental clearance for different kinds of development projects as listed in Scheduled -1 of notification.

Further, pursuance of the order of Hon'ble Supreme Court Petition (C) No. 19628-19629 of 2009, dated 27th Feb.2012 In the matter of Deepak Kumar etc., Vs State of Haryana and others etc., prior environmental clearance has now become mandatory for Mining of Minor Minerals irrespective of the area of Mining Lease.

And also in view of the Hon'ble National Green Tribunal, order dated the 13th Jan.2015 the matter regarding Sand, Brick earth, & borrowed earth cutting for Road Construction has to take prior E.C. For Mining Lease irrespective of the fact that whether the area involved is more or less than 5 hectares. They also suggested to make a policy on E.C. for sand including other minor minerals mining lease in cluster.

MOEF & CC notification S.O.- 141 (E) dated 15 th January 2016, Under 7(iii)(a) it was also suggested to prepare the District survey report for sand mining or river bed mining and mining of other mineral as prescribed in appendix X. This has been modified vide S.O. No.- 3611(E) dated 25th July 2018.

MOEF&CC in consultation with State Government has prepared Guidelines on Sustainable Sand & other Minor minerals mining detailing the provisions on Environmental Clearance for cluster. To ease out E.C. activities MOEF & CC has taken initiative vide S.O.- 190(E) dated 20 th January 2016 to create District Environmental Impact Assessment Authority (DEIAA) & DEAC under the chairman ship of respective district commissioner for proper monitoring of Minor Minerals (0-5 Ha.) Mining using Information Technology to track the mineral out material from source to destination.

Appraisal Committee will scrutinize and recommend the prior environmental clearance of Mining of Minor Mineral on the basis of District Survey report. This will model and guiding document which is a compendium of available mineral resources, geographical setup, environmental and ecological set up of the district and replenishment of minerals and is based on data of various departments, published reports, Journal and websites. The District Survey report will form the basis for application for environmental clearance, preparation of reports and appraisal of projects. District Survey Reports are to be reviewed once in every five years as per statue, however the data bank of DSR can be updated, if required. This order took effect from 01-12-2017

The Main objective of the preparation of District Survey Report is to ensure the following:-

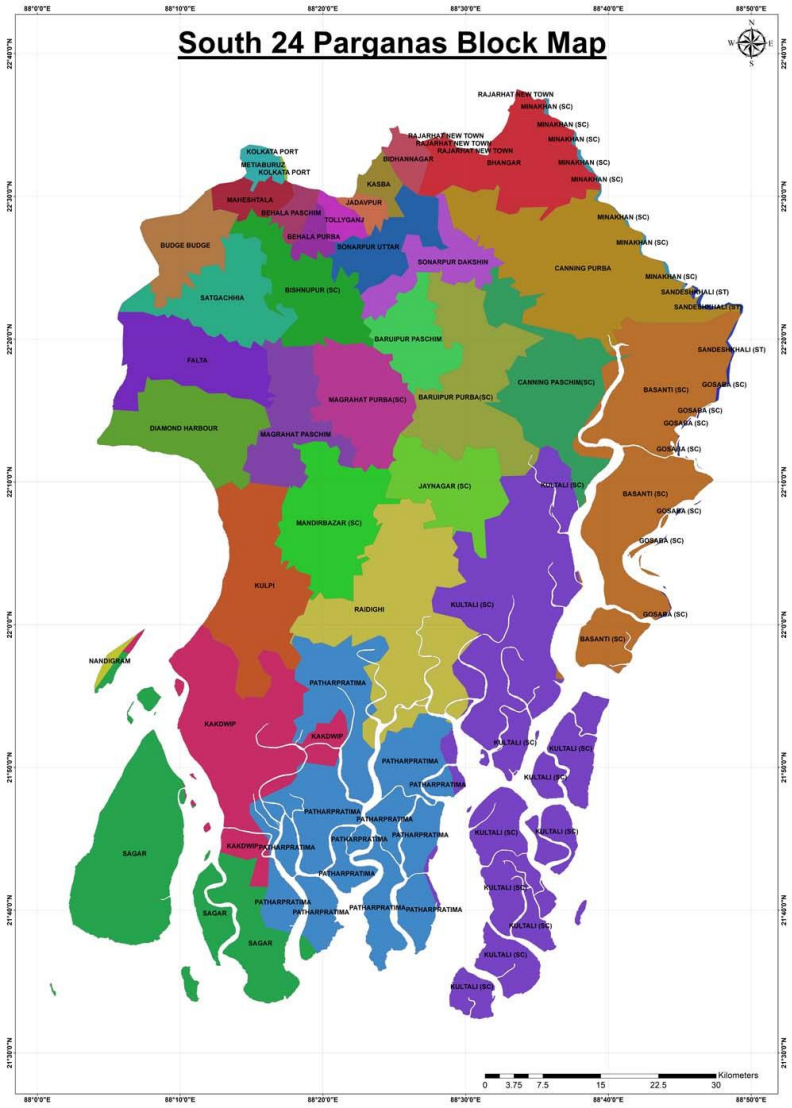
1. Identification of Sand Ghats with geo references.

2. Identification of river silt with geo reference, which is being used for filling purposes and brick manufacturing.

3. Identification of other mineral resources if available.

Chapter - 1 Introduction

❖ *District At A Glance:-*



Location and Geographical Area: The South 24 Parganas district is located between 22° 30′ 45″ to 20° 29′ North latitude and between 89° 4′ 56″ and 88° 3′ 45′′ East longitudes bounded by the river Hooghly in the West, Bay of Bengal in the South, Calcutta city and North 24 Parganas in the North & Eastern boundary is demarcated by Bangladesh and Bidya & Matla River. The district falls under Survey of India Topo Sheet No. 79B/2, 79B/3, 79B/4, 79B/5, 79B/6, 79B/10, 79B/11, 79B/12, 79B/15, 79B/16, 79C/1, 79C/2, 79C/5, 79C/6, 79C/9, and 79C/10. The district of South 24-Parganas has the unique salient features of proximity to the highly urbanized metropolis of Kolkata on the eastern sides as well as the virgin and beautiful natural environs of Sundarbans. It is one of the Southern-most districts of West Bengal and has significant position in the industrial arena of West Bengal.

The district can be categorized into three broad groups (i) The Marshy Riverine Land of Sunderban (ii) The Non-Sundarban Rural Areas and (iii) The Urban And Semiurban Areas.

As regard industrialization, the three noted area have contribution in the field of industrialization for the district. The vast rural area of Sundarban suffers from poor infrastructural and educational facilities which are great hurdles for industrialization. The whole area is prone to storms & cyclones during monsoon and agriculture is mostly monoculture. 89% people depend on agriculture. There is little impact by the presence of humble number of large, medium and some small scale industries in the Sundarban area. The urban and semi-urban areas viz. Thakurpukur, Mahestala, Bishnurpur, Sonarpur, Baruipur which are adjacent to Kolkata has locational advantage for industrialization.

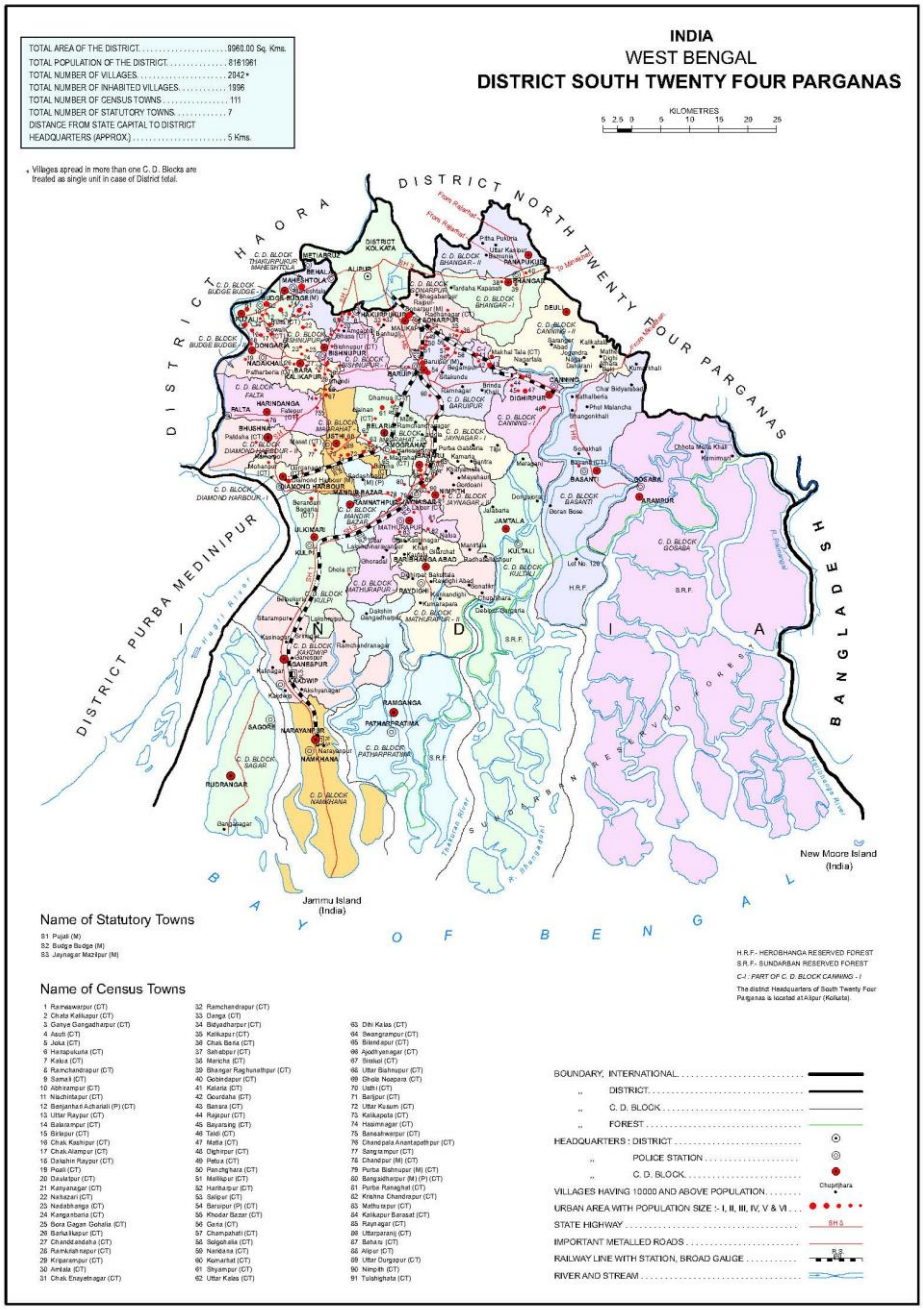
Administrative Units: The South 24-Parganas district got its reorganization as full-fledged district on 1st March, 1986. The present Head Quarters of the district is at Alipore. There are 29 Blocks, 31 Police Stations, 7 Municipalities and 5 Sub-Division.

Sl. No.	Name of the Sub-division	Blocks under Sub-Division	Municipalities under Sub- division
1	Alipore (Sadar)	Bishnupur-I, Bishnupur-II, Budge Budge-I, Budge Budge-II & T/ Maheshtala	Budge Budge, Pujali, Maheshtala
2	Baruipur	Baruipur, Bhagore-I, Bhagore-II, Joynagar-I, Joynagar-II, Kultali & Sonarpur.	Baruipur, Rajpur, Sonarpur, Joynagar, Majilpur
3	Diamond Harbour	D\Harbour-I, D\Harbour-II, Falta, Kulpi, Mograhat-I, Mograhat-II, Mandirbazar, Mathurapur-I & Mathurapur-II.	Diamond Harbour
4	Kakdwip	Kakdwip,Namkhana, Patharpratima & Sagar	
5	Canning	Basanti, Canning-I, Canning-II & Gosaba	

Figure 1: *Sub-divisions, Blocks And Municipalities In South 24 Parganas*

❖ *Connectivity facilities in South 24-Parganas District:-*

Indicative Location of Railway Stations In South 24 Parganas

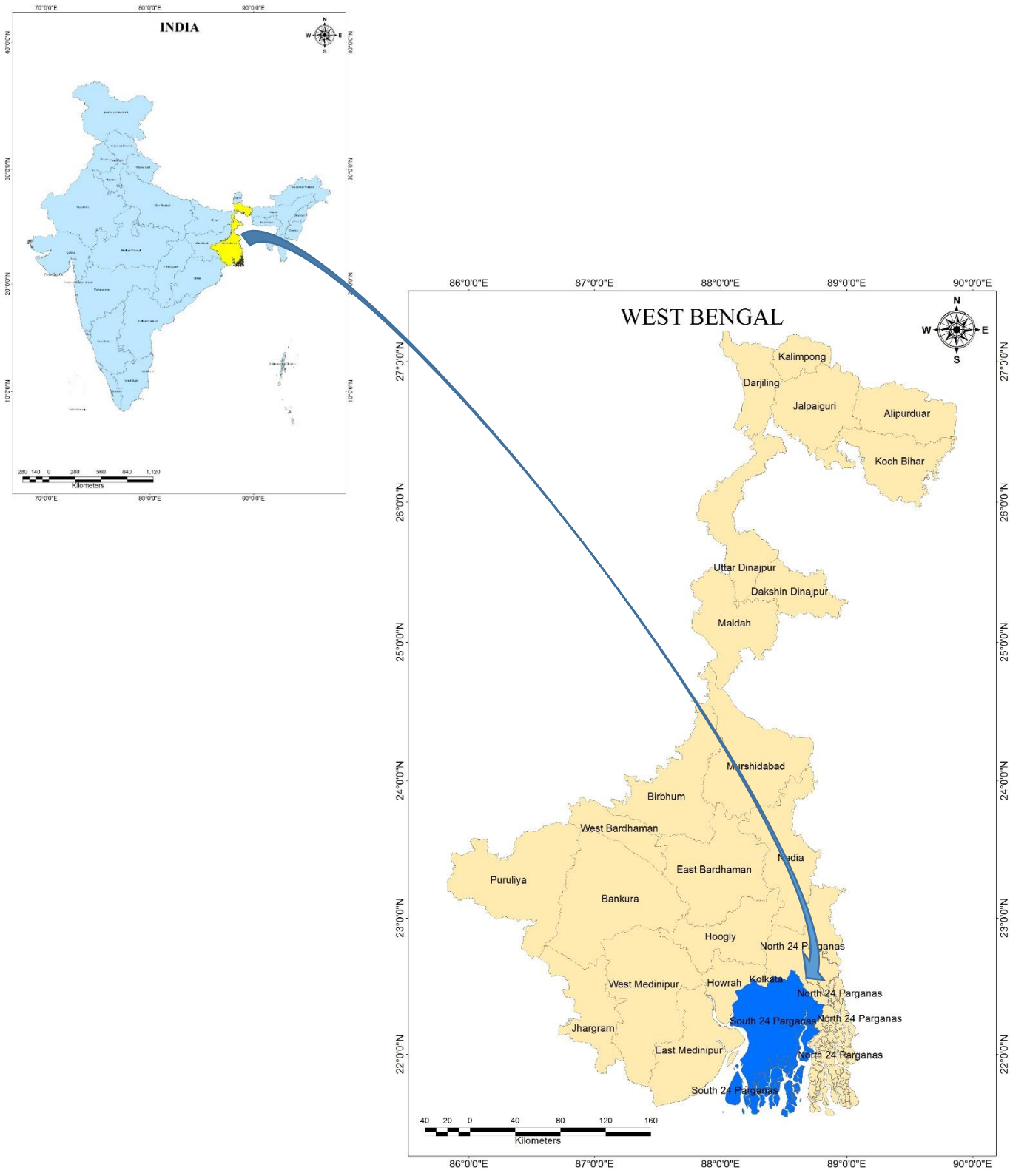


Representative Map of South 24 Parganas

Source: District Census Handbook, 2011, South 24 Parganas

The development of railways in South 24 Parganas has been limited in extension. Thus, a vast part of it is devoid of any rail service and therefore entirely dependent upon road transport. State Highway 1 passes through this district (SH1 from 91 Km to 151 Km) and ends at Kulpi. The district is served by four railway routes connecting different parts of the district with the nodal station at Sealdah of the Sealdah Subdivision of the Eastern Railways of India. These include the Sealdah-Budge Budge route, the Sealdah-Diamond Harbour route, the Seldah-Namkhana route and the Sealdah-Canning route. The Kolkata Metro or Calcutta Metro is a mass rapid transit system serving the city of Kolkata and the districts of South 24 Parganas. The district of is connected with railways and road ways with its surrounding areas. In the

blocks of Sunderbans boat and launch take an important role as a medium of transport. In South 24 Parganas there are a number of coastal blocks like Kakdwip, Namkhana, Patharpratima, Kultali, Gosaba and Basanti where waterways are extensively used in addition to use of waterways.



Location Map of South 24 Parganas District

Chapter - 2 Overview of Mining Activity in the District

❖ *Availability of Minerals:-*

Due to its varied geological structure, West Bengal is endowed with a wide variety of mineral resources. West Bengal falls into the North-Eastern Plateau region along with Jharkhand, Odisha and Chattisgarh.

The district of South 24-Parganas has the unique salient features of proximity to the highly urbanized metropolis of Kolkata on the eastern sides as well as the virgin and beautiful natural environs of Sundarbans. It is one of the Southern-most districts of West Bengal and has significant position in the industrial arena of West Bengal. The district can be categorized into three broad groups (i) the marshy riverine land of Sunderban (ii) The non-Sundarban rural areas and (iii) the Urban and Semi urban areas. As regard industrialization, the three noted area have contribution in the field of industrialization for the district. There is little impact by the presence of humble no. of large, medium and some small scale industries in the Sundarban area. The urban and semi-urban areas viz. Thakurpukur, Mahestala, Bishnurpur, Sonarpur, Baruipur which are adjacent to Kolkata has locational advantage for industrialization.

Sl. No.	Name of Mineral	PRODUCTION in tones 2010-2011
Major Mineral		
1	**NIL**	**-**
Minor Mineral		
1	**Brick Earth**	**1,32,44,001,06**

(Source: Brief Industrial Profile of SOUTH 24-PARGANAS DISTRICT, WEST BENGAL, MSME Development Institute, Govt. of India)

Apart from this, some smaller chunks of filler earth deposit has been identified, but due to it's area being very small and depth is too low, economic viability of these areas are not suitable for mineral concession.

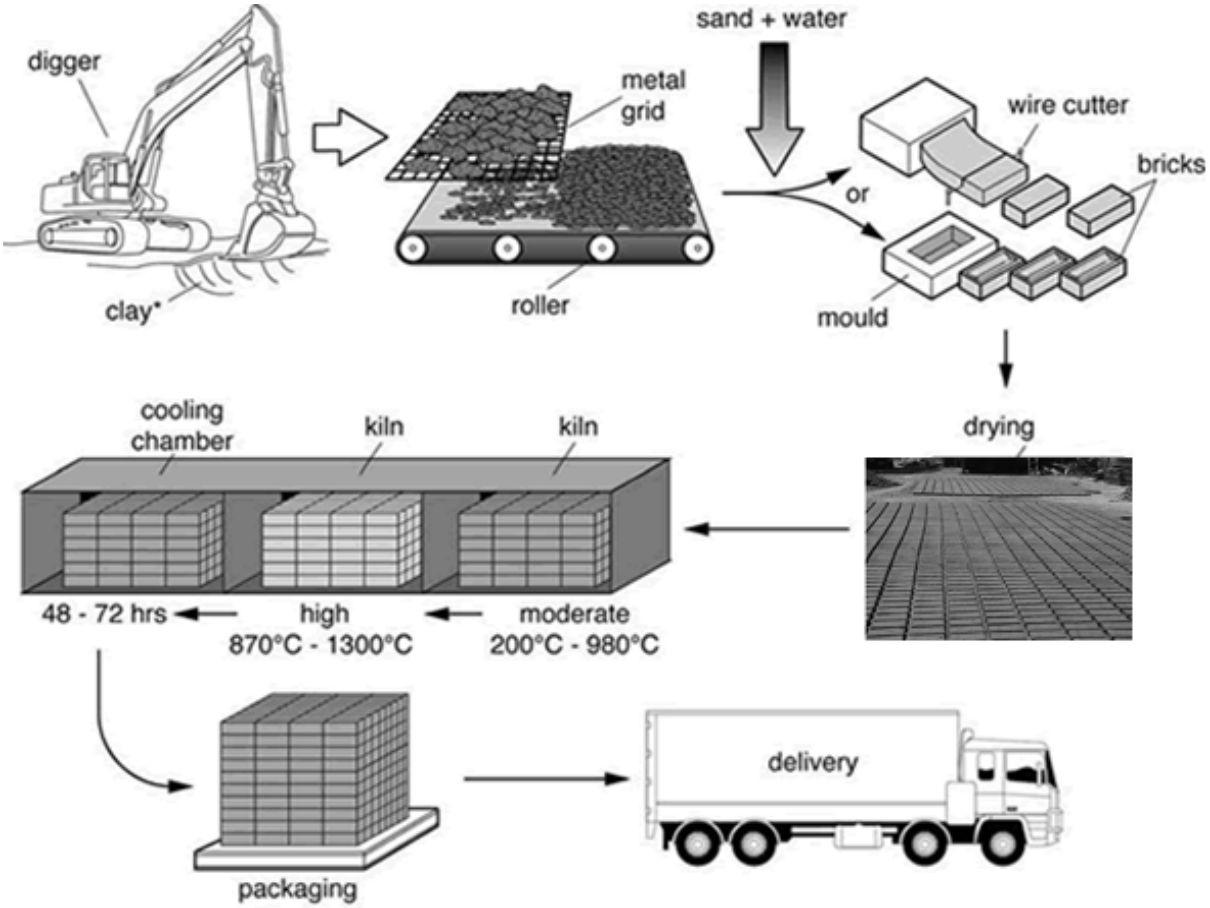
❖ *Silt Earth Brick:-*

Silt Earth Brick manufacturing process in West Bengal was started in way back 200 years ago during English regime. Presently more than 15000 such Brick Manufacturing units are operating in W.B. These units are producing approximately 1200 million Bricks per year which is 70% of the total requirement. Way back since 1936, mostly Silt collection ponds are recorded as 'IT-KHOLA" on ROR (Right of Record) i.e. in revenue record of W.B Govt. till date.

STEPS INVOLVED IN BRICK MANUFACTURING

Manufacturing of bricks consists of the following 4 operations or steps.

1. Preparation of brick clay or brick earth
2. Moulding of bricks
3. Air drying of bricks
4. Burning of bricks



❖ Silt Collection:-

West Bengal have long coastal line from Orissa to Bangladesh, where large number of small & big rivers ends in Bay of Bengal. Apart from about 50 to 60 small rivers from Bhutan enters in West Bengal and goes to Bangladesh. All such rivers also collect Silts while passing from West Bengal. During high tide, the height varies from 1.5 to 3 m (especially during PURNIMA & AAMAWASHYA) in sea (Bay of Bengal) twice in 24 hours the natural flow of river water get reverted back towards up stream side of the river due to high tide. During this period the river water height go up to 1.5 m to 3m from the normal water level of river having no turbulence. The muddy water of river enters in to the series of Silting ponds connecting each other which is at lower level of normal water level of the river through a water canal opening connecting the river & remain stagnant for 2 to 21/2hours, due to nil turbulence which allows the silt ('POLI MITTI"-Local term) to deposit in the silting ponds. During low tide period the water from the silting pond goes back to river natural flow. The complete one cycle takes 12 hrs & the same is repeated in remaining 12hrs of a day. The connecting river canal mouth closing operation starts in the ASTHAMI OR NOVMI TITHI of October every year because of low tide period & full closing completed by AMAWASHYA/PURANIMA, i.e. No Moon or Full Moon of same month to avoid entering of water during high tide period. In the same way the canal mouth is opened in the end of May every year in the similar dates (TITHI) because of start of monsoon season to get higher concentrate of silt from back flow of river.

Silt Rich Water Entering Silt-Tanks

Closing of Canal Mouth

Chapter - 3 List of Mining Lease in the District with location, area and period of validity

Chapter - 4 Detail of Royalty or Revenue Received in last three years

Sl. No	Year	Royalty (Amount in Lakhs)
1		
2		
3		

Chapter - 5 Details of Production of Sand Or Bajri or Minor Mineral In Last Three Years

Sl. No.	Year	Production (in Million Tonne)
1		
2		
3		

Chapter - 6 Process of Deposition of Sediments In The Rivers of The District

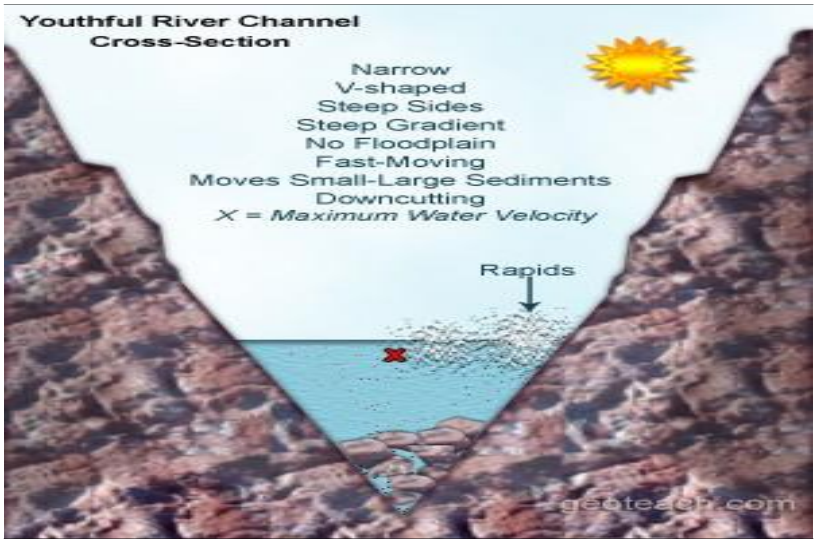
❖ *Classifying Rivers - Three Stages of River Development*

These categories are: Youthful, Mature and Old age. A Rejuvenated River, one with a gradient that is raised by the earth's movement, can be an old age river that returns to a Youthful State, and which repeats the cycle of stages once again.

Characteristics found in the 3 Stages of River Development:

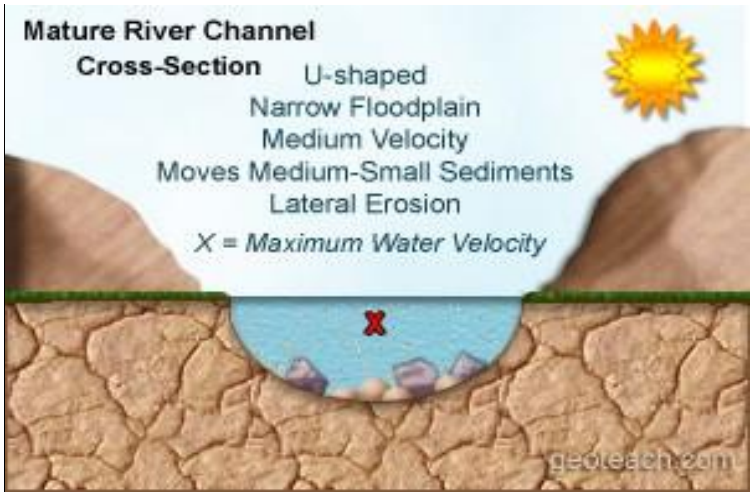
YOUTHFUL RIVER-

Perhaps the most dynamic of all rivers is a *Youthful River*. Characteristically youthful rivers are found at higher elevations, in mountainous areas, where the slope of the land is steeper. Water that flows over such a landscape will flow very fast. Youthful rivers can be a tributary of a larger and older river, hundreds of miles away and, in fact, they may be close to the headwaters (the beginning) of that larger river.



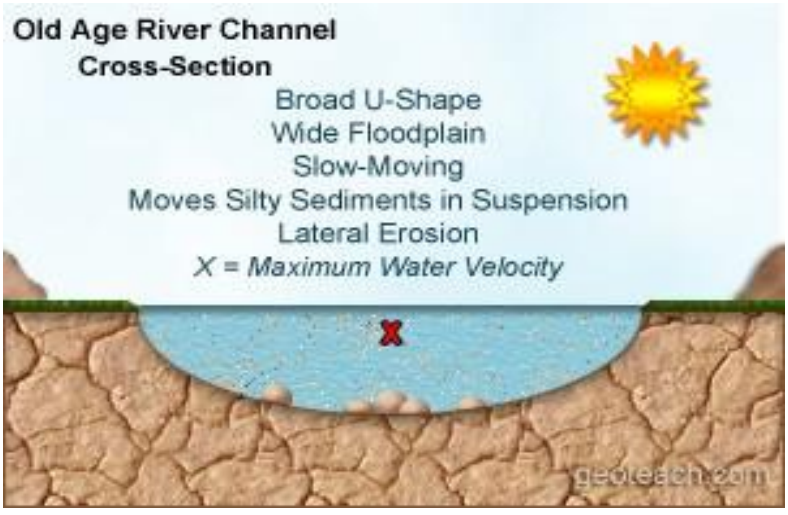
MATURE RIVER:-

The Mature River is an in-between stage. The river still down cuts though to a much lesser degree than the Youthful River does but it also erodes laterally, though not as extensively, when compared to the Old Age River. The landscape over which it passes is steep enough that the river's slope enables a velocity capable of moving not only the finer sediments, but also the larger pebbles and cobbles by way of rolling, bouncing and saltation along the river bed. The area through which the river flows may be mountainous but they will not be as high as the Young River's locale. A "hilly" landscape would be a better description for the surrounding area. Rapids are absent and so is the V-shaped channel. The channel of a Mature River is U-shaped but deeper than and not as wide as the Old Age river's channel.



OLD AGE RIVER:-

Old rivers flow slowest and their rate of erosion is encounter acted by the degree of sediment they deposit. Their course is no longer straight and widened floodplains are a common characteristic. An old river rests in an almost flat valley as a result of the many years of erosion that have taken place.



❖ *STREAM EROSION AND DEPOSITION:-*

Flowing water is a very important mechanism for both erosion and deposition. Water flow in a stream is primarily related to the stream's gradient, but it is also controlled by the geometry of the stream channel. As shown in Figure 2, water flow velocity is decreased by friction along the stream bed, so it is slowest at the bottom and edges and fastest near the surface and in the middle. In fact, the velocity just below the surface is typically a little higher than right at the surface because of friction between the water and the air. On a curved section of a stream, flow is fastest on the outside and slowest on the inside.

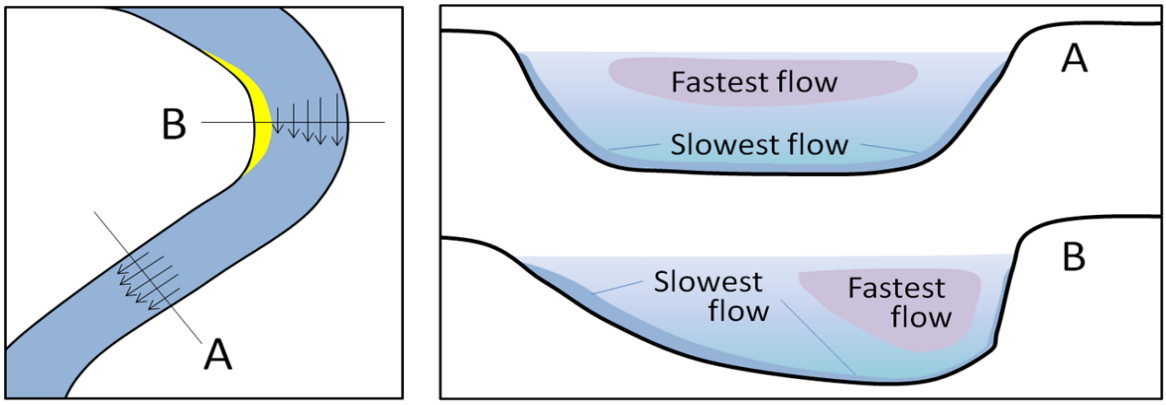


Figure 2: *The relative velocity of stream flow depending on whether the stream channel is straight or curved (left), and with respect to the water depth (right).*

Other factors that affect stream-water velocity are the size of sediments on the stream bed — because large particles tend to slow the flow more than small ones — and the discharge or volume of water passing a point in a unit of time (e.g., m^3/second). During a flood, the water level always rises, so there is more cross-sectional area for the water to flow in; however, as long as a river remains confined to its channel, the velocity of the water flow also increases.

Figure 3 shows the nature of sediment transportation in a stream. Large particles rest on the bottom — bedload — and may only be moved during rapid flows under flood conditions. They can be moved by saltation (bouncing) and by traction (being pushed along by the force of the flow).

Smaller particles may rest on the bottom some of the time, where they can be moved by saltation and traction, but they can also be held in suspension in the flowing water, especially at higher velocities. As you know from intuition and from experience, streams that flow fast tend to be turbulent (flow paths are chaotic and the water surface appears rough) and the water may be muddy, while those that flow more slowly tend to have laminar flow (straight-line flow and a smooth water surface) and clear water. Turbulent flow is more effective than laminar flow at keeping sediments in suspension.

Stream water also has a dissolved load, which represents (on average) about 15% of the mass of material transported, and includes ions such as calcium (Ca+2) and chloride (Cl-) in solution. The solubility of these ions is not affected by flow velocity.

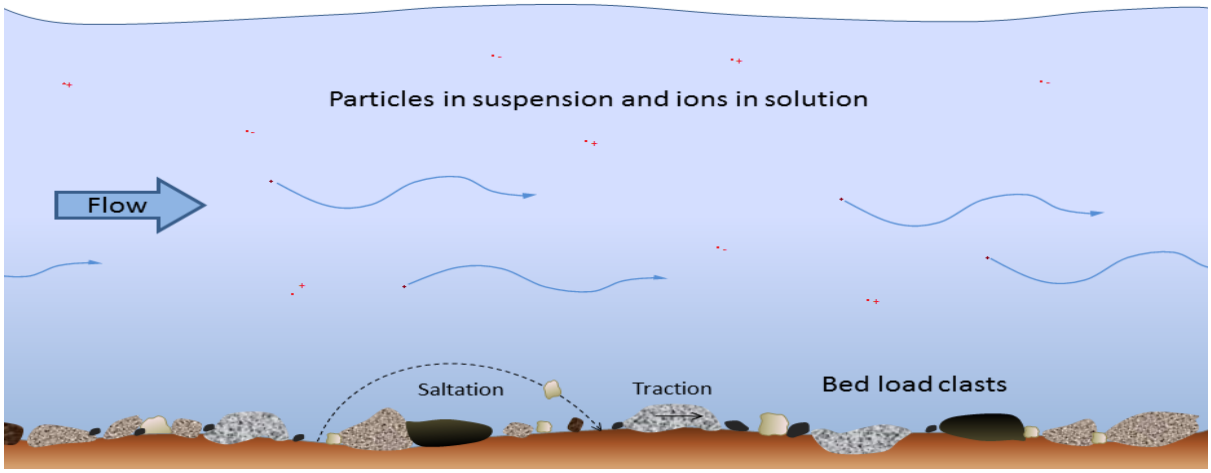


Figure 3: *Modes of transportation of sediments and dissolved ions (represented by red dots with + and – signs) in a stream. [SE]*

The faster the water is flowing, the larger the particles that can be kept in suspension and transported within the flowing water. However, as Swedish geographer Filip Hjulström discovered in the 1940s, the relationship between grain size and the likelihood of a grain being eroded, transported, or deposited is not as simple as one might imagine. Consider, for example, a 1 mm grain of sand. If it is resting on the bottom, it will remain there until the velocity is high enough to erode it, around 20 cm/s. But once it is in suspension, that same 1 mm particle will remain in suspension as long as the velocity doesn't drop below 10 cm/s. For a 10 mm gravel grain, the velocity is 105 cm/s to be eroded from the bed but only 80 cm/s to remain in suspension.

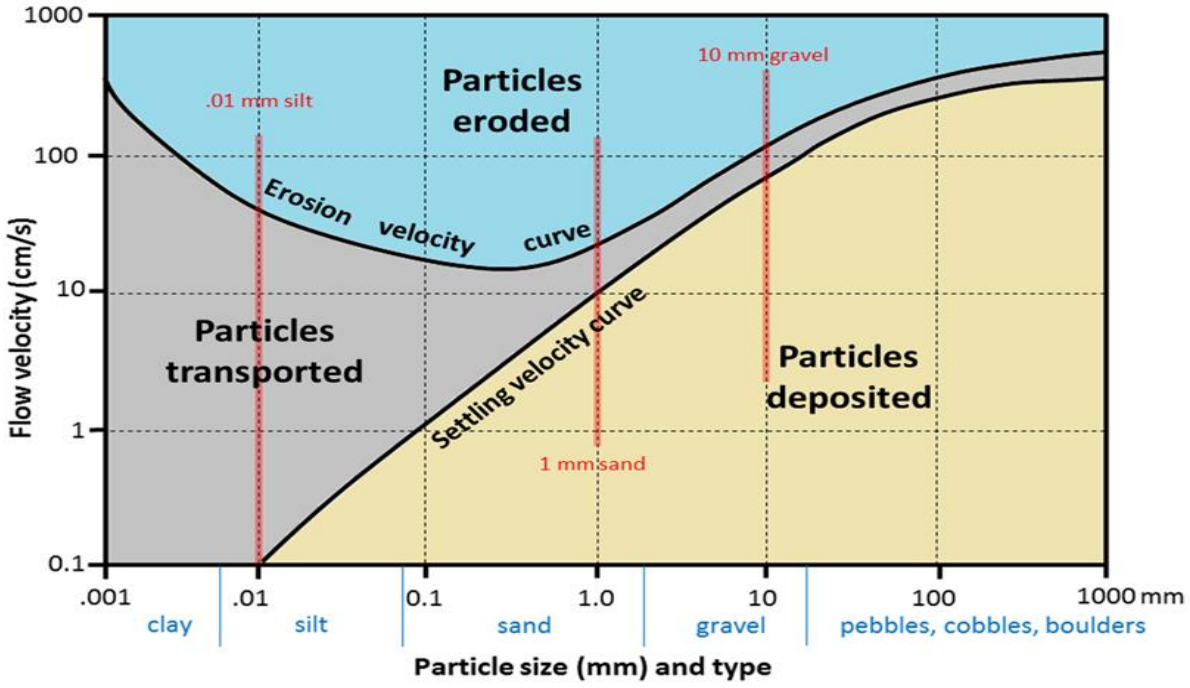


Figure 4: *The Hjulström-Sundborg diagram showing the relationships between particle size and the tendency to be eroded, transported, or deposited at different current velocities*

On the other hand, a 0.01 mm silt particle only needs a velocity of 0.1 cm/s to remain in suspension, but requires 60 cm/s to be eroded. In other words, a tiny silt grain requires a

greater velocity to be eroded than a grain of sand that is 100 times larger! For clay-sized particles, the discrepancy is even greater. In a stream, the most easily eroded particles are small sand grains between 0.2 mm. and 0.5 mm. Anything smaller or larger requires a higher water velocity to be eroded and entrained in the flow. The main reason for this is that small particles, and especially the tiny grains of clay, have a strong tendency to stick together, and so are difficult to erode from the stream bed.

It is important to be aware that a stream can both erode and deposit sediments at the same time. At 100 cm/s, for example, silt, sand, and medium gravel will be eroded from the stream bed and transported in suspension, coarse gravel will be held in suspension, pebbles will be both transported and deposited, and cobbles and boulders will remain stationary on the stream bed.

A stream typically reaches its greatest velocity when it is close to flooding over its banks. This is known as the bank-full stage, as shown in Figure 5. As soon as the flooding stream overtops its banks and occupies the wide area of its flood plain, the water has a much larger area to flow through and the velocity drops significantly. At this point, sediment that was being carried by the high-velocity water is deposited near the edge of the channel, forming a natural bank or **levée.**

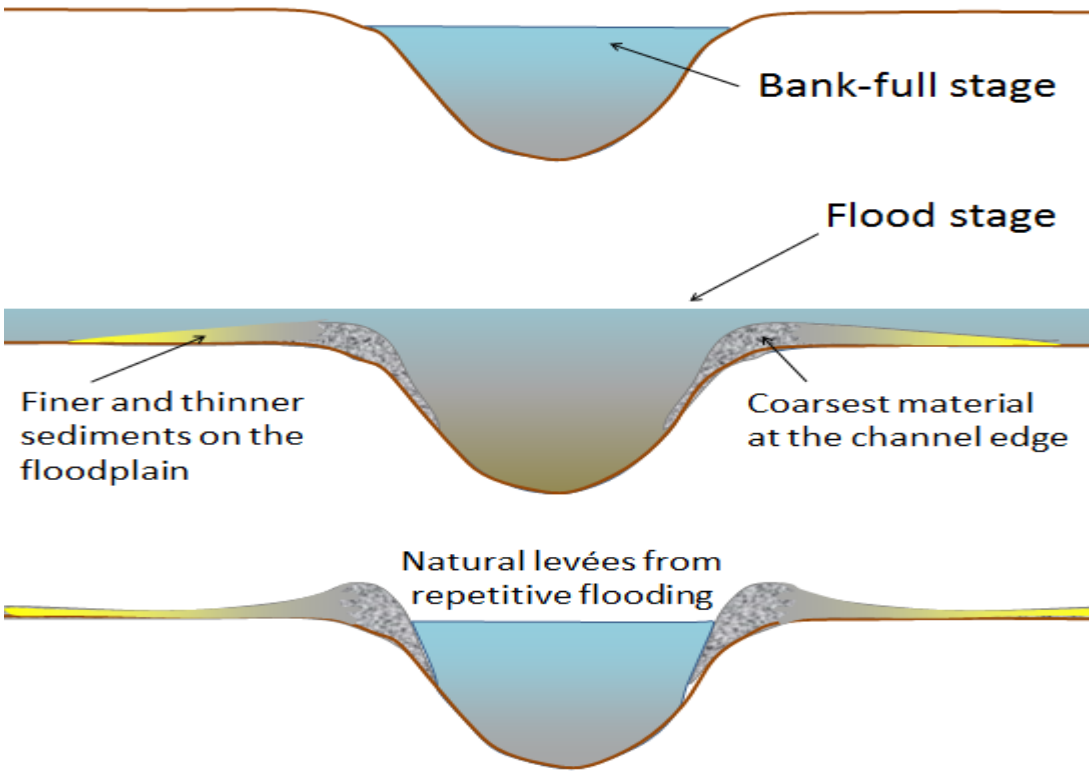
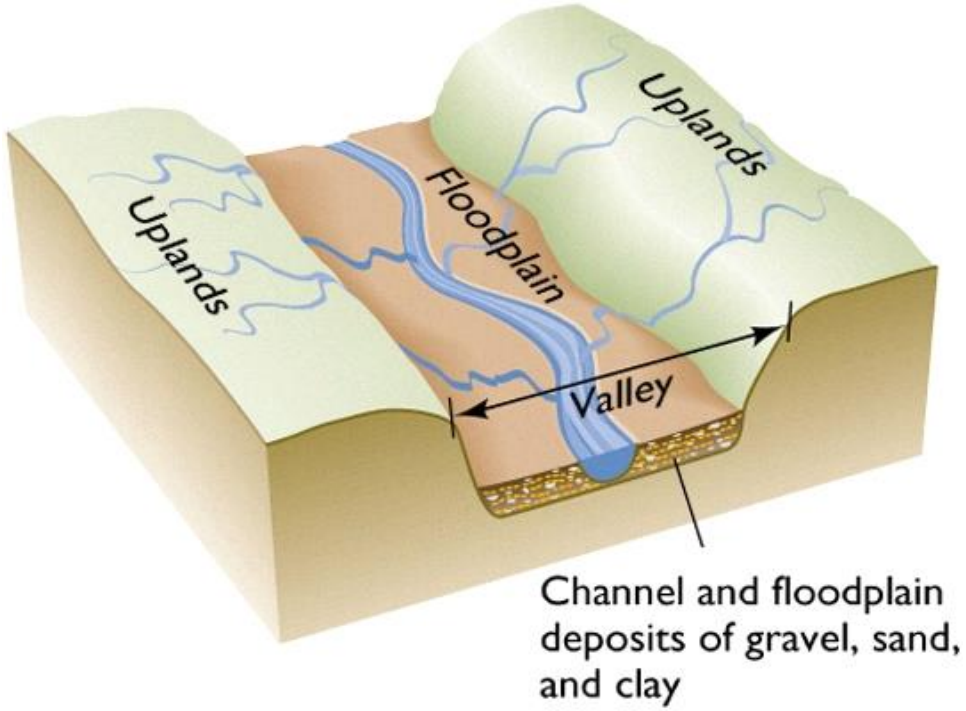


Figure 5: *The development of natural levées during flooding of a stream. The sediments of the levée become increasingly fine away from the stream channel, and even finer sediments — clay, silt, and fine sand — are deposited across most of the flood plain. [SE]*

❖ *Flood Plain:-*

Flood-plain is an area of land adjacent to a stream or river which stretches from the banks of its channel to the base of the enclosing valley walls, and which experiences flooding during periods of high discharge. The soils usually consist of clays, silts, and sands deposited during floods.

Floodplains are formed when a meander erodes sideways as it travels downstream. When a river breaks its banks, it leaves behind layers of alluvium (silt). These gradually build up to create the floor of the plain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream. These are accumulations of sand, gravel, loam, silt, and/or clay, and are often important aquifers, the water drawn from them being pre-filtered compared to the water in the river.



❖ Replenishment of Sand :-

The deposition in a river bed is more pronounced during rainy season although the quantum of deposition varies from stream to stream depending upon numbers of factors such as catchment, lithology, discharge, river profile and geomorphology of the river course where annual deposition is one meters, but it is noticed that during flood season whole of the pit so excavated is completely filled up and as such the excavated area is replenished with new harvest of minerals.

In order to calculate the mineral deposits in the stream beds, the mineral constituents have been categorized as clay, silt, sand, bajri and boulder. However during present calculation, the waste material i.e. silt which vary from 10 to 20% in different streams has also been included in the total production. Further the Survey of India Topo-Sheets are used as base map to know the extent of river course. The mineral reserves have been calculated only upto 1.00 meter depth although there are some portions in the river beds such as channel bars, point bars and central islands where the annual deposition is raising the level of river bed

thus causing shifting of the rivers towards banks resulting in to cutting of banks and at such locations, removal of this material upto the bed level is essential to control the river flow in its central part to check the bank cutting. While calculating the mineral potentials, the mineral deposits lying in the sub- tributaries of that particular stream/river has not been taken into consideration. Since these mineral deposits are adding annually.

❖ *Surface Runoff*

Also known as overland flow is the flow that occurs when excess storm water, melt water, or other sources flows over the Earth's surface. This might occur because soil is saturated to full capacity, because rain arrives more quickly than soil can absorb it, or because impervious areas (roofs and pavement) send their runoff to surrounding soil that cannot absorb all of it. Surface runoff is a major component of the water cycle. It is the primary agent in soil erosion by water.

Runoff that occurs on the ground surface before reaching a channel is also called a nonpoint source. If a nonpoint source contains man-made contaminants, or natural forms of pollution (such as rotting leaves) the runoff is called nonpoint source pollution. A land area which produces runoff that drains to a common point is called a drainage basin. When runoff flows along the ground, it can pick up soil contaminants including petroleum, pesticides, or fertilizers that become discharge or nonpoint source pollution.

In addition to causing water erosion and pollution, surface runoff in urban areas is a primary cause of urban flooding which can result in property damage, damp and mold in basements, and street flooding.

❖ *Effects of Surface Runoff:-*

Erosion and deposition

Surface runoff can cause erosion of the Earth's surface; eroded material may be deposited a considerable distance away.

There are four main types of soil erosion by water:

- Splash Erosion,
- Sheet Erosion,
- Rill Erosion,
- Gully Erosion.

Splash erosion is the result of mechanical collision of raindrops with the soil surface: soil particles which are dislodged by the impact then move with the surface runoff.

Sheet erosion is the overland transport of sediment by runoff without a well-defined channel.

Soil surface roughness causes may cause runoff to become concentrated into narrower flow paths: as these incise, the small but well-defined channels which are formed are known as **rills.** These channels can be as small as one centimeter wide or as large as several meters.

If runoff continue to incise and enlarge rills, they may eventually grow to become **gullies.**

Figure 6: Soil erosion by water on intensively-tilled farmland.

Gully erosion can transport large amounts of eroded material in a small time period.

Reduced crop productivity usually results from erosion, and these effects are studied in the field of soil conservation. The soil particles carried in runoff vary in size from about .001 millimeter to 1.0 millimeter in diameter. Larger particles settle over short transport distances, whereas small particles can be carried over long distances suspended in the water column.

There are many sediment transport equations which are suitable for use in the prediction of the replenishment rate of rivers/ watershed. Some of the Famous sediment transport equations are: -

1. **Dandy – Bolton Equation**
2. Yang Equations
3. Engelund-Hansen Equation
4. Modified Universal Soil Loss Equation (MUSLE)

❖ *DANDY - BOLTON EQUATION*

Dandy Bolton formula is often used to calculate the sedimentation yield. But use of these equations to predict sediment yield for a specific location would be unwise because of the wide variability caused by local factors not considered in the equations development. However, they may provide a quick, rough approximation of mean sediment yields on a regional basis for preliminary watershed planning. Computed sediment yields normally would be low for highly erosive areas and high for well stabilized drainage basins with high plant density because the equations are derived from average values. The equations express the general relationships between sediment yield, runoff, and drainage area. Many variables influence sediment yield from a drainage basin. They include climate, drainage area, soils, geology, topography, vegetation and land use. The effect of any of these variables may vary greatly from one geographic location to another, and the relative importance of controlling factors often varies within a given land resource area. Studies revealed that sediment yield per unit area generally decreases as drainage area increases. As drainage area increases, average land slopes usually decrease; and

there is less probability of an intense rainstorm over the entire basin. Both phenomena tend to decrease sediment yield per unit area. In arid regions, sparse precipitation and low run-off are the limiting factors. As_precipitation increases, density of vegetation also increases, resulting in less erosion. In areas with adequate and evenly distributed precipitation, vegetation thus becomes the limiting factor. The accuracy of the sedimentation surveys varied, ranging from reconnaissance type measurements of sediment deposits to detailed surveys consisting of closely spaced cross-sections or contours. Runoff data are translated to inches per year per unit area and sediment deposition data to tons per year per square mile of net drainage area. Net drainage area is defined as the sediment-contributing area and normally excluded areas above upstream reservoirs or other structures that were effective sediment traps. Actual sediment yields undoubtedly were slightly higher because most reservoirs do not trap inflowing sediment. Sediment Yield vs. Drainage Area: - On the average, sediment yield is inversely proportional to the 0.16 power of drainage area between 1 and 30,000 square miles. Sediment Yield vs. Runoff: - Sediment yield increased sharply to about 1,860 tons per square mile per year as run-off increased from 0 to about 2 inches. As runoff increased from 2 to about 50 inches, sediment yield decreased exponentially. Because sediment yield must approach zero as runoff approaches zero, a curve through the plotted points must begin at the origin. The abrupt change in slope of a curve through the data points at Q equals 2 inches

Precluded the development of a continuous function that would adequately define this relationship. Thus, there are two equations derived for when Q was less than 2 inches and when Q was greater than 2 inches.

❖ *Combined Effect of Drainage area and Surface Run off on Sediment Yield*

Dandy- Bolton determined the combined influence of runoff and drainage area on sediment yield to compute the sediment yield. They developed two equations i.e. for run off less than 2 inch and for run off more than 2 inch, which are given below:-
Where: S = Sediment yield (tons/sq miles/yr)
Q = Mean Annual runoff (inch)
A = Net drainage are in sq mile

For run off less than 2 inch.

(Q<2in) S=1289*(Q) 0.46*[1.43-0.26 Log (A)] F

For run off more than 2 inches.

(Q > 2 in): S= 1958*(e -0.055*Q)*[1.43-0.26 Log (A)]

❖ *UNIVERSAL SOIL LOSS EQUATION*

Sediment loss from water erosion

Modeling sediment loss

MUSLE is a modification of the Universal Soil Loss Equation (USLE). USLE is an estimate of sheet and rill soil movement down a uniform slope using rain- fall energy as the erosive force acting on the soil
(Wischmeier and Smith 1978). Depending on soil characteristics (texture, structure, organic matter, and permeability), some soils erode easily while others are inherently more resistant to the erosive action of rain- fall.
MUSLE is similar to USLE except for the energy component. USLE depends strictly upon

rainfall as the source of erosive energy. MUSLE uses storm-based runoff volumes and runoff peak flows to simulate erosion and sediment yield (Williams 1995). The use of runoff variables rather than rainfall erosivity as the driving force enables MUSLE to estimate sediment yields for individual storm events. The water erosion model uses an equation of the form:

$$Y = X \times EK \times CVF \times PE \times SL \times ROKF$$

where:

Y = sediment yield in tons per hectare
EK = soil erodibility factor
CVF = crop management factor that captures the relative effectiveness of soil and crop management systems in preventing soil loss
PE = erosion control practice factor (including management practices such as terraces, contour farming, and strip cropping)
SL = slope length and steepness factor
ROKF = coarse fragment factor

For estimating MUSLE, the energy factor, X, is represented by

$$X = 1.586 \times (Q \times q_p)^{0.56} \times WSA^{0.12}$$

where:

Q = runoff volume in millimeters
qp = peak runoff rate in millimeters per hour WSA = watershed area in hectares

Runoff volume is estimated using the SCS curve number method. Peak flow was estimated using a modification of the rational method which relates rainfall to peak flow on a proportional basis. The rational equation is:

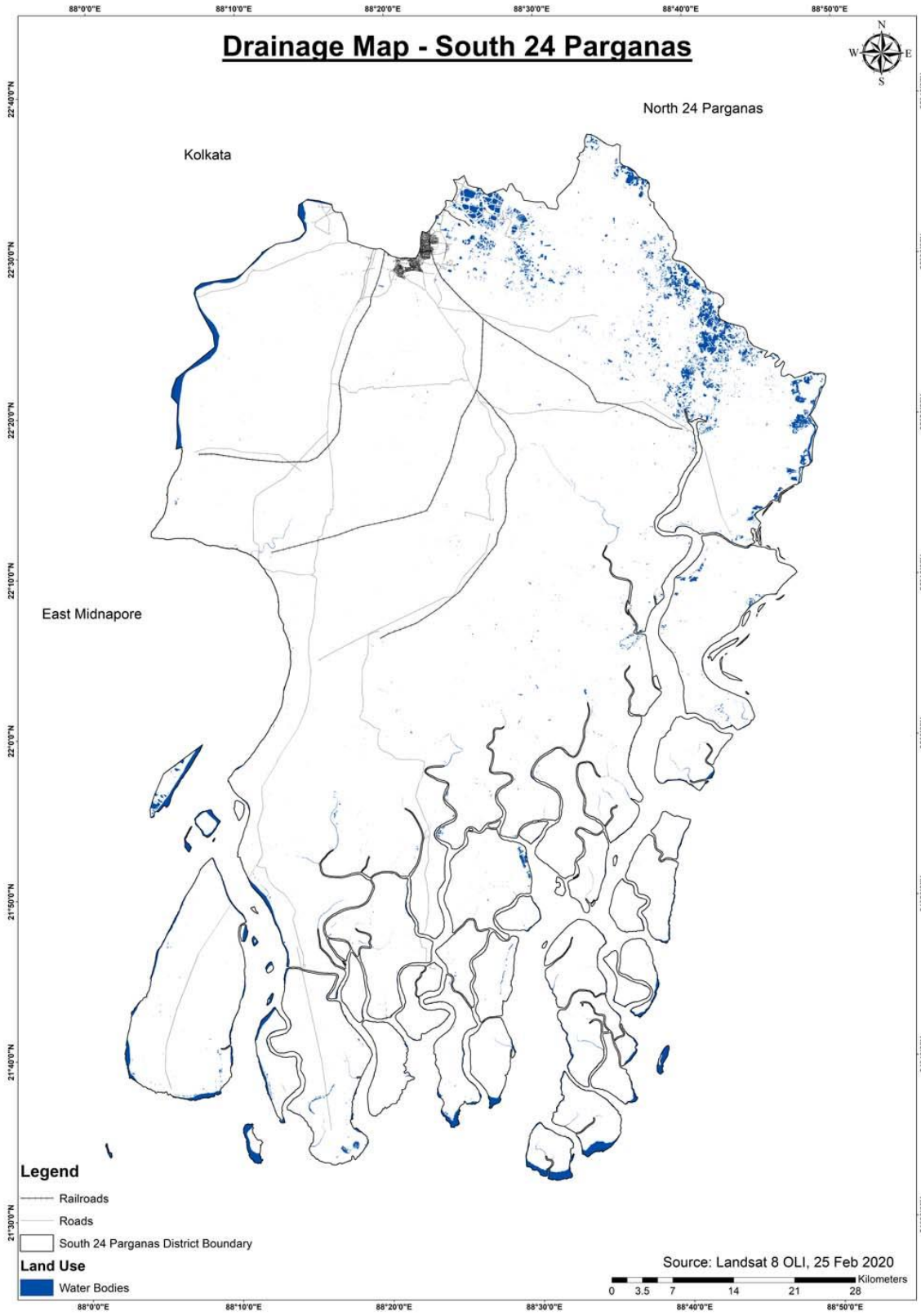
$$q = C \times i \times A$$

where:

q = peak flow rate
C = runoff coefficient representing watershed characteristics
i = rainfall intensity for the watershed's time of concentration
A = watershed area

Chapter - 7 GENERAL PROFILE OF THE DISTRICT

❖ *River System*



Salient Feature:

i. River Basins:	Ganga, Brahmaputra, Subarnarekha
ii. Catchment Area:	1,80,628 sq. km
iii. Flood Prone Area:	37,542 sq. km
iv. Area Already Protected:	35,380 sq. km
v. Length of Embankment:	10,400 km
vi. Length of Drainage Channel:	7,129 km
vii. Surface Water Potential:	132.90 BCM
viii. Ground Water Potential:	14.60 BCM

(Source: Annual Flood Report, 2017, Irrigation & Waterways Directorate)

Ganges enters West Bengal near Rajmahal and then flows in a south-easterly direction. It divides into two near north of Dhulian in Murshidabad district. One branch enters Bangladesh as the Padma or Pôdda, while the other flows through West Bengal as the Bhagirathi and Hooghly River in a southern direction.

The Bhagirathi-Hoogly is the main river in West Bengal which flows past some of the important cities like Murshidabad, Baharampur, Nabadwip, Chinsura, Chandannagar, Srirampur, Howrah, Kolkata, Diamond Harbour and Haldia. It empties its water into Bay of Bengal near Sagar Island in the South 24 Parganas.

The district has numbers of river, the major rivers are:-

- **Matla River**
- **Rajmangal River**
- **Saptmukhi River**
- **Hooghly River**
- **Bidydhari River**
- **Thakuran River**
- **Piyali River**

Matla River-

Matla River forms a wide estuary in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal. The main stream of the Matla River is divided into two arms near Purandar. One passes through Kultali-Garanbose and then passes through the Sundarbans. The other passes through Basanti, Pathankhali, Surjyaberia, Masjidbati and then meets Bidyadhari River

Rajmangal River-

Raimangal River is a tidal estuarine river in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal and Satkhira District in Bangladesh.

The Ichamati breaks up into several distributaries below Hingalganj the chief of which are the Raimangal, Bidya, Jhilla, Kalindi and Jamuna. These fan out into wide estuaries in the Sundarbans. It forms the international boundary between India and Bangladesh for some distance.

Saptmukhi River-

Saptamukhi River is a tidal estuarine river in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal.

The Saptamukhi originates near Sultanpur and flows between Kulpi and Mathurapur blocks. It has a connection with the Muri Ganga River and Deogra Khal. It falls to the Bay of Bengal with a wide mouth after traversing about 80 kilometres (50 mi).

Hooghly River –

The Hooghly River or the Bhāgirathi-Hooghly, called 'Ganga' traditionally, is an approximately 260 kilometres (160 mi) long distributary of the Ganges River in West Bengal, India. It splits from the Ganges as a canal in Murshidabad District at the Farakka Barrage. Hooghly river passes through Murshidabad, Nadia, Purba Bardhaman, Hooghly, Howrah, North 24 Paraganas, Kolkata, **South 24 Paraganas.**

Bidyadhari River-

Bidyadhari River (also spelt Bidyadhari or simply called Bidya), is a 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 the Sundarbans. Eastern boundary of the district is demarcated by Bangladesh and **Bidya** & Matla River. Bidyadhari river, Matla river forms a wide estuary in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal.

Thakuran River-

Thakuran River (also called Jamira) is a tidal estuarine river that forms a wide estuary in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal.

Piyali River-

It originates near Jaynagar and has a number of connections with the Saptamukhi and forms the boundary between Mathurapur and Jaynagar blocks.

Piyali River is a tidal estuarine river in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal.

The Piyali leaves the Bidyadhari River 14 kilometres (9 mi) below Bamanghata and flows south and south-west till it joins the Matla River about 32 kilometres (20 mi) below Canning. The Piyali links to the Matla through the Kultala gang which also links to the Thakuran

❖ *Climate*

The district is characterized by hot and humid climate. It receives adequate rainfall from North-East and South-West monsoons which set in the later half of June and withdraw by the middle of October. Pre-monsoon rains are received during March-April. May is the hottest month with temperature as high as 400 C and January is the coldest month with temperature as low as 100 C.

❖ *Geomorphology*

The district is divided into four geomorphic units:-

i. Deltaic Plains
ii. Levees
iii. Marshes
iv. Islands of Sunderban

Sunderbans

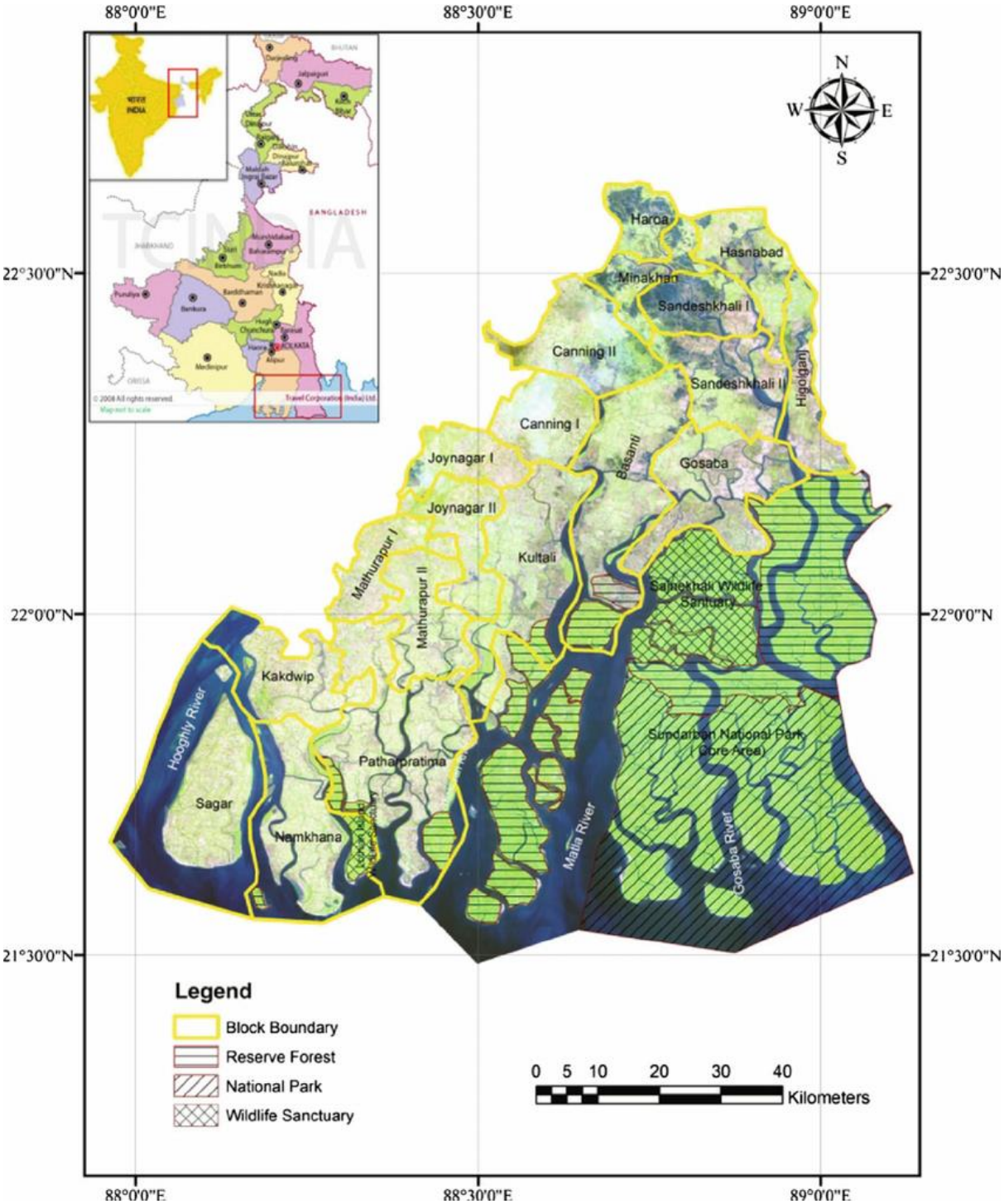


Figure 7: Location Map of Indian Sundarbans

The Sundarbans delta is the largest mangrove forest in the world situated in the South 24 Parganas district. It lies at the mouth of the Ganges and is spread across areas of Bangladesh and West Bengal, India. The Bangladeshi and Indian portions of the jungle are listed in the **UNESCO World Heritage List** separately as the **Sundarbans and Sundarbans National Park** respectively, though they are parts of the same forest. The Sundarbans are intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests, and presents an excellent example of ongoing ecological processes. The general average height of the area is 10 m. This area has been created by deposition of silt by its numerous rivers namely, Hoogly, Matla River, Jamira River, Gosaba River, Saptamukhi River, Haribhanga River and their tributaries. The formation of the delta is an ongoing process and new bars and islands are being created along the rivers and at the river mouth. A large section of the area remains under water during incoming times.

The area is known for its wide range of fauna. The most famous among these is the royal Bengal tiger, but numerous species of birds, spotted deer, crocodiles and snakes also inhabit it. It is estimated that there are now 400 Bengal tigers and about 30,000 spotted deer in the area

Ganges Delta

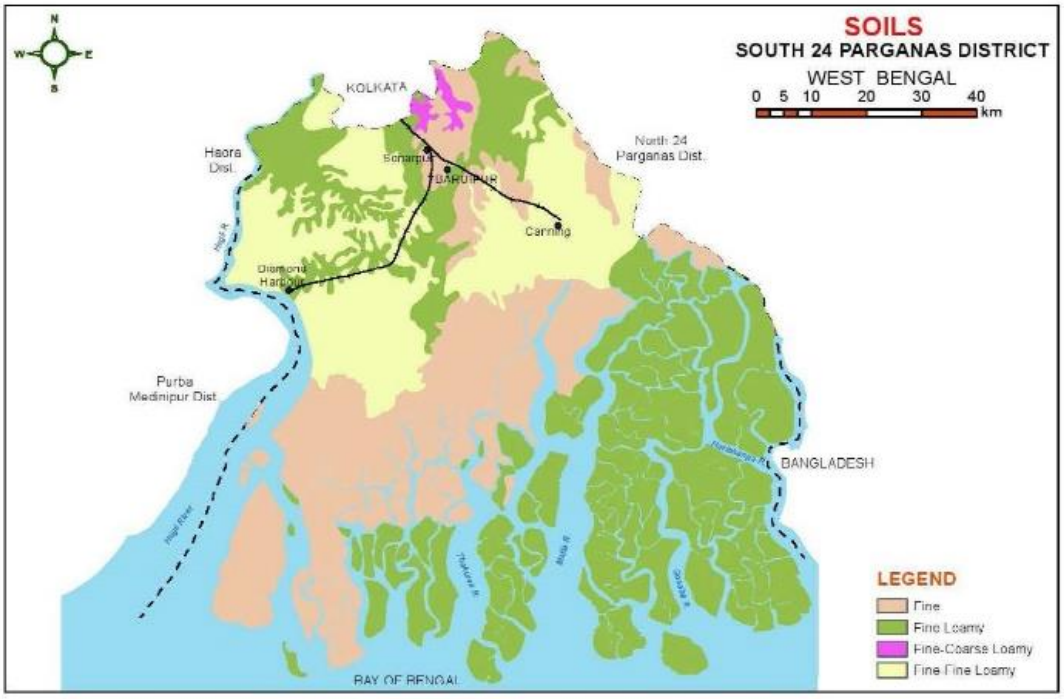
The Ganges delta consists of the whole of Nadia, Kolkata, North 24 Parganas, and South 24 Parganas districts and the Eastern half of Murshidabad district. River Ganges passes through this vast area and divides into three distinct parts – the old delta, the mature delta and the active delta.

The old delta consists of the districts of Murshidabad and Nadia. The formation of delta is complete and the rivers here are heavily silted and many have even dried up in due course of time. Silted rivers, swamps, beels and oxbow lakes forms the area. This area is also known as Bagri region.

The districts of Kolkata and North 24 Parganas form mature delta region. The rivers are slow and meandering and frequently shift their courses. Swamps, beels and oxbow lakes characterises the scenery. **The district of South 24 Parganas is known to be the active delta of the Ganges, where the formation of delta is still an ongoing process.**

❖ *Soil*

Soil Map of South 24 Parganas district



Source: NBSS & LUP Regional Centre, Calcutta

Inceptisol, Alfisol and Entisol soil orders covered 98 % area of the state. About 30.9 % area in West Bengal was affected with various kind of degradation. Erosion affected area was 19.7 %, while area affected with salinity and water logging was mapped on 3.2 and 6.9 %, respectively.

The soil type of the South 24 Parganas district is divided into three groups namely,

i. Entisols
ii. Alfisols
iii. Aridisols

The Entisols are present in the western corner of the district, the Alfisols which are typically deltaic alluvial soils, are present in central portion, and the Aridisols which are saline and saline- alkali in nature are present in the southern part of the district. The soil is alkaline due to excessive presence of Sodium Chloride. It causes the soil more fertile and scanty. The soil is also classified as Gangetic alluvi and Saleni. The texture varies from stiff clay to clay loam.

❖ *Irrigation*

Irrigation is done mainly by groundwater through shallow and deep tubewells along with surface water from rivers through river lifting and also from canals, ponds etc.

Irrigation by different sources:-

1	Shallow Tubewells	136.313 sq.km. area was actually irrigated through 9278 nos. of STW during 2000-01, whereas the culturable command area (151.877) through the existing 9452 nos. of STW.
2	Deep Tubewells	3.434 sq.km. area was actually irrigated through 28 nos. of DTW during 2000-01, whereas, the culturable command area (7.10 sq.km.) through the existing 29 DTW.
3	Surface Flow	299.794 sq.km. area was actually irrigated through 1566 nos. of Surface Flow schemes during 2000-01, whereas, the Culturable Command Area (312.515 sq.km.) through the existing 1575 nos. of SFS.
4	Surface Lift (RLI)	339.128 sq. km. area was actually irrigated through 24912 nos. of RLI during 2000-01, whereas, the Culturable Command Area (470.925 sq.km.) through the existing 25110 nos. of RLI.
5	Actual area irrigated by ground water during 2000-01	139.747 sq.km.
6	Actual area irrigated by Surface Water during 2000-01	638.923 sq.km.

❖ *Horticulture*

Horticulture sector consist of a large variety of fruits, vegetables, flowers, medicinal & aromatic plants, plantation crops, spices, mushrooms, ornamental plants etc. In the northern part of the district the major fruit crops are coconut, sapota, jack-fruit, areca nut etc. The commercial plantation crop is betel vine. In the southern parts, major fruit crops are mango, guava, litchi, banana, papaya and some minor fruits like karamcha , citrus, jamun, star- apple, sapota etc.

Crops	Area	Major Crops	Main Blocks
Fruits	12028 ha	Guava, Banana, Mango, Litchi	Baruipur, Sonarpur, Bhangore-I& II, Falta, Joynagar-I & II
Vegetables	60720 ha	Cabbage, Cauliflower, Lady's Finger, Cucurbits, Radish, Beans	Bhangore I & II, Joynagar I & II, Magrahat I & II, Canning I & II
Spices	4603 ha	Chilli, Turmeric, Ginger	Basanti, Gosaba, Bhangore I & II, Joynagar I & II, Magrahat-I,
Flower	3695 ha	Marigold, Tuberose, Ornamental Plants	Bhangore-I & II, Sonarpur, Budge Budge-I & II, Falta, Bishnupur-I & II
Plantation Crops	7156 ha	Coconut, Betelvine	Sagar, Pathar Pratima, Kakdwip, Gosaba. Basanti, Kultali

❖ *Demography*

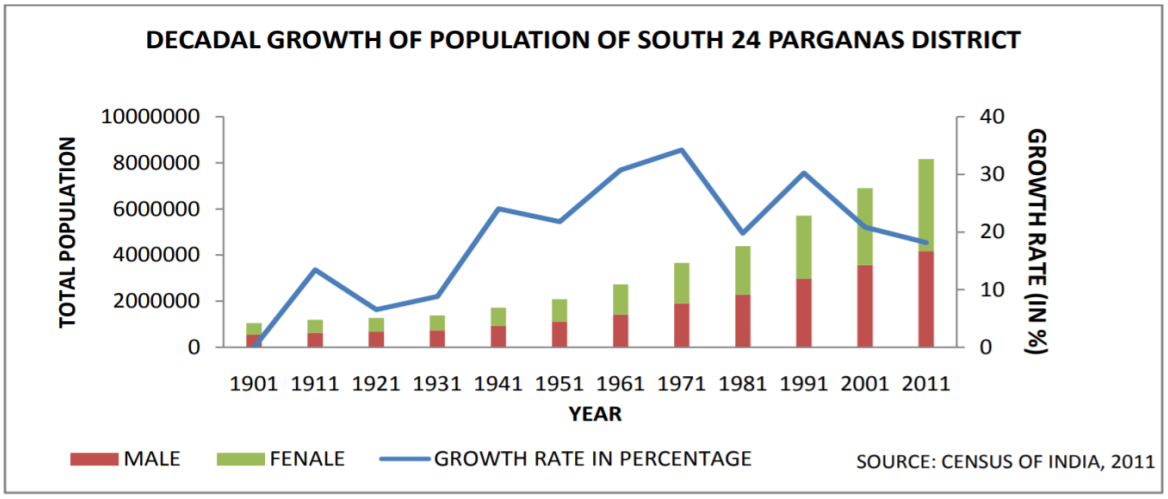
According to the 2011 census of India, South 24 Parganas had population of 8,161,961 of which male and female were 4,173,778 and 3,988,183 respectively. In 2001 census, South Twenty Four Parganas had a population of 6,906,689 of which males were 3,564,993 and remaining 3,341,696 were females. South Twenty Four Parganas District population constituted 8.94 percent of total Maharashtra population. In 2001 census, this figure for South Twenty Four Parganas District was at 8.61 percent of Maharashtra population.

The administrative division and population of the district is given below:-

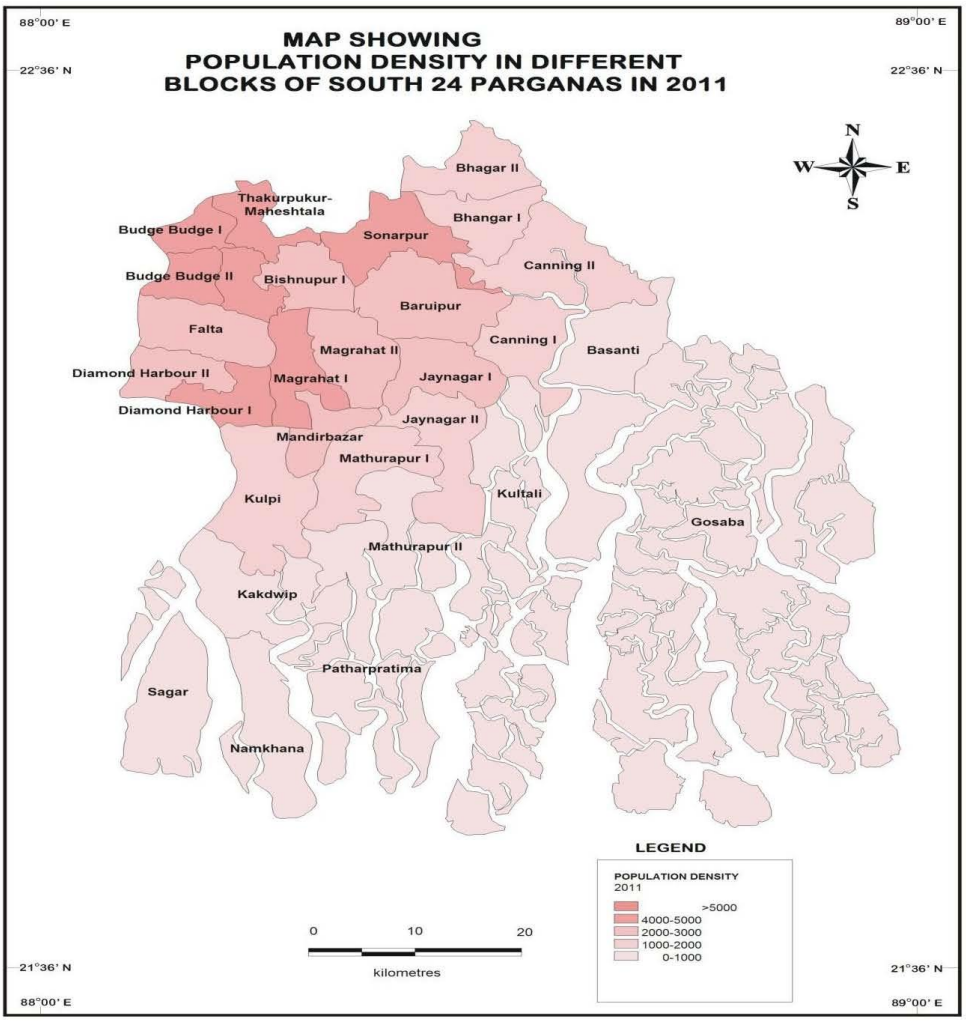
DEMOGRAPHY (Census 2011)	
Total Population	8,161,961
Male Population	4,173,778
Female Population	3,988,183
Population Growth	18.17%
Area Sq. Km.	9,960
Density / Km^2	819
Proportion to West Bengal Population	8.94 %
Sex Ratio (Per 1000)	956
Child Sex Ratio (0-6 Age)	963
Average Literacy	77.51
Male Literacy	83.35
Female Literacy	71.40
Total Child Population (0-6 Age)	1,025,679
Male Population (0-6 Age)	522,552
Female Population (0-6 Age)	503,127
Literates	5,531,657
Male Literates	3,043,277
Female Literates	2,488,380
Child Proportion (0-6 Age)	12.57%

DEMOGRAPHY (Census 2011)	
Boys Proportion (0-6 Age)	12.52%
Girls Proportion (0-6 Age)	12.62%

Source: Census Data of South 24 Parganas (2011)



Source: Census Data of South 24 Parganas (2011)



(Source: Census of India, 2011)

❖ *Forest*

The forests of West Bengal are classified into seven categories viz., Tropical Semi-Evergreen Forest, Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Littoral and Swampy Forest, Sub- Tropical Hill Forest, Eastern Himalayan Wet Temperate Forest and Alpine Forest.

The forests of this state has a rich assemblage of diverse habitats and vegetation designated with the help of eight different forest types. The diverse fauna and flora of West Bengal possess the combined characteristics of the Himalayan, sub-Himalayan and Gangetic plain.

In 1984, South 24 Parganas district became home to **Sundarbans National Park**, which has an area of 1,330 km² (513.5 sq mi). It shares the park with North 24 Parganas district and is also home to four wildlife sanctuaries: **Haliday Island, Lothian Island, Narendrapur, and Sajnekhali.**

Sundarbans, formerly Sunderbunds, is a vast tract of forest and saltwater swamp forming the lower part of the Ganges Delta and extending about 260 kilometres (160 mi) along the Bay of Bengal from the Hooghly River Estuary in the north to the Meghna River Estuary in Bangladesh in the east. The whole tract reaches inland for 100 to 130 kilometres (60– to 80 miles).

A network of estuaries, tidal rivers, and creeks intersected by numerous channels, it encloses flat, marshy islands covered with dense forests. The name Sundarbans is perhaps derived from the word meaning "forest of sundari," a reference to the large mangrove tree that provides valuable fuel. Along the coast the forest passes into a mangrove swamp; the southern region, with numerous wild animals and crocodile-infested estuaries, is virtually uninhabited. It is one of the last preserves of the Royal Bengal tiger and the site of a tiger preservation project. The cultivated northern area yields rice, sugarcane, timber, and betel nuts.

The region is also famous for some commonly domesticated livestock breeds which includes the Garole breed of sheep and China hens or Muscovy ducks, the Garole sheep is considered as the progenitor of the Booroola merino sheep and is noted for its prolific character.

Protected Area (National Park)	Area in Sq. Km.	Flagship Species	District
1. Singalila N.P.	78.60	Red Panda	Darjeeling
2. Neora Valley N.P.	88.00	Red Panda	Darjeeling
3. Buxa N.P.	117.10	Tiger	Alipurduar
4. Gorumara N.P.	79.45	Rhinoceros	Jalpaiguri
5. Sundarban N.P.	**1330.10**	**Tiger**	**S. 24 Parganas**
6. Jaldapara N.P.	216.34	Rhinoceros	Alipurduar
(Wildlife Sanctuary)			
1. Jorepokhri W.L.S.	0.04	Salamander	Darjeeling
2. Senchal W.L.S.	38.88	Himalayan Black Bear	Darjeeling
3. Chapramari W.L.S.	9.60	Gaur	Jalpaiguri
4. Mahananda W.L.S.	158.04	Elephant	Darjeeling
5. Raiganj W.L.S.	1.30	Bird	North Dinajpur
6. Bethuadahari W.L.S.	0.6686	Spotted Deer	Nadia

7. Ballavpur W.L.S.	2.021	Spotted Deer	Birbhum
8. Ramnabagan W.L.S.	0.145	Spotted Deer	Bardhaman
9. Bibhutibhusan W.L.S.	0.64	Spotted Deer	North-24 Parganas
10. Chintamoni Kar Bird	**0.0**	**Bird**	**S. 24 Parganas**
11. Sajnakhali W.L.S.	**362.40**	**Tiger**	**S. 24 Parganas**
12. Halliday Island W.L.S.	**5.9**	**Crocodile**	**S. 24 Parganas**
13. Lothian Island W.L.S.	**38.00**	**Crocodile**	**S. 24 Parganas**
14. Buxa W.L.S.	314.52	Tiger	Jalpaiguri
15. Pakhi Bitan (Bird Sanctuary)	14.09	Bird	Jalpaiguri

In West Bengal emphasis has been given to conservation and management of sustainable resources in order to achieve the goal of long-term biodiversity conservation. The overall strategy involves protection of critical habitats of endangered species. The strategies also focus on improved PA management, development of infrastructure, habitat improvement programme, reduction of man animal conflict, capacity building and involvement of local people in management of PA areas. The Bengal wilderness is also home of an array of highly endangered species like the Asian Elephant , Great one horned Rhino, Serow, Red Panda, Pigmy Hog, Bengal Florican, Black Necked Crane, Great pied Hornbill, Goliath Heron, Estuarine Crocodile, Salvator Lizards, Olive Ridley Marine Turtle, rare Batagur terrapin, let alone being the habitat for most of the cats of India, e.g. Bengal Tiger and Leopard and the Clouded Leopard, Marbled Cat, Leopard Cat, Golden Cat, Jungle Cat and, Fishing Cat representing the lesser cats, etc.

Population status of major wild animal: Elephants in West Bengal

- About 650 wild elephants spread over two distinct regions:
- North Bengal (Jalpaiguri & Darjeeling): around 529
- South Bengal (W. Midnapur, Bankura & Purulia): around 118
- West Bengal also receives seasonal visits from 100-150 elephants from Assam and Jharkhand.
- The elephant habitat in West Bengal extends over 4200 sq km.
- West Bengal has two Elephant Reserves: Eastern Dooars ER and Mayurjharna ER.

Tiger Conservation

Tiger Lands of West Bengal are

1. **Sundarban Tiger Reserve**

   The home of Royal Bengal Tigers. A 'World heritage site'. The world's largest estuarine forest - one of the very few in the world still having its flora and fauna intact, a remarkable feature being the bayonet like roots of mangrove forests sticking out above the water levels.

   64-90 nos. during 2010 (as per report of Wildlife Institute of India, Dehradun's All India Tiger Estimation 2010). A minimum of 81 Tigers during 2012-13 Camera Trap Analysis conducted by WWF & WII.

2. **24 Parganas (South) Division:**

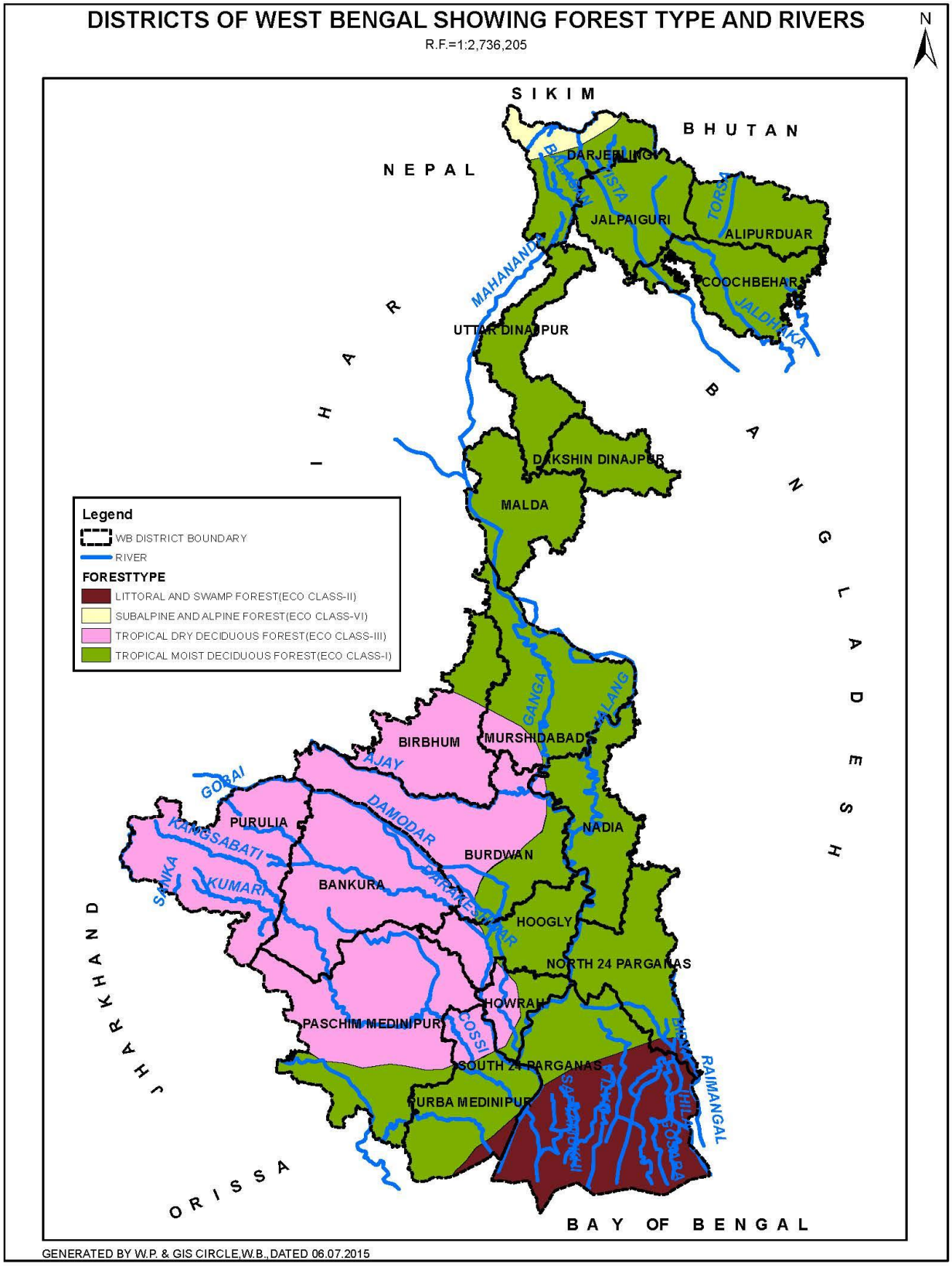
A minimum of 22 tigers during 2011-12 as per Camera Trap Analysis conducted by WWF.

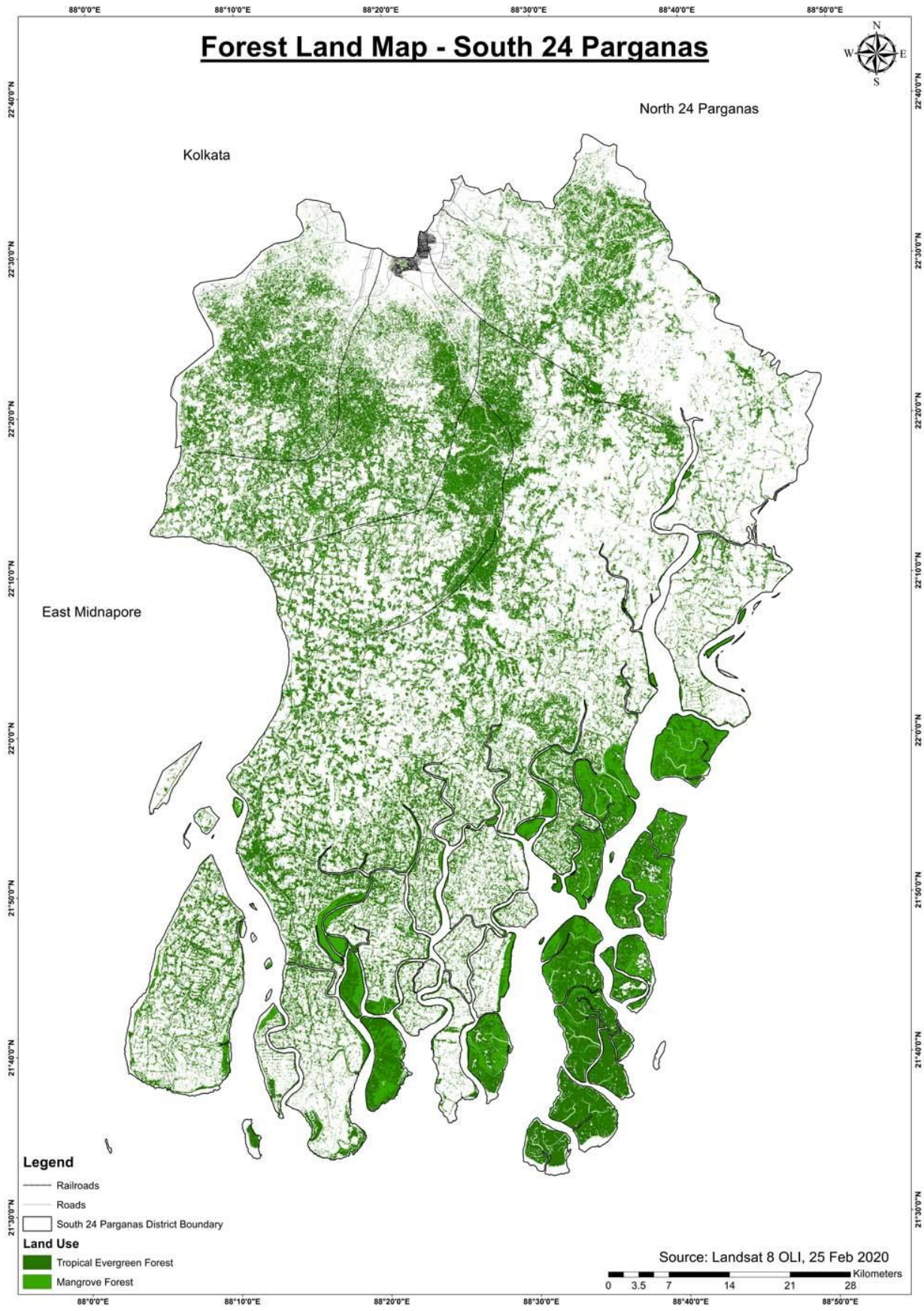
3. **Buxa Tiger Reserve**

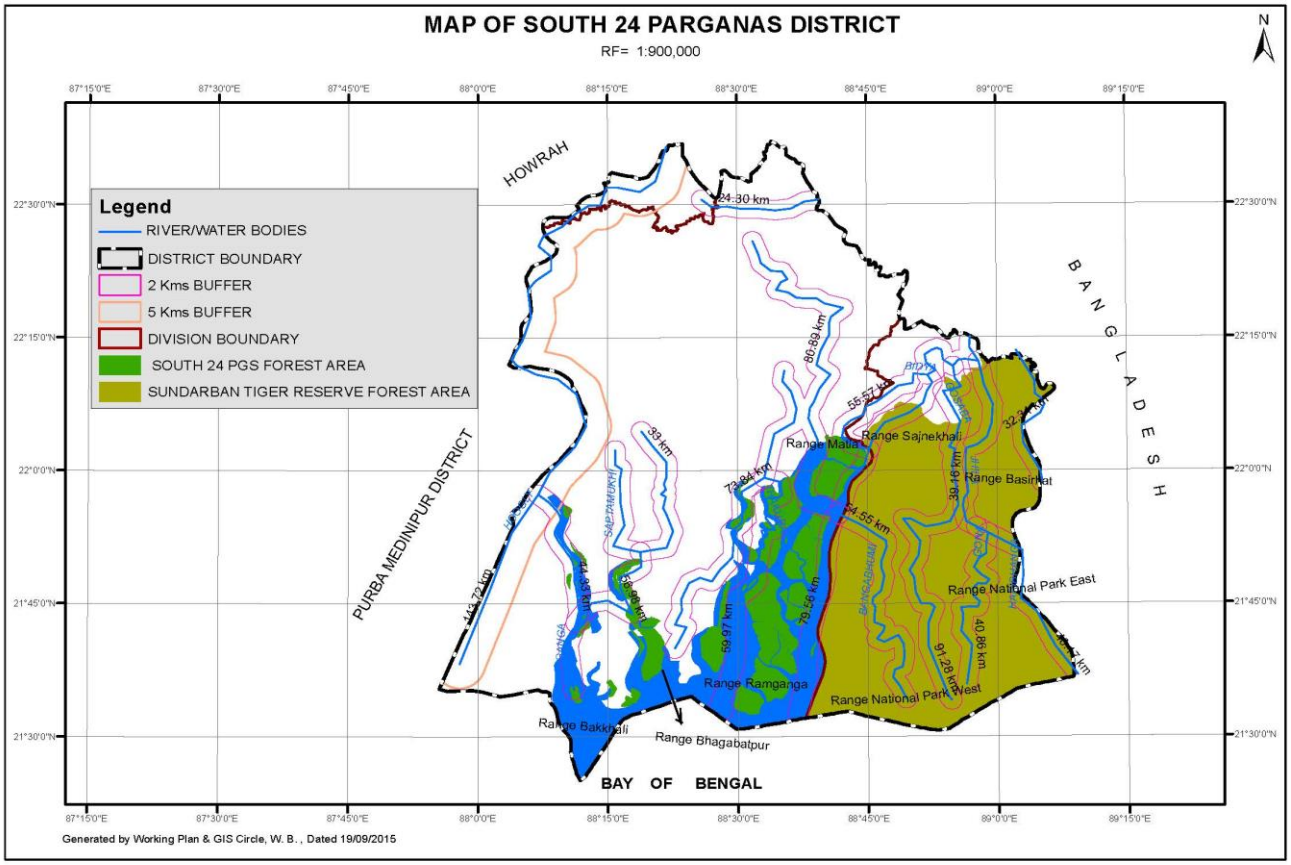
20 nos. during 2011 (as per Scat analysis through DNA finger-printing technique) by CCMB- Hyderabad, Aranyak, Assam & BTR authority)

Rhino Conservation:

- Population increased from 22 (1986) to 255 (2015)
  - Jaldapara WildlifeSanctuary:204
  - Gorumara National Park & adjoining areas: 51


DISTRICTS OF WEST BENGAL SHOWING FOREST TYPE AND RIVERS
R.F.=1:2,736,205
N
SIKIM
BHUTAN
NEPAL
DARJEELING
JALPAIGURI
ALIPURDUAR
COOCHBEHAR
UTTAR DINAJPUR
DAKSHIN DINAJPUR
MALDA
MURSHIDABAD
BIRBHUM
PURULIA
BANKURA
BURDWAN
NADIA
HOOGLY
NORTH 24 PARGANAS
HOWRAH
PASCHIM MEDINIPUR
PURBA MEDINIPUR
SOUTH 24 PARGANAS
MAHANANDA
TORSA
JALDHAKA
GANGA
PADMA
JALANGI
AJAY
DAMODAR
KANGSABATI
KUMARI
SUBARNAREKHA
RAIMANGAL
BAY OF BENGAL
ORISSA
JHARKHAND
BIHAR
BANGLADESH
Legend
WB DISTRICT BOUNDARY
RIVER
FORESTTYPE
LITTORAL AND SWAMP FOREST(ECO CLASS-II)
SUBALPINE AND ALPINE FOREST(ECO CLASS-VI)
TROPICAL DRY DECIDUOUS FOREST(ECO CLASS-III)
TROPICAL MOIST DECIDUOUS FOREST(ECO CLASS-I)
GENERATED BY W.P. & GIS CIRCLE,W.B., DATED 06.07.2015

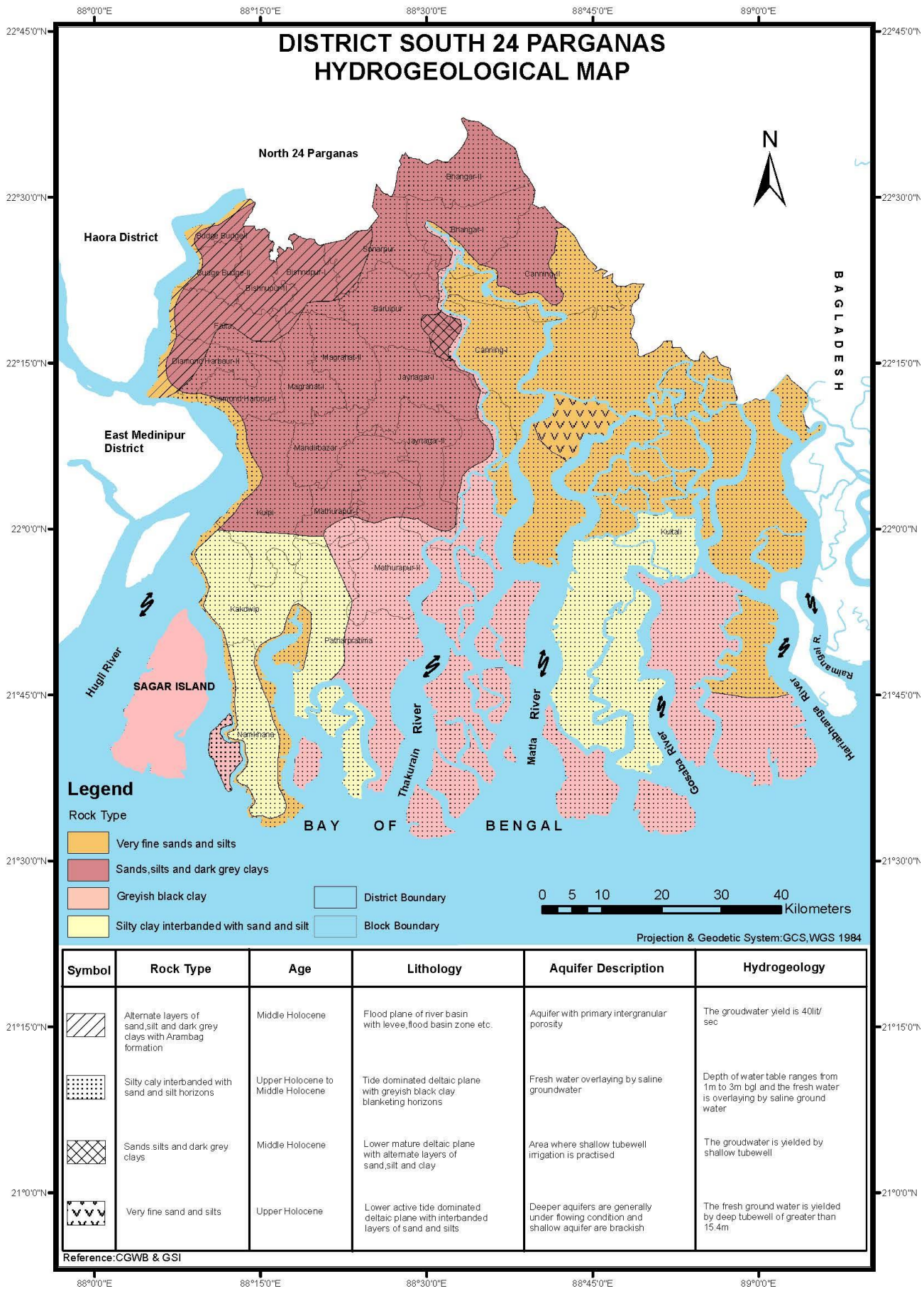

Forest Land Map - South 24 Parganas
N
W
E
S
North 24 Parganas
Kolkata
East Midnapore
88°0'0"E
88°10'0"E
88°20'0"E
88°30'0"E
88°40'0"E
88°50'0"E
22°40'0"N
22°30'0"N
22°20'0"N
22°10'0"N
22°0'0"N
21°50'0"N
21°40'0"N
21°30'0"N
Legend
Railroads
Roads
South 24 Parganas District Boundary
Land Use
Tropical Evergreen Forest
Mangrove Forest
Source: Landsat 8 OLI, 25 Feb 2020
Kilometers
0 3.5 7 14 21 28



❖ *Hydrogeology*

The ground water bearing aquifers are present in the district within Quaternary and Tertiary sediments and generally occur under confined condition in the depth range of 75 to 360 metres with numerous alternations of clayee and sandy layers of varying thickness. The confined aquifers can be divided into two groups in this district from north to extreme south. The upper one, usually in the depth span of 20 to 160 metres has a sandy gravel layer as a marker bed at its base which pinches out eastward. The ground water in general except at a few places occurring in this upper group of aquifers, is brackish to saline (Chloride ranging from 1750 to 6300 ppm) and is not in use.

The lower group of aquifer occurring in the depth range of 160 to 360 metre, is separated from the upper group by a thick impermeable sticky clay bed which is laterally extensive with varying thickness. The ground water occurring in this lower group of aquifer is generally fresh and is used extensively. This confined productive aquifer is recharged by rainwater through the recharging exposed area along Kalyani-Ranaghat-Shantipur area in Nadia district in the north; along Bangaon-Gaighata section in North 24 Parganas district in the north-east; and along Tarakeswar-Nalikul-Mogra-Pandua area in Hugli, district in the north-west.



Symbol	Rock Type	Age	Lithology	Aquifer Description	Hydrogeology
	Alternate layers of sand,silt and dark grey clays with Arambag formation	Middle Holocene	Flood plane of river basin with levee,flood basin zone etc.	Aquifer with primary intergranular porosity	The groudwater yield is 40lit/ sec
	Silty caly interbanded with sand and silt horizons	Upper Holocene to Middle Holocene	Tide dominated deltaic plane with greyish black clay blanketing horizons	Fresh water overlaying by saline groundwater	Depth of water table ranges from 1m to 3m bgl and the fresh water is overlaying by saline ground water
	Sands silts and dark grey clays	Middle Holocene	Lower mature deltaic plane with alternate layers of sand,silt and clay	Area where shallow tubewell irrigation is practised	The groudwater is yielded by shallow tubewell
	Very fine sand and silts	Upper Holocene	Lower active tide dominated deltaic plane with interbanded layers of sand and silts	Deeper aquifers are generally under flowing condition and shallow aquifer are brackish	The fresh ground water is yielded by deep tubewell of greater than 15.4m

Reference:CGWB & GSI

(Source: State Water Investigation Directorate, Govt. of West Bengal)

The piezometric surface of the lower group of confined aquifer as monitored in the year 2006 from the hydrograph network stations, lies from 1.70 m to 6.00 m bgl during pre-monsoon period and from 0.50 m to 5.80 m bgl during post-monsoon period. The average slope of the piezometric surface during pre-monsoon of 2006 in this district is 1:1500 towards the principal direction of South-east.

Aquifer Characteristics:- Exploratory tubewells were constructed by CGWB tapping the productive fresh water bearing zones of depth ranging from 115 to 402 m bgl are capable to yield 100 to 120 m3/hr., with drawdown ranging from 2.3 to 16.5 metres. Transmissivity values range from 400 to 6500 m2/day and the Storativity values range from 0.0002 to 0.0015.

❖ Groundwater Resources:-

Except in a very few parts (where ground water occurs under both unconfined and confined conditions) the fresh water bearing aquifers in this district is under confined condition. Hence it has not been considered for ground water resource estimation by GEC-'97 methodology.

However, in order to have an idea of the dynamic ground water potential of this district, an attempt has been made to estimate the total quantity of ground water flow by applying Darcy's Law equation of flow of fluids through porous media, which is Q = TIL; where Q is the Quantity of water flowing through a section of aquifer, T is the Transmissivity of aquifer, I is the hydraulic gradient of the piezometric surface and L is the length of groundwater flow-path in the section of the aquifer under consideration, perpendicular to the flow direction. For the area under consideration in this district and taking average values of T=2000 m2/day, I = 1:1500 & L = 140 Km., the Q is computed as 68 MCM. Hence, the dynamic groundwater flow towards the principal direction of SE, in this area, is considered to be 68 MCM per annum.

To assess the annual ground water draft through groundwater development structures, the total number of shallow and deep tubewels is taken into account. As per the 3rd Minor irrigation Census 2001, the district has 9278 STWs and 28 DTWs. Considering average unit draft of 0.014 MCM/Yr for STW and 0.21 MCM/Yr for DTW the Net Ground Water draft is computed as 135.77 MCM per annum.

❖ Groundwater Quality:-

Chemical analyses results show that groundwater from unconfined aquifer except a few places is fresher within 60 m bgl than the deeper aquifers within 60 to 125 m bgl. Ground water from the unconfined aquifer is generally neutral to mildly alkaline with pH ranging from 7.2 to 8.1.

Ground water in the western and central part of the district is primarily a Calcium-magnesium-Bicarbonate type. The aquifer within the depth range of 150 m bgl in this area is generally marked by brackishness where chloride value ranges from 1750 to 6300 ppm., however, at few places fresh ground water occurs in a linear tract following the Adi Ganga channel.

The deeper group of confined aquifer occurring within the depth range of 160 to 350 m bgl in the southern and south-eastern part of the district contain fresh water and favorable for exploitation. The ground water is neutral to mildly alkaline with pH ranging from 7.4 to 8.1. Electro-conductivity ranges from714 to 2692 µs/cm (at 25°C) and the chloride value ranges from 14 to 596 ppm., hence suitable for human consumption.

In the coastal belt of this district the aquifers under semi confined to confined condition contain ground water with very high dissolved salts. Maximum value of Electrical conductivity of 8600 µs/cm (at 25°C) and highest value of Chloride content of 2180 ppm were found at Rajar Taluk in Diamond Harbour II block (as observed from CGWB permanent monitoring wells).

Arsenic content of groundwater has been found to be beyond permissible limit of 0.05 ppm in a number of localized patches in sporadic manner in 9 blocks-Baruipur, Sonarpur-Bhangar-I & II, Joynagar-I, Bishnupur-I&II, Magrahat-II and Budge Budge-II in this district. The maximum value of Arsenic content was recorded to be 3.2 ppm at Baruipur in this district. It has been found that a sizeable population in the localities has been suffering from Arsenic dermatosis by drinking ground water rich in Arsenic content.

❖ *Status of Ground Water Development (Block wise):-*

Sl. No.	Block	Occurrence of aquifer and its potentiality (as per the data available with CGWB)	Feasibility of Ground Water Structure	Ground Water abstraction structures for irrigation (as per 3rd Minor Irrigation Census, 2001)	Depth to piezometric level (m bgl) (from NHS of CGWB)	
					Pre-mon-soon	Post-mon-soon
1	2	3	4	5	6	7
1.	Maheshtala	The upper shallow unconfined aquifer System occurs within 50 m bgl. The lower confined aquifer system occurs in between 70 to 160 m bgl and occurs inbetwen 170 to 360 m bgl. Each aquifer system consists one of more granular zones which are more or less interconnected The Transmissivity (T) ranges from 500 to 2000 m2/day and co-efficient of Storativity (S) ranges from 0.3 x 10-1 to 0.5x10-2 in the second i.e., upper confined aquifer system; and in the deper confined aquifer system 'T' ranges from 915 to 3000 m2/day and 'S' ranges from 0.3 x 10-3 to 1.1x10-3.	Low duty shallow tubewells with yield of 20 to 40 m3/hr, and heavy duty deep tubewells with yield of 50 to 150 m3/hr are feasible.	Shallow Tubewells (STW) – 0 Deep Tubewells (DTW) – 0	6.35	5.80

Sl. No.	Block	Occurrence of aquifer and its potentiality (as per the data available with CGWB)	Feasibility of Ground Water Structure	Ground Water abstraction structures for irrigation (as per 3rd Minor Irrigation Census, 2001)	Depth to piezometric level (m bgl) (from NHS of CGWB)	
					Pre-mon-soon	Post-mon-soon
2.	Bishnupur I	-do-	-do-	STW – 1 DTW – 0	5.18	4.98
3.	Bishnupur II	-do-	-do-		-do-	-do-
4.	Budge Budge I	-do-	-do-	STW – 2 DTW – 0	-	-
5.	Budge Budge II	-do-	-do-	STW – 0 DTW – 1	-	-
6.	Sonarpur	-do-	-do-	STW – 578 DTW-4	4.37 To 5.77	2.35 To 3.20
7.	Joynagar I	-do-	-do-	STW – 83 DTW-1	2.67 To 5.64	1.45 to 5.28
8.	Joynagar II	-do-	-do-	STW – 6 DTW – 1	-do-	-do-
9.	Baruipur	-do-	-do-	STW – 1120 DTW-6	2.50 to 5.40	2.19 to 6.30
10.	Bhangar	-do-	-do-	STW – 2933 DTW-3	3.15 to 4.60	2.58 to 4.25
11.	Bhangar II	-do-	-do-	STW 1919 DTW 3	-do-	-do-
12.	Diamond	-do-	-do-	STW – 0 DTW-1	1.35 to 1.68 (Dug Well)	1.34 to 1.35 (Dug well)
13.	Diamond Harbour II	-do-	-do-	STW – 0 DTW – 0	-do-	-do-
14.	Magrahat I	-do-	-do-	STW – 0 DTW – 0	6.80	6.48
15.	Magrahat II	-do-	-do-	STW – 58 DTW – 0	-do-	
16.	Falta	-do-	-do-	STW – 0 DTW – 3	6.70	6.40

Sl. No.	Block	Occurrence of aquifer and its potentiality (as per the data available with CGWB)	Feasibility of Ground Water Structure	Ground Water abstraction structures for irrigation (as per 3rd Minor Irrigation Census, 2001)	Depth to piezometric level (m bgl) (from NHS of CGWB)	
					Pre-mon-soon	Post-mon-soon
17.	Caning I	The upper confined aquifer system occurs in between 80 to 150 m bgl containing brackish water, and the deeper second group of confined aquifer occurs in between 160 to 360 m bgl containing fresh water. Each aquifer system consists one or more granular zones which are more or less interconnected. The Transmissivity (T) ranges from 500 to 2000 m2/day and co- efficient of Storativity (S) ranges from 0.3 x 10-1 to 0.5x10-2 in the second i.e., upper confined aquifer system, and in the deeper confined aquifer system 'T' ranges from 915 to 3000 m2/day and 'S' ranges from 0.3 x 10-3 to 1.1x10-3	Heavy duty deep tube wells with yield of 50 to 150 m3/hr are feasible.	STW – 406 DTW-0	2.70 to 2.80	1.35 to 2.75
18.	Canning II	-do-	-do-	STW – 1093 DTW – 0	-do-	-do-
19.	Mathurapur I	-do-	-do-	STW – 67 DTW-0	3.56 to 5.74	3.30 to 5.34
20.	Mathurapur II	-do-	-do-	STW – 363 DTW – 0	-do-	-do-
21.	Mandirbazar	-do-	-do-	STW – 0 DTW-1	4.90 to 5.90	4.20 to 5.38
22.	Basanti	-do-	-do-	STW – 14 DTW-0	4.14 to 4.18	2.40 to 3.83
23.	Gosaba I	-do-	-do-	STW – 349 DTW – 0	3.88	2.00
24.	Kulpi	-do-	-do-	STW – 2 DTW -2	6.00	5.80
25.	Kultali	-do-	-do-	STW – 174 DTW – 0	4.40	3.36
26.	Kakdwip	-do-	-do-	STW – 3 DTW-0	5.05 to 6.68	4.08 to 6.06

Sl. No.	Block	Occurrence of aquifer and its potentiality (as per the data available with CGWB)	Feasibility of Ground Water Structure	Ground Water abstraction structures for irrigation (as per 3rd Minor Irrigation Census, 2001)	Depth to piezometric level (m bgl) (from NHS of CGWB)	
					Pre-mon-soon	Post-mon-soon
27.	Namkhana	-do-	-do-	STW – 0 DTW-0	5.65 to 6.25	5.45 to 6.45
28.	Pathar-	-do-	-do-	STW – 181 DTW-1	5.22 to 6.90	4.50 to 5.75
29.	Sagar	-do-	-do-	STW – 0 DTW-0	5.30 to 5.65	5.25 to 5.61

Source: Central Ground Water Board Report (CGWB)

❖ *Groundwater Management Strategy:-*

At present groundwater development is controlled by the shallow tubewells and deep tubewells in the district. As per 3rd Minor Irrigation Census, 2001 the district has 9278 shallow and 28 deep tubewells with cumulative draft of 135.77 MCM per annum.

In general ground water in the district occurs under confined condition, and hence total ground water resource could not be estimated by GEC, 1997 method. However, considering Darcy's equation of ground water flow, the annual dynamic ground water flow through the area in the district has been estimated as 68 MCM.

Development of ground water which is almost free from Arsenic and salinity through deeper aquifer for drinking purposes, are taken up by constructing deep tubewells applying cement sealing techniques in the arsenic affected blocks of the district in the northern part, and in the coastal blocks of the district with saline hazards in southern part

❖ *Depth of Ground Water Level (in MBGL):-*

Sl. No.	Block	Average Pre Monsoon 2001	Average Post Monsoon 2001	Average Pre Monsoon 2002	Average Post Monsoon 2002	Average Pre Monsoon 2003	Average Post Monsoon 2003	Average Pre Monsoon 2004	Average Post Monsoon 2004
1	Falta	5.55	N.A.	N.A.	4.38	N.A.	N.A.	N.A.	N.A.
2	Diamondharbour	4.16	N.A.	N.A.	3.52	4.39	N.A.	5.36	6.35
3	Kakdwip	4.46	N.A.	N.A.	N.A.	N.A.	N.A.	4.64	4.47
4	Kulpi	4.87	N.A.	N.A.	4.08	4.41	N.A.	4.23	3.83
5	Namkhana	N.A.	N.A.	N.A.	3.14	3.73	N.A.	4.13	3.42
6	Mathurapur-I	N.A.	N.A.	N.A.	3.10	4.25	N.A.	4.95	N.A.
7	Mathurapur-II	4.54	N.A.	N.A.	1.85	3.91	N.A.	4.94	2.84
8	Mabdirbazar	4.22	N.A.	N.A.	3.37	3.90	N.A.	5.53	3.37
9	Jaynagar-I	4.12	N.A.	N.A.	2.44	3.94	N.A.	4.04	3.05
10	Jaynagar-II	4.53	N.A.	N.A.	2.60	3.75	N.A.	3.78	3.15
11	Baruipur	3.23	N.A.	N.A.	2.73	4.05	N.A.	4.28	4.10
12	Kultoli	2.47	N.A.	N.A.	2.52	2.20	N.A.	2.30	1.67
13	Sonarpur	4.25	N.A.	N.A.	6.50	6.89	N.A.	7.88	4.05
14	Bishnupur-I	5.50	N.A.	N.A.	4.35	6.50	N.A.	6.16	N.A.
15	Bishnupur-II	4.99	N.A.	N.A.	2.87	6.67	N.A.	5.22	N.A.
16	Budgebudge-I	7.75	N.A.	N.A.	7.80	8.98	N.A.	8.95	N.A.
17	Budgebudge-II	4.78	N.A.	N.A.	3.80	5.55	N.A.	5.51	N.A.
18	Canning-I, Minakhan	3.72	N.A.	N.A.	1.75	3.07	N.A.	3.40	N.A.
19	Canning-II	4.46	N.A.	N.A.	1.46	3.73	N.A.	4.27	N.A.
20	Bhangora-I	3.70	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
21	Bhangora-II	4.07	N.A.	N.A.	2.37	4.77	2.57	4.82	N.A.
22	Mograhat-I	4.48	N.A.	N.A.	3.75	4.58	2.85	5.18	N.A.
23	Mograhat-II	4.08	N.A.	N.A.	3.56	4.55	3.35	4.65	N.A.
24	Basanti	2.44	N.A.	N.A.	1.99	2.50	N.A.	1.20	N.A.
25	Sagar	3.30	N.A.	N.A.	2.96	3.52	N.A.	3.65	N.A.
26	Patharpratima	4.23	N.A.	N.A.	5.63	5.65	N.A.	3.88	N.A.
27	Thakurpukur Mahesh	11.72	N.A.	N.A.	9.46	11.09	N.A.	11.14	N.A.
28	Gosaba	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Sl. No.	Block	Average Pre Monsoon 2005	Average Post Monsoon 2005	Average Pre Monsoon 2006	Average Post Monsoon 2006	Average Pre Monsoon 2007	Average Post Monsoon 2007	Average Pre Monsoon 2008	Average Post Monsoon 2008
1	Falta	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
2	Diamondharbour	N.A.	5.48	6.05	5.85	6.75	6.35	N.A.	6.55
3	Kakdwip	N.A.	4.38	4.46	4.28	4.03	3.71	N.A.	4.78
4	Kulpi	N.A.	3.90	N.A.	3.94	4.93	4.13	N.A.	4.13
5	Namkhana	N.A.	3.33	3.59	3.72	3.48	3.27	N.A.	3.42
6	Mathurapur-I	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
7	Mathurapur-II	N.A.	2.51	6.76	3.02	6.15	4.00	7.20	3.90
8	Mabdirbazar	N.A.	3.15	4.40	3.50	4.50	3.15	N.A.	N.A.

9	Jaynagar-I	N.A.	3.23	4.47	2.10	3.45	2.45	N.A.	1.50
10	Jaynagar-II	N.A.	2.95	4.67	2.90	5.30	3.75	N.A.	3.95
11	Baruipur	N.A.	3.68	4.78	3.41	4.94	3.70	N.A.	3.34
12	Kultoli	N.A.	1.60	4.00	1.90	4.20	3.10	N.A.	2.85
13	Sonarpur	N.A.	4.95	7.20	4.97	7.02	4.65	5.15	5.10
14	Bishnupur-I	N.A.	4.05	2.60	4.20	4.20	3.90	4.80	4.18
15	Bishnupur-II	N.A.	3.80	5.50	4.23	5.33	4.10	5.04	2.40
16	Budgebudge-I	N.A.	7.95	N.A.	8.25	9.57	7.90	9.04	8.20
17	Budgebudge-II	N.A.	4.70	5.50	2.85	3.85	2.75	3.50	2.85
18	Canning-I, Minakhan	N.A.	1.53	4.95	2.00	4.43	2.55	4.45	2.11
19	Canning-II	N.A.	1.20	5.25	1.38	4.70	3.15	4.10	1.35
20	Bhangora-I	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
21	Bhangora-II	N.A.	2.46	4.97	2.99	5.18	2.51	4.09	2.40
22	Mograhat-I	N.A.	3.75	N.A.	2.90	2.90	2.15	N.A.	1.60
23	Mograhat-II	N.A.	3.70	5.13	2.88	4.87	3.58	4.23	3.58
24	Basanti	N.A.	N.A.	2.55	1.80	2.25	1.10	N.A.	N.A.
25	Sagar	N.A.	3.53	3.65	2.09	3.67	2.51	2.84	2.48
26	Patharpratima	N.A.	4.18	4.30	N.A.	N.A.	N.A.	N.A.	N.A.
27	Thakurpukur Mahesh	N.A.	10.05	10.69	9.18	10.73	9.33	10.52	9.46
28	Gosaba	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Sl. No.	Block	Average Pre Monsoon 2009	Average Post Monsoon 2009	Average Pre Monsoon 2010	Average Post Monsoon 2010	Average Pre Monsoon 2011	Average Post Monsoon 2011	Average Pre Monsoon 2012	Average Post Monsoon 2012
1	Falta	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
2	Diamondharbour	7.55	N.A.	8.10	N.A.	N.A.	N.A.	N.A.	N.A.
3	Kakdwip	4.88	N.A.	7.13	7.40	N.A.	7.70	7.58	6.30
4	Kulpi	5.68	N.A.	5.95	4.98	N.A.	5.45	6.65	5.70
5	Namkhana	3.11	N.A.	4.89	5.07	N.A.	5.32	5.33	4.78
6	Mathurapur-I	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
7	Mathurapur-II	7.45	N.A.	14.65	N.A.	N.A.	3.60	4.75	N.A.
8	Mabdirbazar	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
9	Jaynagar-I	3.01	N.A.	11.45	1.65	N.A.	N.A.	N.A.	N.A.
10	Jaynagar-II	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
11	Baruipur	5.94	N.A.	N.A.	4.85	N.A.	4.45	6.05	4.7
12	Kultoli	5.70	N.A.	11.8	2.75	N.A.	N.A.	N.A.	N.A.
13	Sonarpur	6.83	N.A.	9.15	7.83	9.94	8.45	10.1	8.10
14	Bishnupur-I	5.62	N.A.	6.17	5.24	N.A.	5.15	6.20	5.60
15	Bishnupur-II	4.20	N.A.	4.00	2.93	4.80	3.00	4.50	3.45
16	Budgebudge-I	10.25	N.A.	10.88	1.85	7.45	2.00	3.30	3.45
17	Budgebudge-II	4.00	N.A.	4.10	3.68	4.66	3.60	4.40	3.90
18	Canning-I, Minakhan	5.95	N.A.	7.05	4.13	5.38	2.65	N.A.	2.75
19	Canning-II	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
20	Bhangora-I	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

21	Bhangora-II	5.19	N.A.	6.17	3.99	5.45	3.41	5.45	4.13
22	Mograhat-I	4.35	N.A.	6.15	5.35	N.A.	5.25	6.42	5.60
23	Mograhat-II	4.95	N.A.	6.15	5.30	N.A.	5.20	6.28	5.55
24	Basanti	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
25	Sagar	2.70	N.A.	4.24	4.89	N.A.	4.25	4.44	4.66
26	Patharpratima	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
27	Thakurpukur Mahesh	11.38	N.A.	12.55	8.55	12.02	10.52	11.23	10.63
28	Gosaba	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Sl. No.	Block	Average Pre Monsoon 2013	Average Post Monsoon 2013
1	Falta	N.A.	N.A.
2	Diamondharbour	N.A.	N.A.
3	Kakdwip	7.83	6.60
4	Kulpi	8.90	5.70
5	Namkhana	5.58	4.85
6	Mathurapur-I	N.A.	N.A.
7	Mathurapur-II	15.6	4.75
8	Mabdirbazar	N.A.	N.A.
9	Jaynagar-I	N.A.	N.A.
10	Jaynagar-II	N.A.	N.A.
11	Baruipur	7.00	4.85
12	Kultoli	N.A.	N.A.
13	Sonarpur	10.75	8.25
14	Bishnupur-I	6.80	5.10
15	Bishnupur-II	4.75	3.45
16	Budgebudge-I	9.65	N.A.
17	Budgebudge-II	4.30	3.40
18	Canning-I, Minakhan	7.15	2.50
19	Canning-II	N.A.	N.A.
20	Bhangora-I	N.A.	N.A.
21	Bhangora-II	6.77	3.32
22	Mograhat-I	6.55	5.10
23	Mograhat-II	6.40	5.00
24	Basanti	N.A.	N.A.
25	Sagar	4.85	4.48
26	Patharpratima	N.A.	N.A.
27	Thakurpukur Mahesh	12.48	9.53
28	Gosaba	N.A.	N.A.

(Source: State Water Investigation Directorate, Govt. of West Bengal)

❖ Water Conservation & Artificial Recharge:-

So far no structure has been constructed by CGWB in this district.

❖ Ground water related issues and problems:-

1) **Ground water quality problem (Geogenic) :**

Arsenic in groundwater in sporadic manner has been identified in 9 blocks in this district. The concentration of arsenic varies from 0.001 to 3.32 mg/lit.
Groundwater exploration by CGWB reveals that in arsenic affected area, arsenic free deeper aquifers are available which are capable of yielding arsenic-free water.
Accordingly, deeper aquifers are exploited and arsenic-free water is supplied by state authorities.
Apart from this, the state govt., as well as other organization/agencies have installed arsenic-removal plants and domestic filters which are producing water with far below the permissible limit of arsenic content.

2) Salinity hazards in coastal belt:-

Due to brackish/ saline nature of shallow aquifers (10 to 150 m bgl) shallow tubewells are not favourable in the coastal blocks. The chemical analyses of the groundwater samples from these shallow aquifers show that, chloride ranges from 1854 to 13581 mg/lit and Electrical Conductivity ranges from 5960 to 41,350 µs/cm at 25°C. Due to salinity, shallow tubewells are not feasible for either drinking or irrigation purposes.
To overcome these problems, fresh groundwater bearing deeper aquifers (160-360 m bgl) are tapped and as alternate source, surface water is used for drinking (after treatment) and irrigation purposes.

3) Declining trend of water level :-

From the long-term monitoring data of water level, the average declining trends have been observed in almost all the blocks in the district except Bhangar-II and Kakdwip blocks.

4) **Risk to natural Disaster:-**

Sagar block of this district is highly prone to flood and cyclones as a result, embankment failures and washing off of villages are taking place. Out of 46 villages in this block already 3 villages, namely – Bishalakshmipur, Lohachara and Khasimara were steepened down into the sea and about 16 villages were partly destroyed by continuous embankment failures and subsequent destructions.

❖ *Awareness & Training Activity:-*

MASS AWARENESS PROGRAM (M.A.P.)

Mass Awareness Programme(MAP) — Two numbers of Mass Awareness Programmes were conducted in this district till date. The details are as follows:

Sl. No.	Place (Block)	Date	No. of Participants	Theme
1.	Canning (Canning I)	13.01.05	130	Scope of Exploration for fresh water and utility of rain water harvesting in coastal belt.

2.	Diamond Harbour (Diamond Harbour I)	02.11.06	280	Groundwater development and management with scope of Rain water harvesting

Source: CGWB Report, Ministry of Water Resources

❖ Water Management Training Programme (WMTP):-

Water Management Training Programme — One number of Water Management Training Programme was conducted in this district. The details are as follows:

Sl. No.	Place (Block)	Date	No. of Participants	Theme
1.	Diamond Harbour (Diamond Harbour I)	03.11.06	18	Groundwater Development and management with special reference to Rain Water Harvesting

❖ Exhibition/Mela/Fair etc.-

CGWB has participated in a Mela-cum-Exhibition in recent years in this district. The details are as follows:

Sl. No.	Place (Block)	Date	Organizer	Objectives
1.	Kultali, Basanti (Basanti)	20th to 29th December, 2005	Kultali Milan Tirtha Society, South 24 Parganas	Displayed various models, charts, maps prepared by CGWB to aware the common people on ground water issues.

Area Notified by CGWB/SGWA:- **Nil**

❖ Conclusions & Recommendations:-

1. Groundwater exploration may be continued and the sites may be selected in grid pattern as far as possible for delineating Arsenic-free and saline-free fresh ground water bearing zones. For identifying the potentiality of individual aquifer, Packer test is recommended.

2. A comprehensive and representative network of hydrograph stations tapping different aquifers may ensure better feedback of water level conditions and chemical conditions for the effective management of ground water development porogramme.

3. During construction of tube wells in Arsenic-free and saline-free fresh groundwater bearing aquifers, proper cement sealing should be done in the thick clay layer for a thickness of 3 to 4 meters for proper protection of the aquifer from the contaminated aquifer.

4. The tubewells withdrawing groundwater for drinking purposes, should be frequently tested for Arsenic. Wherever and whenever a tubewell yields Arsenic-contaminated groundwater, either it should be sealed or Arsenic-removal equipment should be used with proper and regular maintenance.

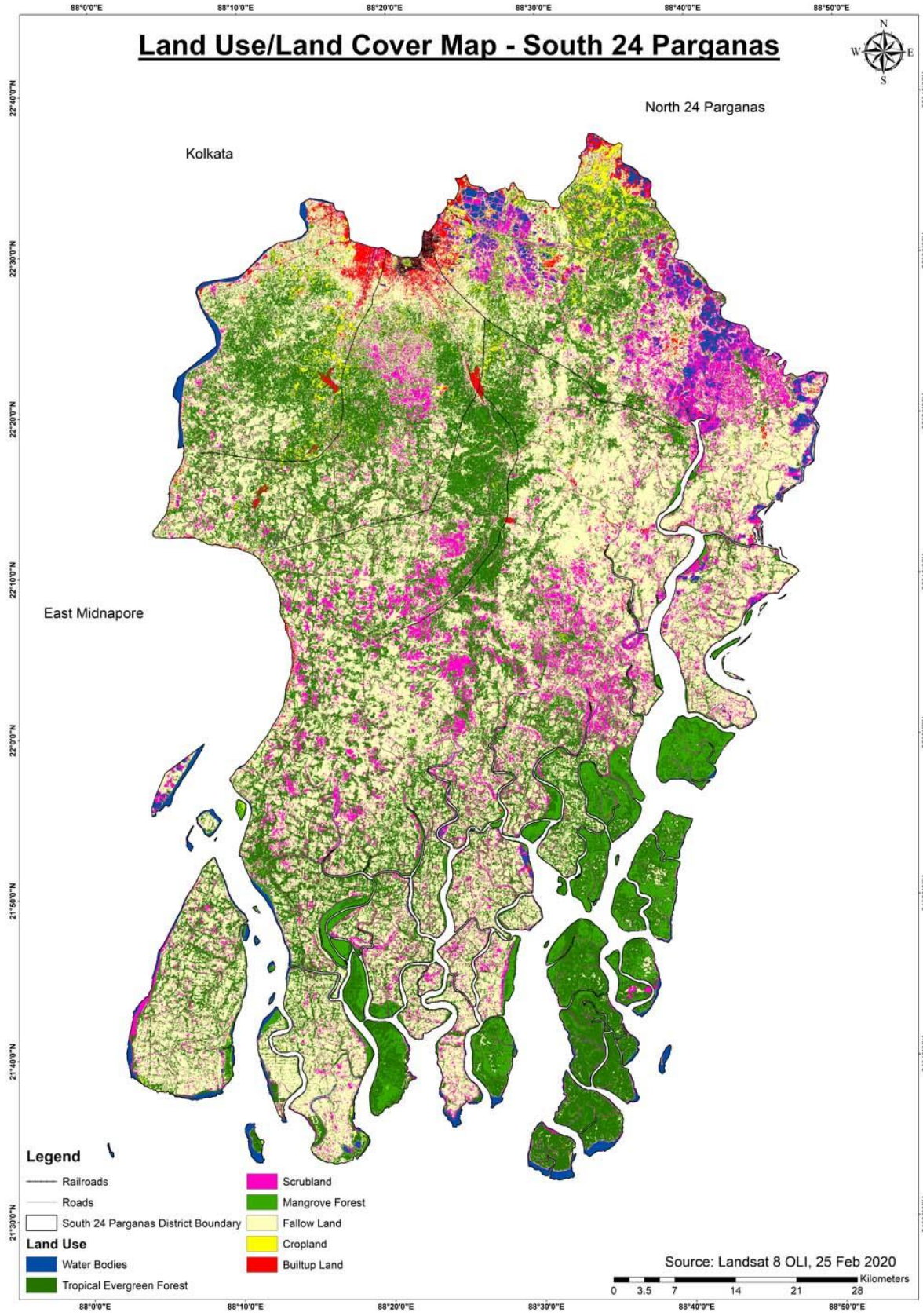
5. Modern agricultural management and irrigation practices should be adopted which includes economic distribution of ground water as well as surface water by maintaining minimum pumping hours and also by selecting most suitable cropping patterns which are economic.

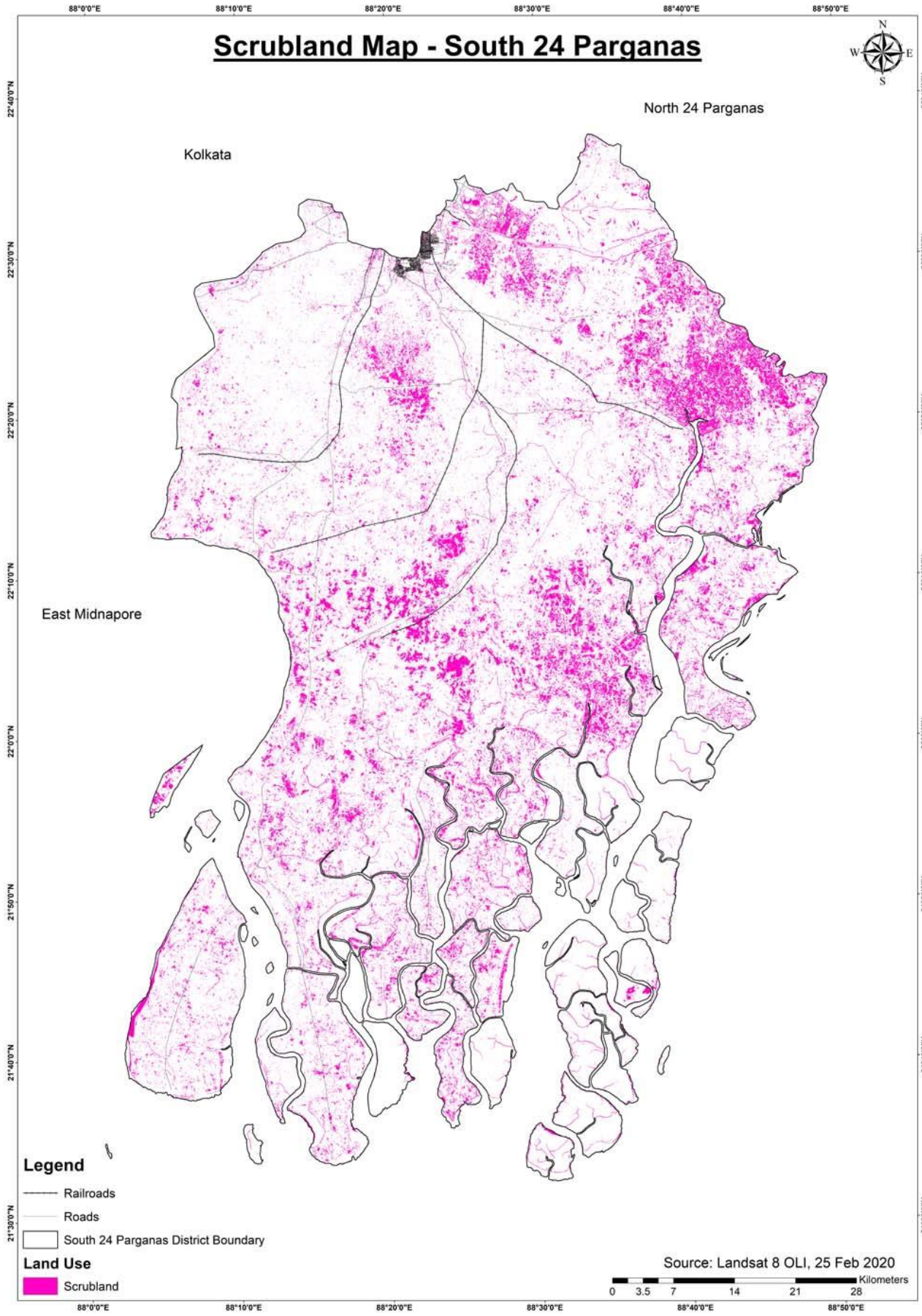
6. To maintain the sustainability of the tapped aquifer zones, large scale rainwater harvesting may act as effective measure to manage and control the groundwater resources for future. More number of rain water conservation structures may be constructed to store the huge rainwater during monsoon and may be used for irrigation and drinking purposes in the lean periods. Since, almost all the tubewells are tapping deeper freshwater bearing zones under confined conditions; artificial recharge to ground water is not feasible in this area.

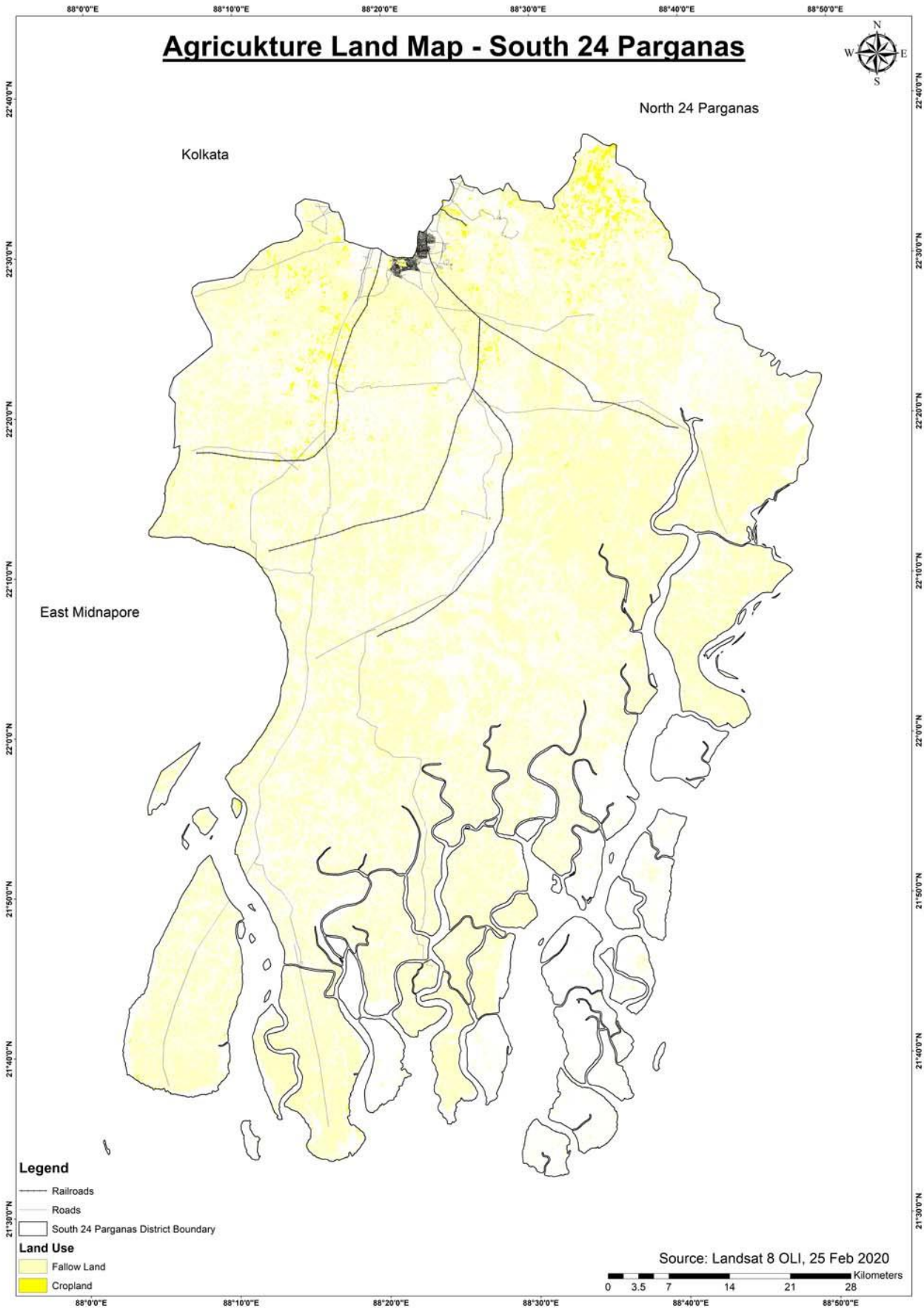
7. Conjunctive use of surface water and ground water for irrigation may be given importance in the area wherever technically and economically feasible in the district, to minimize the load of groundwater withdrawal.

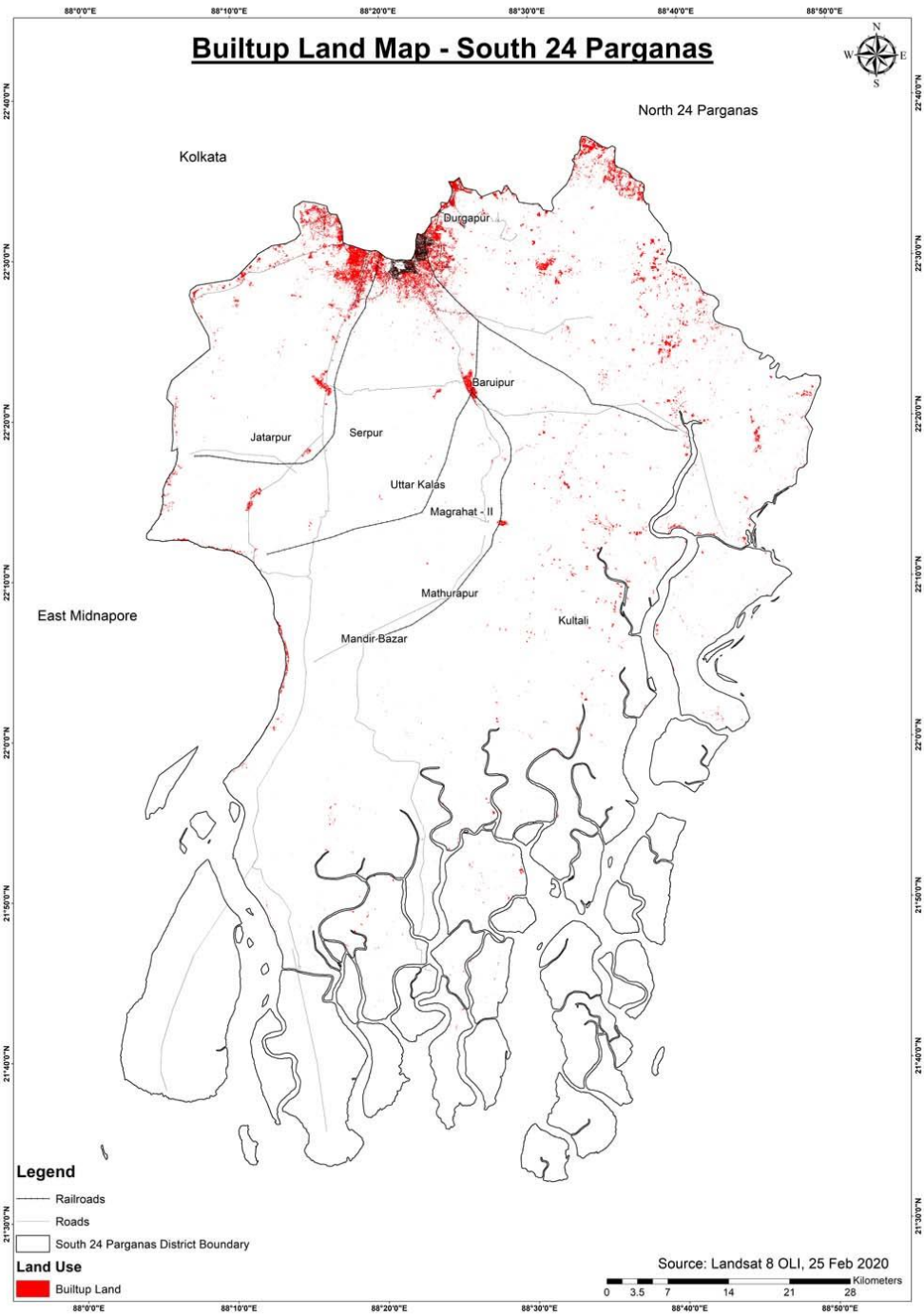
Source- CGWB Report, Ministry of Water Resources (South 24 Parganas District)

Chapter - 8 Land Utilization Pattern In The District



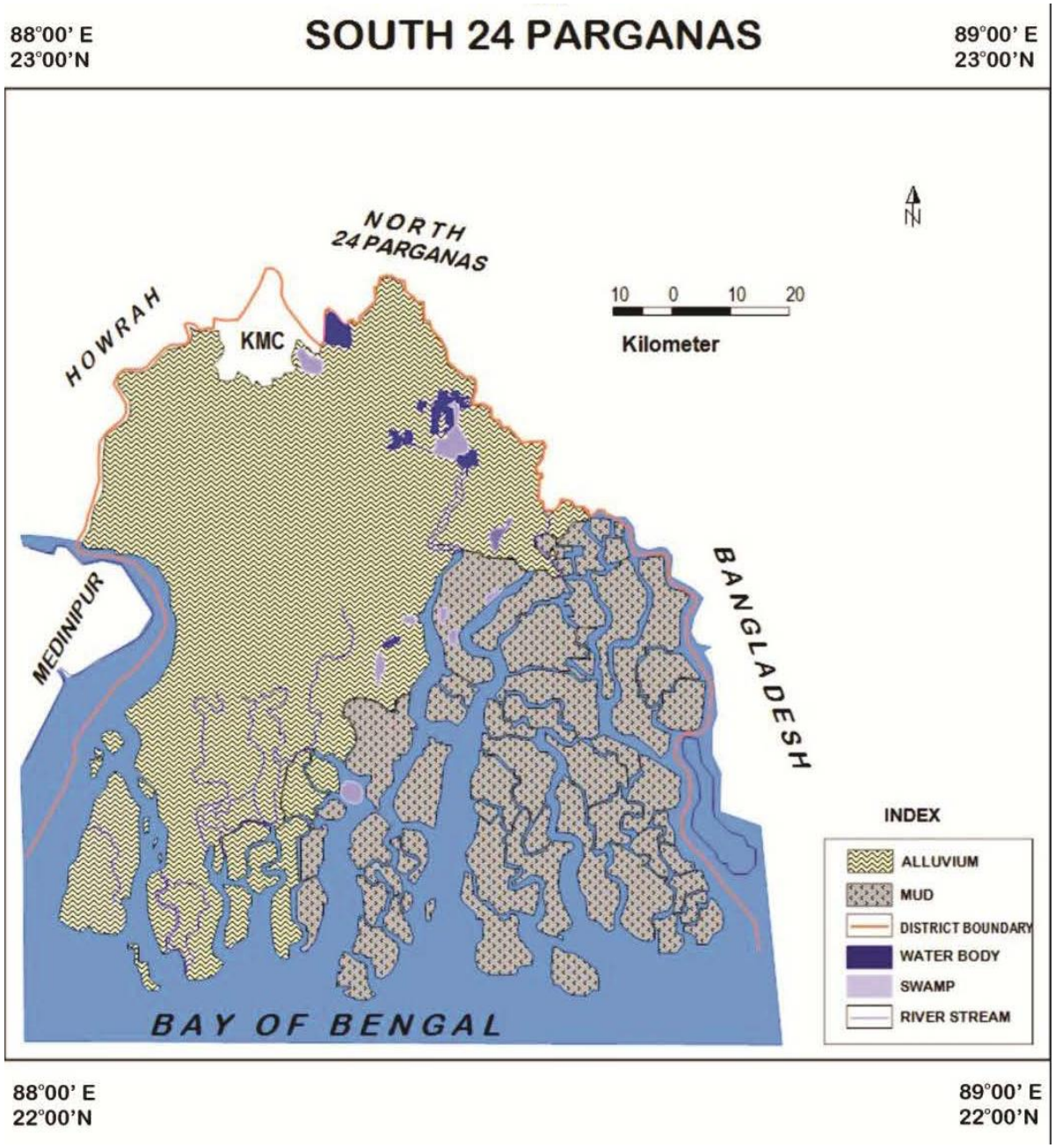

Scrubland Map - South 24 Parganas
North 24 Parganas
Kolkata
East Midnapore
N
S
E
W
88°0'0"E
88°10'0"E
88°20'0"E
88°30'0"E
88°40'0"E
88°50'0"E
22°40'0"N
22°30'0"N
22°20'0"N
22°10'0"N
22°0'0"N
21°50'0"N
21°40'0"N
21°30'0"N
Legend
Railroads
Roads
South 24 Parganas District Boundary
Land Use
Scrubland
Source: Landsat 8 OLI, 25 Feb 2020
0 3.5 7 14 21 28
Kilometers


Agricukture Land Map - South 24 Parganas
North 24 Parganas
Kolkata
East Midnapore
N
S
E
W
88°0'0"E
88°10'0"E
88°20'0"E
88°30'0"E
88°40'0"E
88°50'0"E
22°40'0"N
22°30'0"N
22°20'0"N
22°10'0"N
22°0'0"N
21°50'0"N
21°40'0"N
21°30'0"N
Legend
Railroads
Roads
South 24 Parganas District Boundary
Land Use
Fallow Land
Cropland
Source: Landsat 8 OLI, 25 Feb 2020
Kilometers
0 3.5 7 14 21 28



Land Use	Area (In Hectares)	Percentage
Builtup Land	9110.89	1.63
Mangrove Forest	25710.47	4.61
Cropland	9164.33	1.65
Water Bodies	15844.78	2.84
Tropial Evergreen Forest	177212.54	31.80
Scrubland	68657.74	12.32
Fallow Land	251601.56	45.15
Total	**557302.32**	**100**

Chapter - 9 Physiography of The District



Source: National Atlas and Thematic Mapping Organization

South 24 Parganas district is divided into two distinct physiographic zones: the marine-riverine delta in the north and the marine delta zone in the south. As the sea receded southwards, in the sub-recent geological period, a large low-lying plain got exposed. Both tidal inflows and the rivers have been depositing sediments in this plain. The periodical collapse of both the natural levees and man-made embankments speed up the process of filling up of the depressions containing brackish water wetlands. The marine delta in the south is formed of interlacing tidal channels. As non-saline water for irrigation is scarce, agriculture is monsoon dominated. Some parts of the wetlands are still preserved for raising fish. The entire

district is situated in the Ganges Delta and the eastern part of the district is a flat plain area with small towns, many in clusters.

The district can be categorized into three broad groups:-
a. The marshy riverine land of Sunderban. b. The non- Sundarban rural areas. c. The Urban and Semi Urban areas.

- **Sunderbans**

The Sundarbans delta is the largest mangrove forest in the world situated in the South 24 Parganas district. It lies at the mouth of the Ganges and is spread across areas of Bangladesh and West Bengal, India. The Bangladeshi and Indian portions of the jungle are listed in the UNESCO world heritage list separately as the Sundarbans and Sundarbans National Park respectively, though they are parts of the same forest. The Sundarbans are intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests, and presents an excellent example of ongoing ecological processes. The general average height of the area is 10 m. This area has been created by deposition of silt by its numerous rivers namely, Hoogly, Matla River, Jamira River, Gosaba River, Saptamukhi River, Haribhanga River and their tributaries. The formation of the delta is an ongoing process and new bars and islands are being created along the rivers and at the river mouth. A large section of the area remains under water during incoming times.

The area is known for its wide range of fauna. The most famous among these is the royal Bengal tiger, but numerous species of birds, spotted deer, crocodiles and snakes also inhabit it. It is estimated that there are now 400 Bengal tigers and about 30,000 spotted deer in the area

- **Ganges delta**

The Ganges delta consists of the whole of Nadia, Kolkata, North 24 Parganas, and South 24 Parganas districts and the Eastern half of Murshidabad district. River Ganges passes through this vast area and divides into three distinct parts – the old delta, the mature delta and the active delta.

The old delta consists of the districts of Murshidabad and Nadia. The formation of delta is complete and the rivers here are heavily silted and many have even dried up in due course of time. Silted rivers, swamps, beels and oxbow lakes forms the area. This area is also known as Bagri region.

The districts of Kolkata and North 24 Parganas form mature delta region. The rivers are slow and meandering and frequently shift their courses. Swamps, beels and oxbow lakes characterises the scenery. **The district of South 24 Parganas is known to be the active delta of the Ganges, where the formation of delta is still an ongoing process.**

Rarh is the region that intervenes between the Vajjabhumi and the Ganges Delta. Parts of the districts Murshidabad, Birbhum, Bankura, Purba Bardhaman, Paschim Bardhaman, Purba Medinipur and Paschim Medinipur constitute this region. The region is about 50 to 100 m above the sea level. This region is believed to be created from the soil from the Deccan plateau. The area is formed by the silt brought by the tributaries of Bhagirathi, Mayurakshi River, Ajay River, Damodar and Rupnarayan River which flow over the western plateau region made up of laterite soil make the soil of the area red in colour.

The land slope is from west to the south-east and formation of **natural levees along the river banks is a common phenomenon.**

The district of South 24 Parganas is a part of lower Gangetic plain where the delta building process is very much active in some parts, especially in the Sundarban. The district is covered with Quaternary sedimentation deposited by Ganga and its distributaries. The northern part has reached the mature stage in recent times. Here the land hardly rises above 5 meters from sea level in the northern part and 1 meter or so in the active delta part in the south which is a mesh of twisting rivers and tidal creeks, separating the islands. The entire district can be divided into two physiographic zones namely:

1. Marine River Delta
2. Marine Delta

The northern part of the district is known as the marine river delta. This physiographic zone experiences the influence of fluvial and marine geomorphological processes. In the recent past geological period the recession of sea in south ward direction caused the exposure of this marine river delta part. This large plain land is covered with thick layer of fine clay and subjected to tidal access. The upliftment of the basement complex is the main reason behind the recession of the sea. To maintain their profiles of equilibrium the rivers are deepening their valleys in a faster rate. This physiographic zone is characterized by brackish water wetlands. These wetlands often get filled by the breakdown of natural levees. This phenomenon of collapse of levees is very prominent in the north eastern part of the district of South 24 Parganas.

In the southern part of the district of South 24 Parganas, the marine delta zone is formed of inter-lacing tidal channels. The source of sediment is the tidal influx, which is polishing the continental shelf. The sediments get deposited between the inter-lacing river channels. Sand dunes have been created in the sea face. The entire district can be divided into four geomorphic units, such as delta plain, levee, marshes and islands.

THE LEVEES: The eastern side of the Hugli River is bounded by a strip of levees which are 8 meter higher than mean sea level. These levees extend from the north to the southern part of Kakdwip. The levees follow the meandering channel pattern of the river.

THE PLAINS: On the eastern side of the levees of Hugli River and beside the levees of Matla and Bidyadhari lies the monotonous plain. Elevation of this extensive plain is 3 to 5 meters from the mean sea level. The plain starts mainly from the south eastern and eastern part of Kolkata Metropolis. This plain is highly used for paddy and jute cultivation.

THE MARSHES: There are a number of low lying marshy lands in the bordering zone of the levees. The marshy lands are mainly inundated by the saltwater of estuary. Many of marshy land are filled up with alluvium for agriculture and settlement purpose.

THE ISLANDS: The estuary area of South 24 Parganas is ornamented by numerous islands. The notable islands are: Khashimara, Ghoramara, Lohachara and Sagar island group between Hugli River and Muriganga River. Masuni Island is situated in between Muriganga and Peet's creek. Frezergang Island is surrounded by Edward's creek, Bakkhali River and Saptamukhi Estuary from all the sides. The Susni Char, Lothian, Prentice, Henry's and Frederick Island are situated at the mouth of Saptamukhi River. The Halliday Island is located at the mouth of river Matla. The other islands of this area are Balucherry Island between Jamira and Matla, Dalhousie Island between Matla and Gosaba, Bangaduni Island at the mouth of Gosaba River and there many more islands are formed in Sundarban area which remained unnamed till date.

(Source: Human development Report, South 24 Parganas, West Bengal. 2009)

Chapter - 10 Rainfall: Month Wise & Climate Condition

Dist. - South 24 Parganas Rainfall Data (mm.)					
	2018	2017	2016	2015	2014
Jan	0.00	0.00	7.20	10.90	0.00
Feb	0.40	0.10	63.30	5.70	49.80
Mar	0.40	69.80	1.60	15.50	20.20
Apr	44.20	42.90	7.60	69.10	0.00
May	95.90	42.90	100.40	35.90	190.30
Jun	424.60	149.20	181.90	264.30	214.20
Jul	460.60	540.40	472.40	754.60	323.60
Aug	257.90	276.10	534.50	351.50	352.60
Sep	181.30	207.50	221.60	196.40	317.90
Oct	127.50	310.30	93.90	23.50	109.70
Nov	4.40	26.70	54.00	2.80	0.50
Dec	9.50	24.80	0.00	7.60	1.00

Source: Indian Meteorological Department, Nagpur

The Indian Meteorological Department, Nagpur, vide letter No. NAGPUR RMC/CS-312, dated 18th January, 2016 has provided the period of Rainy Season viz. Normal dates of Onset and Withdrawal of South West Monsoon over India as state-wise. The duration for the period is 10th June to 15th October.

The annual precipitation of the district is from 1750 mm to 1770 mm, while the temperate varies throughout the year is 36.3° C to 13.3° C with relative annual humidity of 71% to 85%.

Chapter - 11 GEOLOGY AND THE MINERAL WEALTH OF THE AREA

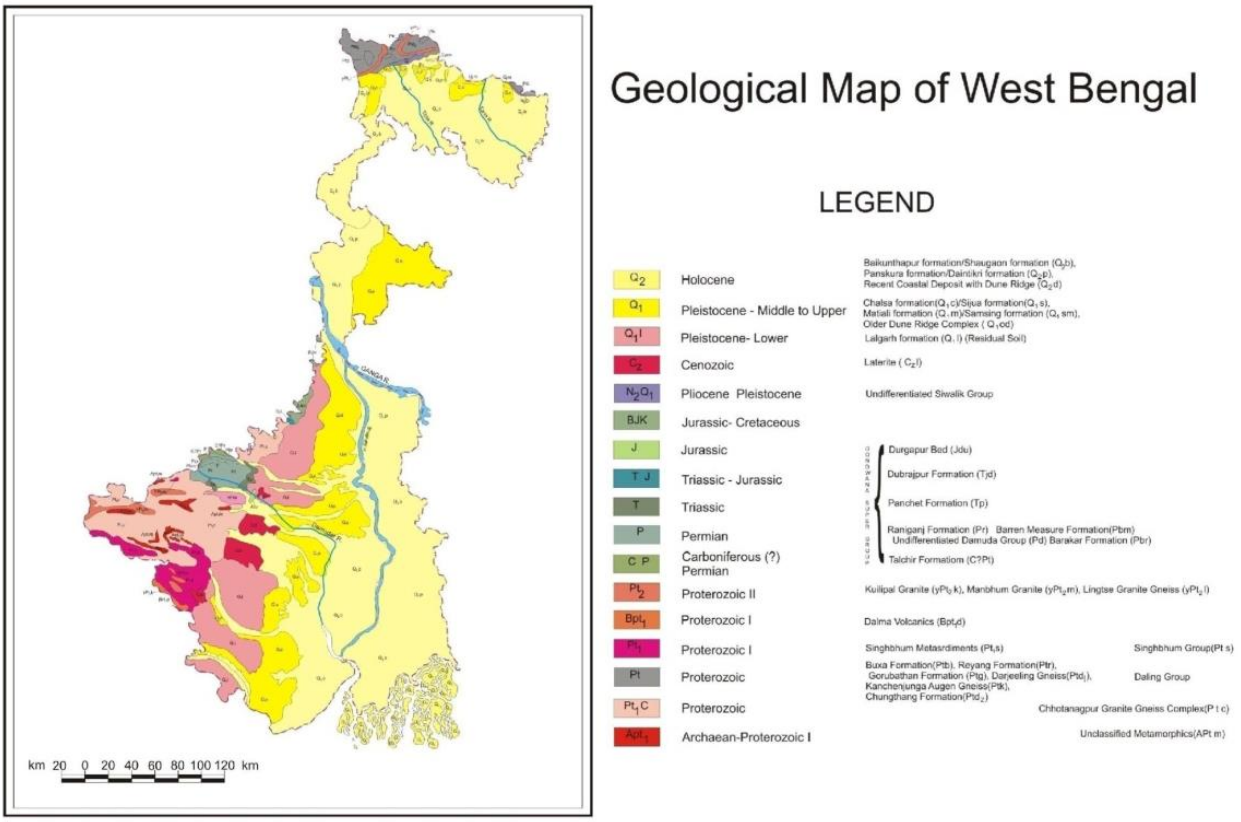
The Bengal Basin in the northeastern part of Indian subcontinent, between the Indian Shield and Indo-Burman Ranges, comprises three geo-tectonic provinces: (1) The Stable Shelf; (2) The Central Deep Basin (extending from the Sylhet Trough in the northeast towards the Hatia Trough in the south); and (3) The Chittagong–Tripura Fold Belt. Due to location of the basin at the juncture of three interacting plates, viz., the Indian, Burma and Tibetan (Eurasian) Plates, the basin-fill history of these geo-tectonic provinces varied considerably. Precambrian metasediments and Permian–Carboniferous rocks have been encountered only in drill holes in the stable shelf province. After Precambrian peneplanation of the Indian Shield, sedimentation in the Bengal Basin started in isolated graben-controlled basins on the basement. With the breakup of Gondwanaland in the Jurassic and Cretaceous, and northward movement of the Indian Plate, the basin started downwarping in the Early Cretaceous and sedimentation started on the stable shelf and deep basin; and since then sedimentation has been continuous for most of the basin. Subsidence of the basin can be attributed to differential adjustments of the crust, collision with the various elements of south Asia, and uplift of the eastern Himalayas and the Indo-Burman Ranges. Movements along several well-established faults were initiated following the breakup of Gondwanaland and during downwarping in the Cretaceous.

By Eocene, because of a major marine transgression, the stable shelf came under a carbonate regime, whereas the deep basinal area was dominated by deep-water sedimentation. A major switch in sedimentation pattern over the Bengal Basin occurred during the Middle Eocene to Early Miocene as a result of collision of India with the Burma and Tibetan Blocks. The influx of clastic sediment into the basin from the Himalayas to the north and the Indo-Burman Ranges to the east rapidly increased at this time; and this was followed by an increase in the rate of subsidence of the basin. At this stage, deep marine sedimentation dominated in the deep basinal part, while deep to shallow marine conditions prevailed in the eastern part of the basin. By Middle Miocene, with continuing collision events between the plates and uplift in the Himalayas and Indo-Burman Ranges, a huge influx of clastic sediments came into the basin from the northeast and east. Throughout the Miocene, the depositional settings continued to vary from deep marine in the basin to shallow and coastal marine in the marginal parts of the basin. From Pliocene onwards, large amounts of sediment were filling the Bengal Basin from the west and northwest; and major delta building processes continued to develop the present-day delta morphology.

Since the Cretaceous, architecture of the Bengal Basin has been changing due to the collision pattern and movements of the major plates in the region. However, three notable changes in basin configuration can be recognized that occurred during Early Eocene, Middle Miocene and Plio-Pleistocene times, when both the paleogeographic settings and source areas changed. The present basin configuration with the Ganges–Brahmaputra delta system on the north and the Bengal Deep Sea Fan on the south was established during the later part of Pliocene and

Pleistocene; and delta progradation since then has been strongly affected by orogeny in the eastern Himalayas. Pleistocene glacial activities in the north accompanied sea level changes in the Bay of Bengal.

The South 24-Parganas district is located in the lower deltaic plain on the composite Gangetic Delta and is covered by the Quaternary sediments deposited by the Ganga and its tributaries. The top of the alluvium is clayee in nature with varying thickness of 15 to 75 metres. Fine sand and silty-clay capping also occurs in small patches in the alluvium. Underlying the clay blankets occurs a huge thickness of unconsolidated sediments composed of silt, fine to coarse grained sand and gravel with increasing thickness towards east- southeast. The gravel zone may be considered as a marker horizon which is underlain by another extensive clay zone at varying depths. Beneath this clay zone, occurs a second group of aquifers in the depth range of 160 to 360 metres with considerable aerial extent. A succession of Tertiary and Mesozoic formations within the depth range of 350 m to 4000 metres is established by the exploration conducted by Standard Vacuum Oil Company. These geological horizons are sloping gently towards south-southeast.



Chapter - 12 ADDITIONAL INFORMATION

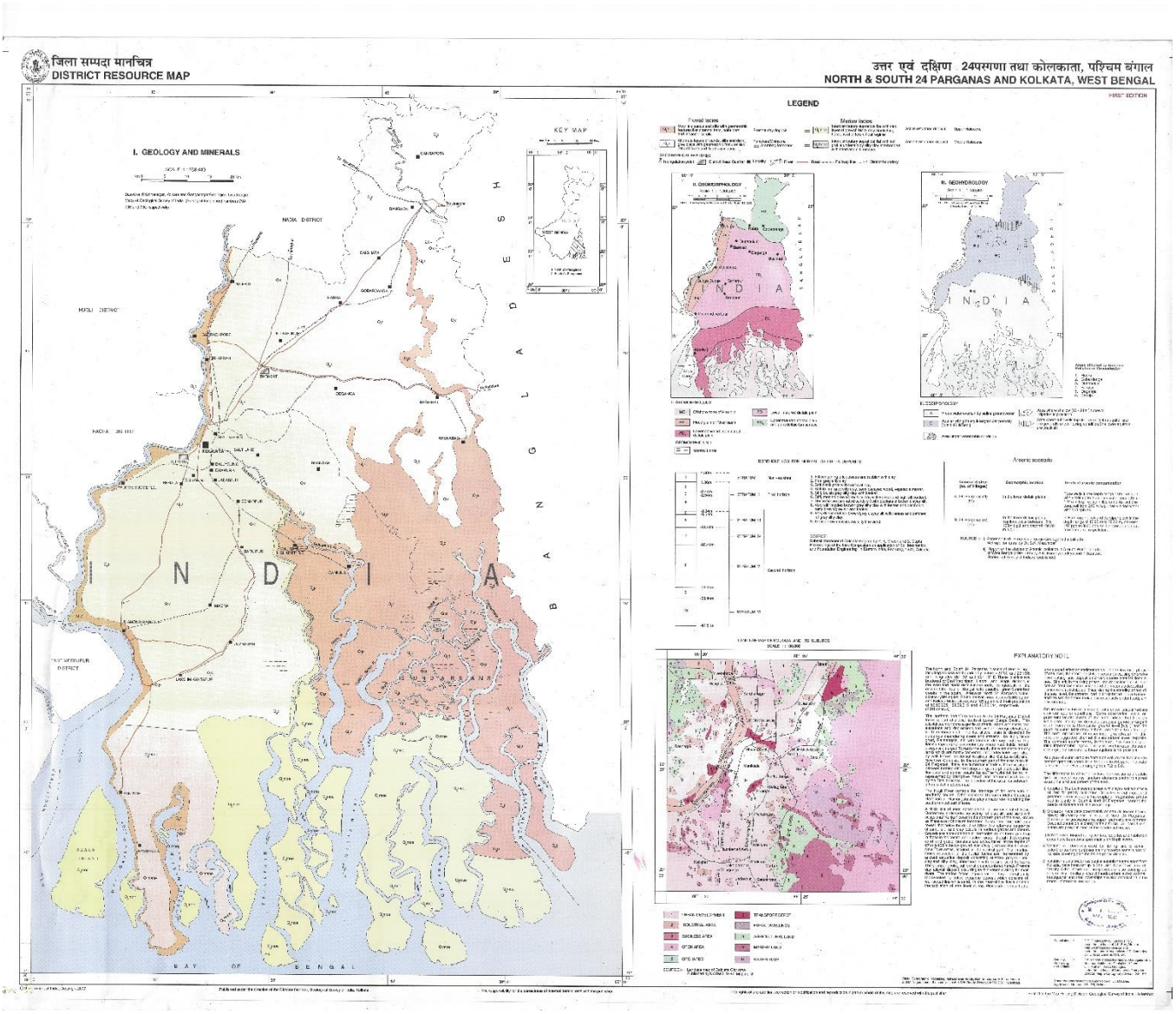
❖ *Drainage system with description of main rivers*

Drainage system with description of main river			
Sl.no	**Name of the River**	**District of Hooghly area in (square km)**	**% Area Drained in the District**
1	Hooghly	166.06	2.97%
2	Thakuran	42.78	0.76%
3	Bidyadhari	338.64	6.07%
4	Matla	276.25	4.95%
5	Piyali	9.45	0.16%

❖ *Salient features of Important Rivers and Streams*

Salient Features of Important River and Streams				
S.no	**Name of the River Stream**	**Total Length in the District (in km)**	**place of Origin**	**Altitude at Origin**
1	Hooghly	42.58	Giria, West Bengal	**27 m**
2	Thakuran	25.02	Jaynagar, West Bengal	8m
3	Bidyadhari	60.58	Haringhata, West Bengal	10m
4	Matla	85.82	Daharani, West Bengal	3m
5	Piyali	13.71	Dhosa, West Bengal	5m

Chapter - 13 MINERAL MAP OF THE DISTRICT



Chapter - 14 DETAILS OF ECO- SENSITIVE AREA IN THE DISTRICT

Sunderban Tiger Reserve is one amongst the initial nine Tiger Reserves constituted at the time of inception of the Project Tiger scheme in the year 1973. Apart from a small area in 24 Parganas (North) it is largely situated within 24 Parganas (South) districts of West Bengal lying at the southern end of the State. It is a part of the famous "Sunderbans" - the largest delta in the world formed by the convergence of two mighty Himalayan rivers the Ganga and the Brahmaputra both of which flow into the Bay of Bengal. This delta consists of 10,200 sq km of mangrove forests spread over India (4,200 sq km) and Bangladesh (6,000sq km) forests areas. The Indian Sunderban region consists of 4,200 sq km of reserved forests along with 5,400 sq km of non-forest area ie a total of 9600 sq. km. Of this the Sundarban Tiger Reserve is spread over 2585 sq. km. The entire area is a conglomeration of river channels, creeks and islands which total about 102 in number. Of these 54 islands are inhabited and the rest 48 islands are forested. The name Sundarbans is thought to be derived from the Sundari (Heritiera fomes) tree. Another view is that the name comes from the Sundar ban meaning a beautiful forest. The Sundarban Tiger Reserve has an area of 2585 sq km and is divided into the Core and the Buffer zone. The Core zone consists of the Sundarban National Park having an area of 1330.12 sq. km considering the ecological importance of this area it has been designated by the UNESCO as a natural World Heritage Site in 1987.

The area lies at the southern end of the state falling mainly within 24(P) South and partly in 24P(N) Districts between the latitudes 21° 31' and 22° 32' North and longitudes 88° 10' and 89° 51'East longitudes.

Chapter - 15 IMPACT ON THE ENVIRONMENT DUE TO MINING

❖ *For Sand Mining:-*

The environmental components that are likely to be influenced or modified by the continuation of mining activities are: Air, Water, Noise, Soil, Hydrology, Ecology & Bio-diversity, Socio-economic status etc.

Major activities involve in the operation phase are -

- Excavation,
- Loading of material on truck by excavator
- Movement of vehicle on 'kaccha' road of villages

✓ Air Pollution

In this mining project the only source of air pollution is excavation, transportation, loading and handling of minerals etc. The proposed mining operations are not anticipated to raise the concentration of pollutants beyond prescribed limits. However, the measures are suggested to mitigate the negative impact of the proposed mining activity to control the pollutants by plantation of trees along haul roads, specially near settlements, to help to reduce the impact of dust on the nearby villages; planning transportation routes of mined material so as to reach the nearest paved roads by shortest route (minimize transportation over unpaved road); regular water sprinkling on unpaved roads to avoid dust generation during transportation etc.

Emission of PM_{10}

The major sources of PM10 emission in case of sand mining project are the loading activity at mine site (loading of material over trucks / trucks by excavators) and the movement of vehicles on unpaved haul roads.

Loading of Material

The excavated materials will be loaded on dumpers using excavators.

Emission of PM10 due to Transportation

The hauling of minerals from the mine lease area to the end users via haul road (unpaved road) will cause emission of particulate matters. This emission will be limited to the extent of unpaved haul road starting from mining pit to nearest paved road connectivity.

Emission of CO from Vehicles

The excavated minerals will be transported outside the mining area for end use. The ARAI emission factors for CO emitting from heavy vehicles (diesel) is 3.92 gm/km or 6.32 g/mile.

Air Emissions

- Dust and air emission particularly due to the excavation, construction and movement of vehicles resulting in air pollution.

- No. of PCU/Hr will increase due to mining in existing traffic scenario lead to air pollution which can cause adverse effect on human health of neighbouring villagers like effect on breathing and respiratory system, damage to lung tissue, cancer and premature death, influenza or asthma.

✓ Noise Pollution

- Noise Impact due to mining activities.
- Human Noise from the machinery can cause hypertension, high stress level, hearing loss, sleep disturbance etc. due to prolonged exposure.
- Increase in the existing traffic due to this mining activity may occur unwanted sound and can also cause impact on human health of neighbouring villagers like effect on breathing and respiratory system, damage to lung tissue, cancer and premature death, influenza or asthma.

✓ Water Pollution

- Flow pattern might be changed due to river bed mining.
- Mining activities depth will be increased, which may result in increase of flow velocity.
- Change in surface water quality and ground water quality.
- Impact on ground water recharge potential as the thickness of the natural filter materials (sediments) is reduce causing less infiltration.
- Waste water discharge.

✓ Soil Environment

- Mining activity may increase the soil erosion and soil degradation which have adverse impact on soil fertility.
- Top soil extraction from outside riverbed may also affect the soil fertility and productivity.
- During the flood, the soil erosion may occur.

✓ Solid Waste Generation / Management

- Flow pattern might be changed due to river bed mining.
- Mining activities depth will be increased, which may result in increase of flow velocity.
- Waste water discharge.

✓ Land Use

- The mining activity in the outside riverbed will be converted into the pit. which may cause soil erosion, soil degradation etc.
- Mining in the riverbed may change complete land use pattern including channel geometry, bed elevation, sediment transportation capacity which can reduce flow of the river and downstream erosion.

✓ Hydrology

- The mining in the riverbed area may cause the ground water contamination due to intersection of the water table.
- Change the topography will divert the river flow.
- Change in topography can change the river flow and flood may occur.
- Slope of mining area will change which can create soil erosion and divert rain water runoff channel.

✓ Topography, Drainage and Ground water Contamination

- Spillage of oil from construction / transportation vehicles and equipment.

✓ Biological Environment

- Transportation of sand in the trucks/dumper will disturb the movement of wild animals like jungle cat, jackal, and other reptiles. Fugitive emission from vehicle movement will form a layer in leaves thus reducing the gaseous exchange process. This ultimately affects the growth of plants. Chances of vehicle collisions with wildlife attempting to cross roads are possible.
- Any human settlement in the mining area will disturb the vegetation cover and reptiles
- Indiscriminate mining from active channels of rivers causes many adverse effects on the benthic fauna, which inhabits the bottom sandy substratum. Excessive sand extraction from rivers affects the eco-biology of many terrestrial insects whose initial life history begins in aquatic environments
- Stomatal index may be minimized due to dust deposit on leaf.

✓ Socio-economic

- Such shops along the roads will generate solid waste and waste water which will have adverse impact on human health.
- Further, the deep pits created in the channel also can contribute to an increase in accidents in the working environment.

❖ *For Mines Other Than Sand Mining:-*

Mining is the extraction of minerals and other geological materials of economic value from deposits on the Earth. Mining adversely affects the environment by inducing loss of biodiversity, soil erosion, and contamination of surface water, groundwater, and soil. Mining can also trigger the formation of sinkholes. The leakage of chemicals from mining sites can also have detrimental effects on the health of the population living at or around the mining site.

- ✓ **AIR POLLUTION**

Air quality is adversely affected by mining operations. Unrefined materials are released when mineral deposits are exposed on the surface through mining. Wind erosion and nearby vehicular traffic cause such materials to become airborne. Lead, arsenic, cadmium, and other toxic elements are often present in such particles. The air borne particulate matter generated by mining of mineral (drilling & blasting), handling of minerals and transportation. The emissions of Sulphur dioxide (SO2), Oxides of Nitrogen (NOx) are from diesel operated excavation/loading equipment, Compressor, DG set and vehicles plying on haul roads. These pollutants can damage the health of people living near the mining site. Diseases of the respiratory system and allergies can be triggered by the inhalation of such airborne particles.

Sources of air pollution are as follows:

- Dust and gaseous emissions due to Drilling & Blasting, stockpiling, extraction and loading of stone by various mining activities.
- Dust and gaseous emissions due to movement of transport vehicles
- Gaseous emissions due to operation of Compressor, DG Set.

WATER POLLUTION

Mining also causes water pollution which includes metal contamination, increased sediment levels in streams, and acid mine drainage. Pollutants released from processing plants, tailing ponds, underground mines, waste-disposal areas, active or abandoned surface or haulage roads, etc., act as the top sources of water pollution. Sediments released through soil erosion cause siltation or the smothering of stream beds. It adversely impacts irrigation, swimming, fishing, domestic water supply, and other activities dependent on such water bodies. High concentrations of toxic chemicals in water bodies pose a survival threat to aquatic flora and fauna and terrestrial species dependent on them for food. The acidic water released from metal mines or coal mines also drains into surface water or seeps below ground to acidify groundwater. The loss of normal pH of water can have disastrous effects on life sustained by such water.

Sources of water pollution from the Mine shall be as follows:

- Domestic waste water from Office & Rest Room
- Run-off from waste dump in rainy season

Adequate control measures will be adopted to check not only the wash-off from soil erosion but also uncontrolled flow of mine water.

NOISE POLLUTION

Mining operations involve deployment of mining machineries, drilling, blasting, excavation and transportation of stone. Noise may be generated by the impact from drill bits and mechanical vibration from drill casings, as well as impulse noise from exhaust and ancillary equipment such as fans and blowers for mine ventilation.

LAND ENVIRONMENT

The creation of landscape blots like open pits and piles of waste rocks due to mining operations can lead to the physical destruction of the land at the mining site. Such disruptions can contribute to the deterioration of the area's flora and fauna. There is also a huge possibility that many of the surface features that were present before mining activities cannot be replaced after the process has ended. The removal of soil layers and deep underground digging can destabilize the ground which threatens the future of roads and buildings in the area.

Chapter - 16 REMEDIAL MEASURES TO MITIGATE THE IMPACT OF MINING ON THE ENVIRONMENT

❖ *REMEDIAL MEASURES FOR SAND MINING :-*

✓ Air Environment

In mining projects the only source of air pollution is excavation, transportation, loading and handling of minerals etc. However, the measures are suggested to mitigate the negative impact of the proposed mining activity to control the pollutants by plantation of trees along haul roads, specially near settlements, to help to reduce the impact of dust on the nearby villages; planning transportation routes of mined material so as to reach the nearest paved roads by shortest route (minimize transportation over unpaved road); regular water sprinkling on unpaved roads to avoid dust generation during transportation etc.

Impact	Mitigation Measures
Air Emissions • Dust and air emission particularly due to the excavation, construction and movement of vehicles resulting in air pollution.	• Provision of spraying water to reduce dust emission on roads and particularly near existing settlements. • Excavated topsoil to be preserved and reused for landscaping. • The amount of exposed ground and stockpiles will be minimized so that re-suspension due to wind and subsequent dust fall is prevented. Heights of stock piles should control dust fall in nearby areas. • Arrangement of the soil will be such that existing drainage pattern, though altered, will still ensure that runoff does not carry away topsoil but reaches the water bodies with which it is linked. Ensuring all vehicles, generators and compressors are well maintained and regularly serviced.

The following measures are suggested to mitigate any negative impacts of mining:

- Planned multiple transportation routes in different direction to minimize the dust generation.
- Planned paved roads outside mine lease area to minimize the dust generation. Alternatively, planning transportation routes so as to reach the nearest paved roads by shortest route. (Minimize transportation over unpaved road).
- Frequent water sprinkling on unpaved roads (>2L/m2).
- Plantation of trees along haul roads, especially near settlements, to reduce the impact of dust on the nearby villages.
- Dust mask shall be provided to the workers engaged at dust generation points like excavations and loading points.
- Transportation of material shall be carried out during day time only.

- The speed of trucks plying on the haul road should limited to 20 km/hour to avoid generation of dust.
- Covering of material by tarpaulin during transportation on trucks to prevent spillage of materials from the trucks.
- Overloading shall be avoided.

Movement of Traffic-

Impact	Mitigation Measures
• No. of PCU/Hr will increase due to mining in existing traffic scenario lead to air pollution which can cause adverse effect on human health of neighbouring villagers like effect on breathing and respiratory system, damage to lung tissue, cancer and premature death, influenza or asthma.	• Vehicles with PUC Certificate will be hired. Regular maintenance of vehicles will be done to ensure smooth running of vehicle. It is proposed to plant local species trees per year with consultation of Forest department with some fruit bearing and medicinal trees, along the haul roads, outer periphery within the lease area to prevent the impact of dust in the nearby village. Regular Health checkup camps will be organized.
• No. of PCU /Hr will increase in the existing traffic due to this mining activity hence vehicle collation may occur unwanted sound and can also cause impact on human health.	• In addition, truck drivers will be instructed to make minimum use of horns in the village area and sensitive zones. It is proposed to plant local species trees per year with consultation of Forest department with some fruit bearing and medicinal trees, along the haul roads, outer periphery within the lease area to reduce the impact of noise in the study area. Regular Health checkup camps will be organized.
• Accidents may be occurring due to fast movement of vehicles.	• To avoid accidents the speed of vehicles will be low near habitation areas.

✓ **Noise Pollution**

It can be stated that the impact on the present noise levels due to mining operations will be minimal and shall be restricted to transportation route only. There is no drilling and blasting envisaged in the sand mining so there is no impact of vibration.

Impact	Mitigation Measures
• Noise Impact due to mining activities. • Human Noise from the machinery can cause hypertension, high stress level, hearing loss, sleep disturbance etc. due to prolonged exposure. • Increase in the existing traffic due to the mining activity may occur	• Noise generated be this equipment will be intermittent and does not cause much adverse impact. • The noise measurement data indicated that present noise levels in the study area is within the permissible limits of National Ambient Noise Quality Standards. • Periodical monitoring of noise will be done. • No other equipment except the transportation vehicles and excavator for loading will be allowed. • Proper maintenance of all equipment / machines will be carried out which help in reducing noise during operations.

Impact	Mitigation Measures
unwanted sound and can also cause impact on human health of neighbouring villagers like effect on breathing and respiratory system, damage to lung tissue, cancer and premature death, influenza or asthma.	• In addition, truck drivers will be instructed to make minimum use of horns in the village area and sensitive zones. • Plantation will be taken up along the approach roads and vicinity of river bank. The plantation minimizes propagation of noise and also arrests dust. • Ear muffs will be provided while working on mining equipment. • Regular health check-ups will be conducted for any such health implications

✓ **Water Environment**

Impact	Mitigation Measures
• Flow pattern might be changed due to river bed mining. • Mining activities depth will be increased, which may result in increase of flow velocity.	• No diversion is proposed. There will not be any adverse impact on flow pattern, surface hydrology and ground water regime. • Mining activities will be restricted to not more than 3m depth, which will not cause much change in flow pattern of the river.
• Change in surface water quality and ground water quality.	• The mining will not be allowed below the water table. • Regular monitoring of water samples will be done as precautionary measures.
• Impact on ground water recharge potential as the thickness of the natural filter materials (sediments) is reduce causing less infiltration.	• Mining will be done as per approved Mine Plan and applicable Rules & Regulation, so that there is no damage on ground water recharge potential due to sand mining.
• Waste water discharge.	• Portable Bio-toilets will be used; hence no sewage / liquid effluent will be generated and contamination is also not expected due to percolation.

✓ **Soil Environment**

Impact	Mitigation Measures
• Mining activity may increase the soil erosion and soil degradation which have adverse impact on soil fertility.	• It is already proposed to plant local species trees per year with consultation of Forest department with some fruit bearing and medicinal trees, along the haul roads, outer periphery within the mining area which enhances the binding property of the soil to check the erosion. • Water will be sprinkled on unpaved roads to avoid dust generation and soil erosion.
• Top soil extraction from outside riverbed may also affect the soil fertility and productivity.	• In case of riverbed, no top soil will be generated during the mining activity.

Impact	Mitigation Measures
• During the flood, the soil erosion may occur.	• Mine lease area has been proposed leaving a safety distance from the bank inwards which will protect the banks. Check dams have been constructed at various places for protection of banks against direct attack of the rivers and avoid bank cutting.

✓ **Solid Waste Generation / Management**

Impact	Mitigation Measures
• Flow pattern might be changed due to river bed mining. • Mining activities depth will be increased, which may result in increase of flow velocity.	• No diversion is proposed. There will not be any adverse impact on flow pattern, surface hydrology and ground water regime. • Mining activities will be restricted to 1.5 m depth, which will not cause much change in flow pattern of the river.
• Waste water discharge.	• Portable Bio-toilets will be used; hence no sewage / liquid effluent will be generated and contamination is also not expected due to percolation.

✓ **Land Use**

Impact	Mitigation Measures
• The mining activity in the outside riverbed will be converted into the pit. Which may cause soil erosion, soil degradation etc.	• It is proposed to plant of local species trees per year with consultation of Forest department with some fruit bearing and medicinal trees, along the haul roads, outer periphery within the mining area which enhances the binding property of the soil.
• Mining in the riverbed may change complete land use pattern including channel geometry, bed elevation, sediment transportation capacity which can reduce flow of the river and downstream erosion.	• The mining is planned in non-monsoon seasons only so that the excavated area will be replenished naturally during the subsequent rainy season for the river bed mining block. • Mine lease area has been proposed leaving a safety distance from the bank inwards which will protect the banks so channel geometry will not be disturbed. Check dams have been constructed at various places for protection of banks against direct attack of the rivers and avoid bank cutting. • Pre and post monsoon survey for sedimentation in the riverbed will be done regularly

✓ **Hydrogeology**

Impact	Mitigation Measures
• The mining in the riverbed area may cause the ground water contamination due to intersection of the water table.	• The water table will not be intersected during mining in the riverbed as ultimate depth is limited Proper analysis/Monitoring will be done to check the ground and surface water
• Change the topography will divert the river flow.	• There is no proposal of any stream modification/diversion due to this mining activity hence there will be no any impact on flow of the river.
• Change in topography can change the river flow and flood may occur.	• Mining will be prohibited in monsoon season.
• Slope of mining area will change which can create soil erosion and divert rain water runoff channel.	• The maximum depth of mining in the river bed will not exceed 3 meters and the maximum depth of mining in outside riverbed will not exceed.

✓ **Topography, Drainage and Ground water Contamination**

Impact	Mitigation Measures
• Spillage of oil from construction / transportation vehicles and equipment.	• Spillage of oil from construction vehicles and equipment will be avoided. These should be inspected by supervisor for any leakage of oil. • Collection of water in pits will be avoided. • Contamination of soil will be avoided by suitable soil conservation measures.

✓ **Biological Environment**

Impact	Mitigation Measures
• Transportation of sand in the trucks/dumper will disturb the movement of wild animals like jungle cat, jackal, and other reptiles. Fugitive emission from vehicle movement will form a layer in leaves thus reducing the gaseous exchange process. This ultimately affects the growth of plants. Chances of vehicle collisions with wildlife attempting to cross roads are possible.	• Transportation of sand will only be day time. Access roads will not encroach into the riparian zones.
• Any human settlement in the mining area will disturb the vegetation cover and reptiles	• No human settlement will be permitted in the lease mining or nearby area. No mining will be

Impact	Mitigation Measures
	carried out during the rainy season to minimize impact on aquatic life.
• Indiscriminate mining from active channels of rivers causes many adverse effects on the benthic fauna, which inhabits the bottom sandy substratum. Excessive sand extraction from rivers affects the eco-biology of many terrestrial insects whose initial life history begins in aquatic environments	• Mining will be done only in riverbed and outside riverbed as per provided by DMG so there will be no impact on benthic fauna in riverbed hence no mitigation will be required.
• Stomatal index may be minimized due to dust deposit on leaf.	• Water will be sprinkled on unpaved roads to avoid dust generation.

✓ **Socio-economic**

Impact	Mitigation Measures
• Due to mining and transportation of sand will generate the small shops, dhabas, garage, restaurant, vegetable shops etc. along the road and generate direct employment.	• Positive Impact
• Mining activity will generate direct employment which will be employed locally and preference will be given to local people.	• Positive Impact
• Such shops along the roads will generate solid waste and waste water which will have adverse impact on human health.	• Garbage bins will be provided for proper disposal of solid waste.
• Further, the deep pits created in the channel also can contribute to an increase in accidents in the working environment. • This creates serious threat to residents in the area who depend on river water for their domestic purposes.	• The mined-out area outside river bed block will be reclaimed and any stored water will be pumped out. • The mining is planned in non-monsoon seasons only so that the excavated area will be replenished naturally during the subsequent rainy season for the river bed mining block.
• The major source of socio-health impacts of transportation will generate from truck, dust etc. Increase in accidents as a result of rash driving of dumpers carrying mineral through the roads may be possible.	• It is proposed to plant of local species per year with consultation of Forest department with some fruit bearing and medicinal trees, along the haul roads, outer periphery within the mining area to control the dust. • Planning transportation routes of mined material so as to reach the nearest paved roads by shortest route. (minimize transportation over unpaved road). Alternatively, graveled road may be constructed between mine lease area and nearest paved road connectivity; The

Impact	Mitigation Measures
	speed of trucks plying on the haul road should limited to avoid generation of dust; and Covering of material during transportation on trucks to prevent spillage of sand from the trucks. The trucks will be covered by tarpaulin. Overloading will be avoided. • Regular water sprinkling on unpaved roads to avoid dust generation during transportation.

❖ ***REMEDIAL MEASURES FOR MINES OTHER THAN SAND MINING:-***

Remedial Measures for Air Pollution

- All machineries and transport vehicles will be properly maintained and pollution check will be done once in a year to keep the emissions from machineries and vehicle under control.
- Water sprinkling will be done on haul road to control emission of dust while transporting minerals and waste. Provision for water spray by tankers on 'kaccha' road shall be done.
- Water sprinkling at loading area.
- Tree plantation along the haul roads & approach road will be done. Plantation along the mine boundary shall be done with tree density of 2000 trees per Hectare as per the norms of MoEF&CC, to control dust & noise.
- Use of personal protective equipment like dust mask.
- Ambient air pollution monitoring will be carried out

Remedial Measures for Water Pollution

- Mining is proposed to plan above the ground water table. Therefore, pumping of ground water from mine pit does not arise in this mine. The rain water during rainy season is proposed to settle in a pit and shall be use for dust suppression and plantation. Excess water, if any shall be discharged in natural stream after settling of suspended particles in the pit. Pump having required capacity will be installed to lift accumulated rain water from working pit and pumped to the settling tank.
- Garland drain shall be made around the Waste dump and the rain water shall be collected in garland drain and allowed to settle in a small pit for settling suspended particles before allowing discharge to natural drainage system.
- For domestic waste water Septic Tank with Soak Pit shall be provided, discharge from Soak Pit, if any shall be used for plantation

Remedial Measures for Noise Pollution

- Diesel powered machineries, which is major source of noise in open cast mining shall be properly maintained. Attention shall be paid towards rigorous maintenance of the silencer of the diesel engines.
- Protective devices shall be provided for use of persons employed in the vicinity of high noise areas.
- With the adoption of controlled blasting techniques, the ground vibrations will be minimized.
- Plantation around the lease boundary will cut the noise levels.

Remedial Measures for Land Environment

Some of the measures followed to minimize the impacts are as follows:

- The mining activities will be restricted within the lease area only.
- The waste material will be utilized for the construction of road and also will be used by the local people for construction work.
- The surface run off from the lease area will be retain within the lease and used for plantation, dust suppression and block cutting. So, there will be no soil erosion from the lease area and its surrounding due to mining activity.
- The dump will have inward slope with catch drains at inward side of the terrace and the catch drain of the individual terrace will be connected to the garland drain outside the periphery of the dump. Retaining wall and garland drain will be constructed around the dumps and the surface runoff water pass through the garland drain and finally settled in a settling pit before released outside.
- Retaining wall and garland drains for the proposed waste dump will be constructed to arrest wash offs from the dump.
- Maintenance/ repair of vehicles and machineries will not be inside the mining area. However, steel trays will be used for any emergency repair and sudden leakage of oil.

Remedial Measures for Waste Management

The solid waste shall be dumped systematically with proper repose angle and stabilization as follows:

- Gradation of dump shall be done automatically as coarser materials go to the bottom and finer at the top and therefore drain of rain water flow freely to the bottom without endangering the stability of dump.
- Stabilization of dump with top soil and tree plantation shall make the dump more stable on long. Dump should be terraced for every 5 m height and stabilized
- 1m height parapet shall be constructed for dumps more than 6m height along the toe to prevent and control wash out from dumps entering into natural system through rain water
- Garland drainage around dump shall prevent under wash of dump by hydrostatic pressure to be developed by surface water and control wash outs and collapse.

Remedial Measures for Flora and Fauna

Extensive plantation comprising of pollutant resistant trees will be undertaken, which will serve not only as pollution sink but also as a noise barrier. It is proposed to include *Azadirachta indica*, and *Ficus religiosa* in the plantation program as they serve as sinks for gaseous emissions.

The impact on the fauna of the buffer zone due to the mining activity will be insignificant. The proposed progressive plantation over a period of time will reduce the impact, if any, on the fauna.

Chapter - 17 RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

❖ *RISK ASSESSMENT FOR SAND MINING*

Since the Sand Mining Operation does not attract Mine Act 1952, it does not require any statutory personals, however the entire operation must be under the supervision of experience qualified person who can handle the labour employment effectively. The person must have knowledge of transportation activities with traffic rule & safety. It is always advisable to appoint such person who can understand the language of Mine plan & implement the same.

1. As such in case of sand mining activities does not have any short of risk in operational activity except prior to start the monsoon period all the manpower & equipment's to be withdrawn to safe location.
2. In case of temporary discontinuation of operation due to natural calamity or labour strike & Risk management plan to be developed based in the local condition.

ACCIDENTS DUE TO TRANSPORTATION AND MOVEMENT OF MINING MACHINERIES

Risk

Most of the accidents occur during transportation by tippers/ trucks and movement of Mining machineries.

Mitigation Measures

- This can be prevented by regular training of all vehicle/machinery drivers/operators, regular maintenance of equipment and ensuring safe operations.
- All safety precautions and provision of MMR 1961 shall be strictly followed during all mining operations.
- Regular maintenance and testing of all mining equipment as per manufacturer's guidelines.
- All transportation within the main working area should be carried out under the direct supervision and control of the management;
- The vehicles must be maintained in good repairs and checked thoroughly at least once a week by a competent person authorized for this purpose by the management;
- Broad signs should be provided at each and every turning point specially for the guidance of the drivers of vehicles.
- To avoid dangers while reversing the trackless vehicles, especially at the embankment and tripping points, all areas for reversing of lorries should, as far as possible, be made

man free, and there should be a light and sound device to indicate reversing of trucks; and

- A statutory provision of the fence, constant education, training etc. will go a long way in reducing the incidence of such accidents.

RISK ASSESSMENT

HAZARD IDENTIFICATION & RISK ASSESSMENT (HIRA)

The entire mining operation will be done under the supervision of the Mines Engineer/Mines manager having second class mines manager's certificate of competency and supported by a team of competent persons. Nevertheless, the following natural/industrial problems may by encountered during the mining operation:

- Accident due to Fly-rock generation
- Slope failure at Mine faces
- Accident due to sliding of dumps
- Accident due to Transportation or movement of heavy machineries
- Operation of mining equipment
- Accident due to use of explosive
- Accident due to storage of Fuel
- Filling of Mine due to excessive rain

RISK AND MITIGATION MEASURES

OVER BURDEN

Risk

The overburden dumps may cause landslides. High overburden dumps created at the quarry edge may cause sliding of the overburden dump or may cause failure of the pit slope due to excessive loading, thereby causing loss of life and property. Siltation of surface water may also cause run-off from overburden dumps.

Mitigation Measures

- To prevent the failure of overburden slopes, especially during the rainy season, proper garland drain & bund are constructed around the dump.
- To prevent this, height of overburden dumps will be restricted. Further, no stone or loose rock or loose tree will be allowed to remain within 3 meters of the edge of the quarry. To prevent siltation of surface water, retaining wall will be constructed on the down side of each OB dump.

ACCIDENTS DUE TO TRANSPORTATION AND MOVEMENT OF MINING MACHINERIES

Risk

Most of the accidents occur during transportation by tippers/ trucks and movement of Mining machineries.

- Operations of jackhammers are often attributable to mechanical failures and human errors.

Mitigation Measures

- This can be prevented by regular training of all vehicle/machinery drivers/operators, regular maintenance of equipment and ensuring safe operations.
- All safety precautions and provision of MMR 1961 shall be strictly followed during all mining operations.
- Regular maintenance and testing of all mining equipment as per manufacturer's guidelines.
- All transportation within the main working area should be carried out under the direct supervision and control of the management;
- The vehicles must be maintained in good repairs and checked thoroughly at least once a week by a competent person authorized for this purpose by the management;
- Broad signs should be provided at each and every turning point specially for the guidance of the drivers of vehicles.
- To avoid dangers while reversing the trackless vehicles, especially at the embankment and tripping points, all areas for reversing of lorries should, as far as possible, be made man free, and there should be a light and sound device to indicate reversing of trucks; and
- A statutory provision of the fence, constant education, training etc. will go a long way in reducing the incidence of such accidents.

FUEL STORAGE

- No major storage of fuel envisaged in the mining lease area

WATER LOGGING

Risk

Filling of mine pit with excessive rain

Mitigation Measures

- Provision of adequate capacity pumps for pumping out water from the mining pit with standby arrangements.
- Checking and regular maintenance of garland drainage and earthen bunds to avoid any inflow of surface water into the mine pit.

- Proper drainage will be maintained to eliminate inundation of working pits during rains from run-off water. Suitable garland drain will be provided around pit along with sedimentation pits on each side.

SAFETY MEASURES AT MINE

- The gradient of the haul road inside the pit, access trench and on the dumps will not be steeper than 1 in 16
- The slope of the sides of the OB dump to the horizontal will not exceed 300, and the height of the OB dumps has been restricted to a max of 3 m;
- The quarries will be protected by garland drains around the periphery for storm water drainage;
- A minimum safe distance of 100m will be kept between the surface edge of the quarry and the nearest public building, roads etc. When the surface edge of the quarry approaches within a limit of 300 m from any road, public building special permission from DGMS will be taken to conduct controlled blasting to prevent damage/injury to public life and property;
- All mining operations both within the quarry and outside will be conducted as per the conditions laid down by DGMS and under the strict supervision of competent persons appointed under Metalliferous Mines Regulations, 1961.

CARE AND MAINTENANCE DURING TEMPORARY DISCONTINUANCE:

In case of emergency arise as situation of temporary discontinuance due to court order or due to statutory requirements or any other unforeseen circumstances pit will be fenced and locked properly so as no one can enter in pit. All plantation will be protected with all due care for their survival. Maintenance and monitoring of discontinued mining operations i.e. maintenance of haul roads, will be done in view of re-open in near future.

DISASTER MANAGEMENT PLAN

❖ Vulnerability of the State

West Bengal has been no exception as far as sufferings inflicted by natural and man-made hazards are concerned. The state has been frequented by cyclones, floods, droughts, landslides, subsidence and occasional earthquakes. Progressive trends of any region are controlled to a large ex- tent by the requirements of the inhabitants, agriculture, industries, transportation, communication, education and culture, which generally form the vulnerability attributes. Because of the high population density and concentration of industrial and agricultural activities across West Bengal, risk or vulnerability to natural or man-made disasters is particularly high. With increasing developmental activities in high-hazard zones, e.g. the coastal regions, the vulnerability scenario appears to be worsening with time.

❖ The Regional Perspectives

The prevailing hazards are seen interlinked to each other in many cases. Nevertheless, individualistic hazard scenario is reviewed in the regional context to understand the needs and priority distribution.

❖ Floods

Approximately 55.8% of the region is susceptible to floods. Furthermore, complicacy is implicated by the origination of major flood-producing rivers beyond the state jurisdictional limits.

An outline of flood management

A monograph on flood management prepared on the basis of hands-on experience of the State Government officials recommends a standard operating procedure. Three phases of actions are specified: pre-flood, during flood and post-flood. The pre-flood phase activities consist of preparatory measures, which involve vulnerability assessment, personnel and organizational database development, viable emergency action plan such as deployment of early warning system, training of personnel for rescue and evacuation, verification and updating of existing search, rescue and evacuation plans, and inventories of essential commodities and relief materials. A district disaster management committee is expected to be coordinated before the onset of the monsoon season to ensure adequate preparedness. Participation of various government and non-governmental organizations is anticipated in knowledge and expertise sharing. Strategic planning focuses on hazard elements and formulates actions such as construction, restoration or improvement of drainage channels, and removal of human encroachment along the riverbanks. On the very onset of the hazard, the highest priority is on 'search, rescue and evacuation', in addition to 'organization of relief facilities'. Quick and correct dam- age assessment would enable speedy restoration and re-habilitation in terms of physical, economic and social aspects. The disaster related information should be well documented to enable future management plans.

The overall impetus at the national and global level is on preparedness and mitigation 7, 8. Several recent com- missions have been formed at the national level, such as National Water Policy, 1987; National Commission for Integrated Water Resource Development Plan, 1996 and Regional Task Forces, 1996, and the ensuing recommendations adopted. However, effectiveness of recommendations seems to be lacking in several cases. The National

Commission for Integrated Water Resources Development, 1999, recommended management approach rather than control, emphasizing failure to render complete protection. The strategies include flood-plain zoning, flood proofing, forecasting, disaster preparedness, response planning and insurance, etc. In respect of flood-plain zoning, the National Commission on Floods–1980 proposed a legislation to classify flood-prone zones according to occurrence and intensity. However, in West Bengal, the problem is rather vexing due to high population density and large flood-prone areas. While it is imperative to pre- vent encroachment of river beds, it is not feasible to relocate structures and developmental activities from all the hazard-prone areas. In recent times, flood forecasting is advancing with utilization of satellite and remote-sensing techniques. If the approaching flood can be predicted/ observed, evacuation through monitoring and warning is possible.

❖ *Cyclones And Storm Surges*

West Bengal has been one of the most cyclone-affected territories of the country.

Perspectives on cyclone management

The Cyclone Distress Mitigation Committee was launched nationwide during 1969 for the coastal states, with a major objective to formulate a communication system for quick dissemination of meteorological warnings and prevention measures thereof. The World Meteorological Organization established in 1972, introduced a Tropical Cyclone Project to assist member countries in increasing their capabilities to forecast tropical cyclones, and in developing strategies for disaster prevention and preparedness.

At the state level, the Relief Department has developed a disaster-management system, outlining sustainable development with disaster mitigation at state and district levels13. This involved delineation of planning areas for departmental activities, including those at the village level within two frameworks – prevention and crisis management. The approach embodies integrated coastal environmental planning combined with cyclone mitigation strategies to reduce susceptibility. The strategies include development of accurate and prompt cyclone-warning systems, design and construction of robust structures ('cyclone proofing' through incorporation of storage and sleeping areas high-off the ground and use of water-resistant materials), implementation of hazard-reduction methods such as construction and strengthening of sea embankment, drains, shelterbelts, conservation and promotion of natural windbreakers (mangrove), reliable communication system, mass awareness on preparedness and mitigation, and community preparedness at all levels to meet the exigencies. Further, landuse planning is suggested to reduce the risk. Timely relay of information is of utmost importance. In this respect, a cyclone dissemination sys- tem has been set up by India Meteorological Department at Kolkata. Special addresses are given to cyclone fore- cast and warning services, rapid dissemination of warnings to the government agencies, ports, fisheries, shipping, the general public, and organizations to construct cyclone shelters in cyclone-prone areas and ready machinery for evacuation of people, and involvement of the local community.

The Meteorological Department has been equipped with cyclone surveillance radars, and satellite picture-receiving equipment. Further, Indian geo-stationary satellite INSAT- 1B (operative since 1983) has enhanced tracking and fore- casting through continuous monitoring. The operations are carried out through Area Cyclone Warning Centres and Cyclone Warning Centres. The present scientific knowledge and tools enable predictions with an average error of about 200 km for a 24 h forecast.

Formulation of contingency plans must be done at all levels – community, government and civil society. Fore- casting and early warning systems involve coordination by a steering committee for continual appraisal and improvement in the analyses of different forecasting

methods, facilitating resources sharing and collaborations, training of personnel, and capacity enhancement. The working plan for an integrated coastal zone and flood control developed for the state addresses natural windbreak development and preservation, assessment of impacts and risks, com- munity participation, education and awareness, and village-level planning. Technical aspects include a multi- disciplinary approach towards environmental and social concerns, water-flow management, relocation/resettlement if needed, and designing break waves and sea walls. Preparedness implies mitigation and prevention rather than just response. Therefore, the need to link disaster management with development plans.

❖ *Landslides*

The landslide hazard in West Bengal has been observed mostly in the hilly terrains of Darjeeling District. However, incidents of landslide have also been reported to have occurred on the banks of Hooghly River. In 1968, floods in the Darjeeling area destroyed vast areas of West Bengal and neighbouring state of Sikkim by unleashing about 20,000 landslides and killing thousands of people16. These landslides occurred over a three-day period, with precipitation ranging from 500 to 1000 mm in an event of a 100-yr return period. The 60 km hilly highway from Siliguri to Darjeeling was cut off at 92 locations by land- slides, resulting in total disruption of the road transporta- tion system.

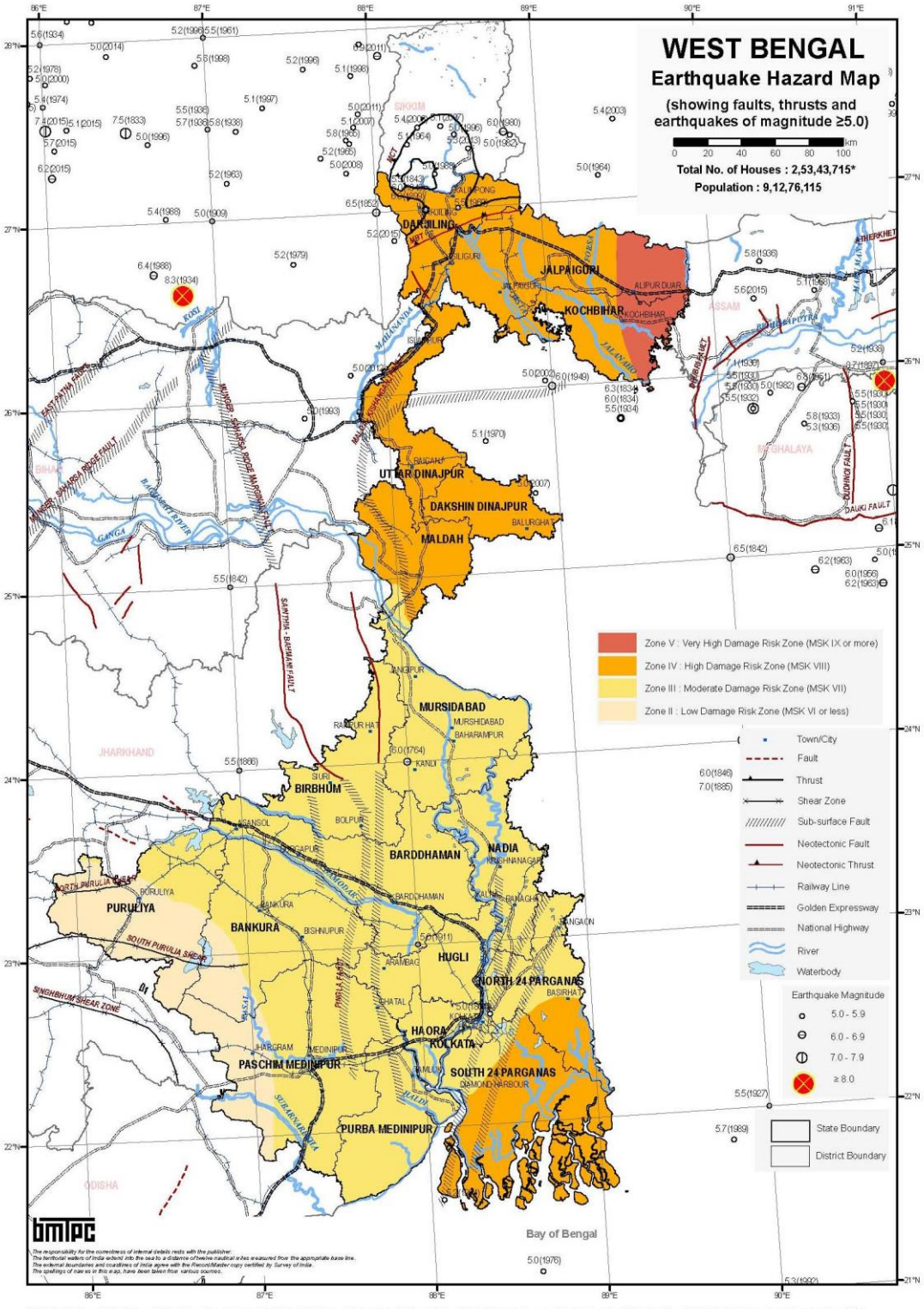
Urbanization, especially in the hilly terrains, involving construction activities often causes perturbations in the hill slopes triggering landslides. Prior identification of the hazard potential is therefore necessary. Major tools em- ployed for hazard delineation include remote sensing and GIS techniques. Various thematic layers describing the geological characteristics, water conditions, material prop- erties, topographical inclinations, seismic activities, pre- diction of soil behaviour under load, etc. are considered for the thematic integration to achieve hazard zonation.

❖ *Earthquakes*

West Bengal experiences earthquakes at a relatively lower frequency of the seismic hazard zonation map. The Bureau of Indian Standards places the region in the seismic zones II–IV, corresponding to peak ground acceleration (PGA) of 0.1, 0.2 and 0.25 (1 g = 980 Gal) respectively 2, 19. The lowest perceived hazard, zone II, is in the southwestern part of West Bengal (Purulia), while zone IV covers the north and southeast of Kolkata. Zone V is delineated on the eastern parts of Jalpaiguri and Coochbehar. The districts of Kolkata, Murshidabad, Birbhum, Bardhaman, Hooghly, Howrah, Nadia, Bankura and East and West Midnapur come under zone III. Darjeeling, North and South Dinajpur, the remaining parts of Jalpaiguri and Coochbehar, North and South 24-Parganas and Malda fall under zone IV. Similarly, the Global Seismic Hazard Assessment Programme classifies the seismic hazard variation in terms of PGA from low (0.2 m/s2) in the southwest to high (6.0 m/s2 and above) in the north, with 10% probability of non-exceedance in 50 years20. The earthquakes mostly occur either in the Himalayan ranges in the north or in Northeast India, and a few also occur in the Bengal Basin/ Fan areas. The Great Assam earthquake of 1897 is reported to have caused widespread damage in Kolkata. The largest instrument-recorded earthquake occurred on 15 April 1964, West of Sagar Island (mb 5.2), which caused damages in West Bengal and Orissa.

The region has considerable area close to river basins and deltas that are characterized by Holocene alluvium deposits, which are likely to soften and hence are susceptible to liquefaction during an earthquake. Considerable spatial variation is associated with seismic hazards owing to the variation of geological-dependent site response. This necessitates local specific analysis, especially in urban areas where the implications are far higher. The utility of seismic microzonation is emphasized in such cases. Seismic microzonation combines geological, geotechnical, seismological and earthquake engineering approaches towards

spatial hazard classification. The zonation enables decision-making process towards planning and organization of landuse, response and mitigation. The site-specific design parameters obtained through microzonation would enable cost-effective structural designs.



Earthquake Hazard Map of West Bengal

(Source: Ministry of Earth Sciences)

❖ *Tsunamis*

Although hazards due to trans-oceanic tsunamis have not been quantified for the coastal areas of West Bengal, be- cause of the presence of mangroves and shallow continental shelf (unlithified fan deposits at the mouth of the Meghna– Ganges estuary) extending to several hundred kilometres, tsunamis are unlikely to pose a significant hazard. As such, there is no report of damage in the territory due to the catastrophic tsunami earthquake of 26 December 2004. However, any future offshore developments off the coast may be affected by tsunamis

❖ *Subsidence*

Subsidence hazard has been exhibited in underground coal mining areas of the state, such as Raniganj and Asansol. A fundamental preventive approach towards avoidance of adverse impacts of the hazard is reliable prediction23 and the ensuing geotechnical considerations. The techniques involve tomography–sub-surface mapping, subsidence profiles and behaviour model, e.g. viscoelastic model.

❖ *Conclusion*

The predominant natural hazards in the West Bengal territory are investigated through historical accounts and prevailing mitigation aspects. A preliminary integrated perspective on the prevailing hazards has been qualitatively estimated as a first-order composite vulnerability distribution across the state. Consequently, a holistic outlook of disaster management as envisaged is emphasized to incorporate (a) collaborations of different organizations, local participation, (c) inputs from scientific and re- search institutions, (d) awareness and promotion, and (e) delivering appropriate regulations and policies. Addressing multiple hazards, such as usage of multi-hazard maps, synergized methodologies, etc. is recommended to be more pragmatic.

References

- District Census Handbook, 2011, South 24 Parganas, Directorate of Census Operation, West Bengal
- Human development Report, 2009, South 24 Parganas, Development & Planning Department, Govt. of West Bengal
- Annual Flood Report For The Year 2017, Irrigation & Waterways Directorate, Govt. of West Bengal
- Agriculture Contingency Plan for District South 24 Parganas, West Bengal
- State Water Investigation Directorate
- Office of The District Land And Land Reforms Officer - South 24- Parganas
- Divisional Forest Office - South 24- Parganas
- National Institute of Disaster Management Report
- Report of Central Ground Water Board, Ministry of Water Resources
- http://s24pgs.gov.in
- https://en.wikipedia.org/wiki/South-24-Parganas
- Maps from Geological Survey of India
- Survey of India Topo Sheets
- Butterflies of Sundarban Biosphere Reserve, West Bengal, eastern India: a preliminary survey of their taxonomic diversity, ecology and their conservation by Soumyajit Chowdhury - July 2014 - Journal of Threatened Taxa 6(8):6082-6092, DOI: 10.11609/JoTT.o3787.6082-92
- An indicator based approach to assess coastal communities' resilience against climate related disasters in Indian Sundarbans by Rajarshi Dasgupta and Rajib Shaw - January 2015 - Journal of Coastal Conservation 19(1) - DOI: 10.1007/s11852-014-0369-1