



DISTRICT SURVEY REPORT, ASSAM

KAMRUP METROPOLITAN

As per Sustainable Sand Mining Management Guidelines, 2016
and Enforcement & Monitoring Guidelines for Sand Mining,
2020, Ministry of Environment, Forest and Climate Change
(MoEF & CC)

SEPTEMBER 2024

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LIABILITY CLAUSE

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RSP Green Development & Laboratories PVT.LTD undertakes the technical responsibility for the entire report. All the authenticated Secondary data included in the report has been obtained from the Various Government departments and all the report verifying by Sub-Divisional Committee

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Sr. Director, NABET
Dated: September 15, 2022

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June 18, 2024

RSP Green Development & Laboratories Pvt. Ltd.
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Sub.: Extension of Validity of Accreditation till September 17, 2024– regarding
Ref.. 1. Certificate no NABET/EIA/2124/SA 0176
2. Request mail June 15, 2024

Dear Sir/Madam

This has reference to the accreditation of your organization under QCI-NABET EIA Scheme, the validity **RSP Green Development & Laboratories Pvt. Ltd.** is hereby extended till September 17, 2024, or completion of the assessment process, whichever is earlier.

The above extension is subject to the submitted documents/required information with respect to your application and timely submission and closure of NC/Obs during the process of assessment.

You are requested not to use this letter after the expiry of the above-stated date.

With best regards.

(A K Jha)
Sr. Director, NABET

Extension of the NABET Certificate of the respected Consultant

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ABBREVIATION

ABBREVIATIONS & SYMBOLS USED	:	FULL FORMS
%	:	Percent
'	:	Minute
"	:	Second
<	:	less than (strict inequality)
=	:	Equal to (strict equality)
>	:	greater than (strict inequality)
≈	:	approximately equal
°	:	Degree
°C	:	Degree Centigrade
°F	:	Degree Fahrenheit
ArcGIS	:	ArcGIS is a GIS for working with maps and geographic information maintained by the ESRI.
CD blocks	:	Community development blocks
cm	:	Centimeter
cum	:	Cubic meter
Dec	:	December
DEIAA	:	District Level Environment Impact Assessment Authority
DSR	:	District Survey Report
E	:	East
<i>e.g.,</i>	:	<i>'exempli gratia'</i> (Latin phrase) means 'for example'
EC	:	Environmental Clearance
<i>et.al.,</i>	:	<i>'et alia'</i> (Latin phrase) means 'and others'
G:2 stage	:	General Exploration (stage of exploration as per UNFC norms)
G:3 stage	:	Prospecting (stage of exploration as per UNFC norms)
GIS	:	Geographical Information System
Govt.	:	Government
GPS	:	Global Positioning System
Ha	:	Hectare
<i>i.e.,</i>	:	<i>'id est'</i> (Latin phrase) means 'that is'/'in other words'
ICAR	:	Indian Council of Agricultural Research
Inch	:	inches

ABBREVIATIONS & SYMBOLS USED	:	FULL FORMS
kg/ha	:	Kilogram per hectare
km	:	kilometer
km/ hour	:	Kilometer per hour
km²	:	kilometer square
LANDSAT	:	Land Satellite stands for Low Altitude Satellite
LULC	:	Land use and land cover
m	:	Meter
Mar	:	March
Max.	:	Maximum
mbgl	:	Meter Below Ground Level
Min.	:	Minimum
mm	:	Millimeter
MoEF&CC	:	Ministry of Environment, Forest and Climate Change
N	:	North
NH	:	National Highways
No.(s)	:	Number(s)
RI value	:	River Index value
S	:	South
SEIAA	:	State Environment Impact Assessment Authority
Sept	:	September
sp.	:	species
sq.km	:	Square kilometer
Temp	:	Temperature
viz.,	:	Latin phrase ' <i>videre licet</i> ', and is used as a synonym for "namely",
W	:	West

CHAPTER 1: PREFACE

The need for District Survey Report (DSR) has been necessitated by MoEF & CC vide their Notification No. 125 (Extraordinary, Part II Section 3, and Sub-section ii), S.O. 141 (E), dated 15th January 2016. The notification was made to bring certain amendments with respect to the EIA notification 2006 and in order to have better control over the legislation, district level committees for introduction into the system. Preparation of District Survey Reports has been introduced as a part of the above notification. Subsequently, MOEF & CC has published Notification No. 3611 (E), DT. 25th July 2018 regarding the inclusion of the “Minerals Other than Sand” and specified the format of the DSR. Monitoring Guidelines for Sand Mining (EMGSM) January 2020, issued by the Ministry of Environment, Forest and Climate Change is prepared in consideration of various orders/directions issued by Hon’ble NGT in matters pertaining to illegal sand mining and based on the reports submitted by expert committees and investigation teams. This DSR has been prepared in conformity with the S O 141 (E), S O 3611 (E), and other sand mining guidelines published by MOEF & CC from time to time as well as the requirement specified in Assam Minor Mineral Concession rule 2013, (AMMCR), 2013.

The purpose of the District Survey Report (DSR) is to identify the areas of deposition where mining can be permitted and also, to identify the areas where mining will not be permitted due to proximity to infrastructural structures and installations and areas of erosion. The DSR would also help to calculate the total amount of replenishment.

Preparation of this DSR required both primary and secondary data generation. The primary data generation involved the site inspection, survey, ground truthing etc. while secondary data has been acquired through various authenticated sources and satellite imagery studies. The secondary data related to district profile, local geology, mineralization and other activities are available in rather a piecemeal fashion. The district survey report of Kamrup Metropolitan district also describes the general geographical profile of the district, distribution of natural resources, livelihood, climatic condition, inventory of minor minerals and revenue generation.

The state of Assam itself is very rich in mineral resources. Here “liquid gold” (fuel oil) and other natural resources are found. During the last 70 years, the mineral sector has grown considerably in Assam. In spite of this, the economic growth of this state has been slow. In order to expedite the development process, exploitation of available mineral resources by developing mines & establishment of mineral-based value-added industries has an imperative upshot. Developments achieved in the mining & mineral industries so far, availability of resources & existing trend would offer a glimpse of the future of the mineral sector in the state.

Minor minerals include building stones, gravel, ordinary clay, ordinary sand, limestone used for lime burning, boulders, kankar, morrum, brick earth, bentonite, road metals, slate marble, and stones used for making household utensils. But sand is used for stowing purposes. Coal is considered a major mineral. In the case of Assam, exploitation of minor minerals comes under Rule, 2013 52 (1) of the Assam Minor Minerals Concession Rule. Therefore, this District Survey Report (DSR) will give authentic field data sets and relevant information about the presence of riverbed sand deposits, ordinary earth & brick earth along with river bed boulder and/or fossilized channel deposits which in turn will bestow excellent guidance for systematic and scientific utilization of mineral resources, so that present and future generation may be benefitted at large.

DISTRICT SURVEY REPORT OF KAMRUP METROPOLITAN DISTRICT, ASSAM

It is also mentioned here that the procedure of preparation of this District Survey Report is as per notification guidelines issued by the Ministry of Environment, Forests and Climate Change (MoEFCC), SO No. 141(E), Dated 15.01.2016, and the format given by SO No. 3611(E), New Delhi, dated 25 July 2018 regarding the preparation of District survey report of mining and other minor minerals as specified in appendix 10 of the notification. The district Kamrup Metropolitan has an extremely remarkable value from the geological aspect. In mining, this district has been made to cover minor mineral mining locations, areas, and an overview of mining activity in the district with all its relevant features pertaining to geology & mineral wealth. From this point of view, minor minerals are slightly different from other districts of Assam. Far-reaching geological fieldwork and thorough study of different minerals along with inselbergs and geostatistical studies of different mineralogical attributes of different minerals, the mines, and their proprietors have been undertaken to find out the plausible causes for proper documentation of the geological history of the total Kamrup Metropolitan district. Some precious minerals that are found in Assam is Platinum (Pt), Gold (Au), etc. this report also contains details of the forest, drainage, land use & land cover, etc.

CHAPTER 2: INTRODUCTION

The District Survey Report of Kamrup Metropolitan District has been prepared as per the guide line of Ministry of Environment, Forests and Climate Change (MoEF& CC), Government of India vide Notification S.O.-1533(E) dated 14th Sept, 2006 and subsequent MoEF& CC Notification S.O. 141(E) dated 15th Jan, 2016. This report shall guide systematic and scientific utilization of natural resources, so that present and future generation may be benefitted at large. Further, MoEF& CC published a notification S.O. 3611(E) Dated 25th July, 2018 and recommended the format for District Survey Report.

The main objective of DSR is identification of areas of aggradations or deposition where mining can be allowed; and identification of areas of erosion and proximity to infrastructural structures and installations where mining should be prohibited and calculation of annual rate of replenishment and allowing time for replenishment after mining in that area. The DSR would also help to calculate the annual rate of replenishment wherever applicable and allow time for replenishment. Besides sand mining, the DSR also include the potential development scope of in-situ minor minerals.

The objectives of the District Survey Report are as follows:

1. To identify and quantify minor mineral resources for its optimal utilization.
2. To regulate sand and gravel mining, identification of site-specific end-use consumers and reduction in demand and supply gaps.
3. To facilitate use information technology (IT) for surveillance of the sand mining at each step.
4. To enable environmental clearance for cluster of sand and gravel mines.
5. To restrict illegal mining.
6. To reduce occurrences of flood in the area.
7. To maintain the aquatic habitats.
8. To protect ground water in the area by limiting extraction of material in riverbeds to an elevation above the base flow.
9. To maintain data records viz. details of mineral resource, potential area, lease, approved mining plan, co-ordinates of lease hold areas, and revenue generation.
10. To design a scientific mining plan and estimate ultimate pit limit.
11. To frame a comprehensive guideline for mining of sand and other minor minerals.

The District Survey Report (DSR) comprises secondary data on geology, mineral resources, climate, topography, land form, forest, rivers, soil, agriculture, road, transportation, and irrigation etc. of the district collected from various published and un-published literatures and reports as well as various websites. Data on lease and mining activities in the district, revenue etc. have been collected from the DL&LRO office of the district and from Government of Assam Mines & Minerals Directorate of Geology & Mining.

2.1 Statutory Framework:

Ministry of Environment, Forest, and Climate Change (MoEF& CC) has published several notifications time to time to formulate and implement the District Survey Report (DSR) for every district. Statutory Framework and its legal aspect with respect to DSR is tabulated in Table 01.

Table 01: Statutory Framework and guidelines on DSR with time scale

Year	Particulars
1957	Mines and Minerals (Development and Regulation) act, 1957 Act is the principal Act for regulation of mines and development of minerals.
1986	The environment (Protection) act, 1986 was enacted in 1986 by the Ministry of Environment and Forests with the objective of providing for the protection and improvement of the environment
1994	The Ministry of Environment, Forest & Climate Change (MoEF&CC) published Environmental Impact Assessment Notification 1994 which is only applicable for the Major Minerals more than 5 ha.
2006	In order to cover the minor minerals also into the purview of EIA, the MoEF & CC has issued EIA Notification SO 1533 (E), dated 14 th September 2006, made mandatory to obtain environmental clearance for both Major & Minor Mineral more than 5 Ha.
2012	Further, Hon'ble Supreme Court wide order dated the 27th February, 2012 in I.A. No.12- 13 of 2011 in Special Leave Petition (C) No.19628-19629 of 2009, in the matter of Deepak Kumar etc. Vs. State of Haryana and Others etc., ordered that "leases of minor minerals including their renewal for an area of less than five hectares be granted by the States/Union Territories only after getting environmental clearance from MoEF"; and Hon'ble National Green Tribunal, order dated the 13th January, 2015 in the matter regarding sand mining has directed for making a policy on environmental clearance for mining leases in cluster for minor Minerals.
2013	Assam Minor Mineral Concession rule 2013 recommended rules for regulating the grant of various forms of mineral concessions to prevent illegal mining in the district, The Rules detail restrictions on mining operations near villages, highways, and other structures, and the process for granting mining leases and contracts through competitive bidding or auctions and payments. It also covers General conditions to grant any mineral concession, regulation and control of mining operations, Restoration and Rehabilitation fund, illegal or un-authorized Mining and its consequences. It highlights the significance of scientific mining, detailed reporting, and adherence to environmental and safety regulations. Overall, the Rules aim to ensure responsible mineral extraction, prevent unauthorized activities, and promote sustainable mining practices in Assam, while providing a structured framework for granting and managing mineral concessions in the region.

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March 2015	The Mines and Minerals (Development and Regulation) Amendment Act,2015 is an act to amend the Mines and Minerals (Development and Regulation) Act, 1957 which enacted on March 26, 2015,and become effective from January 12, 2015,it introduced several key amendments, including the establishment of Special Courts for mining-related offenses, the requirement for prior approval from the Central Government for certain mining permits, and the extension of mining leases for captive purposes until March 31, 2030. It also revised provisions regarding the auctioning of expired leases and introduced new clauses related to the District Mineral Foundation payments. Additionally, the Act amended definitions and parameters related to mineral content and the powers of the Central Government in regulating mining activity
September 2015	Ministry of Mines notification on 17 th September,2015 focuses on exercise of the powers conferred by sub-sections (5) and (6) of Section 9B of the Mines and Minerals (Development and Regulation) Act, 1957 (67 of 1957), the notification focused on specific rules made by Central Government specifying the amount to be paid by holder of a mining lease or a prospecting license-cum-mining lease, in addition to the royalty, to the District Mineral foundation of the district established by the concerned State Government through notification.
2016	The MoEF&CC in compliance of above Hon'ble Supreme Court's and NGT'S order has prepared "Sustainable Sand Mining Guidelines (SSMG), 2016" in consultation with State governments, detailing the provisions on environmental clearance (EC) for cluster, creation of District Environment Impact Assessment Authority, preparation of District survey report and proper monitoring of minor mineral. There by issued Notification dated 15.01.2016 for making certain amendments in the EIA Notification, 2006, and made mandatory to obtain EC for all minor minerals. Provisions have been made for the preparation of District survey report (DSR) for River bed mining and other minor minerals.
2018	MoEF& CC published a notification S.O. 3611(E) Dated 25th July, 2018 and recommended the format for District Survey Report. The notification stated about the objective of DSR i.e. "Identification of areas of aggradations or deposition where mining can be allowed; and identification of areas of erosion and proximity to infrastructural structures and installations where mining should be prohibited and calculation of annual rate of replenishment and allowing time for replenishment after mining in that area."
2020	Enforcement & Monitoring Guidelines for Sand Mining (EMGSM) 2020 has been published modifying Sustainable sand Mining Guidelines, 2016 by MoEF& CC for effective enforcement of regulatory provisions and their monitoring. The EMGSM 2020 directed the states to carry out river audits, put detailed survey reports of all mining areas online and in the public domain, conduct replenishment studies of river beds, constantly monitor mining with drones, aerial surveys, ground surveys and set up dedicated task forces at district levels. The guidelines also push for online sales and purchase of sand and other riverbed materials to make the process transparent. They propose night surveillance of mining activity through night-vision drones.
October 2020	(In IA No 40/2020 41/2020, 46/2020, 47/2020) and vide order dated 14th October 2020 NGT also mandates that DSR/Replenishment Study should be

DISTRICT SURVEY REPORT OF KAMRUP METROPOLITAN DISTRICT, ASSAM

	prepared by a consultant having accreditation from NABET which further should be appraised by SEAC and approved by SEIAA. The consultant must follow procedure laid down under SSMMG-2016 and EMGSM-2020 during preparation of DSR.
February 2021	Government of Assam through Assam Minerals regulation and dealers' rule 2020 proposed rules to regulate the possession, storage, trading and transport of minerals and mineral products to check evasion of royalty or seigniorage fee, to stop illegal mining and transportation in the state of Assam. The rule is applicable to all Minerals Dealers and all industries/ factories connected with the sale, purchase, transportation, processing and consumption of minerals for commercial purpose in the state of assam.
October 2021	Assam Minor Mineral Concession (Amendment) Rules, 2021 notified on October 7 th , 2021, it focuses to reorganize the royalty payment process for minor minerals utilized by government departments and agencies. It establishes specific rates of royalties based on the project cost, excluding taxes, and mandates that these royalties be deducted at the time of payment to contractors or suppliers. Additionally, the rules introduce a structured collection process for urban local bodies, requiring royalties to be collected in installments throughout the construction phase, thereby ensuring compliance and proper financial management in the use of minor minerals.

Important statutory provisions of Assam Minor Mineral Concession rule:

Mining operation under mining a mineral concession.

- No person shall undertake any prospecting or mining operation activity in respect of any minerals in any part of the State, except under and in accordance with the terms and conditions of a permit or a prospecting licence or a mining lease or a mining contract or a permit, or a concession in any other form, as the case may be, granted:
- Provided that nothing in this sub-rule shall apply to any prospecting operation undertaken by the Geological Survey of India, the Indian Bureau of Mines, and the Atomic Minerals Directorate for Exploration and Research of the Central Government, the Directorate of Geology & Mining, Assam or the Mineral Exploration Corporation Limited.

Restriction on grant of mining lease/contract/ permit.

- I. No mining lease/contract /permit shall be granted in respect of any land within a distance of: -
 - (i) Fifty metres from the outer periphery of the defined limits of any village habitation, National Highway, State Highway and other roads where such excavation does not required use of explosives.
 - (ii) Two hundred fifty metres for the outer periphery of the defined limits of any village habitation, National Highway, State Highway and other roads where use of explosives if required.

(iii) Five hundred metres from major structures like R.C.C. Bridge, Guide bund etc.

Provided that the Government may relax the above distance parameters, wherever required in the interest of working, mineral conservation or for any unforeseen reasons subject to such condition as may be imposed under the said relaxation.

(2) No mining lease/contract/permit or any other mineral concession shall be granted in respect of any such minor mineral or in respect of any specific or general area which the Government may notify.

Condition on which the Permit for mining/quarrying shall be granted

- I. Any mining operation in the case of mining of brick earth or ordinary clay or alluvial deposit below a depth of 1.5 metre shall necessarily require formation of benches for safe mining. The benches would be formed in a manner that the width of the bench is not lesser than the height of the bench.
- II. Any quarrying permit granted under these rules shall contain information with regard to the following:
 - a) Manner, mode and place of payment of rent, royalties, permit money, Rehabilitation and Restoration Fund amount and interest on delayed payments or any other dues as admissible under these rules.
 - b) Particulars of the receipt heads of the Government to which the payments are to be credited.
 - c) Grant, compensation of damage to the land owner for the land covered by the permit.
 - d) Felling the trees, pumping of ground water.
 - e) Restriction of surface operations in any area provided by any authority.
 - f) Entering and working in any forest area.
 - g) Reporting all accidents, use of explosives.
 - h) Indemnity to the Government against claim of third parties.
 - i) Mineral to be stacked, measured and dispatched.
 - j) Applicability of the provisions of all other statutes/rules framed by the Central and State Government.
 - k) Reclamation or restoration of the mining areas and security thereof.
 - l) Development and conservation of minerals and environment and ecology of the area.
 - m) Extent of the area or land from where the minor mineral shall be extracted.
 - n) Period within which the minor mineral shall be extracted and removed and delivery of possession of land on the expiry of such period or on removal of the quantity of the minor mineral for which the permit is valid/granted.

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- o) Release of security by the authority issuing permit after having satisfied that the permit holder has fulfilled all the conditions of the permit satisfactorily.
- p) Any other condition, as may be found expedient by the competent authority to grant the permit, may be imposed in the interest of scientific mining, mineral conservation and mineral development.

III. In case of the permit holder is not able to remove the whole or any part of the mineral for which he obtained the permit within the permissible time for any reason, whatsoever, he shall not be entitled to claim the refund of permit amount/ royalty or any part thereof.

IV. The permit holders for the brick kilns shall furnish a solvent surety within fifteen days of the issue of the permit by submitting an undertaking of such surety that he would be responsible for deposit of all dues in case the permit holder fails to deposit the same.

Special conditions for river-bed

Following condition shall be application for excavation of minor mineral (s) from river beds in other to ensure safety of river-beds, structures and the adjoining areas:

- ❖ No mining would be permissible in a river-bed up to a distance of five times of the span of the bridge on up-stream side and ten times the span of such bridge on down-stream side, subject to minimum of 250 meters on the up-stream side and 500 meters on the down-stream side.
- ❖ There shall be maintained an un-mined block of 50 meters width after every block of 1000 meters over which mining is undertaking or at such distance as may be directed by the competent authority.
- ❖ The maximum depth of mining in the river-bed shall not exceed three meters measured from the un-mined bed level at any point of time with proper bench formation.
- ❖ Mining shall be restricted within the central 3/4th width of the river/ rivulet.
- ❖ No mining shall be permissible in an area up to a width specified by the competent authority from the action edges of embankments.
- ❖ Any others condition as may be required by the competent authority in public interest.

➤ **Sustainable Sand Mining Management Guidelines (SSMMG), 2016 by MoEF & CC.**

The sustainable sand Mining Management Guidelines 2016 has been prepared after extensive consultation with the States and Stakeholders over a period of one year. The main objective of the Guideline is to ensure sustainable sand mining and environment friendly management practices in order to restore and maintain the ecology of river and other sand sources.

1. Parts of the river reach that experience deposition or aggradation shall be identified first. The Lease holder/ Environmental Clearance holder may be allowed to extract the sand and gravel deposit in these locations to manage aggradation problem.
2. The distance between sites for sand and gravel mining shall depend on the replenishment rate of the river. Sediment rating curve for the potential sites shall be developed and checked against the extracted volumes of sand and gravel.

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3. Sand and gravel may be extracted across the entire active channel during the dry season.
4. Abandoned stream channels on terrace and inactive flood plains be preferred rather than active channels and their deltas and flood plains. Stream should not be diverted to form inactive channel.
5. Layers of sand and gravel which could be removed from the river bed shall depend on the width of the river and replenishment rate of the river.
6. Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.
7. Segments of braided river system should be used preferably falling within the lateral migration area of the river regime that enhances the feasibility of sediment replenishment.
8. Sand and gravel shall not be extracted within 200 to 500 meters from any crucial hydraulic structure such as pumping station, water intakes, and bridges. The exact distance should be ascertained by the local authorities based on local situation. The cross-section survey should cover a minimum distance of 1.0 km upstream and 1.0 km downstream of the potential reach for extraction. The sediment sampling should include the bed material and bed material load before, during and after extraction period. Develop a sediment rating curve at the upstream end of the potential reach using the surveyed cross-section. Using the historical or gauged flow rating curve, determine the suitable period of high flow that can replenish the extracted volume. Calculate the extraction volume based on the sediment rating curve and high flow period after determining the allowable mining depth.
9. Sand and gravel could be extracted from the downstream of the sand bar at river bends. Retaining the upstream one to two thirds of the bar and riparian vegetation is accepted as a method to promote channel stability.
10. Flood discharge capacity of the river could be maintained in areas where there are significant flood hazard to existing structures or infrastructure. Sand and gravel mining may be allowed to maintain the natural flow capacity based on surveyed cross-section history.
11. Alternatively, off-channel or floodplain extraction is recommended to allow rivers to replenish the quantity taken out during mining.
12. The Piedmont Zone (Bhabhar area) particularly in the Himalayan foothills, where riverbed material is mined, and this sandy-gravelly track constitutes excellent conduits and holds the greater potential for ground water recharge. Mining in such areas should be preferred in locations selected away from the channel bank stretches.
13. Mining depth should be restricted to 3 meter and distance from the bank should be 3 meters or 10 percent of the river width whichever less.
14. The borrow area should preferably be located on the river side of the proposed embankment, because they get silted up in course of time. For low embankment less than 6 m in height, borrow area should not be selected within 25 m from the toe/heel of the embankment. In case of higher embankment, the distance should not be less than 50 m. In

order to obviate development of flow parallel to embankment, cross bars of width eight times the depth of borrow pits spaced 50 to 60 meters centre-to-centre should be left in the borrow pits.

15. Demarcation of mining area with pillars and geo-referencing should be done prior to start of mining.

➤ **Enforcement & Monitoring Guidelines for sand Mining, 2020 (MoEF& CC)**

Ministry of Environment Forest & Climate Change formulated the Sustainable Sand Management Guidelines 2016 which focuses on the Management of Sand Mining in the Country. But in the recent past, it has been observed that apart from management and systematic mining practices there is an urgent need to have a guideline for effective enforcement of regulatory provision and their monitoring. Section 23 C of MMDR, Act 1957 empowered the State Government to make rules for preventing illegal mining, transportation and storage of minerals. But in the recent past, it has been observed that there was large number of illegal mining cases in the Country and in some cases, many of the officers lost their lives while executing their duties for curbing illegal mining incidence. The illegal and uncontrolled illegal mining leads to loss of revenue to the State and degradation of the environment.

1. Parts of the river reach that experience deposition or aggradation shall be identified. The Leaseholder/ Environmental Clearance holder may be allowed to extract the sand and gravel deposit in these locations to manage aggradation problem.
2. The distance between sites for sand and gravel mining shall depend on the replenishment rate of the river. Sediment rating curve for the potential sites shall be developed and checked against the extracted volumes of sand and gravel.
3. Sand and gravel may be extracted across the entire active channel during the dry season.
4. Abandoned stream channels on the terrace and inactive floodplains be preferred rather than active channels and their deltas and flood plains. The stream should not be diverted to form the inactive channel.
5. Layers of sand and gravel which could be removed from the river bed shall depend on the width of the river and replenishment rate of the river.
6. Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.
7. Segments of the braided river system should be used preferably falling within the lateral migration area of the river regime that enhances the feasibility of sediment replenishment.
8. Sand and gravel shall not be extracted up to a distance of 1kilometre (1 km) from major bridges and highways on both sides, or five times (5x) of the span (x) of a bridge/public civil structure (including water intake points) on up-stream side and ten times (10x) the span of such bridge on down-stream side, subjected to a minimum of 250 meters on the upstream side and 500 meters on the downstream side.
9. The sediment sampling should include the bed material and bed material load before, during and after the extraction period. Develop a sediment rating curve at the upstream

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end of the potential reach using the surveyed cross-section. Using the historical or gauged flow rating curve, determine the suitable period of high flow that can replenish the extracted volume.

10. Calculate the extraction volume based on the sediment rating curve and high flow period after determining the allowable mining depth.
11. Sand and gravel could be extracted from the downstream of the sand bar at river bends. Retaining the upstream one to two-thirds of the bar and riparian vegetation is accepted as a method to promote channel stability.
12. The flood discharge capacity of the river could be maintained in areas where there is a significant flood hazard to existing structures or infrastructure. Sand and gravel mining may be allowed to maintain the natural flow capacity based on surveyed cross-section history. Alternatively, off-channel or floodplain extraction is recommended to allow rivers to replenish the quantity taken out during mining.
13. The Piedmont Zone (Bhabhar area) particularly in the Himalayan foothills, where riverbed material is mined, and this sandy-gravelly track constitutes excellent conduits and holds the greater potential for groundwater recharge. Mining in such areas should be preferred in locations selected away from the channel bank stretches.
14. Mining depth should be restricted to 3 meters and distance from the bank should be $\frac{1}{4}$ th or river width and should not be less than 7.5 meters.
15. The borrow area should preferably be located on the riverside of the proposed embankment because they get silted in the course of time. For low embankment, less than 6 m in height, borrow area should not be selected within 25 m from the toe/heel of the embankment. In the case of the higher embankment, the distance should not be less than 50 m. In order to obviate the development of flow parallels to the embankment, crossbars of width eight times the depth of borrow pits spaced 50-to-60-meter centre-to-centre should be left in the borrow pits.
16. Demarcation of mining area with pillars and geo-referencing should be done prior to the start of mining.
17. A buffer distance /un-mined block of 50 meters after every block of 1000 meter over which mining is undertaken or at such distance as may be the directed/prescribed by the regulatory authority shall be maintained.
18. A buffer distance /unmined block of 50 meters after every block of 1000 meters over which mining is undertaken or at such distance as may be the directed/prescribed by the regulatory authority shall be maintained.
19. River bed sand mining shall be restricted within the central $\frac{3}{4}$ th width of the river/rivulet or 7.5 meters (inward) from river banks but up to 10% of the width of the river, as the case may be and decided by regulatory authority while granting environmental clearance in consultation with irrigation department. Regulating authority while regulating the zone of river bed mining shall ensure that the objective to minimize the effects of riverbank erosion and consequential channel migration are achieved to the extent possible. In general, the area for removal of minerals shall not exceed 60% of the

mine lease area, and any deviation or relaxation in this regard shall be adequately supported by the scientific report.

20. Mining Plan for the mining leases (non-government) on agricultural fields/Patta land shall only be approved if there is a possibility of replenishment of the mineral or when there is no riverbed mining possibility within 5 KM of the Patta land/Khatedari land. For government projects mining could be allowed on Patta land/Khatedari land but the mining should only be done by the Government agency and material should not be used for sale in the open market.

The minerals reserve for riverbed area is calculated on the basis of maximum depth of 3 meters and margins, width and other dimensions as mentioned in para (s) above. The area multiplied by dept gives the volume and volume multiplied with bulk density gives the quantity in Metric Ton. In case of riverbed, mineable material per hectare area available for actual mining shall not exceed the maximum quantity of 60,000 MT per annum.

➤ **Demand and Utilisation of Sand**

Sand is a multi-purpose topographical material. It is known as one of the three fundamental ingredients in concrete. The composition of sand is diverse. Mostly sand is made of silica which is a common element. It can also come from another source of minerals like quartz, limestone, or gypsum.

From beds to flood plains to coastlines- we can find the sand at almost everywhere. The robustness of sand has played a significant role in everyday life. We use sand practically every other day.

Sand extraction from river beds and brick earth mining for making raw bricks are the main mining activities in the district. With a spurt in construction of real estate sectors and various govt. sponsored projects, the demand for both sand and bricks has increased manifold. The extraction of sand is carried out either manually or through semi- mechanized system. The depth of mining for both river bed sand and brick earth is restricted due to statutory provision in the regulations pertaining to conservation and development of minor minerals.

River sand mining is a common practice as habitation concentrates along the rivers and the mining locations are preferred near the markets or along the transportation route, for reducing the transportation cost.

In the real world, there are a lot of situations where we can find uses of sand. Followings are the common sand uses.

1. While bunging metal, we can mix sand with clay binder for frameworks used in the foundries.
2. Sand can be used for cleaning up oil leak or any spill by dredging sand on that spill. The material will form clumps by soaking up, and we can quickly clean the mess.
3. Sand can be used as a road base which is a protective layer underneath all roads
4. Industrial sand is used to make glass, as foundry sand and as abrasive sand.

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5. One creative usage of sand is serving as a candle holder. We can try putting some sand before pouring tea light or any candle in a glass. It holds the candle still and refrain the candle from rolling by giving it an excellent decoration.
6. Adds texture and aesthetic appeal to space.
7. Sand is mostly pure to handle, promptly available and economically wise.
8. We use sand in aquariums, fabricating artificial fringing reefs, and in human-made beaches
9. Sandy soils are ideal for growing crops, fruits and vegetables like watermelon, peaches, peanuts, etc.
10. Sand can light a path by filling mason jars with sand and tea light which is another inexpensive way to make a walkway glow.
11. Sand helps to improve resistance (and thus traffic safety) in icy or snowy conditions.
12. We need sand in the beaches where tides, storms or any form of preconceived changes to the shoreline crumble the first sand.
13. Sand containing silica is used for making glass in the automobile and food industry- even household products for the kitchen.
14. Sand is a strong strand which is used for plaster, mortar, concrete, and asphalt.
15. The usual bricks formulated of clay only are way weaker and lesser in weight than blocks made of clay mixed with sand.

2.2 Methodology of DSR Preparation

The steps followed during the preparation of District Survey Report are given in Figure 2.1. The individual steps are discussed in following paragraphs.

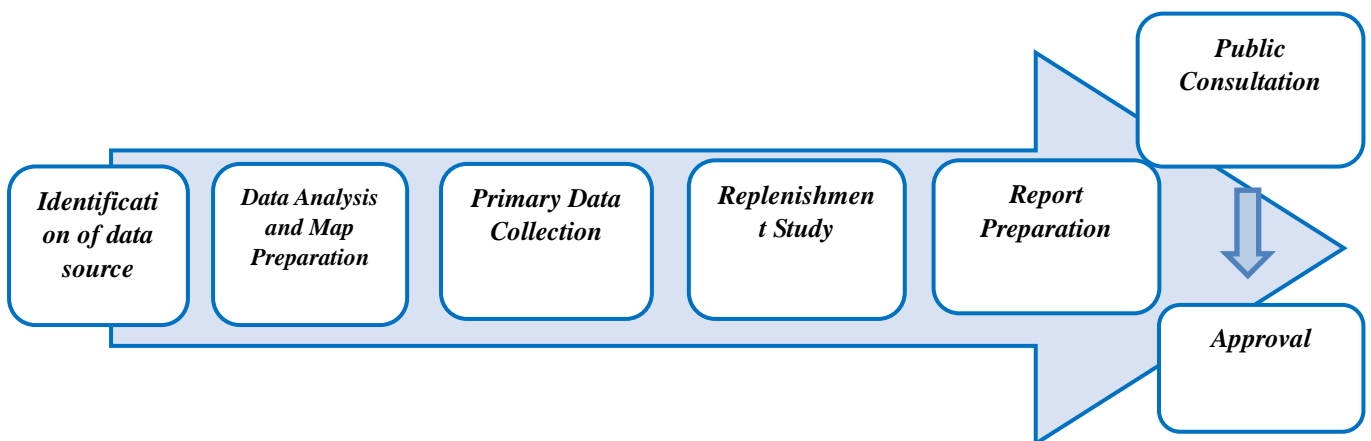


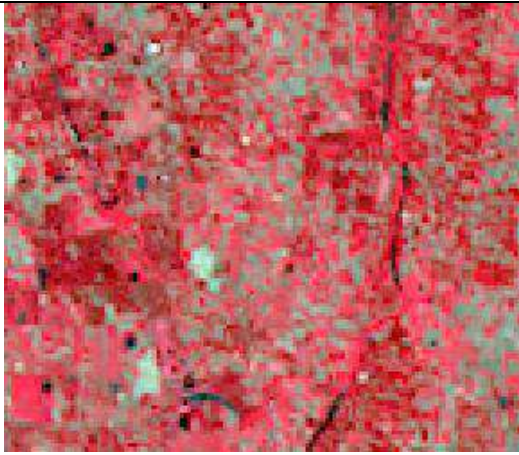

Figure 01: Steps followed in preparation of DSR

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Data source Identification: District Survey Report has been prepared based on the primary data base and secondary data base collected and collated from different sources. It is very critical to identify authentic data sources before compiling the data set. The secondary data sources which are used in this DSR are mostly taken from public domain or from the published report in reputed journals. Information related to district profile has been taken from District Census Report, 2011 and District Statistical Handbook published by the Govt. of Assam. Potential mineral resources of the district have been described based on the published report of Geological Survey of India (GSI) or any other govt. agencies like MECL etc. List of mining lease, name of lease holder, lease/block area, resource in already allotted mining lease, revenue from minor mineral sector etc. have been collected from the concern DL & LRO offices of the district. Satellite images have been used for map preparation related to physiography and land use/land cover of the district.

Data Analysis and Map Preparation: To prepare the Maps of the district, we have collected the data set which are captured during the report preparation. They have gone through detail analysis work. District Survey Report involves the analytical implication of captured dataset to prepare relevant maps. Methodology adopted for preparation of relevant maps is explained below:

Land Use and Land Cover Map: Land Use and Land Cover classification is a complex process and requires consideration of many factors. The major steps of image classification include determination of a suitable classification system via Visual Image Interpretation, selection of training samples, Satellite image (FCC-False Color Composite) pre-processing, selection of suitable classification approaches, post classification processing, and accuracy assessment. Here LISS-III satellite imagery has been taken for supervised classification as supervised classification can be much more accurate than unsupervised classification, but depends heavily on the training sites, the skill of the individual processing the image, and the spectral distinctness of the classes in broader scale. According to the Visual Image Interpretation (Tone, Pattern, Texture, Shape, Color etc.) training set of the pixel has been taken. Pictorial descriptions of Land Use classification are explained in Figure 01.

	
Agricultural Land - Based on their Geometrical shape, Red and Pink color tone, Agricultural Land has been identified.	Vegetation Covered Area - Area with continuous Red color tone, Vegetation Covered Area has been classified.

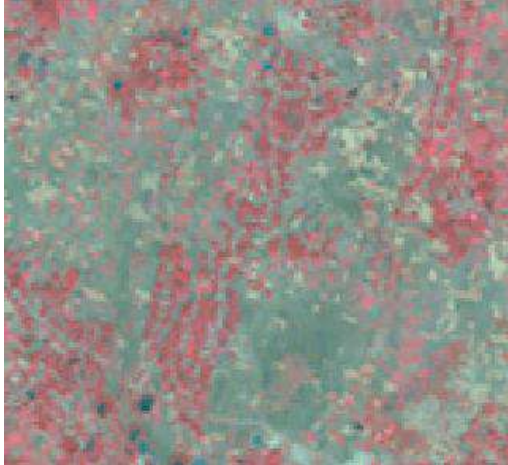
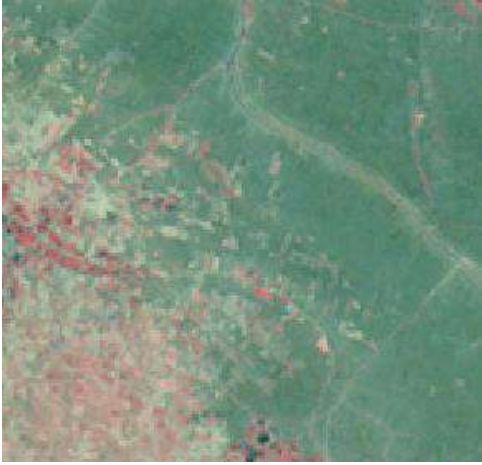


	
<p>Agricultural Fallow Land - Based on their Geometrical shape, Yellowish green color tone, Agricultural Fallow Land has been identified.</p>	<p>Badland Topography- Area with Non geometrical shape and Yellowish green color tone has been identified as Bad Land Topography.</p>
	
<p>Settlement – Area with some geometrical shape in a Linear Pattern including Light Cyan Color has been recognized as Settlement Area.</p>	<p>Water Bodies – Area with Blue color has been classified as Water Bodies.</p>

Figure 02: Pictorial description of Land Use Classification methods

Geomorphological Map: The major step of preparing Geomorphological Map is identifying features like – Alluvial Fan, Alluvial Plain, Hilly Region etc. from Satellite Imagery (FCC- False Colour Composite) via Visual Image Interpretation and then digitisation has been taken into the consideration to prepare map including all the Geomorphological features according to their location. Pictorial descriptions of Geomorphological unit’s classification are explained in Figure 03.



	
<p>Flood plain-Flood plain is a generally flat area of land next to a river or stream. It stretches from the banks of the river to the outer edges of the valley.</p>	<p>OX-BOW Lake- An ox-bow lake starts out as a curve, or meander, in a river. This “U” shaped body of water identified as Ox- Box Lake from Satellite Imagery.</p>

Figure 03: Pictorial description of Geomorphological Units Classification methods

Physiographical Map: The major step of preparing Physiographical Map is generating contour at a specific interval to show the elevation of the area using Cartosat DEM.

Block Map/Transportation Map/Drainage Map:

- Raw Data collected from National Informatics Centre (NIC Website) during May 2024.
- Data has been geo-referenced using GIS software.
- Digitization of block boundary, district boundary, state boundary, international boundary, and district headquarter, sub–district headquarter, places, road, railway, river, nala etc.
- Road name, River name, Railway name has been filled in attribute table of the Layers
- Final layout has been prepared by giving scale, legend, north arrow, etc.

Earthquake Map:

- Raw data collected from Ministry of Earth Science.
- Data has been geo-referenced using GIS software.
- Digitization of Earthquake zone and superimposed it over Block Boundary.
- Zone name has been filled in attribute table of the Layers
- Final layout has been prepared by giving scale, legend, north arrow, etc.

Soil Map:

- Raw data collected from National Bureau of Soil Survey and Land Use Planning during May 2024.
- Data has been geo-referenced using GIS software.
- Digitization of Soil classification zone and superimposed it over District Boundary.
- Soil classification has been filled in attribute table of the Layers.
- Final layout has been prepared by giving scale, legend, north arrow, etc.

Wildlife Sanctuary and National Park location Map:

- Raw data obtained from ENVIS Centre on Wildlife & Protected Areas during August 2020.
- Data has been geo-referenced using GIS software.
- Digitization of Wildlife Sanctuary and National Park and superimposed it over Block Boundary.
- Wildlife Sanctuary & National Park name has been filled in attribute table of the Layers
Final layout has been prepared by giving scale, legend, north arrow, etc.

Primary Data Collection: To prepare DSR, primary data has been collected and field work has also been carried out for the district. Field study involves assessment of the mineral resources of the district by means of pitting / trenching in specific interval. This provides clear picture of mineral matters characterization and their distribution over the area.

Replenishment study: One of the principal causes of environmental impacts of river bed mining is the removal of more sediment than the system can replenish. Therefore, there is a need for replenishment study for riverbed sand in order to nullify the adverse impacts arising due to excess sand extraction. We have conducted Physical survey by the help of DGPS to define the topography, contours and offsets of the riverbed. The surveys clearly depict the important attributes of the stretch of the river and its nearby important civil and other feature of importance. This information will provide the eligible spatial area for mining. The annual rate of replenishment carried out on every river of the district to have proper assessment of the sand reserve for mining purposes. The surveys clearly depict the important attributes of the stretch of the river and its nearby important civil and other feature of importance. This information will provide the eligible spatial area for mining.

Report Preparation: The district survey report portrays general profile, geomorphology, land use pattern and geology of the district. The report then describes the availability and distribution of riverbed sands and other minor minerals in the district. Apart from delineation the potential mining blocks, the report also includes Inventorisation of the minerals, recent trends of production of minor minerals and revenue generation there from. Annual replenishment of the riverbed sand has been estimated using field observation, satellite imagery and empirical formula. The road network connecting arterial road to potential mining blocks has been identified. Potential environmental impacts of mining of these minerals, their mitigation measures along with risk assessment and disaster management plan have also been discussed. Finally, the reclamation strategy for already mined out areas is also chalked out.

Public Consultation & Approval: In accordance with the Enforcement and Monitoring Guidelines for Sand Mining, the UT Government would look for public feedback on the list of mining zones that will be placed up for auction. The DSR, which includes the list of zones will be advertised in local and national newspapers as well as in district administration website. The public will have twenty one days to provide their input or any comment which will then be considered by the district committee. Sand mining zones, including clusters and contiguous clusters, will be defined in the final DSR. The final list of sand mining areas, including riverbed, Patta land, Khatedari, desiltation locations and M-sand Plants will be defined in the final DSR, following the public hearing as per Annexure-V. Details regarding clusters and contiguous clusters will be provided in Annexure-VI and Annexure-VII. The process flow diagram is as follows:



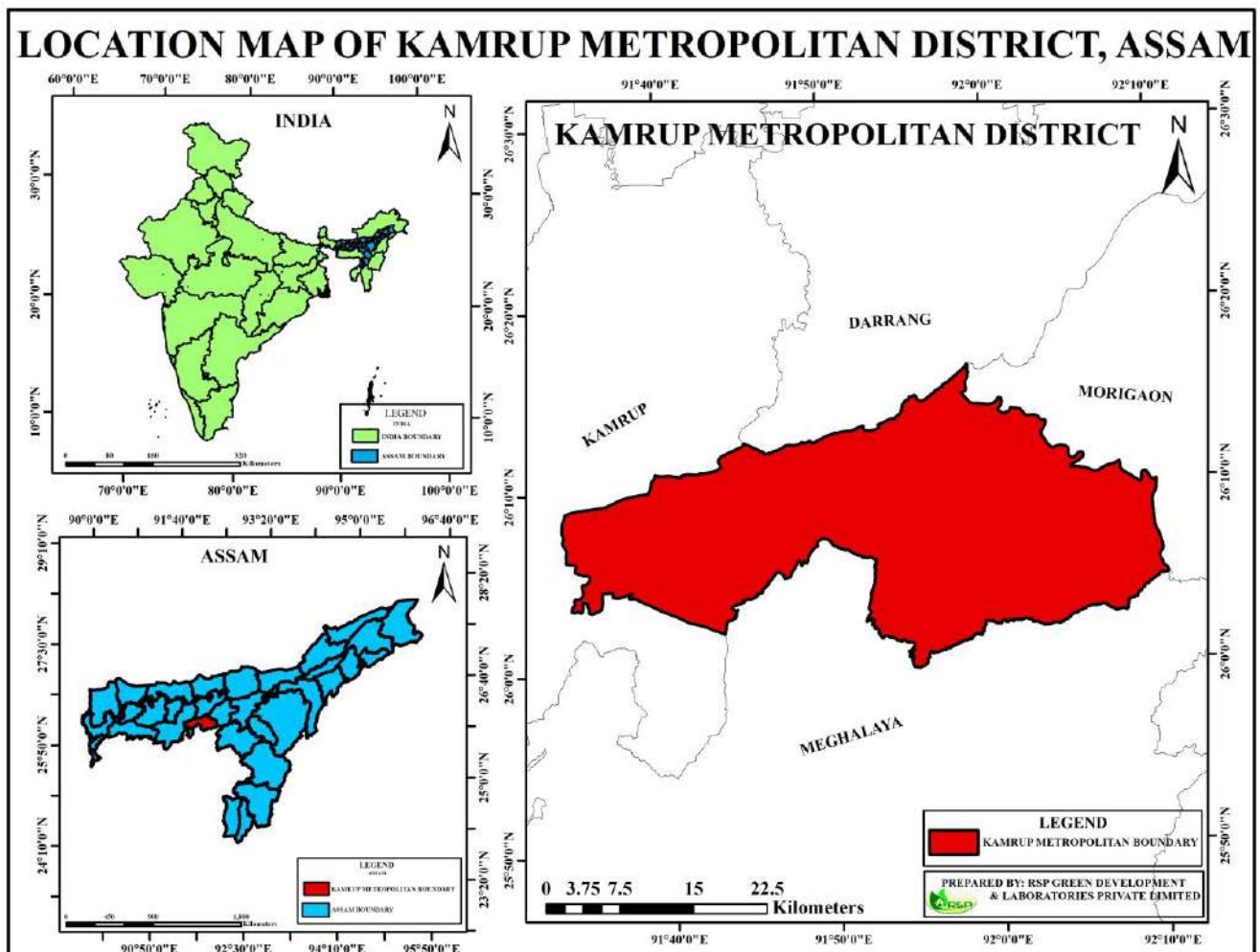
Figure 04: Schematic Representation of Public Consultation

CHAPTER 3: GENERAL PROFILE OF THE DISTRICT

a) General information:

The district Kamrup formed in 2003 when the undivided Kamrup district was split into two, the other being Kamrup Rural district. The district lies between 25°43'–26°51' N Latitude and 90°36'–92°12' E Longitude. The district is located in the lower Brahmaputra Valley zone, bounded by foot hills of Bhutan and Nalbari district at the North, State of Meghalaya at South, Kamrup Metropolitan and Darrang district at East and Goalpara & Nalbari district at the West. Toposheet numbers of the district are 78N/12, 78N/15, 78N/16, 78O/13, and 83B/4.

Figure 05: Location Map of Kamrup Metropolitan



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Table No 02: Administrative units of the Kamrup Metropolitan District

Sl. No.	ADMINISTRATIVE UNITS	STATISTICS
1	District Head Quarter	Guwahati
2	Sub divisions	0
3	Parliamentary Constituency	04
4	Legislative Assembly Constituency	-
5	Revenue Villages	316
6	No. of CD Blocks	03
7	Central Information Commission	-
8	Revenue Circles	05
9	Mouza	
10	Police station	05

(Source: <https://kamrupmetro.assam.gov.in>)

Table No. 03: List of Development Blocks

Sl. No.	Name of Block
1.	Chandeapur
2.	Dimoria
3.	Rani

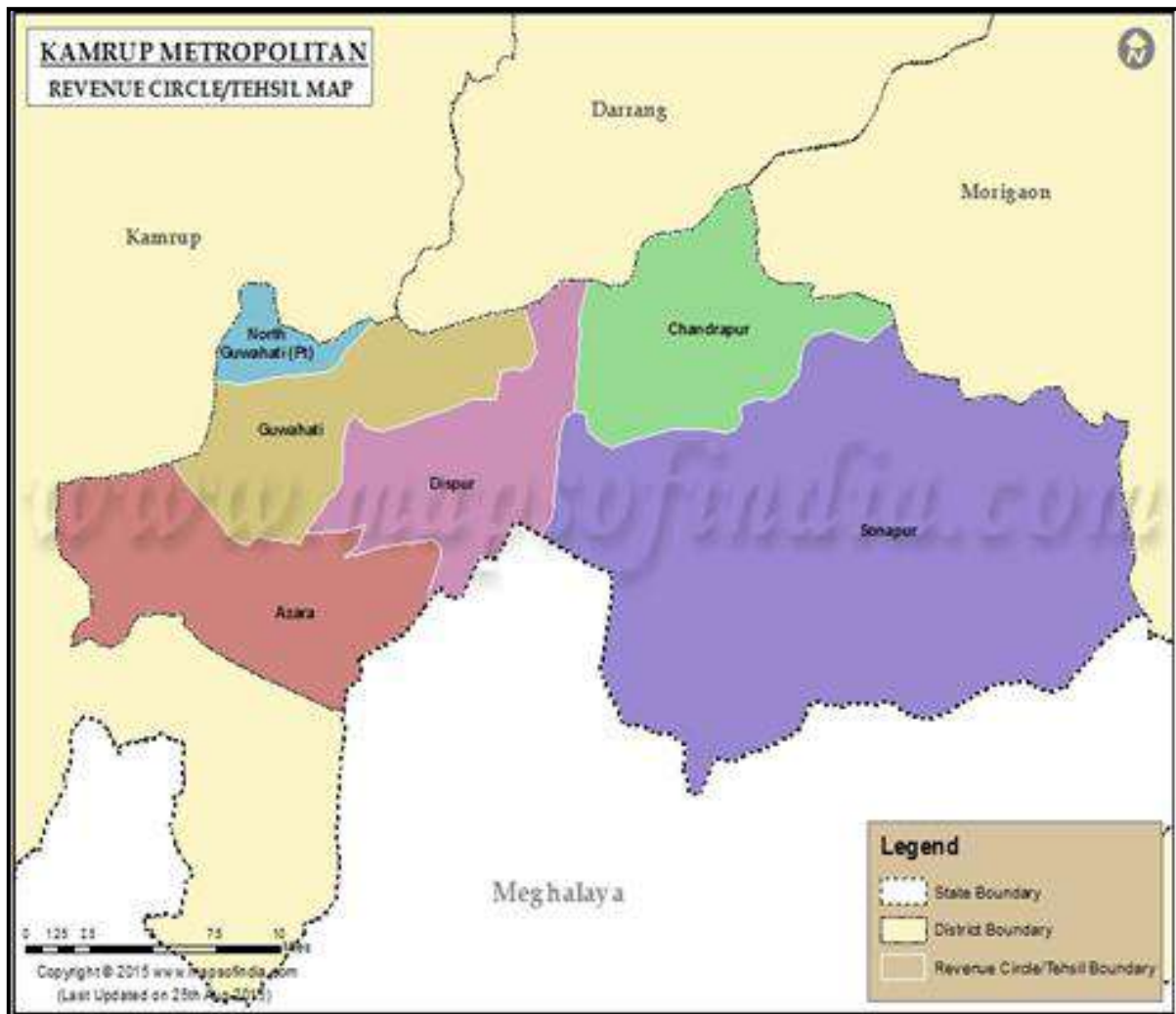
Table No. 04: List of Revenue Circle

Sl. No	Revenue Circle
1.	Sonapur
2.	Guwahati
3.	Azara
4.	Chandrapur
5.	Dispur

Table No.05: 3-Autonomous District (ST) Parliamentary and Legislative Assembly Constituency

Sl. No.	Parliamentary Constituency
1.	51-Jalukbari
2.	52-Dispur
3.	53-Gauhati East
4.	54- Gauhati West

Figure 06: Administrative Map of Kamrup metropolitan district



b) Climatic Condition

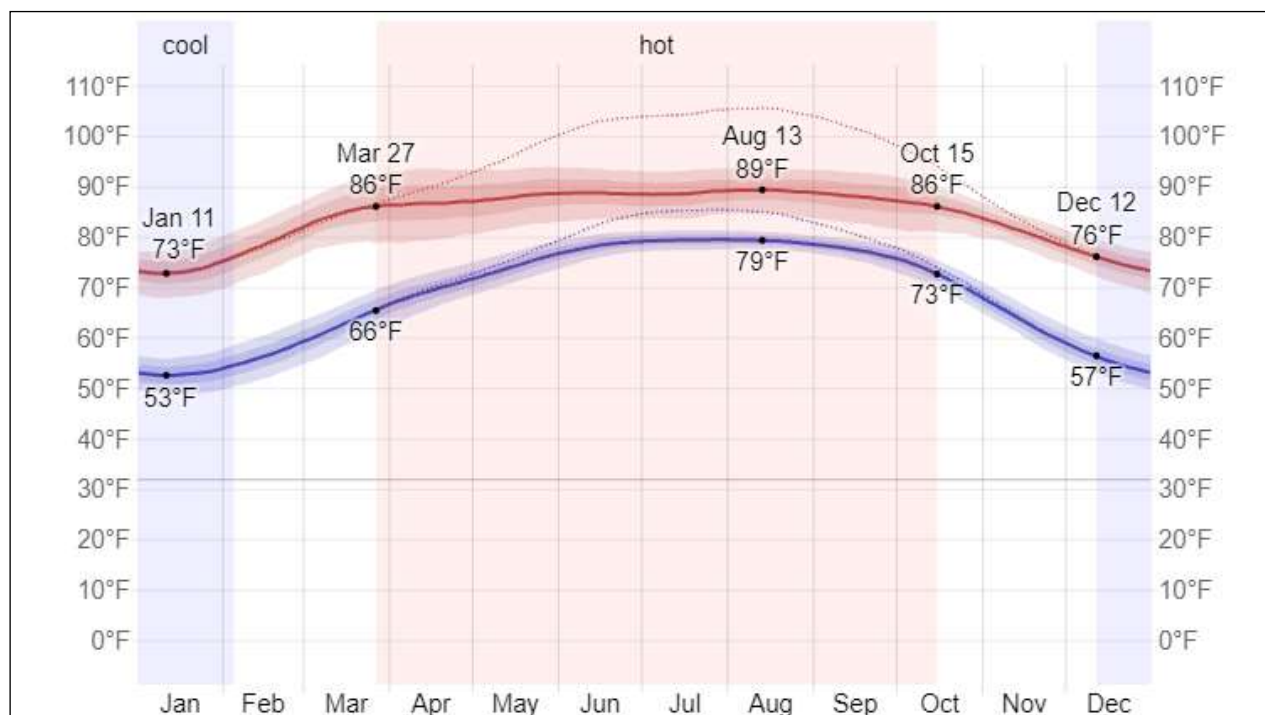
Mother Nature is undeniably very benevolent to this district with diversified climate due to different types of topography. The zone blended with hills and plains and experiences different climates in different parts. The climate of Kamrup Metropolitan District in Assam, India is sub-tropical humid with heavy rainfall, hot summers, and high humidity:

- Annual rainfall: Ranges from 1500–2600 mm
- Average humidity: 76%
- Maximum temperature: 37–39°C
- Minimum temperature: 6–7°C

The district is located between 25°43' and 26°51' N Latitude and 90°36'–92°12' E Longitude. The major rivers in the district are the Brahmaputra, Bharalu, Digaru, and Kolong.

The district's physiography is divided into three units: a hilly region in the south, an alluvial plain in the central and western part, and swampy areas along the Brahmaputra plains.

Figure 07: Kamrup Metropolitan Average Temperature



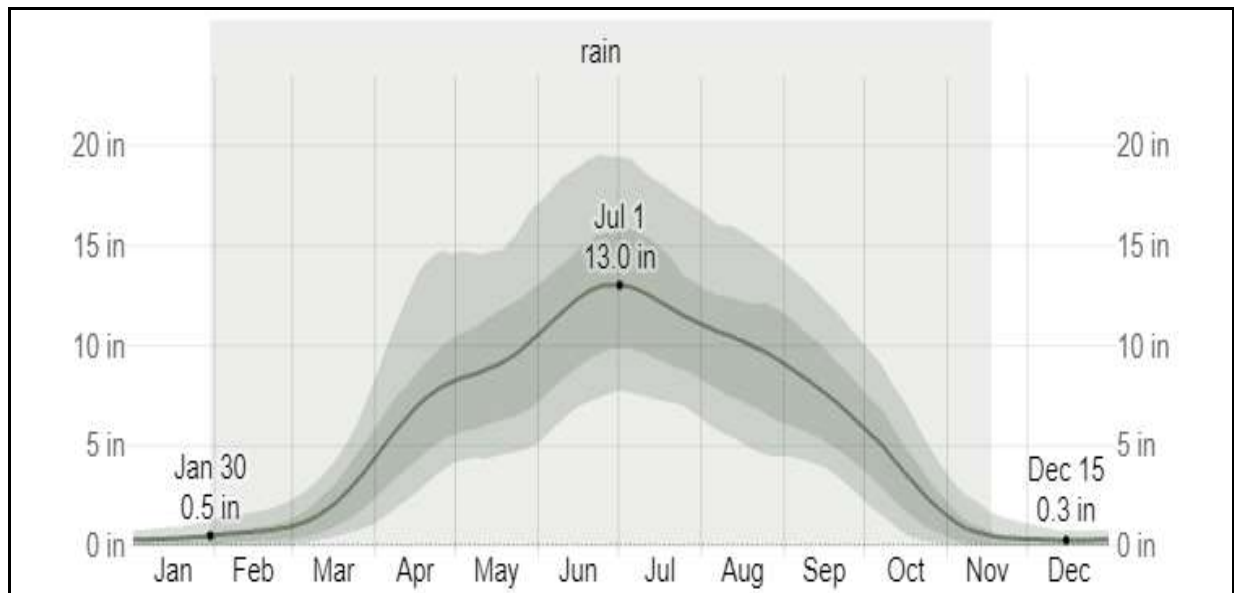
(Source: <https://weatherandclimate.com>)

c) Rainfall: Monthwise

In 2020, rainfall actual level for Kamrup metropolitan was 1,320.78 mm. Though Kamrup metropolitan rainfall actual level fluctuated substantially in recent years, it tended to decrease through 2001 - 2020 period ending at 1,320.78 mm in 2020. Figure 05: Average Monthly Rainfall in Guwahati The North-East region receives heavy rainfall than other parts of India. It

is one of the highest rainfall regions in India. Analysis of rainfall, temperature and flow pattern of the river across this region would be of great importance to water resources planners. The present work deals with the impacts of climate change in the rainfall pattern and changes in trend of temperature in the Kamrup District of Assam. Historical trends in rainfall, discharge and temperature is analysed for the past several years. Changes in rainfall pattern is presented showing changing trend in annual rainfall from 1901-2017. No significant trend of rainfall is observed but post 2000, the trend follows a declining trend of rainfall pattern. Similar analysis of temperature variation over the period 1901-2002 depicts almost a similar pattern between the year 1901 and 1997 and a rise in temperature in the beginning of 2000's. Trend of peak discharge in Brahmaputra river shows a declining pattern over the study period whereas the annual flow of the river shows a positive trend. The main aim of this study is to observe the flow pattern of Brahmaputra river gauged at Pandu station in Guwahati and to observe the rainfall pattern and the trend of temperature due to climate variation in the Kamrup District. The result is hoped can support the project design of water resources structures. (<https://en.climate-data.org/>)

Figure 08: Rainfall Graph of Kamrup Metropolitan District



(Source: <https://weatherandclimate.com>)

d) Topography & Terrain:

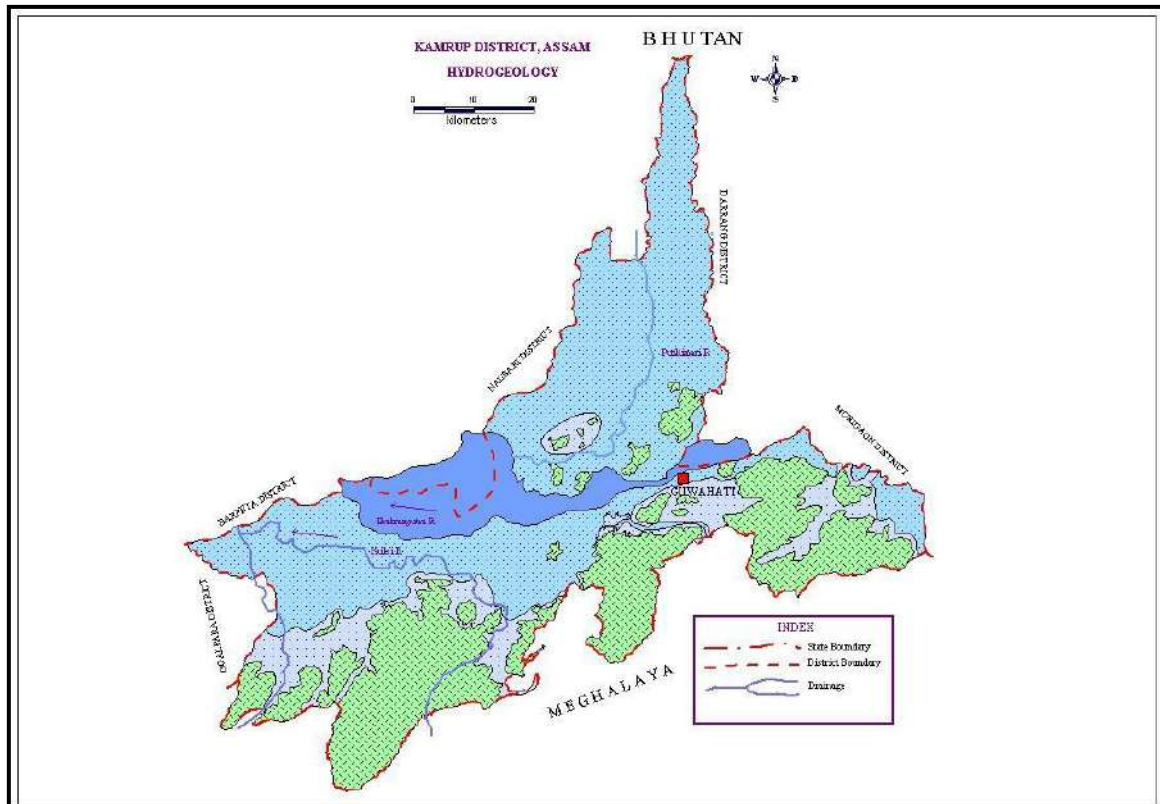
At a comparatively short distance from the river banks the ground begins to rise in undulating knolls towards the mountains of Bhutan on the north, and towards the Khasi hills on the south. The hills south of the Brahmaputra in some parts reach the height of 800 feet (240 m). The Brahmaputra, which divides the district into two nearly equal portions, is navigable by river steamers throughout the year, and receives several tributaries navigable by large native boats in the rainy season. The chief of these are the Manas, Chaul Khoya and Barnadi on the north, and the Kulsi and Dibru on the south bank.

e) Water Course & Hydrology:

Hydrological condition at a particular point is guided by topography, geology, and rainfall of the region. Central Ground Water Board (CGWB) has carried out detail hydrogeological investigation of the district.

The area consists of two broad hydrogeological units – 1) **Pre-Cambrian consolidated rocks** and 2) **Quaternary alluvium** consisting of unconsolidated sediments. Pre-Cambrian consolidated rocks are confined to hilly areas and inselbergs, where ground water occurs in shallow weathered zone and this can be developed through open wells. The joints and fractures developed due to tectonic activities form potential water bearing zones and suitable for development through construction of bore wells. In the alluvial plain, groundwater occurs in regionally extensive aquifers down to the depth of 305 m. It has a very good yield prospect. The aquifers are consisting of sands of various grades with gravel and are suitable for construction of both shallow and deep tube wells. Groundwater occurs under unconfined to semiconfined condition occupying an area of about 200 sq. km. in and around Haihata – Dumunichowki which is under artesian condition. In other parts also, the water level rests at shallow depth and in major part, it rests between 2 – 5 m bgl during primonsoon period. The study of long-term water level trend shows no significant change in rise/fall in water level in the last 10 years. The shallow tube wells tapping aquifers within 50 m depth are capable of yielding about 10 lps in major places, deep tube wells constructed within 95 m depth tapping about 30 m granular zones are yielding 10 – 20 lpm. The transmissivity of the aquifer ranges from 41 to 6162 m² /day and the permeability varies from 10 to 59 m/day. In hard rock, the yield of bore well-constructed in greater Guwahati area ranges from 4 to 300 lpm.

Figure 09: Hydrogeology Map of Kamrup Metropolitan district



**KAMRUP DISTRICT, ASSAM
HYDROGEOLOGY**

LEGEND

MAP UNIT	FORMATION	LITHOLOGY/GEOMORPHIC FEATURES	AQUIFER DISPOSITION	GROUND WATER PROSPECT
	Recent Alluvium	Sand, gravel, boulders with clay partings/Flood Plain zones and Younger alluvial plain	Aquifer thickness, 30-70m within 150-300m depth	Highly potential. Suitable for shallow tubewells with yield 30-50m ³ /hr and deep tube wells of 150-200m depth with yield 50-150m ³ /hr.
	Older Alluvium	Sand, gravel, clay, boulders/Older Alluvial Plain, Valley fill, Piedmont Plain	Aquifer thickness, 10-50m within 50-100m depth.	Suitable for shallow tube wells with yield 10-20m ³ /hr and deep tube well upto 100m depth with yield 30-50m ³ /hr. Dug wells feasible at the foothills
	Shillong Group	Granite gneiss and weathered materials/ Denudational hill and Inselberg	Weathered zones, joints and fractures. Thickness in weathered zones, 5-15m	Poor potential. Dug wells are feasible in weathered zones. Boreholes at fracture zones at selected points.

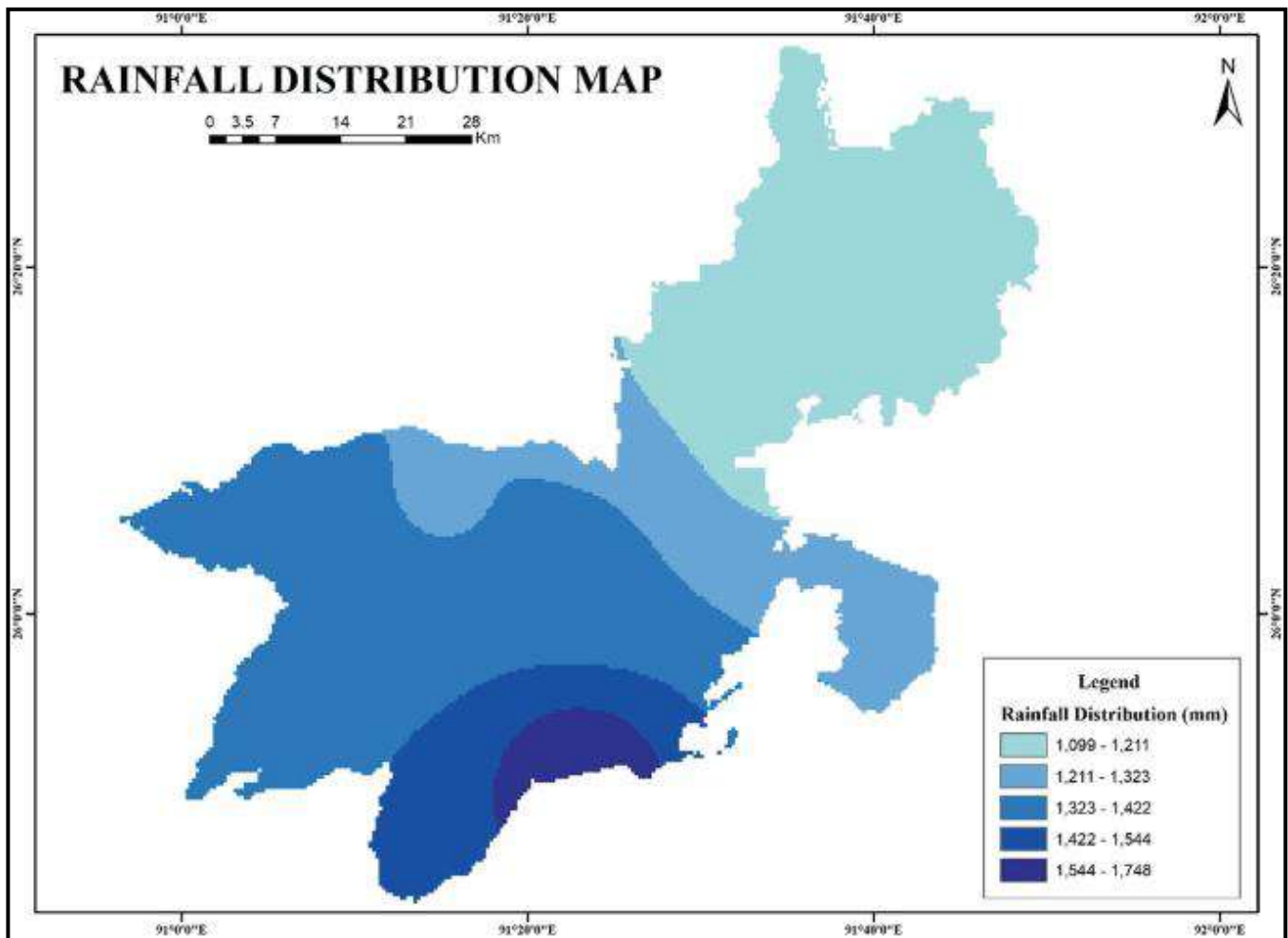
Source: Central Ground Water Board

f) Ground Water Development:

Ground water development is at low key at present and estimated to be 644 MCM only against the vast annual dynamic resources of 1482 MCM. After allocation for domestic and industrial requirement of 105 MCM for a population estimated in 2025, the net annual dynamic resources of 790 MCM are still available for development. At present, groundwater draft is mainly for domestic and irrigation purposes and a negligible amount is for industry. The water supply schemes for drinking purpose are executed by Assam Public Health Engineering Department through groundwater structures like dug well, hand pump and deep tube well. The groundwater draft for irrigation is mainly from shallow tube well implemented by Agriculture Department through the farmers. The existing draft for irrigation is estimated to be 586 MCM.

❖ **Ground water quality:** The water samples collected from the monitoring stations and the exploratory wells drilled in different parts of the district were analyzed in the Chemical Laboratory of C.G.W.B., NER, and Guwahati. The results of the chemical analysis of ground water samples reveal that ground water is fresh, potable and suitable for both domestic and irrigation purposes. However, due to slightly higher content of iron in some sporadic patches of the area and fluoride content exceeding permissible limit in some pockets in and around Guwahati City, water needs to be treated before being used for drinking purpose.

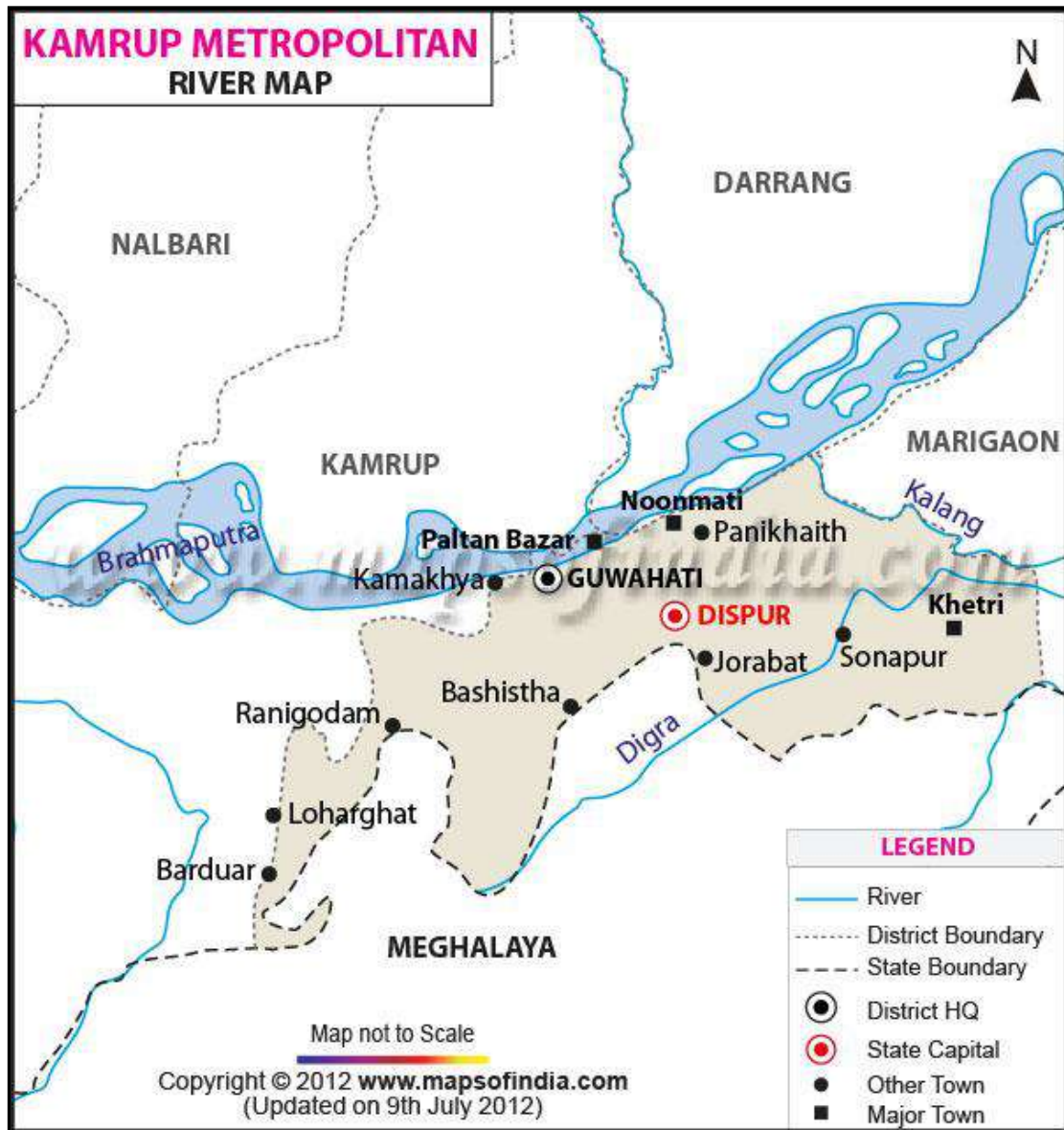
Figure 10. Rainfall map of Kamrup Metropolitan district



g) Drainage System (general):

The Kamrup Metropolitan District in Assam, India is drained by several rivers, including the Brahmaputra, Bharalu, Digaru, and Kolong. The Brahmaputra is the major river in the area, and its drainage area is roughly 935,500 sq km. The Bharula, Khana-jan, and Bondajan rivers meet the Brahmaputra on its south bank. A blockage in the drainage system of these rivers can cause backflow from the Brahmaputra, leading to frequent flooding in the city during the summer.

Figure 11. Drainage Network Map of the Kamrup Metropolitan district



h) Demography:

As per census 2011 area of Kamrup Metropolitan district is 2287 sq.km.

Table No. 06: Demographic data table

Considerations	Statistical Data
Area of Kamrup Metropolitan	1527.84 sq.km
Total No. of villages	220
Total Population	1,253,938
Male	6.48 lakhs
Female	6.06 lakhs
Density of Population	2010/sq.km
Sex Ratio (Adult)	946 females/1000 males
Sex Ratio (Child)	986 females/1000 males

(Source: <https://www.census2011.co.in>)

Table No. 07: Town wise Population, Literacy rate:

Description	Urban
Literates (Total)	88.66%
Male Literates	94.08%
Female Literates	88.09%
Schedule caste Population	7.15%
Schedule tribe Population	12.45%

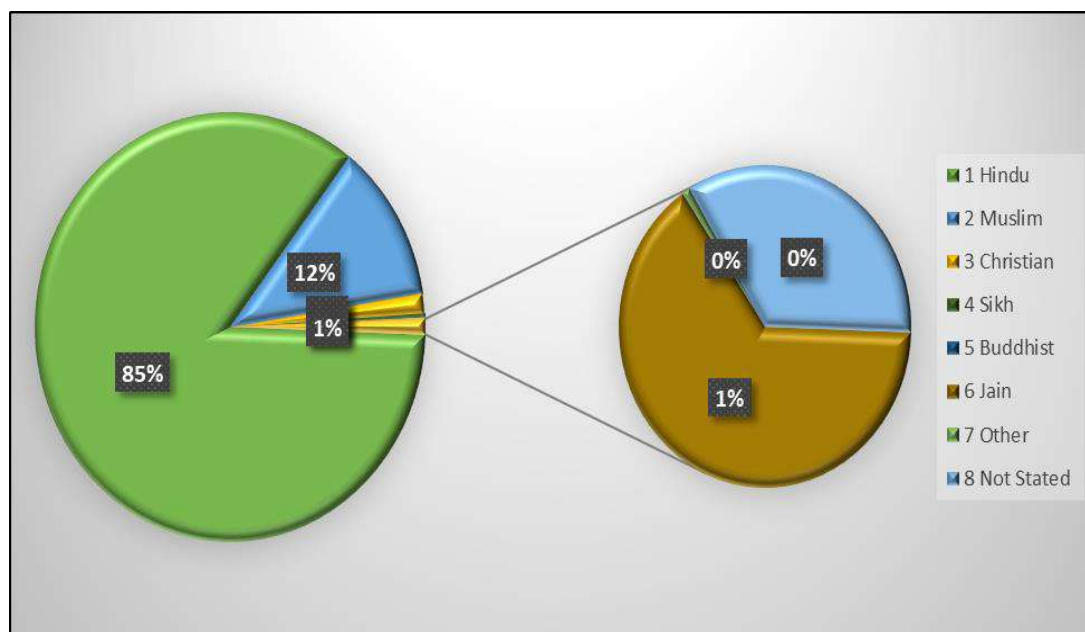
(Source: www.census2011.co.in)

Table No. 08: Religion data of the Kamrup Metropolitan district

Sl. No.	Description	Percentage (%)
1.	Hindu	84.89
2.	Muslim	12.05
3.	Christian	1.50
4.	Sikh	0.29
5.	Buddhist	0.13
6.	Jain	0.74
7.	Other	0.01
8.	Not Stated	0.39

(Source: www.census2011.co.in)

Figure 12: Percentage of Population of different religion



i) Cropping Pattern:

Agriculture is the main source of income of this region. The economic development of the district is highly dependent on agriculture and allied activities. Due to rich geographical and agro-climatic diversity, various types of crops are grown in the district of Kamrup Metropolitan. A large portion of the area in Kamrup Metropolitan District is mostly rainfed as the District has been blessed with heavy rainfall during Kharif season. However, there is need and scope to improve irrigation facility to increase Cropping Intensity.

Table no 09 : Agricultural landuse data of the Kamrup Metropolitan district

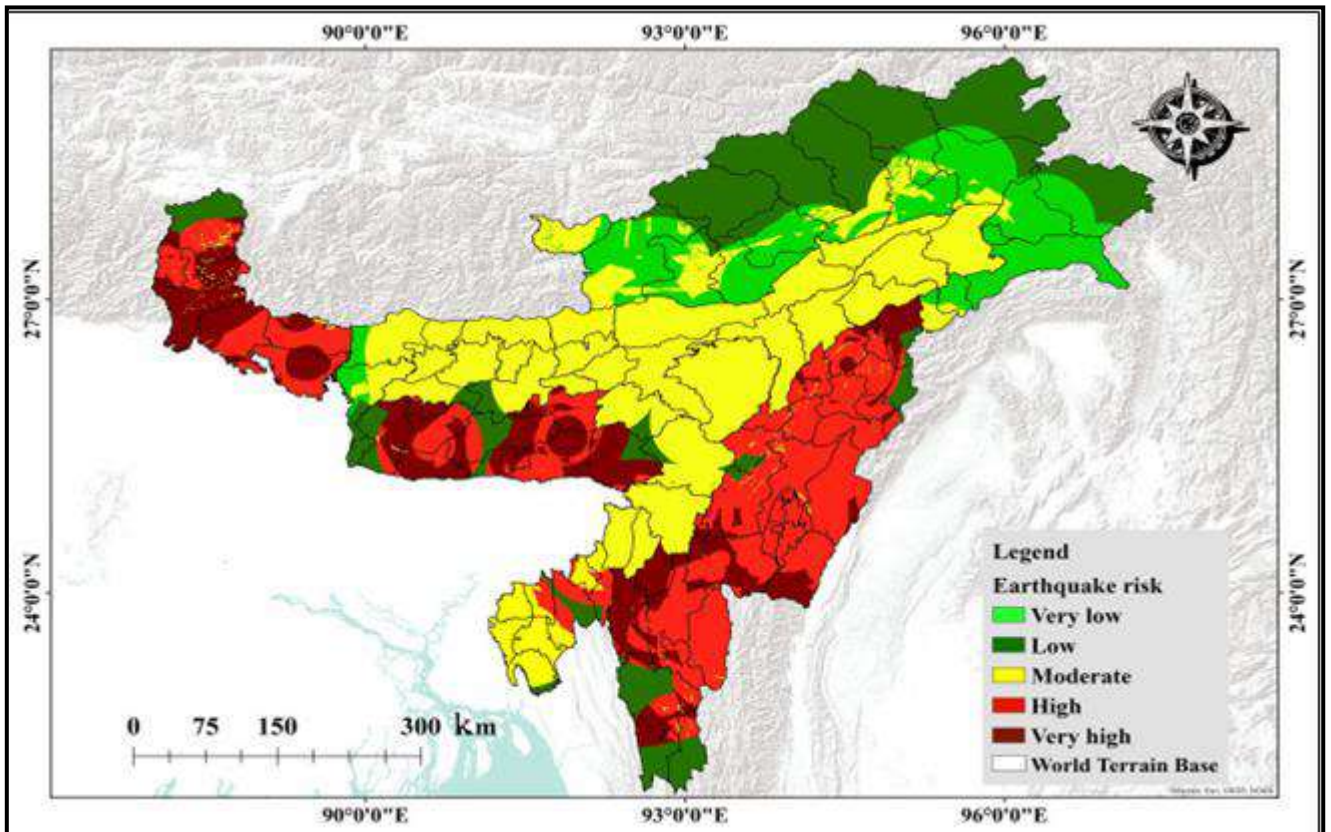
Crop Type	Kharif (Area in ha.)			Rabi (Area in ha.)			Summer Crop (Area in ha.)		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Cereals	0	17189	17189	0	0	0	6916	5564	12480
Coarse Cereals	0	0	0	2	0	2	0	0	0
Pulses	0	0	0	153	493	646	0	0	0
Oil Seeds	0	0	0	339	1083	1422	0	0	0
Fibre	0	2	2	0	0	0	0	0	0
Any Other Crop	0	0	0	0	0	0	0	0	0
Total	0	17189	17189	494	1576	2070	6916	5564	12480

(Source: (www.icar-crida.res.in))

j) Land Form and Seismicity:

Kamrup is in zone V, which is one of the most seismically active regions in India. Kamrup is vulnerable to earthquakes because of its high population density and poorly designed buildings. The combination of the region's high seismic hazard situation, Guwahati's topographical and geological site conditions, the city's vulnerable building stock which has resulted from a rapid building development over the past decades, the city's large and dense population as well as the city's strategic importance, makes Guwahati a perfect candidate to develop a more advanced earthquake damage and loss information system which will be the first of its kind in India and the southeast Asian region. The region is vulnerable to large earthquakes within 100 km due to its high population density and poorly designed buildings.

Figure 13: Seismic map of Assam and North East Part



k) Major Flora of Kamrup Metropolitan:

Biodiversity has ethical, social, scientific, aesthetic and economic value distinct from that of biological resources. Information about the characteristics and status of biodiversity is severely lacking for most ecosystems. The National Bio-diversity Strategy and Action Plan (NBSAP) has been engaged in looking at, analysing, strategizing and planning for the conservation and enhancement of bio-diversity in diverse fields in all the states of India, as Assam. The plant diversity in Kamrup Metro is mainly determined sub-tropical climate. The floral species which are predominant in the district are as follows:

Table No. 10: The predominant floral species in Kamrup Metropolitan District

Botanical name	Family	Local Name	Part(s) used	Ethnomedicinal uses
<i>Cyperus rotundus</i>	Cyperaceae	Keya bon	Whole plant	Estrogenic
<i>Datura metel</i>	Solanaceae	Kola-dhatura	Leaves, seed	Dysmenorrhea
<i>Dolichos biflorus</i>	Fabaceae	Kulthi mah	Seed	Dysmenorrhea
<i>Hyptianthera strica</i>	Rubiaceae	Mirherai	Leaves	Ease labour
<i>Jatropha curcus</i>	Euphorbiaceae	Bhotera	Leaves, seed	Amenorrhea, oligomenorrhea
<i>Nelumbo nucifera</i>	Nymphaeaceae	Lotus/ Podum	Carpel	Prevent Miscarriage
<i>Swertia chirayita</i>	Gentianaceae	Chiretta	Root	Prevent Abortion
<i>Bombax ceiba</i>	Bombaceae	Semalo	Bark, Root	Gynaecological disorder
<i>Anthocephalus kadamba</i>	Rubiaceae	Kadam	Leaf, Flower	Labour pain
<i>Terminalia arjuna</i>	Combrataceae	Arjun	Bark, Fruit	Erectile dysfunction, Leucorrhoea
<i>Lawsonia inermis</i>	Lythraceae	Jetuka	Leaves, root, bark	Infertility
<i>Ageratum conyzoides</i>	Asteraceae	Sagun tuloshi	Leaves, flower, seed	Prostrate problem
<i>Andrographis paniculata</i>	Acanthaceae	Kalpatita, Kalmegh	Whole plant	sexual disorder
<i>Aloe barbadensis</i>	Liliaceae	Chalkuwari	Leaves	Parturient, irregular menstruation
<i>Mangifera indica</i>	Anacardiaceae	Aam	Fruit	Impotency
<i>Hemidesmus indica</i>	Asclepiadaceae	Anantamul/ Sarsaparilla	Stem, Root	Leucorrhoea
<i>Enydra fluctuans</i>	Asteraceae	Helochy	Whole plant	Impotency/Infertility
<i>Semecarpus anacardium</i>	Anacardiaceae	Velaguti	Fruit	Inducing fertility
<i>Terminalia bellirica</i>	Combrataceae	Bhomora	Fruit, Seed	Impotency
<i>Costus speciosus</i>	Zinziberaceae	Jamla khuti	Tuber	Leucorrhoea, Impotency
<i>Desmodium gangeticum</i>	Fabaceae	Shalaparni	Whole plant	Infertility

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<i>Leea macrophylla</i>	Vitaceae	Doolmudra	Leaf, Root	Impotency, Infertility
<i>Cardiospermum helicacabum</i>	Sapindaceae	Jaal koroi	Leaf, Root	Impotency
<i>Vitex negundo</i>	Verbenaceae	Posotia	Whole plant	Placentitis
<i>Portulaca oleracea</i>	Portulacaceae	Pusley	Root	Enhancing fertility
<i>Centella asiatica</i>	Apiaceae	Bor-manimuni	Whole plant	Pelvic inflammatory disease
<i>Citrus aurantifolia</i>	Rutaceae	Kaji nemu	Fruit	Male, female infertility
<i>Dychoriste perrotteti</i>	Acanthaceae	Buohoh	Leaves	Female infertility
<i>Benincasa hispida</i>	Cucurbitaceae	Komora	Seed, fruit	Induced fertility
<i>Colocasia esculanta</i>	Araceae	Kola kochu	Whole plant	Induced fertility
<i>Crotolaria juncea</i>	Fabaceae	Shan	Leaves	Induced fertility
<i>Saraca asoca</i>	Caesalpinaceae	Ashok	Flower, bark	Fertility enhancement
<i>Musa paradisiaca</i>	Musaceae	Banana	Root	Inducing fertility
<i>Pongamia pinnata</i>	Fabaceae	Karos	Seed, root, Bark, leaf	Increase fertility, potency
<i>Solanum Indicum</i>	Solanaceae	Gos alu	Fruit, root	Induce fertility
<i>Ipomoea Aquatica</i>	Convolvulaceae	Kalmou	Fresh twig	Treatment of impotency, infertility
<i>Cynodon Dactylon</i>	Poaceae	Dubori- bon	Whole plant	Infertility treatment
<i>Clitoria ternatea</i>	Fabaceae	Aparajita	Leaf, root, seed	Enhancing fertility
<i>Argyreia speciosa</i>	Convolvulaceae	Bichtarak	Flower, Root	Aphrodisiac, induce Fertility
<i>Putranjiva Roxhburgii</i>	Euphorbiaceae	Putrajiv	Seed, Leaves	Induction of fertility
<i>Cleome gynandra</i>	Capparaceae	Bhutmula, Gandhali bon	Leaves	Induction of fertility
<i>Sterospermum Suaveolens</i>	Bignoniaceae	Patla	Leaves	Increase fertility, potency
<i>Amaranthus tricolor</i>	Amaranthaceae	Morisha hak	Whole plant	Induce fertility
<i>Amaranthus spinosus</i>	Amaranthaceae	Kutura hak	Tender aerial part, root	Increase fertility, potency

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<i>Asparagus racemosus</i>	Liliaceae	Satamul	Root	Facilitate delivery, Check abortion
<i>Mesua ferrea</i>	Clusiaceae	Nahor	Flower, seed	Impotency
<i>Nerium indicum</i>	Apocynaceae	Karabi	Root	Abortive
<i>Symplocos paniculata</i>	Symplocaceae	Bhomloti	Leaves, bark	Check threatened abortion
<i>Sida rhombifolia</i>	Malvaceae	Boriala	Whole plant	Enhance sexual strength
<i>Wedelia chinensis</i>	Asteraceae	Maha- bhringaraj	Leaves	Menorrhagea

(Source: ETHNOBOTANICALLY IMPORTANT MEDICINAL PLANTS OF KAMRUP DISTRICT, ASSAM, INDIA, USED IN FERTILITY TREATMENT;Deka J *, Kalita J. C. Department of Zoology, Gauhati University, Guwahati-781014, Assam, India)

1) Major Fauna of Kamrup Metropolitan:

The wild biodiversity of Kamrup Metro is well known. But the studies conducted by few individual and conservation biologists have revealed that it is one of the key sites for conservation of threatened and endemic flora as well as fauna. Kamrup Metro district is a home to a great variety of wildlife, mammals like tiger, elephant, bear, hoolock gibbon, leopard, clouded leopard, Indian pangolin, small Indian civet, pig-tailed macaque, leopard cat, sambar, barking deer, porcupine, and mongoose. Seven species of primates, i.e., Hoolock Gibbon *Hylobates hoolock*, Capped Langur *Trachypithecus pileatus*, Rhesus Macaque *Macaca mulatta*, Pig-tailed Macaque *M. nemestrina*, Assamese Macaque *M. assamensis*, Stump-tailed Macaque *M. arctoides* and Slow Loris *Loris tardigradus*, are predominant species (Choudhury 1996). The reptiles as king cobra, monitor lizard, python etc., are also abundant in EKAWLS. Around 250 avian species have been recorded like great Himalayan hornbill, lesser racket-tailed drongo, black hooded oriole, imperial pigeon, green pigeon, emerald dove, hill partridge, jungle fowl, pheasant, hoopoe, koel, king fisher, stork, heron, pelican, wood pecker, myna, yellow bittern and egret etc. (www.assaminfo.com). Few important animals in EKAWLS are enlisted below:

Table No. 11: Scientific names and the species types of few important animals

COMMON NAME (IN ASSAMESE/ ENGLISH)	SCIENTIFIC NAME	SPECIES TYPE
Dhekiapotia bagh/Tiger	<i>Panthera tigris</i>	Mammal
Clouded leopard	<i>Neofelis nebulosa</i>	Mammal
Leopard cat	<i>Prionailurus bengalensis</i>	Mammal
Hati/ Elephant	<i>Elephas maximus indicus</i>	Mammal
Indian civet	<i>Viverra zibetha</i>	Mammal
Hoolock gibbon	<i>Hoolock leuconedys</i>	Mammal
Pig-tailed macaque	<i>Macaca leonina</i>	Mammal
Assam macaque	<i>Macaca assamensis</i>	Mammal
Barking deer/ Kakar	<i>Muntiacus muntjak</i>	Mammal

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Sambar	<i>Rusa unicolor</i>	Mammal
Indian pangolin	<i>Manis crassicaudata</i>	Mammal
Himalayan hornbill	<i>Buceros bicornis</i>	Aves
Lesser racket-tailed drongo	<i>Dicrurus remifer</i>	Aves
Black hooded oriole	<i>Oriolus xanthornus</i>	Aves
Imperial pigeon	<i>Ducula badia</i>	Aves
Hill partridge	<i>Arborophila torqueola</i>	Aves
Jungle fowl	<i>Gallus gallus</i>	Aves
Hoopoe	<i>Upupa epops</i>	Aves
Yellow bittern	<i>Ixobrychus sinensis</i>	Aves
King cobra	<i>Ophiophagus hannah</i>	Reptilian
Monitor lizard	<i>Varanus varius</i>	Reptilian
Python	<i>Python molurus</i>	Reptilian
Brown tortoise	<i>Manouria emys</i>	Amphibian
Hill tortoise	<i>Melanochelys tricarinata</i>	Amphibian

SOURCE: www.assaminfo.com & www.indiabiodiversity.org/;

Figure 14: Wildlife Sanctuaries and National Parks of Assam



(Source: <https://www.mapsofindia.com/maps/wildlife/wildlife-assam.htm>)

CHAPTER 4: PHYSIOGRAPHY OF THE DISTRICT

4.1 General Land form:

Physiographically the district can be divided into three units; i.e. the hilly region in the south, the alluvial plain in the central and western part and the swampy areas along Brahmaputra plains. The distinguishable geomorphic units are as follows.

- a) Flood plain of river Brahmaputra and its tributaries.
- b) Younger alluvial plain which occupies major part of the area, having slightly higher elevation than flood plain.
- c) Older alluvium/valley fill, gently sloping plain, having higher elevation than the younger alluvial plain.
- d) Piedmont, gently sloping plain along the foothills.
- e) Inselberg occurs as very small isolated hills.
- f) Denudational hills considering of granite, gneissic rocks the different rock formation occurring in the district has been subjected to various soil forming processes through agents of weathering and transportation during different geological ages. Soils comprising various proportions of sand, silt, clay and organic material in the district are grouped into three broad categories – **a) newer alluvial soil, b) valley fill/older alluvial soil and c) soils over forest and hilly terrain.**

4.2 Soil & Rock pattern

Soil Type

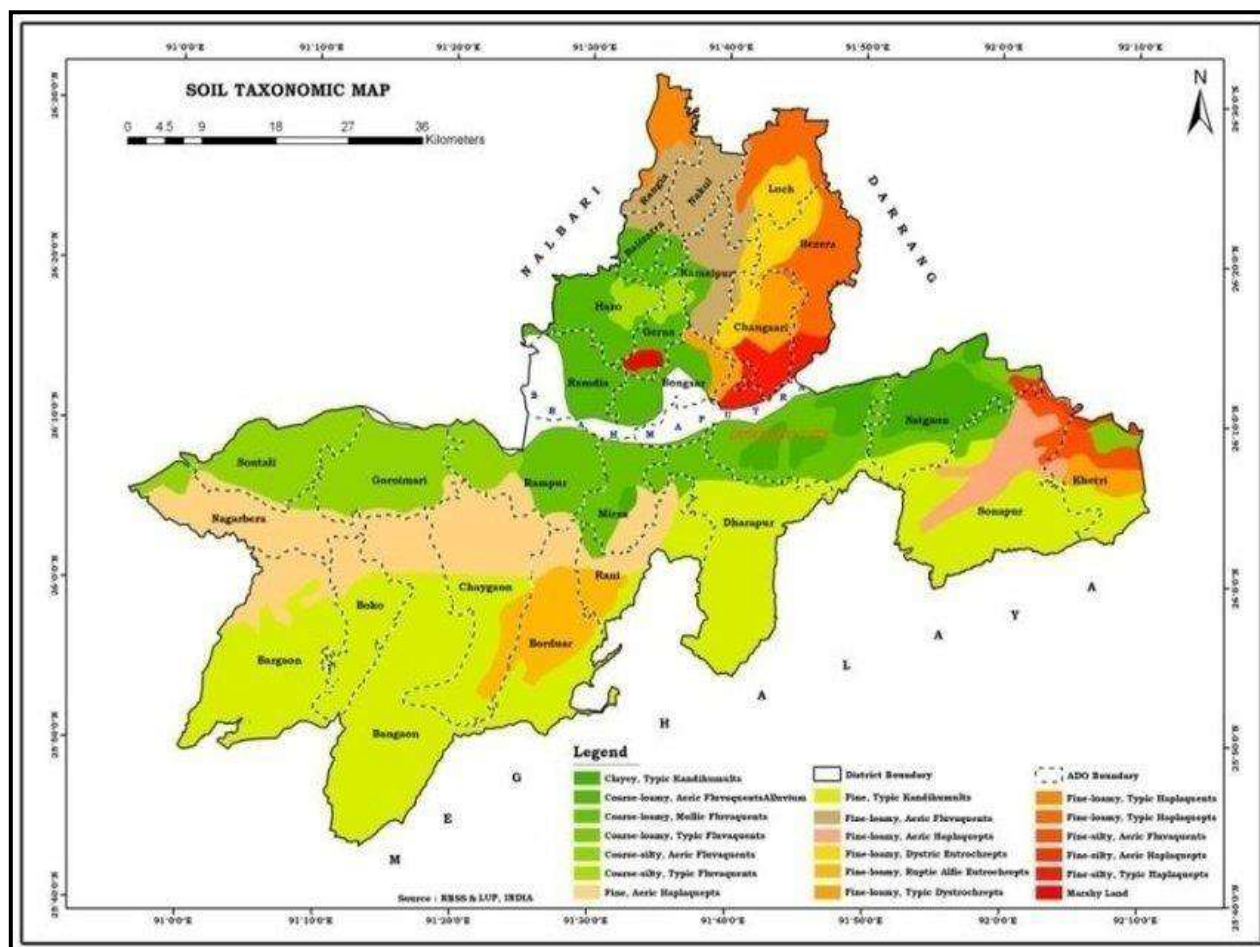
The different rock formation occurring in the district has been subjected to various soil forming processes through agents of weathering and transportation during different geological ages. Soils comprising various proportions of sand, silt, clay and organic material in the district are grouped into three broad categories – a) newer alluvial soil, b) valley fill/older alluvial soil and c) soils over forest and hilly terrain.

Table No. 12: Soil profile of Kamrup Metropolitan

Blocks	Soil Type	Land Slope				
	Soil Classes	Area (ha)	0-3% (ha)	3-8% (ha)	8-25% (ha)	>25% (ha)
Chandrapur	Sandy Loam	60296	35000	25000	–	–
Dimoria	Sandy Loam, Clay Loam	28628				
Rani (Part)	Sandy Loam	6620.8				

(Source: NBSS & LUP & Soil Survey Office)

Figure 15: Soil Map of the Kamrup Metropolitan district



The salient feature of district soils:

- 0-3% : - Level to very gentle sloping plain
- 3-8% : - gentle sloping plain
- 8-25%: - moderately sloping to moderately steeply sloping
- >25%: - steeply sloping to very steeply sloping

Rock type:

The Kamrup Metropolitan district in Assam, India has a variety of rock formations, including granite and gneissic rocks:

- Precambrian consolidated rocks: These rocks form hills and inselbergs.
- Recent to sub-recent unconsolidated alluvial formation: This formation is also present in the district.
- Denudational hills: These hills are made of granite and gneissic rocks.

The district's soil is made up of various proportions of sand, silt, clay, and organic material. The soil is grouped into three broad categories: newer alluvial soil, valley fill/older alluvial soil, and soils over forest and hilly terrain.

The study area is situated to the south of Guwahati, in Kamrup district of Assam, India, which is a part of the northerly extension of the Shillong Plateau. The granite gneiss is the most dominant rock type in the area. Gradation of granite gneiss to migmatitic variety is commonly observed.

4.3 Different geomorphological units:

In general, geomorphology of a particular region includes physiographic features and drainage basins.

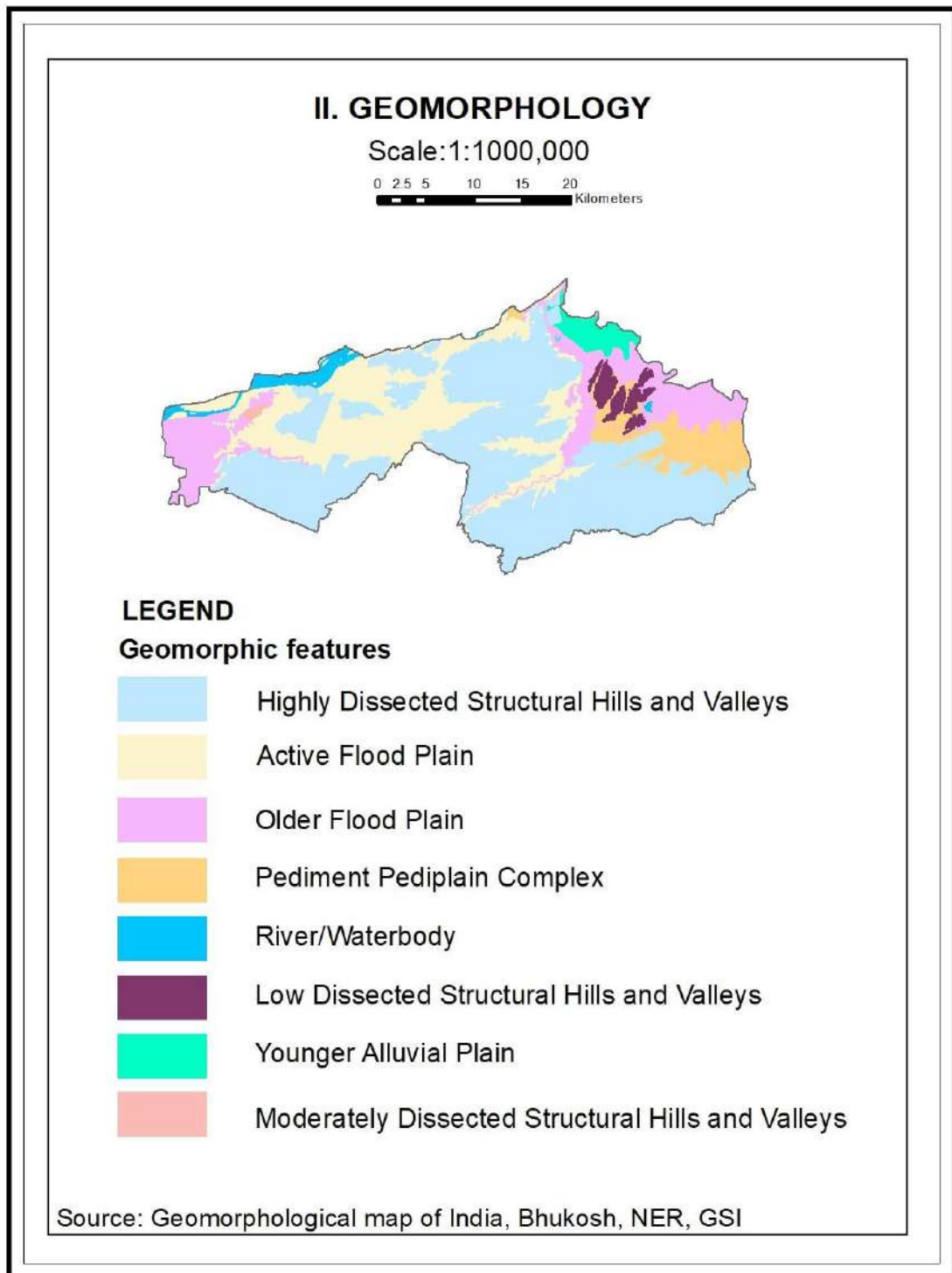
Physiographic Features

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Figure 16: Geomorphology Map of the Kamrup Metropolitan district



CHAPTER 5: LAND USE PATTERN OF THE DISTRICT

The total geographical area (TGA) of Kamrup Metro District is 93080.8 hectare. The largest Block of the district is Chandrapur comprises of a TGA of 60296 hectares i.e. about 63.1% of the TGA of the district

- **Land cover:** is the physical material at the surface of the earth. Land covers include grass, asphalt, trees, bare ground, water, etc. Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Water types include wetlands or open water.
- **Land use:** shows how people use the landscape – whether for development, conservation, or mixed uses. Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use and to identify the land use changes from year to year.
- **Forest & Plantation:** The important forest types found in Kamrup Metropolitan District are: Moist semi-evergreen forests, Moist Mixed Deciduous forests, Rivera in Type Miscellaneous type with scattered pure or mixed patches of bamboos. The Kamrup Metropolitan Soil Conservation Division plants bamboo, medicinal plants, ginger, and broom in areas that are suitable for these crops. They also bring degraded wasteland and riverine non-agricultural land under plantation to provide permanent cover to the top soil. (<http://assam.gov.in/>).
- **Cropland:** Wet-Cultivation, shifting (Jhum) Cultivation/ terrace Cultivation are well-practiced in this district. The cropped area of Kamrup Metropolitan district has been decreasing, from 373,517 hectares in 2002–2003 to 339,496 hectares in 2018–2019.
- **Built up land:** a developed area, any land on which buildings and/or non-building structures are present, normally as part of a larger developed environment such as: developed land lot, rural area, urban area. Land covered by buildings and other man-made structures.
- **Shrub land:** Land with woody vegetation less than 2 m in height and with greater than 10% shrub canopy cover. The shrub foliage can be either evergreen or deciduous. Shrub land, scrubland, scrub, brush, or bush is a plant community characterised by vegetation dominated by shrubs, often also including grasses, herbs, and geophytes. Shrub land may either occur naturally or be the result of human activity.
- **Fallow land:** Fallow Land is farmland that has no crops on it, usually for a year, to recover its fertility to grow crops. Land taken up for cultivation temporarily allowed remaining uncultivated for one or more seasons. The amount of fallow land in Kamrup Metropolitan district has been increasing.
- **Wasteland:** Sparsely vegetated land with signs of erosion and land deformation that could be attributed to lack of appropriate water and soil management, or natural causes. These are land identified as currently underutilized and could be reclaimed to productive uses with reasonable effort. Degraded forest (<10% tree cover) with signs of erosion is classified under wasteland.

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- **An empty area of land:** especially in or near a city, which is not used to grow crops or built on, or used in any way and/or a place, time or situation containing nothing positive or productive, or completely without a particular quality or activity.
- **Water body:** Areas with surface water, either impounded in the form of ponds, lakes, reservoirs or flowing as streams, rivers, etc. can be either fresh or salt-water bodies.
- **Wetland:** A wetland is a distinct ecosystem that is inundated by water, either permanently or seasonally. Wetland distribution at district level reveals that Kamrup Metropolitan district has number (379) of wetlands among all the districts of the state. The genesis and development of wetland are closely related to the geomorphic and tectonic history of the study area, hydrological behavior of the nearby river and prolonged human use of peripheral lands, depending upon their locational characteristics, wetlands is prone to various kinds of geo-environmental problems. Therefore, with growing need of wetland management it has become highly imperative to study genesis and development of wetlands and the present study is to focus on the wetlands of Kamrup Metropolitan district, Assam.

Table No. 13: Area under LULC of Kamrup Metropolitan District (Block Wise)

Name of the Dev. Block	TGA (ha.)	Area under Agriculture				Area under Forest (ha)	Area under Wasteland (ha)	Area under other uses (ha)
		GCA(ha)	NSA(ha)	AST(ha)	CI (%)			
Chandrapur	60296	15527	15527	0	100	3830.7	4667.52	35531.6
Dimoria	26164	20167	13927	7684	145%	7873	1235.7	6068.3
Rani (Part)	6620.8	3151	2160	999	145.8%	801.5	618.59	3037.9
Total	93080.8	38845	31614	8683	123%	12505.2	6521.81	44637.8

Table No. 14: Area under LULC of Kamrup Metropolitan

1.	Total Geographical Area	93080.8
2.	Total Area under Forest	12505.2
3.	Net Cultivable Area	31614
4.	Gross Cultivable Area	38845
5.	Total Area under Waste Land	6521.8
6.	Total Area under other uses	44637.8

(Source: Department of Agriculture, Kamrup Metro)

Figure 17: Changes in LULC in Kamrup Metropolitan District in % in respect to total geographical area

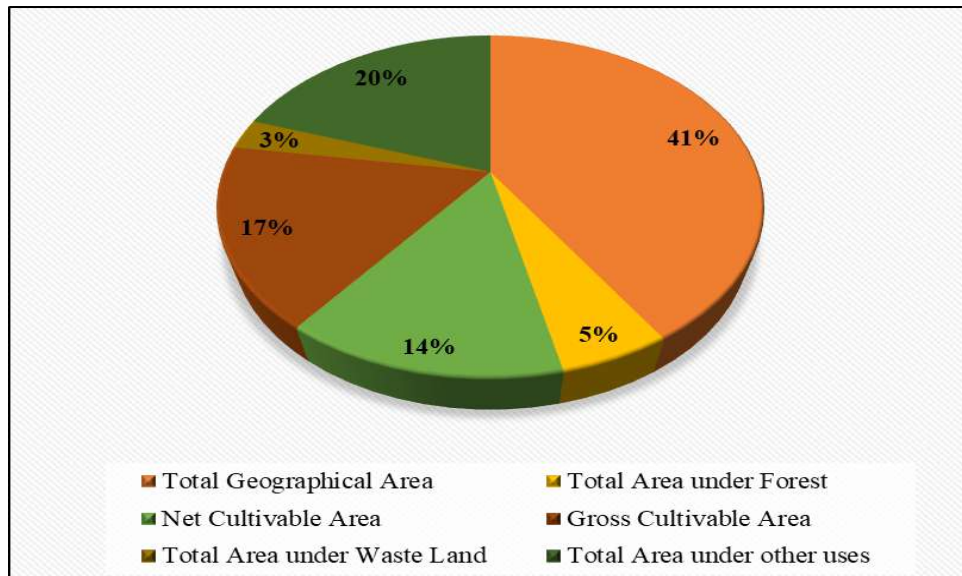
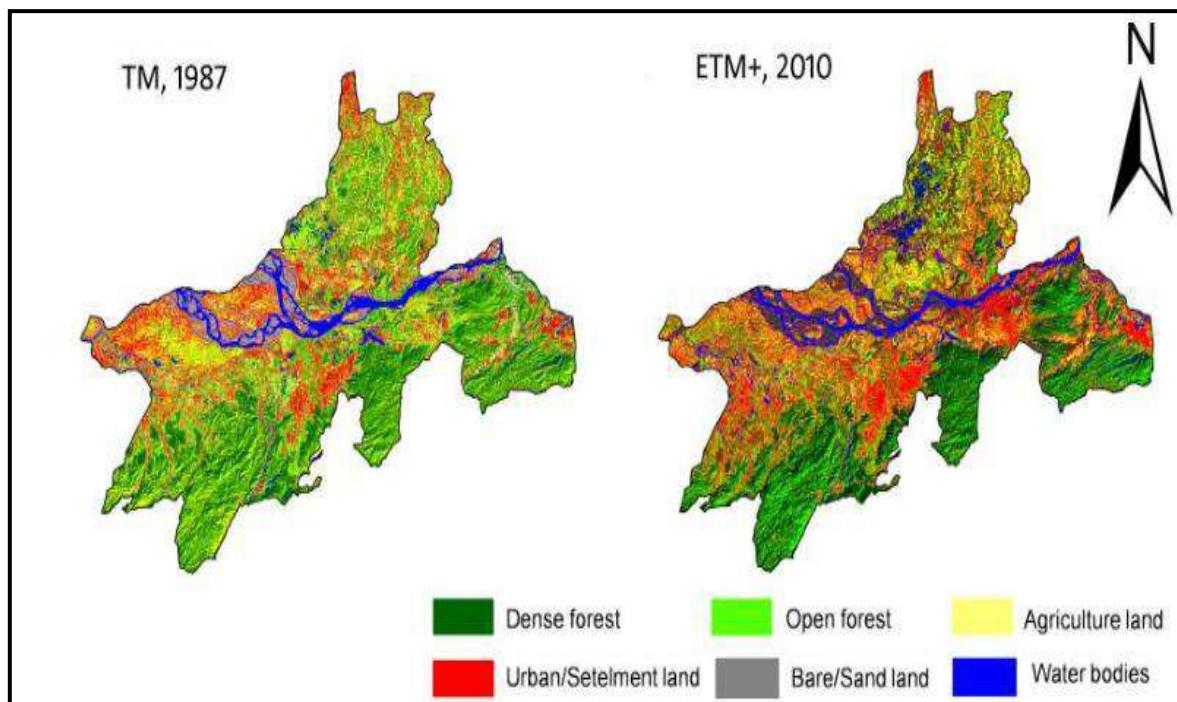


Figure 18: Land Use and Land Cover Map of the Kamrup Metropolitan district



5.1) Forest:

Here's some information about forests in the Kamrup Metropolitan district of Assam, India:

- Tree species: In the Kamrup sal forest, *Shorea robusta* is the most common tree species.
- Forest cover: In 2010, Kamrup Metropolitan had 22.7 kha of tree cover, which was 29% of its land area.
- Forest management: The Guwahati SF Division manages the forests in the Kamrup Metro District and parts of Kamrup District.
- Forest types: The forests in Assam and Meghalaya are mostly evergreen forests.
- Wildlife: The chief wildlife warden plans to conduct a leopard census in Guwahati to reduce conflicts between humans and leopards.

In the sanctuary area where as open mixed forest covers 6024.56 ha. which is the maximum area cover in this sanctuary. Degraded mixed forest covers 3181.74 ha. Dense Sal Forest covers 55.81 ha. open Sal Forest covers 82.40 ha. And degraded Sal Forest covers 23.38 ha.

❖ Area under State Reserve Forests under Kamrup Metropolitan

The Kamrup Metro district in Assam, India has 15 reserve forests, including:

South Kalapahar, Fatasil, Jalukbari, Gotanagar, Hengrabari, Sarania Hills, Gorbhonga, West Apricola, Mota Pahar, and Tetuluguri. The Kamrup Metro district also has two wildlife sanctuary, the Amchang Wildlife Sanctuary and Deepor Beel.

5.2 Agriculture and Irrigation

The main crops grown in Kamrup Metro in Assam, India include: Paddy, Maize, Jute, Pulses, and Vegetables.

Other agricultural activities in the district include:

- Dairy farming: Farmers in Kamrup Metro use high-yielding breeds of cows such as cross, jersey, and holstein friesan. They practice intensive zero grazing farming, where the cattle are tied with rope in neck by a wooden or bamboo fence.
- Poultry farming: The district is suitable for poultry farming, especially commercial broilers.
- Handloom: Handloom plays a major role in the district.
- The major crops grown in the district are Paddy, maize, jute, pulses and vegetables.

The district is primarily rainfed. Out of the gross cropped area of 38845 ha, the extent of irrigated land is only 9330 ha, i.e. 24% of total cropped area. Considering the blockwise data, percentage of gross irrigated land to cropped area is maximum in Dimoria block, followed closely by Rani Block, i.e. 36.2% and 33.6% respectively. A total of 29515 ha of area is under rainfed cultivation. While comparing the ratio of area under rainfed cultivation to gross

cropped area in each block, Chandrapur block comes at the top position with 93.7% (gross cropped area of 15527 ha) under rainfed irrigation, followed by Rani block with 66.4% area under rainfed cultivation (gross cropped area of 3151 ha). The area under partial irrigation has been reported to be zero across all the blocks the district.

5.3 Plantation & Horticulture:

Assam is traditionally rich in horticulture due to its diverse and unique agro-climatic situation conducive for growing wide range of fruits, vegetables, spices, nut crops, flowers, medicinal and aromatic plants, mushroom etc.

Here are some details about horticulture in Kamrup Metropolitan, Assam:

➤ Oil palm

The oil palm plant was introduced in Kamrup Metropolitan in 2014–15 as part of the Mini Mission II of the Department of Agriculture & Horticulture. Farmers are adopting the crop well, but it takes four years for the plant to yield.

➤ Nursery

The Directorate of Horticulture & Food Processing has an automated nursery in Ulubari, Guwahati, which produces high value vegetable seedlings for farmers.

➤ Crop intensification and diversification

The government is focusing on increasing the production and productivity of crops through horizontal expansion.

➤ Tree canopy management

The government is focusing on rejuvenating old orchards to increase productivity and profitability.

➤ High density planting

The government is focusing on high density planting to increase the return from a given area.

➤ Protected cultivation

The government is focusing on protected cultivation of high value crops, including off season crops.

➤ Export oriented varieties

The government is promoting export oriented varieties of ginger, turmeric, and chilies.

➤ Horticulture mechanization

The government is focusing on horticulture mechanization to increase efficiency.

Table No 15: Horticulture scenario of Kamrup Metropolitan

SL NO	CROP	AREA IN HA	PRODUCTION IN TONNES	PRODUCTIVITY IN TONNES/HA
1	PADDY	1,40,383	3,80,555	2.71
2	RAPE & MUSTARD	15820	12972.4	0.82
3	POTATO	3967	29752.5	7.50
4	BLACK GRAM	6250	3843.75	0.62
5	MAIZE	6425	13068.5	2.03
6	SUGARCANE	916	46472	50.73
7	GREEN GRAM	2797	1678	0.60
8	BANANA	4295	66344.8	15.45
9	ORANGE	3128	37335.8	11.94
10	PINEAPPLE	2563	52131.4	20.34
11	JACK FRUIT	978	8778	8.98
12	LEMON	623	5178	8.31
13	CABBAGE	805	18479	22.96
14	CAULIFLOWER	1334	25678	19.25
15	OKRA	830	11345	13.67

(Source: Department of Agriculture, Kamrup Metro)

5.4 Mining:

Major minerals of the district are granite, quartz. Minor minerals as railway ballast, road metal, sand and brick clays are found in this district. The granites and gneisses near Jagiroad are being quarried for railway ballast and road metal. Granites and gneisses are also being quarried in many other parts of the district. The clay found extensively in the alluvial tract of the district is quite suitable for the manufacture of bricks and earthenware.

The main rocks that underlie the Kamrup Metropolitan district in Assam are granites and gneisses from the Precambrian age, and rocks from the Barail and Surma series of the Tertiary age. The district has quartz and silica sand. The Jiajuri deposit in Kamrup Metropolitan district has been explored for friable quartzite, which is glass and sand.

CHAPTER 6: GEOLOGY AND MINERAL WEALTH

6.0 GEOLOGY

Regional Geology:

The overall geological set up of India is divided into three parts i.e., Extra-peninsula, Peninsula and Indo-Gangetic Plain. The Assam states is partially covered by Himalayan Mountain System as the thick sequence of marine rocks followed by freshwater rocks was deposited in Cenozoic times. Another part of this state is partially occupied by Indo-Gangetic plains.

The different types of rocks from different ages are found in Assam state belonging to

- a) Proterozoic Gneissic Complex;
- b) Meso-Palaeo Proterozoic Shillong Group;
- c) Neo-Proterozoic Lower Palaeozoic Granite Plutons;
- d) Permo-carboniferous Lower Gondwana sedimentary rocks.
- e) Alkali Complexes of Samchampi, Borpung and volcanic rocks represented by Sylhet Trap of Cretaceous age,
- f) Lower Tertiary (Paleocene-Eocene) shelf sediments of the Jaintia Group extending along the southern and eastern flanks of Mikir Hills and geo-synclinal sediments of the Disang Group in parts of the North Cachar Hills;
- g) Upper Tertiary (Oligocene to Pliocene) shelf and volcanic rocks represented by the Cretaceous Sylhet Trap and geo-synclinal sediments covering the southern flanks of Mikir Hills, the North Cachar Hills and the hills of the Cachar district in the Surma valley area exposed in the northern foothills of Naga-Patkai range covering the southern margin of Sibsagar, Jorhat and Dibrugarh districts. The northern part of Assam is comprised with southern foothills of Eastern Himalaya forming a narrow strip.
- h) The Quaternary deposits consisting of Older and Newer Alluvium present in flood plains and terraces of the Brahmaputra valley, Surma valley and other river basins of Assam.

Geologically the district is mainly composed of the rocks generally belongs to Proterozoic to Meghalayan in age. The district partially covers the west Brahmaputra valley area. Major formation encountered in Kamrup Metropolitan district are Assam-Meghalaya Gneissic Complex (Paleoproterozoic- Neo-Proterozoic), Granite Plutons (Nongpoh) (Neoproterozoic-Early Paleozoic), Chapar (Middle to Late Pleistocene), Hauli (Holocene), Barpeta (I) and Barpeta (II) (Meghalayan). In Precambrian eon, Assam Meghalaya Gneissic-Complex consists of hornblende-biotite-gneiss, migmatites, and gray to pink granite gneiss. These rocks are forming the basement of the Assam valley. Large enclaves of older metamorphites, including hornblende-biotite-schist, are often found in the gneissic suite. Paleo-Proterozoic to Neo-Proterozoic time, Granite Plutons unconformably lies over Gneissic Complex. This group of formation comprises banded gneiss, quartzo-feldspathic

DISTRICT SURVEY REPORT OF KAMRUP METROPOLITAN DISTRICT, ASSAM

gneiss, Unclassified Gneiss. The Precambrian rocks are overlain by the Quaternary sediments.

There are two types of alluviums observed in this area viz. Older alluvium and Newer Alluvium. Older Alluvium unconformably overlies the Granite Pluton. Middle to Late Pleistocene time period, Chapar formation shown highly Oxidized dark brown to red brown loamy sand, forming the oldest boundary of Quaternary deposit. Newer Alluvium formations are Hauli, Barpeta (I), Barpeta (II). The Upper part of the Hauli Formation is made up of feebly oxidized sand, silt and clay, Unoxidised sand. Its surface helps in Human Cultivation, Industrial Purpose like Brick making, Building Construction, fisheries pond making etc. Barpeta I Formation consists of White to greyish sand, silt, pebble and clay. The most recent strata, known as the Barpeta-II Formation, are found in the current river channel and are made of Unstabilised & unoxidized sand, silt & clay.

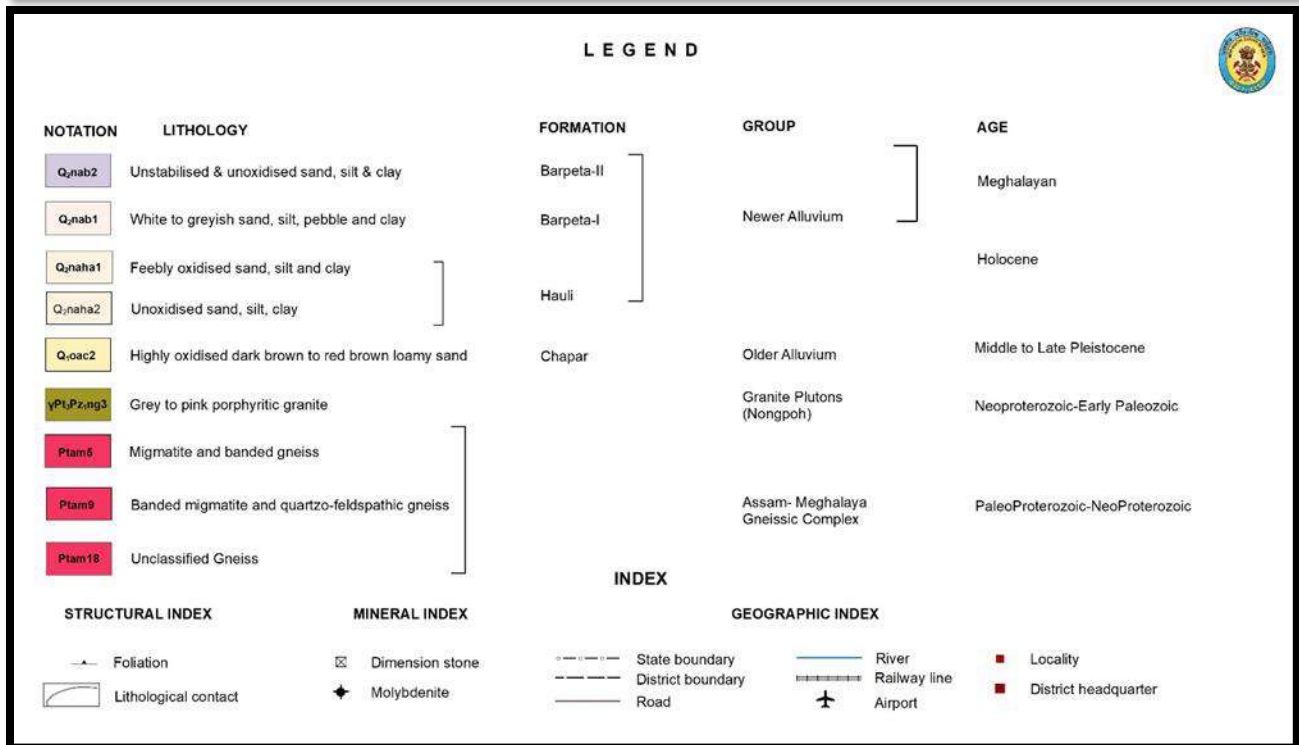
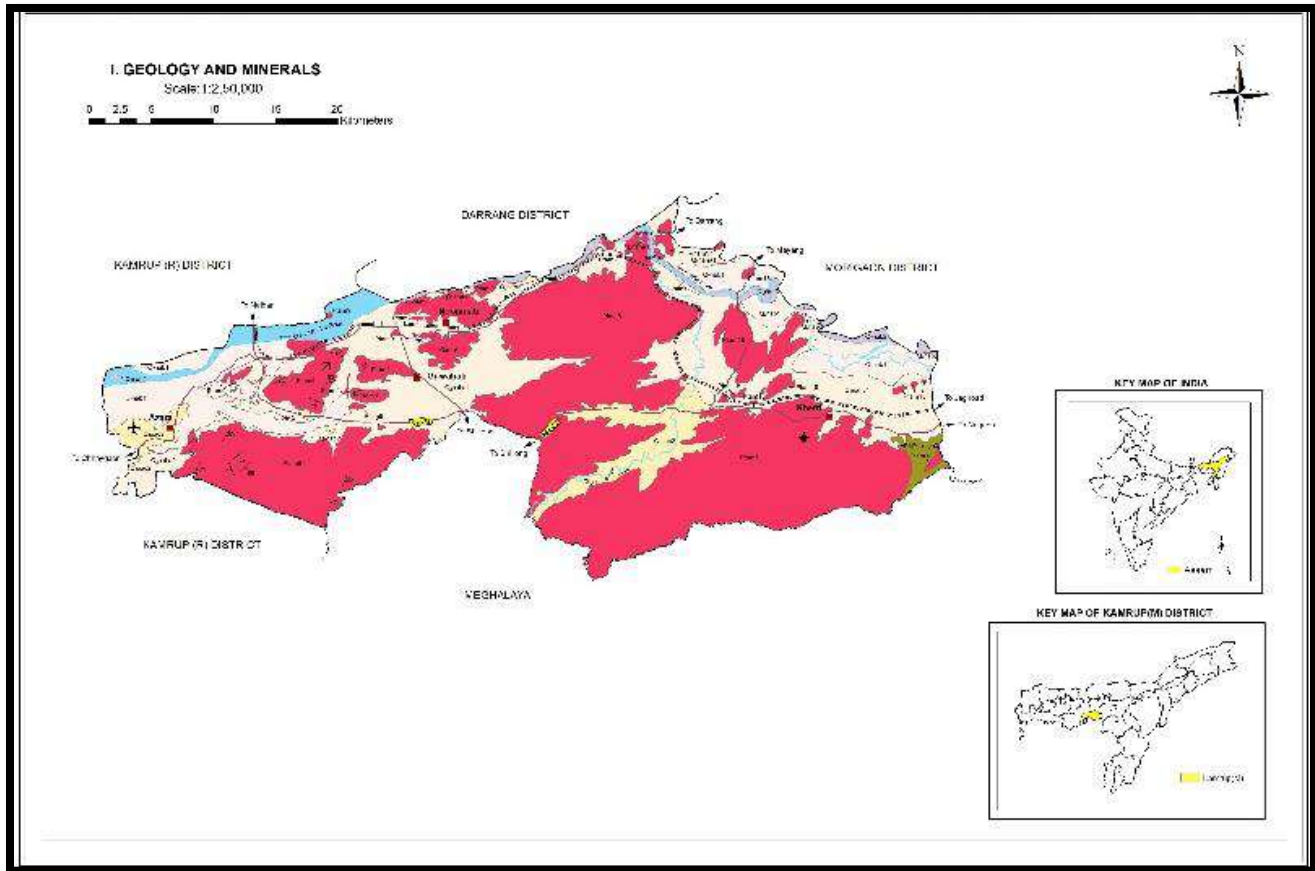
Table No. 16: Stratigraphic succession of Kamrup Metropolitan District

AGE	GROUP NAME	FORMATION	LITHOLOGY
Meghalayan	Newer Alluvium	Barpeta (II)	Unstabilised & unoxidized sand, Silty & clay.
		Barpeta (I)	White to greyish sand, silt, pebble and clay.
Holocene		Hauli	Feebly oxidized sand, silt and clay, Unoxidised sand.
Middle to Late Pleistocene	Older Alluvium	Chapar	Highly Oxidized dark brown to red brown loamy sand
		Unconformity/ Tectonic	
Neoproterozoic-Early Paleozoic	Granite Plutons (Nongpoh)	Grey to pink porphyritic granite.
		Unconformity	
PaleoProterozoic-NeoProterozoic	Gneissic Complex (Assam-Meghalaya Gneissic Complex)		Banded gneiss, quartzo-feldspathic gneiss, Unclassified Gneiss.

Source-GSI (2009), Geology and Mineral Resources of Assam.

DISTRICT SURVEY REPORT OF KAMRUP METROPOLITAN DISTRICT, ASSAM

FIGURE 19: GEOLOGY AND MINERAL MAP OF THE DISTRICT



Local Geology:

Regarding geology, the Pre-Cambrian gneissic complex (493 sq.km.) and New Alluvium or Recent Formation (290 sq.km.) make up most of the district. The Kamrup Metropolitan district, located in the foothills of the Assam-Meghalaya border, is characterized as a Pre-Cambrian gneissic complex consisting of granite gneiss, biotite schist, gneiss, and quartz. While portions of the study region display characteristics of the Assam valley, these hills are sections of the West Khasi hills, which are mostly comprised of gneisses and schists of Gondwana land with intrusive granite. The district is made up of litho units that range in age from Proterozoic to Meghalayan. The younger acidic rocks (granite, aplite, and pegmatite) have intruded the gneiss, schist, and migmatitic granitoid that make up the Assam Meghalaya Gneissic Complex. Porphyritic granite plutons from the Neo-Proterozoic to Early Paleozoic have intruded basement rocks in the southeast portion of the district. The district's northwest and north are covered in Quaternary sediments of clay, silt, and sand. They are divided into the Chapar, Hauli, and Barpeta-I & Barpeta-II formations, which make up three morpho stratigraphic units. The plain area is made up of an undulating and faulted basement of granitic rocks, over which the Quaternary sediments are deposited, taking up the valleys.

Following litho-units have been encountered from Kamrup Metropolitan District.

- Sand, Silty Clay
- Sand, Silt, Pebble and Clay
- Granite, Gneiss and Migmatite

CHAPTER 7: MINERAL WEALTH

7.1 Overview of mineral resources:

Assam today is considered as “Mineral Paradise” having commercially exploitable major and minor minerals though there are reports of minerals and metals being used during early historic age, scientific mining and metallurgical industries in Assam started only after independence. During last 70 years, the mineral sector has grown here considerably. Rejecting all sorts of geological congregations and perturbations, it can be said that the economic progress of Assam is manifested in the form of retrogressive progress. In order to accelerate the economic growth exploitation of available mineral resources by developing mines with its full safety and establishment of target oriented and value-added industries is an imperative. Development achieved, without jeopardizing the environment, in the mining and mineral beneficiation industries so far, availability of resources and existing trend would offer a glimpse of future, eradicating all types of schism in mineral economy, of mineral sector in the state of Assam. Not every natural resource is found on or above the surface of the earth. Deep beneath the surface of the earth, where humans live, lie many resources. Even beneath the sea and river floors, they are deeply buried. These underground resources are quite important in the current industrial period.

Systematic investigation especially surface & subsurface mining in all the mineral & ore-bearing promising zones selectively will cater the light and then people will not be able to throw a volley of questions about the mineral wealth of Assam. A strong foundation in case of mining especially in Kamrup (M) district of Assam must give perspective and confidence. It is pertinent to say that the preparation of DSR of Kamrup (M) is a laudable attempt. So, sustainable management of mineral resources is of immense importance & it is increasing at an exponential rate, therefore, sustainable management of mineral resources requires a long-term perspective so that these all last for the generations to come.

7.2 Details of Resources:

MAJOR MINERALS

Occurrences of Oil Seepages is present in the district. Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) have been involved in oil prospecting in the area.

REE (Rare Earth Elements): A reconnaissance study of 75 square kilometers on a 1:12,500 scale was conducted to look for rare earth elements (REE) in biotite gneiss and granitic rocks in the Garbhanga-Jorabat region, Kamrup (Metro) district, Assam, and Ri-Bhoi district, Meghalaya. In addition to collecting 75 pit/trench samples, two blocks totaling 1.5 square kilometers each underwent grid-pattern trenching and pitting of 75 cubic meters. The total REE content ranged from 268.901 to 505.72 ppm (Avg. 381.94) according to the chemical analysis results of the pitting and trenching samples. Total REE concentration ranged from 26.55 to 760.89 ppm (average 366.12 ppm) in BRS samples.

Tungsten: A 1:12,500 scale map of an area of 90 square kilometers was created during a reconnaissance assessment for tungsten mineralization in and around the Khetri region of the Kamrup (metro) district. Higher W (216 & 238 ppm), Sn (16.5 & 15.8 ppm), and Mo (8.28 &

DISTRICT SURVEY REPORT OF KAMRUP METROPOLITAN DISTRICT, ASSAM

11.94 ppm) levels were found in the hydrothermally altered quartz veins at Barbitli. The quartz vein sample in Sametapathar, at the interface of migmatite and pelitic schist, revealed 463.8 ppm W, 12.4 ppm Mo, and 8.45 ppm Sn. 2.89 to 10.88 ppm Mo and 5.19 to 96.09 ppm Sn were found in the miarolitic pegmatites from Helagog. Sn value of 28.98 ppm and Mo value of 15.49 ppm were found in garnetiferous pegmatite located 1.2 km NW of Gumaria. (Source: *Indian Mineral Yearbook, Assam, 2019*)

MINOR MINERALS

The world scenario of reserve and production of river bed sand deposits indicate that although India stands among the top, from point of view, reserve, Assam is not also a solitary exception. Kamrup (M) district is amongst the last few in sand production. Sand production of Digaru River and Kopili River play a vital role. The basement rocks in the Kamrup (m) district are found varying depths beneath the Quaternary sediments. Natural resources such as sand, hard rock boulders good for building, and bands of clay appropriate for pottery and brick-making were found during the survey. The region has a large amount of granite and granite gneiss quarried for dimension stones and building stones. Granitic rocks found in Nakhula Pahar Gaon

- Riverbed sand and River bank sand deposits
- Ordinary earth and Brick earth material.
- Granite, Quartzite, the river borne materials comprising boulders of sandstone.

Molybdenum: Initial exploration for related mineralization and molybdenum in the Kamrup Metropolitan district, Assam (G3), between Helagog and Khaloibari: Throughout the project, a comprehensive 1:2000 geological mapping of 03 square kilometers, a 3 sq.km. Magnetic and gravity geophysical survey, and 25 linear kilometers of resistivity and IP surveys were completed. Pegmatite veins containing molybdenite were clearly visible in the Helagog and Khaloibari quarry areas. At least four molybdenite-bearing pegmatite veins, which appeared as dikes (veins), segregations, or pods, were found in the Helagog quarry. The veins have an anastomosing pattern and vary in length from 3 to 21 meters and diameter from 0.15 to 12 meters. Six molybdenite bearing pegmatite veins were found in the Khaloibari quarry, spaced widely apart and extending over a length of 38 to 40 meters. These veins are in addition to the two molybdenite bearing pegmatite veins that were previously reported. Pegmatite veins vary in length from 5 to 15 meters and in thickness from 0.2 to 0.7 meters. A small number of veins form as segregations with arbitrary orientations. Chemical investigation of samples taken from pyrite-chalcopyrite containing pegmatite veins in the Helagog quarry revealed values of tungsten (W) ranging from 85.264 to 169.301 ppm and abnormal concentrations of fluoride (F) from 104 to 1,200 ppm. (Source: *Indian Mineral Yearbook, Assam, 2021*)

7.2.1 SAND AND OTHER RIVERBED MINERALS:

I. Drainage System

The drainage pattern of the studied area is the Southern bank of Brahmaputra and its tributaries are Kopili river. In the entire area, drainage pattern is dendritic to sub-parallel and totally is controlled by several of structural features and concealed lithology below the surface. The district's drainage system primarily feeds into the Brahmaputra River, which is the major river flowing through Assam, along the entire northern boundary of the district. Major rivers are Brahmaputra River, Kapili, Digaru River. Over all flow direction S-N except Brahmaputra River, it flows E-W direction of the district.

During the survey of the investigated area of Kamrup (M) District. It is noticed that the streams, rivulets and river courses vary depending on the topography and physiography of the area. The streams, rivulets and rivers follow the lowest elevation courses for which the drainage courses vary widely in the district. The river carries enormous amounts of suspended material and sediments. The region experiences seasonal flooding, particularly during the monsoon season. Effective management of riverbanks and floodplains is crucial to mitigate the impact of floods.

Brahmaputra River

In Kamrup (m) district, the Brahmaputra is the most important river. The river rises to a height of 5300 meters in the Himalayan Kailash hills. It passes via Tibet before entering India through Arunachal Pradesh, then on through Assam and Bangladesh until entering the Bay of Bengal. It's an important Assamese canal that passes across the area from ENE to WSW. The Bhamputra is the main source of silt/ordinary clay. The river sand found in the plain/ bed of this river is not suitable for construction purpose. The river gives the local inhabitants essential supplies and facilitates transportation and agriculture.

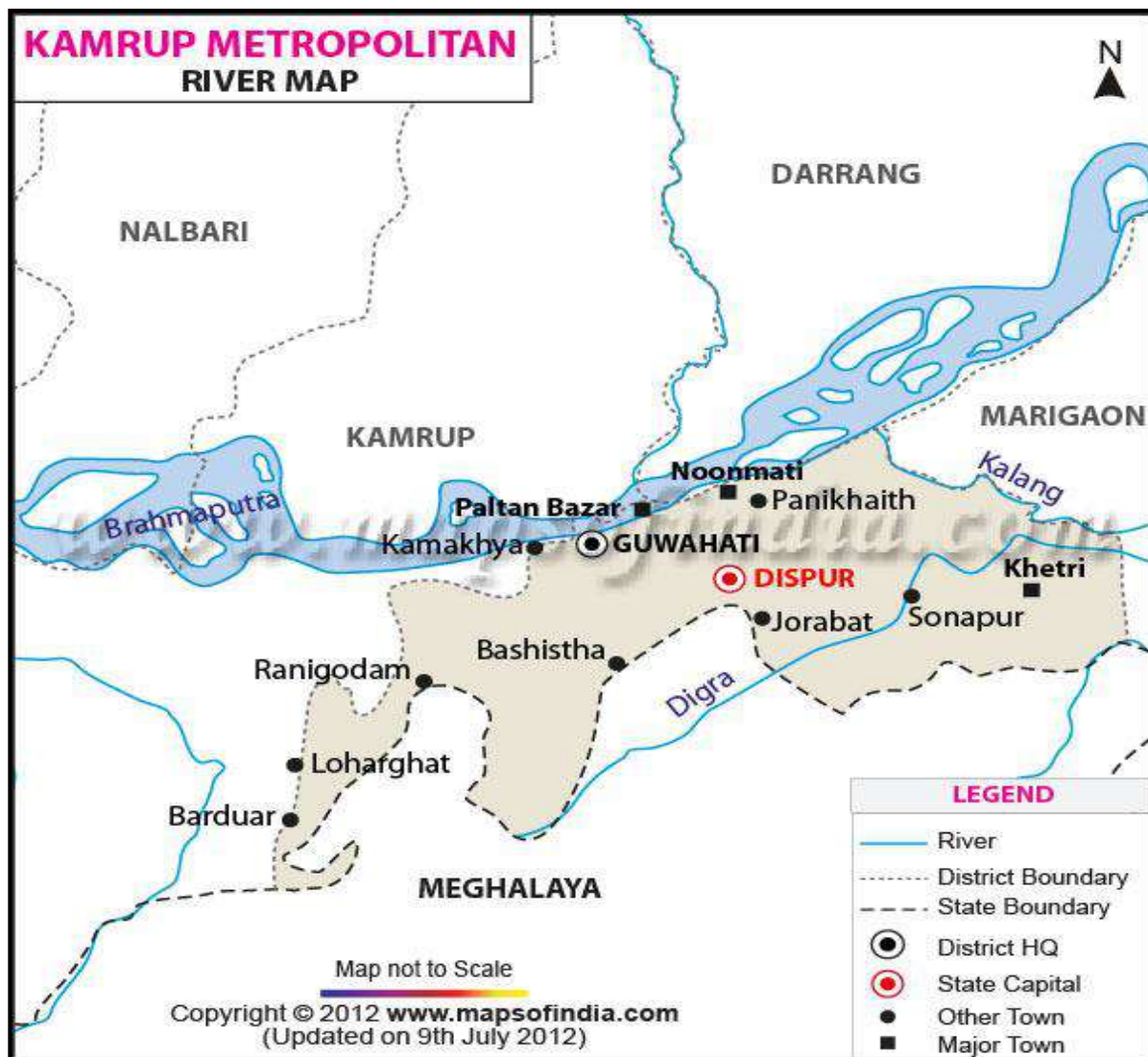
Kopili River

Originating from the North Cacliar hills, the Kapili come from the Barail range. Its join with Kiling River, this rivers' former channels have left behind several Beels. That's are Sholmari, Dandua, Marakalang, Sara, Sarumanaha, Dekhal, Baral, Habari, Nakara-Maudubi, Goranga, Taranga, Donga, Jan, Khar, Udmari Bils. This river enters to the district territory in Kamarpur pahar, Kamrup (M).

Digaru River

Digaru River originates from Kyrdemkulai Dam in Meghalaya. In upstream flow, it's named Umtru River. After entering the district, it is known by the name Digaru River. River flows in a SW-NE direction. In Chandrapur, the river meets the Kopili River, and both streams flow towards the north and join the Brahmaputra.

Figure 20. River Map of the Kamrup Metropolitan district



a) Drainage System with description of main rivers

Table No. 17: Drainage system with description of main rivers

Sl. No.	Name of the River	Area drained (sq.km.)	% Area drained in the district
1	Brahmaputra	80.325	5.25 %
3	Kapili	3.268	0.21 %
7	Digaru	2.095	0.14 %

b) Salient Features of important rivers and streams

Table No.18: Salient Features of important rivers and streams

Sl. No.	Name of the River or Stream	Total Length in the District (in Km.)	Place of Origin	Altitude of Origin(m)
1	Brahmaputra	45.9	The Himalayan Kailash hills, Tibet	5300
3	Kapili	17.2	North Cacliar hills, Assam	710
7	Digaru	41.9	Kyrdemkulai Dam in Meghalaya.	702

II. Annual deposition of riverbed minerals

Annual deposition of riverbed minerals is dependent on various factors which are explained below.

A) Geomorphological studies

Geomorphological characteristic of a river is foremost factor for annual deposition of sedimentary load. The study includes following parameter:

i) Place of Origin

Details of origin of rivers of Kamrup (M) District are furnished in Table.

Table No.19: Place of Origin of important rivers and streams

Sl. No.	Name of the River or Stream	Place of Origin
1	Brahmaputra	The Himalayan Kailash hills, Tibet
2	Kapili	North Cacliar hills, Assam
3	Digaru	Kyrdemkulai Dam in Meghalaya.

ii) Catchment Area

Kamrup (M) district of Assam is mainly drained by the Brahmaputra, Kapili, Digaru River which are forming the main catchment area. The catchment area of a river, also known as its drainage basin or watershed, is the region of land where precipitation collects and drains into the river and its tributaries. This area encompasses all the land that contributes to the river's flow, including all the streams, rivers, and other water bodies that feed into it. The land's elevation and slope can influence how water flows and accumulates. Mountains or highlands often define the boundaries of a catchment area. The amount and distribution of precipitation within the catchment area affect the river's flow. Areas with high rainfall contribute more water to the river. Soil type and vegetation cover impact how much water infiltrates into the ground versus how much runs off into the river. Forested or vegetated areas generally reduce runoff and increase groundwater recharge. Land use, such as agriculture, urban development, and deforestation, can alter the natural flow of water within a catchment area.

Table No. 20: Catchment areas of main rivers of Kamrup (M) district, Assam

Sl. No.	Name of the River or Stream	Catchment Area (sq. km.)
1	Brahmaputra	80.325
2	Kapili	3.268
3	Digaru	2.095

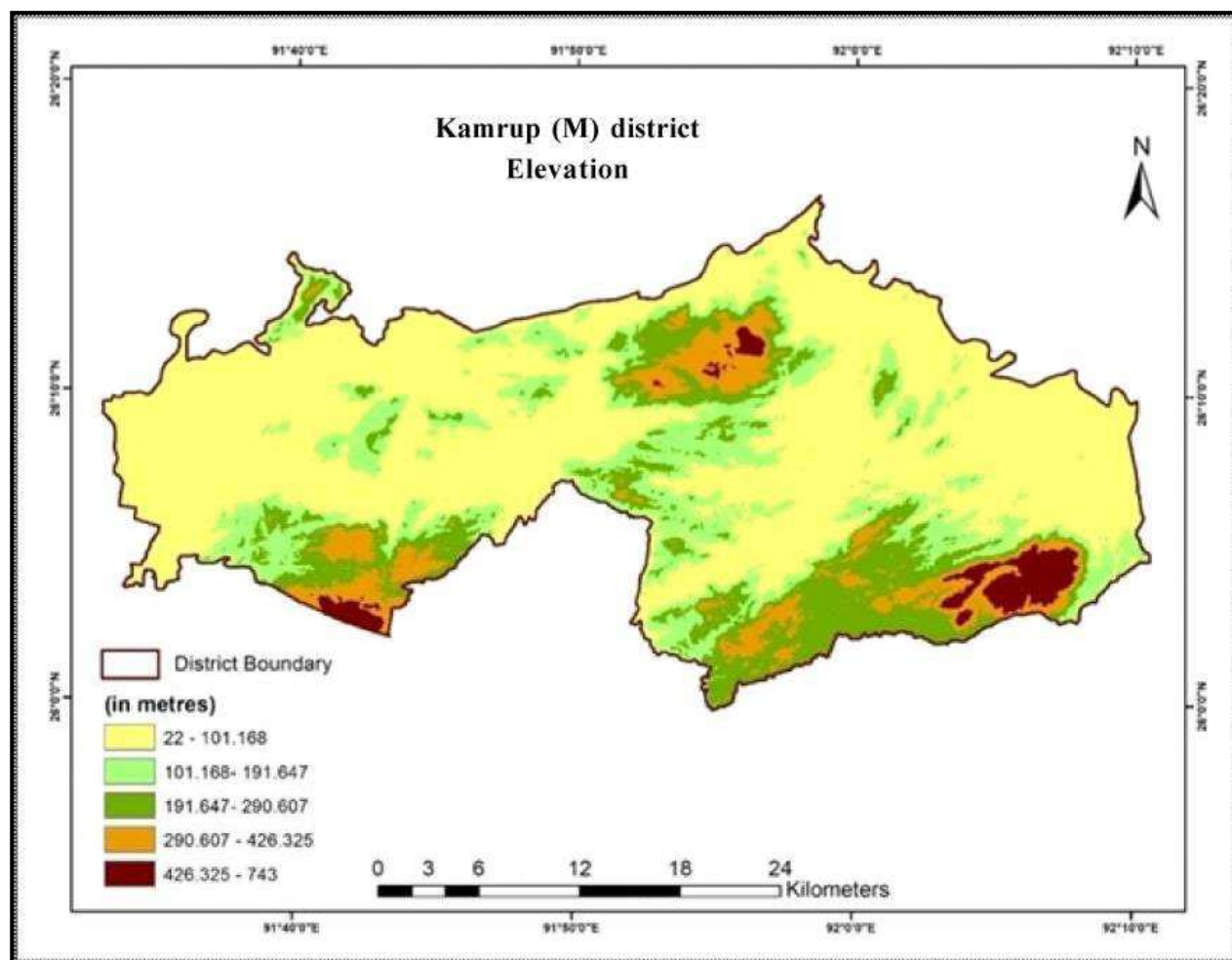
iii) General profile of river stream

If rivers are always straight i.e., if rivers follow straight course the meaning of slope becomes value less, but if the river is curvy and follows a sinusoidal pattern (as is usually the case, at least to some extent), then we have to measure the horizontal distance along the sinuous projection of the course of the river on a horizontal plane. The slope can be measured in feet per mile or some metric units like meters per kilometers. Recalling some trigonometry, we might recognize the tangent of a slope angle although measuring the slope of a river is not an easy matter. The slope of the rivers of the district, in this case, has been measured following the method of Digital Elevation Model (DEM).

To reach the targeted approach, here contour lines are digitized from topographic map using a scale of 1:8000; from this map few contours are also digitized in flat areas. Spot heights are also digitized. From this height data, contour interpolation is completed in ArcGIS approach. This slope map is exported to ERDAS for further processing. The slope map is classified to 0-15 degree or more than 15 degree.

The longitudinal profile and the cross-sectional profile of the streams or rivers is provided in **Annexure IX**.

Figure 21: Elevation Map of the Kamrup (M) district, Assam



(Source: Delineation of groundwater potential zones (PGZs) using geospatial techniques and Analytical Hierarchy Process (AHP) in Kamrup Metropolitan district, Assam by Parimita Saikia and Bijay Singh Mipun)

iv) Annual deposition Factor

Rivers are important geological agents for erosion, transportation and deposition. Deposition and erosion in river valleys can strongly modulate the downstream delivery of sediment (Fan and Cai, 2005; Malmon et al., 2005). A riverine sediment budget provides an effective conceptual framework within which to quantify sediment mobility, transport, deposition, and storage within a drain-age basin, as well as sediment output from the basin (Walling et al., 2002). It is therefore critical to understand this modulation effect (Walling and Horowitz, 2005). Annual deposition of riverbed materials depends on various factors which are as follows:

Geological erosion and soil erosion are the two basic terms used to describe erosion processes. Geological erosion refers to regular or natural erosion brought on by long-term geological processes that wear down mountains and produce floodplains, coastal plains, and other

landforms to develop. Soil erosion happens gradually or at an alarming rate, but it is a continual process. It leads to various negative effects, including ongoing topsoil erosion, ecological harm, soil collapse, and many more.

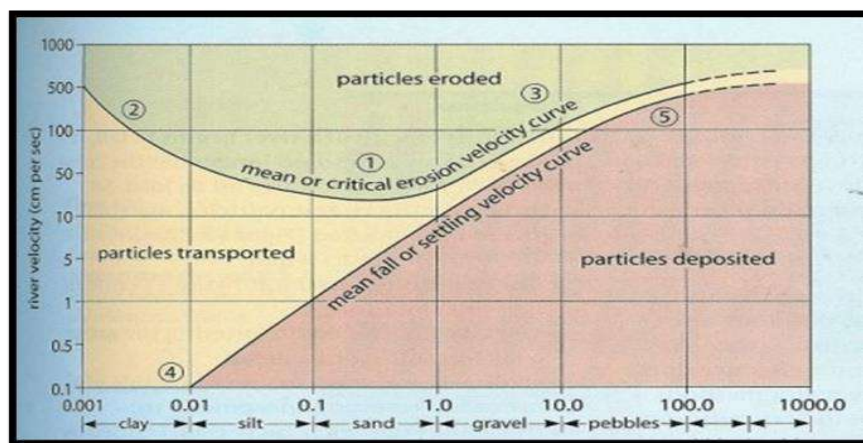
The soil fragments are loosening or being washed away in the valleys, oceans, rivers, streams, or far-off regions throughout this process. Human activities like agriculture and deforestation have contributed to this situation getting worse.

Fluvial erosion is the direct removal of soil particles by moving water. The force of the flowing water and the resistance of the bank material to erosion both affect the pace of fluvial erosion.

1. Process of deposition

After erosion, the eroded materials get transported with running water. When the river loses its energy and velocity falls, the eroded material is deposited. A river can lose its energy when rainfall reduces, evaporation increases, friction close to river banks and when enters a shallow area (flood plain) or towards its mouth where it meets another body of water. Hjulström curve showing the relationship between particle size and the tendency to be eroded, transported or deposited at different current velocities.

Figure 22: HJULSTRÖM CURVE



Source: Sediment Petrology, Pettijohn

In this diagram, X-axis indicates the grain size in mm and Y-axis indicates the flow velocity of the river in cm. s^{-1} . The lower line of the diagram shows the relationship between flow velocity and particles in motion, with pebbles at 20-30 cm. s^{-1} , medium sand grains at 2-3 cm. s^{-1} , and clay particles at 0 cm s^{-1} . The grain size of particles can indicate the velocity at the time of sediment deposition. The upper line shows the flow velocity required to move a particle from rest, with smaller particles needing higher velocity to move them below coarse silt size due to the properties of clay minerals, which dominate the fine fraction in sediment. Clay minerals are cohesive and stick together, making it difficult to entrain them in a flow. The behavior of fine particles in a flow which has important consequences for deposition in natural depositional

environments. Mud can accumulate in any setting where flow stops for long enough for clay particles to be deposited, and resumption of flow does not re-entrain the deposited clay unless the velocity is relatively high. Alterations of mud and sand deposition are seen in intermittent environments, such as tidal settings.

2. Mode of sediment transport in rivers

Sediment transport is the transportation of detrital particles via air, water, ice, or gravity. When transported by air and water (fluid transport), grains (which may be sand particles) travel as a bed load (by rolling, sliding, and saltation) or in suspension when the turbulence keeps the grains moving.

The amount and size of sediment moving through a river channel are determined by three fundamental controls: competence, capacity and sediment supply.

The sediment load of a river is transported in various ways although these distinctions are to some extent arbitrary and not always very practical in the sense that not all of the components can be separated in practice:

- i. Dissolved load
- ii. Suspended load
- iii. Saltation load
- iv. Wash load
- v. Bed load

(i) **DISSOLVED LOAD:** The amount of sediment carried in solution by a stream's total sediment load, particularly ions from chemical weathering, is known as the dissolved load. Along with suspended load and bed load, it makes up a significant portion of the overall number of debris removed from a river's drainage basin.

(ii) **SUSPENDED LOAD:** The term "suspended load" describes the portion of the total sediment transport that is kept suspended by turbulence in the flowing water for extended periods of time without contact with the stream bottom. Sometimes the particles may float on the surface of the water and thus become the part of the fluid mass. The duration of a particle's suspension is determined by the intensity of turbulence and velocity of the river-flow. It is nearly moving at the same speed as the flowing water.

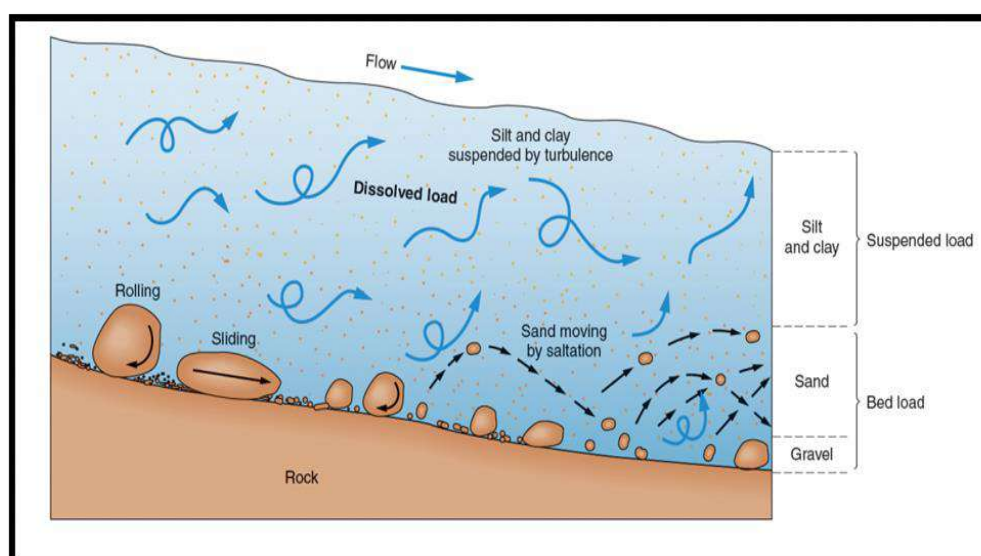
(iii) **SALTATION LOAD:** The portion of the bed load that is moving, either directly or indirectly, as a result of the impact of bouncing, i.e., the intermittent jumping motion of the particles due to presence of eddies, along the stream bed. The smaller particles show higher lift and longer jump.

(iv) **WASH LOAD:** Particle sizes smaller than those found in substantial amounts in the bed material make up that portion of the suspended load. It is conveyed through the stream

without deposition since it is in almost permanent suspension. The discharge of the wash load through a reach is determined solely by the rate at which these particles become available in the catchment area, not by the flow's transport capacity.

- (v) **BED LOAD:** Particles that are too large to be carried as suspended load are bumped and pushed along the stream bed as bed load. The larger particles move close to the surface floor by rolling or sliding and occasional low leap. Bed load sediments do not move continuously. Streams with high velocity and steep gradients do a great deal of down cutting into the stream bed, which is primarily accomplished by movement of particles that make up the bed load.

Figure 23: Mode of Sediment Transport in Rivers



Source: [https://www.bgs.ac.uk/discovering-geology/geological-processes/deposition/#:~:text=Deposition%20is%20the%20laying%20down,sea%20shells\)%20or%20by%20evaporation.](https://www.bgs.ac.uk/discovering-geology/geological-processes/deposition/#:~:text=Deposition%20is%20the%20laying%20down,sea%20shells)%20or%20by%20evaporation.) (British Geological Survey)

3. Sediment Transport Rate

The rate at which sediment is moved past a cross section of the flow is called either the sediment transport rate or the sediment discharge. It is related to the sediment load, but it's different, just because different fractions of the sediment load are transported at different rates. It can be measured in mass per unit time, or in weight per unit time, or in volume per unit time. The sediment transport rate is commonly denoted by Q_s .

4. Estimation of Sedimentation

There are two approaches to obtaining values describing sediment loads in streams. One is based on direct measurement of the quantities of interest, and the other on relations developed between hydraulic parameters and sediment transport potential.

The total bed material load is equal to the sum of the bedload and the bed material part of the suspended load; in terms of volume transport per unit width, $q_t = q_b + q_s$. Here wash load, i.e.

that part of the suspended load that is too fine to be contained in measurable quantities in the river bed, is excluded from q_s .

There are number of equations to compute the total sediment load. Most of these equations have some theoretical and empirical bases.

In 1973, Ackers and White developed a general theory for sediment transport which was calibrated against the flume-transport data then available. Their functions have been widely accepted as one of the best available procedures for estimating the total bed load over the full width of the flow section.

Dendy 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. 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.

5. Sediment Yield

The water that reaches a stream and its tributaries carries sediment eroded from the entire area drained by it. The total amount of erosional debris exported from such a drainage basin is its sediment load or sediment discharge and the sediment yield is the sediment discharge divided by the total drainage area of the river upstream of the cross section at which the sediment discharge is measured or estimated. Sediment yield is generally expressed as a volume or weight per unit area of drainage basin—e.g., as tons per square kilometre. Further, sediment yield is usually measured during a period of years, and the results are thus expressed as an annual average.

v) Replenishment Study (As per EMGSM guidelines, 2020):

Replenishment defines rejuvenation of riverbed sand deposition phenomena. The word replenishment is the fulcrum of riverbed sedimentation under different depositional environmental conditions especially during rainy seasons. The rate of gross or absolute silt production (erosion) in the watershed and the ability of the stream system to transport the eroded material in a river have a direct relation with the quantity of sediment delivered into a river. The rate of gross erosion is dependent upon many physical factors like climatic conditions, nature of soil, and slope of the area, topography and land use. Hydro-physical conditions of the watershed govern the capability of transporting the eroded material. It has been observed that the average rate of sediment production decreases as the size of drainage area increases. And also, larger the watershed, the lesser is the variation between the rates. The larger watershed presents more opportunity for deposition of silt during its traverse from the point of production. The watershed with maximum land use class of forest, generate very low rate of production unless the forests are degraded or open forest. The cultivated watersheds with unscientific farming produce very high rate of silt production. The total amount of eroded material, which reaches a particular hydraulic control point, is termed as sediment yield. The rotational mining is being adopted to

facilitate the replenishment of the excavated pits during rainy season. Thus, the mineable area is to be divided in two blocks i.e., the upstream block and the downstream block. The mining of these blocks is suggested on rotation basis in such a way that pit of previous year mining will act as depository for the monsoon season. Sand is extracted from the said lot during one year; more than the extracted quantity of the same are automatically replenished by rainfall in the monsoon by the river/nallah itself on account of its flow and velocity.

For sustainability of river sand mining, it is necessary that the mine pits formed as a result of sand excavation are refilled with sand by natural process of replenishment in a reasonable period of time so that the area is again available for mining. The rate of excavation should be decided in accordance with the rate of replenishment which is the rate at which sand/gravel is deposited on the river flood plain by the river during monsoon season. However, determination of site-specific rate of replenishment is quite difficult as it is dependent on several factors such as geology and topography of the catchment area of the river, breadth of the flood plain, rainfall in that particular year (which is quite variable and not very much predictable much in advance) etc. Dandy-Bolton formula is generally used to calculate the sediment yield. But it is to be kept in mind that to prepare the mining plans of the mines, the factor of annual replenishment is to be taken into consideration while calculating the mineral reserves. It has also been observed that during flooding, all the pits replenish with sand. Hence, mined out areas in the pre- monsoon season will be completely replenished with sand during monsoon. Therefore, it has been assumed that the pits will be replenished after each monsoon.

Base Flow is influenced by incoming groundwater to aquifers and is closely related to watershed characteristics. Understanding baseflow characteristics is of great importance to river ecosystems and water management. Baseflow is the portion of stream flow that is delayed subsurface flow and generally maintained by groundwater discharge. Regardless of the specific climatic environment, its main features are tightly related to geological catchment properties. Understanding the baseflow process is important to deal with various water resource issues, such as water resources management strategies, low flow conditions assessment, hydrological modeling calibration, and water quality studies. However, no direct approach exists for continuously measuring the variability of streamflow recession under different conditions and the corresponding baseflow, because the baseflow is usually affected by diverse climatological and geological factors, with considerable variations in spatio-temporal watershed characteristics (e.g., geology, land use, soil type, etc.) and climatic conditions influence baseflow discharge to streams. Addressing such processes requires quantitative estimates of baseflow discharge across a gradient of watershed types. The development of quantitative methods for baseflow estimation is also necessary to understand water budgets (Stewart et al., 2007), estimate groundwater discharge (Arnold and Allen, 1999) and associated effects on stream temperature (Hill et al., 2013), and address questions of the vulnerability and response of the water cycle to natural and human-induced change in environmental conditions, such as stream vulnerability to legacy nutrients (Tesoriero et al., 2013). Given the importance of baseflow, many methods have been used to quantify the baseflow component of stream discharge beginning with Boussinesq (1877). Approaches for baseflow estimation can be grouped into two general categories: graphical hydrograph separation (GHS) methods, which rely on stream discharge data alone, and tracer mass balance (MB) methods, which rely on chemical constituents in the stream, stream discharge, and the streamflow end-member constituent concentrations (runoff and baseflow). Many different approaches for GHS exist, including recession curve methods and digital filter

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methods. Recession curve methods are generally considered more objective than digital filter methods because they provide an assumed integrated signal of basin hydrologic and geologic characteristics through identification of a linear recession constant based on the falling limb of the hydrograph (Barnes, 1939; Hall, 1968; Gardner et al., 2010).

However, in context of the rivers of district, the volume (weight) of the precipitated sand has been derived during Pre-monsoon and Post-monsoon period along with the thickness of the sand layers deposited in the respective periods. But, to erect hydrograph model which is essential for estimation of depth of base flow, data on daily discharge of water volume (weight) is required. Hence, it can be proposed that if these data are provided from the concerned authority of the state government (secondary data- already requested for providence), depth of base flow as well as the hydrograph model can be estimated. The quantitative estimation of the depth of base flow cannot be done due to absence of data. But a relative comparison between the mining depth and depth of baseflow has been done on the basis of collected data by making pit on the river bed.

Usually, replenishment or sediment deposition / depletion quantities can be estimated in the following ways:

- Direct measurement of the sand bar upliftment;
- Monitoring of the new sand bars created in the monsoons within the channel;
- Elimination of sand bars during the monsoon etc.;

With systematic data acquisition over a period of several years, regression equations can be developed for modeling of the sediment yield and annual replenishment with variable components.

Several theoretical and empirical formulae can be used for the calculation of catchment runoff and sedimentation loads as thumb rules. Sedimentation in riverbeds depends on catchment areas / characteristics, peak flood of the river. Some of the common empirical formulae used for rough estimation of the Catchment runoffs, Peak Discharge, Bed load transportation and sediment yields for replenishment studies are as under:

➤ **COMMON METHODS FOR REPLENISHMENT:**

- ❖ List of instruments: DGPS, GPS and Hammer.
- ❖ List of software: ARC GIS, Google Earth, Microsoft and Google Maps.

➤ **CATCHMENT YIELD CALCULATION**

The total quantity of surface water that can be expected in a given period from a stream at the outlet of its catchment is known as yield of the catchment in that period. The annual yield from a catchment is the end product of various processes such as precipitation, infiltration and evapotranspiration operating on the catchment. Catchment Yield can be estimated using following formula:

Catchment Yield (m³) = Catchment area (m²) * Runoff coefficient (%) * Rainfall (mts/annum)

The runoff generated from a watershed is estimated using Strange's Tables Method to get obtain approximate yield results. Runoff from a catchment is dependent upon annual rainfall as well as catchment area and characteristics such as soil types and the type of groundcover / land usage. Remote sensing is used for demarcation of catchment boundaries and computation of catchment area relevant to the drainage system. Strange's table is used to determine the Runoff coefficient of the catchment.

➤ **PEAK FLOOD DISCHARGE CALCULATION**

The term "peak discharge" stands for the highest concentration of runoff from the basin area. The accurate estimation of flood discharge remains one of the major challenges as it depends upon physical characteristics of the catchment area and the flood intensity, duration and distribution pattern. There have been many different approaches for determining the peak runoff from an area. As a result, many different models (equations) for peak discharge estimation have been developed. Formulae used for Peak Discharge calculation are as below:

i. As per Dicken's formula, $Q = CA^{3/4}$

Where: **Q** is Maximum flood discharge (m³/sec); **A** is Area of catchment in Sq. Km and **C** is Constant whose value varies widely between 2.8 to 5.6 for catchments in plains and 14 to 28 for catchments in hills

ii. As per Jarvis formula, $Q = CA^{1/2}$

Where: **Q** is Maximum flood discharge (m³/sec); **A** is Area of catchment in Sq. Km and **C** is Constant whose value varies between 1.77 as minimum and 177 as maximum. Limiting or 100 percent chance floods are given by the value of **C** of 177.

iii. As per Rational formula, $Q = CIA$

Where: **Q** is Maximum flood discharge (m³/sec); **A** is Area of catchment in Sq. Km and **C** is the Runoff coefficient (ratio of runoff to total rainfall) which depends on the characteristics of the catchment area.

I is Intensity of rainfall (in m/sec).

➤ **BED LOAD TRANSPORT CALCULATION**

The most difficult problem in river engineering is to accurately predict bed load transport rates in torrential floods flowing from mountainous streams. Three modes of transport namely; rolling, sliding and saltation may occur simultaneously in bed load transport. The different modes of transportation are closely related, and it is difficult, if not impossible, to separate them completely. There are a number of equations to compute the total sediment load. Most of these equations have some theoretical and empirical bases.

i. Ackers and White Equation:

Ackers and White (1973) used dimensional analysis based on flow power concept and their proposed formula is as follows.

$$C_t = C_s G_s (d_{50}/h) (V/U^*)^{n'} [(F_{gr}/A_1) - 1]^m$$

The dimensionless particle d_{gr} is calculated by:

$$D_{gr} = d_{50} (g(G_s - 1)/\nu^2)^{1/3}$$

The particle mobility factor F_{gr} is calculated by:

$$F_{gr} = (U^* n' / (G_s - 1) g d_{50})^{1/2} * (V / (5.66 \log (10h / d_{50}))^{1-n'}$$

Where,

A_1 = Critical particle mobility factor

C_s = Concentration coefficient in the sediment transport function

C_t = Total sediment concentration

d_{50} = Median grain size

d_{gr} = Dimensionless particle diameter

F_{gr} = Particle mobility parameter

g = Acceleration of gravity

D_s, S_g = Specific gravity

h = Water depth

m = Exponent in the sediment transport function

n' = Manning roughness coefficient

U = Shear velocity

V = Mean flow velocity

ν = Kinematic viscosity

ii. Meyer – Peter's equation:

Meyer-Peter's equation is based on experimental work carried out at Federal Institute of Technology, Zurich. Mayer-Peter gave a dimensionless equation based, for the first time, on

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rational laws. Meyer- Peter equations giving an empirical correlation of bed load transport rates in flumes and natural rivers. The simplified Meyer-Peter's equation is given below:

$$gb = 0.417[\tau_0 (\eta' / \eta)^{1.5} - \tau_c]^{1.5}$$

Where,

gb = Rate of bed load transport (by weight) in N per m width of channel per second. η' = Manning's coefficient pertaining to grain size on an unrippled bed and Strickler formula i.e., $\eta' = (1/24) \times d^{1/6}$ where d is the median size (d_{50}) of the bed sediment in m.

η = the actual observed value of the rugosity coefficient on rippled channels. Its value is generally taken as 0.020 for discharges of more than 11 cumecs, and 0.0225 for lower discharges.

τ_c = Critical shear stress required to move the grain in N/m^2 and given by equation $\tau_c = 0.687d_a$, where d_a is mean or average size of the sediment in mm. This arithmetic average size is usually found to vary between d_{50} and d_{60} .

τ_0 = Unit tractive force produced by flowing water i.e., $\gamma_w R S$. Truly speaking, its value should be taken as the unit tractive force produced by the flowing water on bed = $0.97\gamma_w R S$. R is the hydraulic mean depth of the channel (depth of flow for wider channel) and S is the bed slope.

➤ **SEDIMENT YIELD ESTIMATION**

Sedimentation occurs as the stream velocity decreases thus reducing its ability to carry sediment. Coarse sediments deposit first, which may then interfere with the channel conveyance and may cause rivers to meander and form distributaries. As the area of the flowing water increases, the depth decreases, the velocity is reduced, and eventually even fine sediments begin to get deposited. As a result, deltas may be formed in the upper portion of reservoirs. The deposited material may later be moved to deeper portions of the reservoir by hydraulic processes within the water body.

There are many sediment transport equations which are suitable for use in the prediction of the rate of replenishment of rivers. Some of the common equations used to estimate sediment yields are:

- Dandy – Bolton Equation
- Modified Universal Soil Loss Equation (MUSLE) developed by Williams and Berndt (1977)

Dandy – Bolton Equation:

The formula uses catchment area and mean annual runoff as the key variables. It does not differentiate between the characteristics of basins and streams.

Dandy and Bolton equation estimates all types of sediment yield i.e., through Sheet and rill Erosion, gully Erosion, Channel Bed and bank erosion and mass movement etc. Dandy- Bolton

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determined the combined influence of runoff and drainage area to compute the sediment yield. They developed two equations *i.e.*, for run off less than 2 inches and for run off more than 2 inches, which are given below:

For run off less than 2 inches:

$$(Q < 2 \text{ in}) S = 1289 * (Q)^{0.46} * [1.43 - 0.26 \text{ Log } (A)]$$

For run off more than 2 inches:

$$(Q > 2 \text{ in}): S = 1958 * (e^{-0.055 * Q}) * [1.43 - 0.26 \text{ Log } (A)]$$

Where: S = Sediment yield (tons/sq miles/yr) Q = Mean Annual runoff (inch) A = Net drainage area in sq mile

Modified Universal Soil Loss Equation (MUSLE):

Modified universal soil loss equation (MUSLE) for estimation of sediment yield is also used widely. 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 (weight) 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 generalized formula of MUSLE is as below:

$$Y = 11.8 * (Q * qP)^{0.56} * K * Ls * C * P$$

Where,

Y = sediment yield of stream (t/yr/km²),

Q = average annual runoff (m³),

K = soil erodibility factor,

qP = Highest discharge recorded (m³/s),

Ls = gradient/slope length,

C = cover management factor,

P = erosion control practice.

A. REPLENISHMENT STUDY BASED ON SATELLITE IMAGERY

To delineate replenishment percentage in the river bed of the district, below mentioned steps have been followed.

➤ **Satellite imagery studies**

Satellite imagery study involves demarcation of sand/ RBM zones on riverbed of the district. Both pre and post monsoon images need to be analysed to established potential sand/ RBM zones.

➤ **Field data collation**

Field data collation was carried out during May- June for all the sand/ RBM zones on continuous basis for pre monsoon period and November – December for all the sand/ RBM zones on continuous basis for post monsoon period. In both the cases, relative elevation levels were captured through GPS/DGPS/ Electronic Total Station. Thickness of the sand/ RBM zones was measured through sectional profiles. The field survey for collect post-monsoon data has been conducted November- December time period in 2023 while preparing the District Survey Report of Kamrup Metropolitan district.

➤ **Selection of study profiles**

Study profiles are selected based on the occurrence of the sand / RBM zones in the channel profiles. Aerial extents of each of the profiles are mapped from satellite imageries. Frequency distribution did while selection of the ground truthing of the zones.

➤ **Data compilation:**

Following data were compiled for generation of this annual replenishment report:

- Elevation levels of the different sand/ RBM zones as measured at site.
- Extents of the sand/ RBM zones are measured from the pre monsoon satellite imageries.
- Sand/ RBM zones production data of the district.

All these data were compiled while estimation of the replenished sand/ RBM zones in the district.

➤ **Assessment of sediment load in the river:**

Assessment of sediment load in a river is subjective to study of the whole catchment area, weathering index of the various rock types which acts as a source of sediments in the specific river bed, rainfall data over a period not less than 20 years, and finally the detail monitoring of the river bed upliftment with time axis. Again, the sediment load estimation is not a dependent variable of the imaginary district boundary, but it largely depends upon the aerial extents of the catchment areas, which crossed the district and state boundaries.

➤ **METHODOLOGY FOR CALCULATING THE TOTAL POTENTIAL OF MINOR MINERAL IN THE RIVER BED ANNUAL DEPOSITION**

For estimating the reserve of River Bed Material [Sand/Gravel (Minor Mineral)], the following parameters were considered:

- a) The volumes of the reserves are calculated on the basis of the established width, thickness and length of the deposit as per actual field data.
- b) The tonnage of the reserve quantity is obtained by multiplying the above volume with the bulk density of mineral to arrive at tonnes per cum (as per lab report).
- c) The depth of the reserves has been estimated considering the available deposit thickness and the water level/red line.

The same procedure shall be followed for acquiring post monsoon data, its reserve estimation and then correlating between pre and post monsoon volumes as per table given below:

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Table No. 21: Estimation of Sand/ RBM zones Reserves in Pre & Post Monsoon periods in sand/ RBM zones

Estimation of Sand Reserves in Pre & Post Monsoon periods in sand bars										
Sl. NO.	Deposit zone code	Area in Sq. m.	Ave. Thickness (m)	Quantity (CUM)	Sl. NO.	Deposit zone code	Area in Sq. m.	Ave. Thickness (m)	Quantity (CUM)	Difference (cum) 'YY'
PRE-MONSOON					POST-MONSOON					
1					1					
This table would be added after post-monsoon survey										
<i>Source: Field Survey and DGPS data</i>										

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Table No. 22: Sediment Load Comparison Pre & Post monsoon period for different rivers of Kamrup (M) District

River Name	Pre-monsoon No of Ghats	Post-monsoon No of Ghats	Pre-monsoon Sediment Load (CUM)	Post-monsoon Sediment Load (CUM)	Difference (CUM) 'YY'	Percentage Variance (%) (Postmosoon - Premosoon / Postmonsoon *100)
This table would be added after post-monsoon survey						
<i>Source: Field Survey and DGPS data</i>						

B. Geological studies

i) Lithology of the catchment area

- **Brahmaputra:** Lithological units are Sand, Silt, and Clay with Carbonaceous matter.
- **Kapili:** Sand, Silt, Clay with pables.
- **Digaru:** Dark brown to red brown loamy Sand, Silt, Clay with pebbles.

ii) Tectonics and structural behavior of rocks

The Himalayas, which formed from the NER (North-eastern Region) of India to the Hindu Kush area (Afghanistan) in the west, are a result of the contact between the Indian and Eurasian plates, which is why high seismicity prevails in NER (Ghosh et al., 2018). The Himalayan belt is one of the world's most seismically active regions due to the Indian plate's average annual convergence with the Eurasian plate (Catherine, 2004). Because of the tectonic activity underlying it, the active tectonic zone experiences changes that might be slow, quick, or rapid. Folds, fractures, and basin formation are markers of previous tectonic activity-induced deformation (Das et al., 2011). However, the region's sluggish geomorphological changes cannot be seen as modifications in surface deformations or basin drainage patterns and features that are easily seen (Agrawal et al., 2022). The Kamrup Metropolitan district is partially situated in Lower Brahmaputra valley and along with the northern extension of Shillong Plateau.

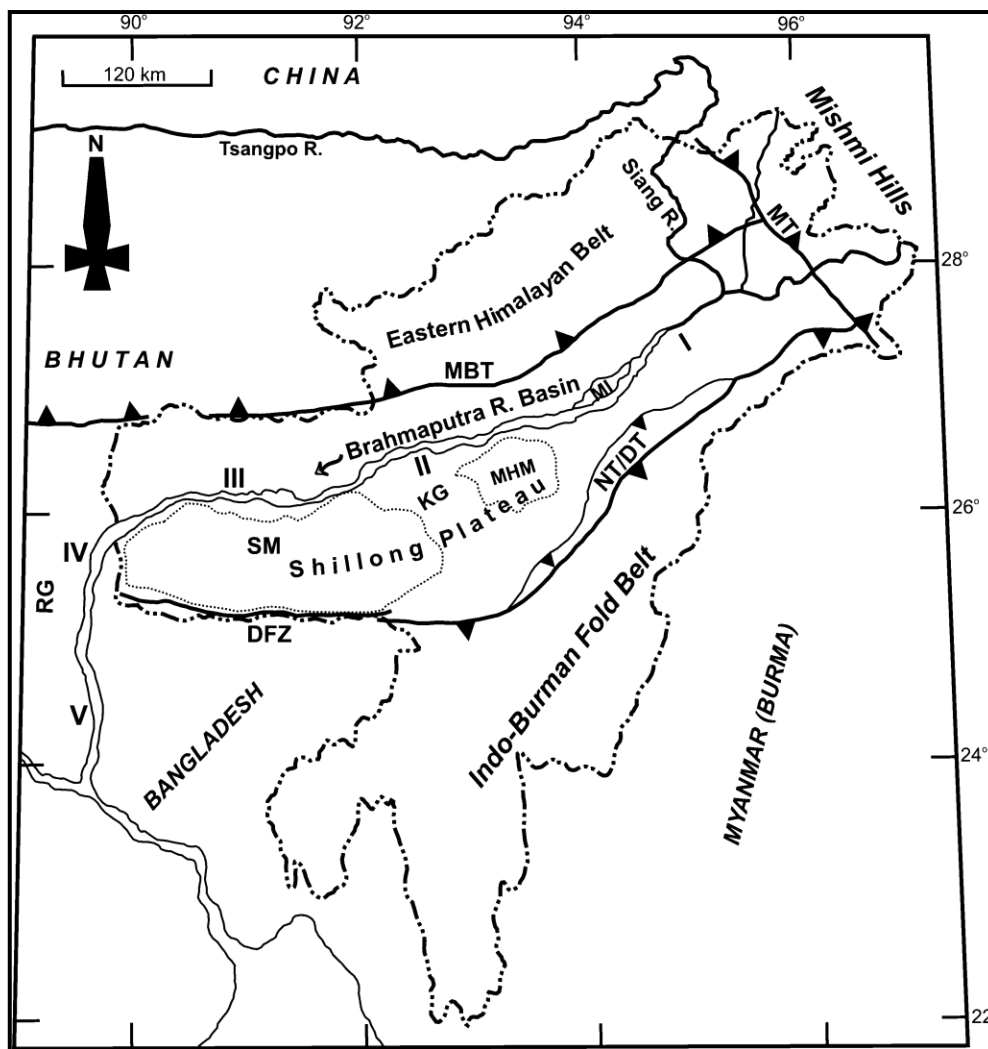
The Himalayan Mountain ranges, the Mishmi Hills, the Naga Hills (part of the Indo-Burman fold belt), and the fault that bounded and block-uplifted Shillong Plateau in the south all influence the shape of the relatively narrow Brahmaputra basin in Assam. This basin is an example of a tectonically generated sag in the crust that occurred during the Miocene epoch. The foundation rocks that form the river basin have westward exposures. In the Upper Assam region, the basement likewise dips away from the central high and toward the north-west and south-east, with 400 meters of sediments covering it (Murthy and Sastri 1981). In the Upper Assam region, the basement likewise dips away from the central high and toward the north-west and south-east, with 400 meters of sediments covering it (Murthy and Sastri 1981). According to the Geological Survey of India (2000), the basement is approximately 7.2 km deep at the Mishmi Thrust and 6 km deep northeast of the Mikir Hills Massif (MHM) (Mukhopadhyay 1984). Many basement highs and lows, impacted by down faulting in multiple locations, are indicative of the underlying basement (Murthy et al. 1976, Barooah and Bhattacharya 1981, Murthy and Sastri 1981). There are reports of significant down faulting from the main shield onto the well-known Jorhat fault, which controls the river alignment (Chansarkar 1981). The sedimentary deposit dips monoclinaly in the direction of the foothills of the Himalayas on the northern side of the river.

The Shillong plateau, which is around 47614 square kilometers in size, is the only example of the Precambrian cratonic block in northeastern India that has been tectonically separated from the Indian Peninsula's mainland. The diagonally advancing Dauki fault to the south, the Brahmaputra lineament to the north, the Garo-Rajmahal Graben to the west, the Dhubri/Madhupur lineament to the west, and the belt of Schuppen to the east encircle this cratonic block. It is composed of high- to medium-grade Paleoproterozoic basement gneisses and

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schist known as the Basement Gneissic Group (BGG), which are covered in Mesoproterozoic metasediments and Shillong Group metavolcanics. Neoproterozoic acidic intrusives, including Myllem pluton, South Khasi pluton, Umroi granite, Nongpoh pluton, and a few others mentioned by Mazumdar (1976); Ghosh et al. (2005); Devi and Sarma (2011), have also been found to be present.

Figure 24: Tectonic set-up of the area.



(Shillong Massif (SM), Mikir Hills Massif (MHM), Main Boundary Thrust (MBT), Mishmi Thrust (MT), Naga Thrust/Disang Thrust (NT/DT), Dauki Fault Zone (DFZ), Majuli Island (MI), Rajmahal Gap (RG), Kopili Gap (KG)).

C. Climate Factors

i) Intensity of rainfall

Rainfall and humidity are closely allied in terms of climatology. The district has a climate which is characterized by a humid atmosphere, abundant rain and general coolness. Therefore, heavy summer rainfall and high humidity affect the weather of Kamrup (M) district. The area enjoys a sub-tropical climate with abundance of monsoonal rain. The rainfall is not uniform throughout the district. The average annual rainfall is ranging 1500 mm to 2600 mm. Southwest Monsoon rainfall hits the district from the month of June and continues up to September/October. The average monthly rainfall was highest in the month of May with 483.6 mm.

ii) Climate zone

The Kamrup (M) district has sub-tropical tropical/ Equatorial climate as Assam lies in the regime of monsoon climate of the sub-tropical belt. So, people of Kamrup(M) district enjoy heavy summer rainfall, abundance of monsoonal rain, experiences winter drought, high humidity and relatively pleasant temperature throughout a year. The relative humidity ranges from 43.7% to 99.7%, with an average of 82.5%.

iii) Temperature variation

The end of February marks the beginning of a steady increase in temperature, which peaks in June, July, and August. Throughout these months, the average high temperature rarely falls below 31°C and occasionally rises beyond 40°C. Every year, these months are regarded as the district's hottest months. In summer weather becomes hot and humid during June/July, winter begins from month of October to February. The winter months include daytime highs of 15 to 25 °C and nighttime lows of 8 to 15 ° C. The summer time temperature is between 25 and 38 °C during the day and 15 to 25 °C at night.

Annual Deposition:

Annual deposition of riverbed minerals has been calculated on post-monsoon sand volume. The pre-monsoon sand volume of the river is the depleted resources and is replenished by the monsoon rainfall.

TOTAL POTENTIAL OF MINOR MINERAL IN THE RIVER BED ANNUAL DEPOSITION

According to Sustainable Sand Mining Guidelines, 2016 and Enforcement & Monitoring guidelines, for Sand Mining, 2020 mining depth of the mining zones are 1 meter for hilly area.

The annual deposition of riverbed minerals is shown in the Table given below.

Table No. 23: Annual deposition

River Name	Zone	Type of Material	Quantity in CUM (as per YY)	60% of quantity in CUM
Brahmaputra				
Kapili				
Digaru				
This table would be added after post-monsoon survey				

1. Riverbed minerals zone area recommended for mineral concession in the above table has been calculated as per the Enforcement & Monitoring Guidelines for Sand Mining (EMGSM) 2020.
2. As per guidelines, mining depth has been restricted to 3 meters depth and distance from the bank is $\frac{1}{4}$ th of river width and not be less than 7.5 meters.
3. Also, mining is prohibited up to a distance of 1 kilometer (1 km) from major bridges and highways on both sides, or five times (5x) of the span (x) of a bridge/public civil structure (including water intake points) on up-stream side and ten times (10x) the span of such bridge on down-stream side, subjected to a minimum of 250 meters on the upstream side and 500 meters on the downstream side.
4. Riverbed minerals zone deposits acting as potential sites for sand mining along with other aspects as mentioned above are illustrated in Satellite images in **Annexure VIII**.

III. Riverbed Mineral Potential

Process of disposition etc.:

Sand: Huge quantities of quality sands are found to occur in part of rivers. Smaller patches are also available locally in the other smaller rivers as well.

Table 24: Resources of Potential Riverbed Mineral

Boulder (Mcum)	Pebbles/Gravel (Mcum)	Sand/White sand (Mcum)	Total Mineable, Mineral Potential (Mcum)

DETAILS OF POTENTIAL SOURCES / SITES OF RIVER BED MATERIAL

Potential sensitive sites for mining near forests, protected areas, habitation, bridges etc., shall be avoided. For this, a sub-divisional committee may be formed which after the site visit shall decide its suitability for mining. The list of mining leases as per the recommendation of the Committee needs to be defined in the following format given in as **Annexure –V**.

The Sub-Divisional Committee shall make recommendations regarding the suitability of all potential mining sites and also record the reason for approving the specific mining leases on the basis of its field inspections. The details regarding cluster and contiguous cluster formation will be provided as in **Annexure-VI**.

No mining Zone

Mining of river bed materials is prohibited in some places on the river channel due to presence of notable landmarks like, sanctuary or national parks, forests, bridge/public civil structure or highways.

A definition of a protected area was established by IUCN in 1994, which is described as

“An area of land and /or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.”

As per the Enforcement & Monitoring Guidelines for Sand Mining (EMGSM) 2020 the restricted zone for mining is a distance from the bank is ¼th of river width and not be less than 7.5 meters. Also, there is a no mining zone up to a distance of 1 kilometre (1 km) from major bridges and highways on both sides, or five times (5x) of the span (x) of a bridge/public civil structure (including water intake points) on upstream side and ten times (10x) the span of such bridge on down-stream side, subjected to a minimum of 250 meters on the upstream side and 500 meters on the downstream side.

No mining zone has been marked for an area up to a width of 100 meters from the active edge of embankments. Also, the concave side of the river is marked as no mining zone, as mining in this area will affect the course of river in future and will erode the river bank.

Mining has a range of environmental consequences for protected areas, whether operations are undertaken within them or nearby. The types of impact may be listed as follows:

- Direct land take and loss of vegetation cover in the mined area and other parts directly affected by associated activities such as deposition of tailings, or consequences such as subsidence;
- Pollution affects, especially on water supplies, aggravated by accidents (e.g., to tailing dams);
- Impacts due to access associated with mining (roads, railways, pipelines, power lines etc.), which permit illegal hunting, habitat fragmentation and alien invasions;
- Secondary effects of human immigration in association with real or perceived livelihood opportunities (e.g., on water supplies, illegal hunting, harvesting of vegetation, alien invasions, illegal land settlements);
- Impacts on other protected area values from noise and visual intrusion, arising from both mining and secondary activities, including transportation.

The 2020 guidelines for sand mining stress on protecting rivers and habitats of species including turtles and calls for such sensitive areas to be declared as no-mining zones. It also called for using the latest technology for surveillance of illegal mining as well as estimating minable reserves.

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A United Nations Environment report has said that, led by China and India, the world is mining sand at unsustainable levels exceeding the replenishment rate and that can have far-reaching social and environmental implications. Unsustainable sand mining practices are rampant in India. Despite a set of guidelines in 2016 to curb the practice, illegal and unsustainable sand mining has continued to be common, spurring the Indian government to take another step toward enforcing rules. The environment ministry has now come out with, Enforcement & Monitoring Guidelines for Sand Mining 2020“ to regulate sand mining and check illegal mining.

This comes four years after the Government’s Sustainable Sand Management Guidelines 2016, which was unsuccessful in putting an end to rampant illegal sand mining across the country. The latest guidelines suggest the use of technologies like drones with night vision for surveillance of sand mining sites, steps to identify sources of sand, procedures for replenishment of sand, post environmental clearance monitoring of sand mining sites, a procedure for environmental audit of such areas and steps to control the instances of illegal mining.

Among these, the focus on monitoring of sand mines after environment clearance is considerable given that so far it has been an area where the performance of authorities, central or state, is considered very poor.

The need for the latest version of the guidelines was felt after illegal and unsustainable sand mining continued despite the 2016 guidelines and many court cases. Since 2016, the National Green Tribunal, in many of the cases, stressed on the need of regulating sand mining and passed several orders. The court in some cases even expressed concern over the death of officials who tried to stop illegal mining and noted that on the ground level, illegal mining is still going on. The guidelines are thus a result of many such orders by the NGT wherein the tribunal passed directions to control it.

The new guidelines also laid special emphasis on the protection of rivers and species from sand mining as it called for surveys for identifying the stretches with freshwater turtles or turtle nesting zones. “Similarly, stretches shall be identified for other species of significant importance to the river ecosystem. Such stretches with adequate buffer distance shall be declared as no-mining zone and no mining shall be permitted,” the guidelines said.

It also called for a survey report in every district for identifying the sand bearing area but also the “mining and no mining zones” considering various environmental and social factors like the distance of the mining area from the protected area, forest, bridges, important structures and habitation. According to the Sand Mining Framework 2018 of the central Government’s Ministry of Mines, in India, there is a shortage of sand in the country, similar to the situation in other developed and developing countries. It estimated that the demand of sand in the country is around 700 million tons (in the financial year 2017) and it is increasing at the rate of 6-7 percent annually even as the quantity of natural generation of sand is static.

Due to uncertainties and inadequateness in supply, the selling rate of the material varies significantly leading to black marketing and illegal mining of the mineral. It noted that illegal and uncontrolled extraction of sand has an adverse environmental impact.

Protect the rivers from illegal sand mining

The main sources of sand in India are considered to be rivers (riverbed and flood plain), lakes and reservoirs, agricultural fields, coastal/marine sand and manufactured sand.

The guidelines focus on identifying sand mining sources, its quantification and feasibility for mining considering various environmental factors like proximity of protected area, wetlands, creeks, forest etc. and presence of important structures, places of archaeological importance, habitation, prohibited area etc.

To protect the rivers from illegal sand mining, the guidelines said that abandoned stream channels on the floodplains should be preferred rather than active channels and their deltas and floodplains.

CHAPTER 8: OVERVIEW OF THE MINING ACTIVITY IN THE DISTRICT

8.1 GENERAL OVERVIEW

To prepare the DSR of Kamrup Metropolitan district of Assam, geological studies along with structural studies in the quest from knowing more and more pertaining to tectonic set up of this regime, suitability for river bed sand mining and time of deposition of different types of minerals are also important. The common hydrological regime plays a pivotal role for deposition of sand and other minor minerals mainly pebbles and boulder. Assam, from climatological aspect gives a best fit result for economic sand deposits. Here grey to greyish-brown sand is noticeable in the riverbed of Brahmaputra River, Kapili River, Digaru River. The spatiality of rain is controlled here by the orientation of the axis of monsoon trough. River bed sand mining or sand mining adjacent to a river or stream has a direct impact on the physical characteristics of the stream such as channel geometry, bed elevation, substratum composition and stability, in-stream roughness of the bed, pro velocity, discharge capacity, sediment transport capacity, turbidity, temperature etc. Alteration or modification of the said attributes may cause hazardous impact on ecological equilibrium of riverine regime.

8.2 LIST OF THE EXISTING MINING LEASES OF THE DISTRICT (LOCATION, AREA, PERIOD FOR EACH MINOR MINERAL):

The existing Sand Mahals of Kamrup Metropolitan District are attached in ANNEXURE II.

8.3 DETAILS OF PRODUCTION OF SAND AND OTHER MINERALS DURING LAST THREE YEARS:

- **Total Mineral production of River Bed Minerals in the district during last three years:**

Table No. 25: Production of the District for the year 2020-21

Sl. No.	Name of the Mineral	Production (MTs)
1		

Table No. 26: Production of the District for the year 2021-22

Sl. No.	Name of the Mineral	Production (In m³)
1		

Table No. 27: Production of the District for the year 2022-23

Sl. No.	Name of the Mineral	Production (MTs)
1		

- **Total Mineral production of In-situ Minerals (Minerals other than River Bed Minerals) in the district during last three years:**

Table No. 28: Production of the District for the year 2020-21

Sl. No.	Name of the Mineral	Production (MTs)
1		

Table No. 29: Production of the District for the year 2021-22

Sl. No.	Name of the Mineral	Production (MTs)
1		

Table No. 30: Production of the District for the year 2022-23

Sl. No.	Name of the Mineral	Production (MTs)
1		

CHAPTER 9: DETAILS OF REVENUE GENERATED FROM MINERAL SECTOR DURING LAST THREE YEARS

9.1 REVENUE GENERATION FROM MINERAL SECTOR:

- Revenue generated in the district for River Bed Minerals for during last three years:

Table No. 31: Revenue Generated in the district for year 2020-21

Sl. No.	Name of the Mineral	Rate	Royalty (In Rs.)	Cess (Rs.)	Total Revenue
1	Sand				

Table No. 32: Revenue Generated in the district for year 2021-22

Sl. No.	Name of the Mineral	Rate	Royalty (In Rs.)	Cess (Rs.)	Total Revenue
1	Sand				

Table No. 33: Revenue Generated in the district for year 2022-23

Sl. No.	Name of the Mineral	Rate	Royalty (In Rs.)	Cess (Rs.)	Total Revenue
1	Sand				

- Revenue generated in the district for In-situ Mineral (Mineral other than River Bed Minerals) during last three years:

Table No. 34: Revenue Generated in the district for year 2020-21

Sl. No.	Name of the Mineral	Rate	Royalty (In Rs.)
1			

Table No. 35: Revenue Generated in the district for year 2021-22

Sl. No.	Name of the Mineral	Rate	Royalty (In Rs.)
1			

Table No. 36: Revenue Generated in the district for year 2022-23

Sl. No.	Name of the Mineral	Rate	Royalty (In Rs.)
1			

CHAPTER 10: TRANSPORT

In Kamrup Metropolitan District, Assam, road transport is a vital component of the local infrastructure, facilitating the movement of people and goods both within the district and to neighboring regions. Here's an overview of road transport in Kamrup Metropolitan District. Major district road present. Name of the Major District Road are Azara Rani Loharghat (Rani NEC Road) Road (Rani Chowk - Loharghat), Borkhat Barni Road (Borkhat Chowk - 14 Mile), Sonapur Umden Nongpo Road (Sonapur Baligate Tiniali - Aporkula Nongpo). Kamrup (M) is connected to major cities and other parts of Assam by National Highway 37. The government frequently invests in road infrastructure to enhance transportation efficiency and support economic growth. The region faces challenges such as maintenance issues, seasonal flooding, and infrastructural development needs. Addressing these challenges is crucial for improving road connectivity. Bus services, both state-run and private, operate in Kamrup (M), providing connectivity to various destinations within and outside the district.

Northeast Frontier Railway (NFR) network passes through the district. District Railway Stations are Narangi (NNGE), New Guwahati (NGC), Azara (AZA), Agthori (AGT), Amin Gaon (AMJ), Tetelia (TTLA), Pandu (PNO), Noonmati (NMY). The district is well connected with other districts by rail. The Guwahati Railway station is a major railway junction of the North-east Frontier Railway (NFR). By this route, people are providing access to other parts of Assam as well as India. The station itself is equipped with various facilities to cater to passengers, including waiting rooms, ticket counters, and refreshment options. Ongoing improvements and expansions aim to enhance passenger experience and capacity.

Kamrup (M) district in Assam has an airport named Lokapriya Gopinath Bordoloi International Airport, also known as Guwahati Airport. It is also known as largest airport in the state of Assam. It is located at Located in Borjhar, it is 26 km (16 mi) away from Assam's capital city of Dispur and 28 km (18 mi) from Guwahati. Airport is well-connected to major cities in India. Regular flights operate to and from cities like Kolkata, Guwahati, Delhi, and Mumbai etc. It also provides flights to other regional destinations within the northeastern states of India. The airport has basic amenities, including check-in counters, baggage claim, and passenger lounges. There are also facilities for refreshments and ground transportation options like taxis and rental cars. The airport plays a vital role in connecting Dibrugarh with other parts of Assam and the northeastern region. It also facilitates travel to international destinations, although direct international flights are limited.

Existing sand mining area of the district are connected with the state highways by blacktop or village/link roads. However, there is a scope for development of infrastructural structure. Mining of riverbed sand in the potential areas can generate considerable revenue and can be utilized for development of road network and infrastructure of the district.

A transportation map demarcating approach road to the potential sand blocks from the nearest National Highway/ State Highway has been prepared and presented in Figure 10.2.

CHAPTER 11: IN-SITU MINERALS

11.1 MINERAL RESERVE

The sediments of Tertiary Age formed a treasury of few economic mineral deposits in Assam State. Kamrup Metropolitan District is no exception of these. Oil and Natural Gas are present in this district as Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) have been involved in oil prospecting in the area. REE elements are also present in biotite gneiss and granitic rocks in Garbhanga-Jorabat region, Kamrup (Metro) district. Tungsten is also observed in and around Khetri region. Granite also present in this district. Ordinary Earth is also present in this district as in-situ mineral. Molybdenum is also occurred in Molybdenum containing Pegmatite veins in between Helagog and Khaloibari in the Kamrup Metropolitan district, Assam. Ordinary Earth is used for filling and levelling purposes in construction or embankment, roads, railway or buildings. Brick Earth is also present in this district for manufacturing the bricks. (Source: Miscellaneous Publication of GSI, Indian Mineral Yearbook of Assam 2019 & 2021)

Mineral resources of the district are explained below.

Occurrences of Oil Seepages is present in the district. Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) have been involved in oil prospecting in the area.

REE (Rare Earth Elements): A reconnaissance study of 75 square kilometers on a 1:12,500 scale was done to explore for Rare Earth Elements (REE) in biotite gneiss and granitic rocks in the Garbhanga-Jorabat area, Kamrup (Metro) district, Assam, and Ri-Bhoi district, Meghalaya. Two blocks comprising 1.5 square kilometers each underwent grid-pattern trenching and 75 cubic meters of pitting in addition to the collection of 75 pit/trench samples. The chemical analysis findings of the trenching and pitting samples showed that the total REE concentration ranged from 268.901 to 505.72 ppm (Avg. 381.94). In BRS samples, the total concentration of REE varied from 26.55 to 760.89 ppm (average 366.12 ppm).

Tungsten: During a reconnaissance evaluation for tungsten mineralization in and around the Khetri region of the Kamrup (metro) district, a 1:12,500 scale map covering an area of 90 square kilometers was developed. The hydrothermally altered quartz veins at Barbitli have higher amounts of W (216 & 238 ppm), Sn (16.5 & 15.8 ppm), and Mo (8.28 & 11.94 ppm). At the junction of migmatite and pelitic schist in Sametapathar, a quartz vein sample showed 463.8 ppm W, 12.4 ppm Mo, and 8.45 ppm Sn. The miarolitic pegmatites from Helagog had 2.89 to 10.88 ppm Mo and 5.19 to 96.09 ppm Sn. In garnetiferous pegmatite situated 1.2 km NW of Gumaria, Sn values of 28.98 ppm and Mo values of 15.49 ppm were discovered.

MINERAL POTENTIAL

Potential minor mineral occurrences have been demarcated in this district survey report. This DSR encompasses the presence of different types of in-situ minor minerals such as Molybdenum, granite pebble, cobbles boulder and silt and ordinary earth etc.

Molybdenum: Initial investigation between Helagog and Khaloibari in the Kamrup Metropolitan district, Assam (G3), for related mineralization and molybdenum: Throughout the project, a comprehensive 1:2000 geological mapping of 03 square kilometers, a 3 sq.km. magnetic and gravity geophysical survey, and 25 linear kilometers of resistivity and IP surveys were completed.

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Molybdenite-containing pegmatite veins were plainly visible in the quarry areas of Helagog and Khaloibari. In the Helagog quarry, at least four pegmatite veins containing molybdenite were discovered. These veins manifested as dikes, segregations, or pods. The veins range in length from 3 to 21 meters and in diameter from 0.15 to 12 meters, with an anastomosing pattern. Six pegmatite veins containing molybdenite were discovered in the Khaloibari quarry. These veins were spaced widely apart and measured between 38 and 40 meters in length. These veins are in addition to the two pegmatite veins that previously reported molybdenite. Pegmatite veins can range in thickness from 0.2 to 0.7 meters and in length from 5 to 15 meters. A limited quantity of veins emerge as arbitrary-oriented segregations. Samples collected from pegmatite veins containing pyrite-chalcopyrite in the Helagog quarry were subjected to a chemical investigation, which revealed tungsten (W) concentrations ranging from 85.264 to 169.301 ppm and abnormal fluoride (F) concentrations from 104 to 1,200 ppm.

Pebbles, cobbles, boulders are generally found in river channel deposit. It is generally used for building material purposes and also as the road metals.

Ordinary earth is also present in this district. It is generally used for making bricks for building construction and also for embankments, roads railway or buildings etc.

CHAPTER 12: REMEDIAL MEASURE TO MITIGATE THE IMPACT OF MINING

12.1 Environment Sensitivity

Kamrup Metropolitan district represents a unique geo-environmental setup. The district has a dense vegetation cover; almost 48.46% of total geographical area falls under forest. Deepor Beel bird sanctuary is located in kamrup metropolitan district, it is one of the important fresh water lakes of Assam which consists of a good variety of Avian species. Amchang wildlife sanctuary is another wildlife sanctuary situated in the district, it also consists of very diverse biodiversity making it dreamland for nature lovers. As human population increases, forests are being depleted for the extension of agricultural lands, introduction of new settlements, roadways etc. the Government of Assam has complied several legal frameworks to protect the reserve forests and other eco-sensitive zones from all sorts of forest degradation including encroachment, illegal felling, lopping, grazing, illegal collection of NTFP, illegal clearance of forests for coal mining, illegal removal of minor minerals etc.

Due to unprecedented growth of population during the last few decades, nature has started reacting sharply to the accumulated human guilt. Soil erosion and its conservation play an important role. The land use practices play the most important role in determining the stability factors in respect of landslide hazards.

12.2 Sand and Stone mining Impact

Another serious environmental problem around the globe in recent years is of sand and gravel mining. Sand mining is a process of extraction of sand from an open pit, river bed, sea beaches, ocean floor, river banks, deltas and island dunes. The extracted sand could be utilized for various types of manufacturing, such as concrete used in the construction of building and other structures. The sand can also be used as an abrasive. The demand for sand will increase with population growth and urbanization. The high demand of sand has led to unsustainable sand mining process resulting in illegal mining.

Although most jurisdictions have legal limit on the location and volume of sand that can be mined, illegal sand extraction is taking place in many parts of the country due to rapid urbanization and industrialization.

Removal or extraction of too much sand from rivers leads to erosion of river banks. Deltas can recede due to sand mining. These destructive effects of sand mining ultimately result in loss of fertile land and property. It also destabilizes the ground and causes failure of engineering structures.

In-stream mining directly alters the channel geometry and bed elevation. Removing sediment from the channel disrupts the pre-existing balance between sediment supply and transporting capacity, typically inducing incision upstream and downstream of the extraction site. The resultant incision alters the frequency of floodplain inundation along the river courses, lowers valley floor water table and frequently leads to destruction of bridges and channelization structures.

In Kamrup Metropolitan district, any minor minerals mining operation would be done under strict supervision of forest officer following all rules and regulations stipulated in Assam Minor Mineral Concession Rules to avoid any environmental and ecosystem degradation.

12.3 Remedial measure

12.3.1. Sustainable Mining Practices:

- The depth mining in riverbed shall not exceed 3 meter or base flow level whichever is less, provided that where the Joint Inspection Committee certifies about excessive deposit or over accumulation of mineral in certain reaches requiring channelization, it can go above 3 meters.
- Mining shall be done in layers of 1 meter depth to avoid ponding effect and after first layer is excavated, the process will be repeated for the next layers.
- No stream should be diverted for the purpose of sand mining. No natural water course and/ or water resources are obstructed due to mining operations.
- No blasting shall be resorted to in river mining and without permission at any other place.

12.3.2 Monitoring the Mining of Mineral and its Transportation:

- For each mining lease site, the access should be controlled in a way that vehicles carrying mineral from that area are tracked and accounted for.
- There should be regular monitoring of the mining activities in the State to ensure effective compliance of stipulated EC conditions and of the provisions under the Minor Mineral Concessions Rules framed by the State Government.

12.3.3 Noise Management:

- Noise arising out of mining and processing shall be abated and controlled at source to keep within permissible limit.
- Restricted sand mining operation has to be carried out between 6 am and 7 pm.

12.3.4 Air Pollution and Dust Management:

- The pollution due to transportation load on the environment will be effectively controlled and water sprinkling will also be done regularly.
- Air pollution due to dust, exhaust emission or fumes during mining and processing phase should be controlled and kept in permissible limits specified under environmental laws.
- The mineral transportation shall be carried out through covered trucks only and the vehicles carrying the mineral shall not be overloaded. Wheel washing facility should be installed and used.

12.3.5 Bio-Diversity Protection:

- Restoration of flora affected by mining should be done immediately. Five times the number of trees destroyed by mining to be planted preferably of indigenous species. Each EC holder shall have to undertake plantation of trees over at least 20% of the total area of lease in the same plot or plots utilised for such working.

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- No mining lease shall be granted in the forest area without forest clearance in accordance with the provisions of the Forest Conservation Act, 1980 and the rules made there under.
- Protection of natural home of any wild animal shall have to be ensured.
- No felling of tree near quarry is allowed. For mining lease within 10km of the National Park / Sanctuary or in Eco-Sensitive Zone of the Protected Area, recommendation of Standing Committee of National Board of Wild Life (NBWL) has to be obtained as per the Hon'ble Supreme Court order in I.A. No. 460 of 2004.
- Spring sources should not be affected due to mining activities. Necessary protection measures are to be incorporated.

12.3.6. Management of Instability and Erosion:

- Removal, stacking and utilization of top soil should be ensured during mining. Where top soil cannot be used concurrently, it shall be stored separately for future use keeping in view that the bacterial organism should not die and should be spread nearby area.
- The EC should stipulate conditions for adequate steps to check soil erosion and control debris flow etc. by constructing engineering structures.
- Use of oversize material to control erosion and movement of sediments.
- No overhangs shall be allowed to be formed due to mining and mining shall not be allowed in area where subsidence of rocks is likely to occur due to steep angle of slope.
- No extraction of stone / boulder / sand in landslide prone areas.
- Controlled clearance of riparian vegetation to be undertaken.

12.3.7. Waste Management:

- Site clearance and tidiness is very much needed to have less visual impact of mining.
- Dumping of waste shall be done in earmarked places as approved in Mining Plan.
- Rubbish burial shall not be done in the rivers.

12.3.8. Pollution Prevention:

- Take all possible precautions for the protection of environment and control of pollution.
- Effluent discharge should be kept to the minimum and it should meet the standards prescribed.

12.3.9. Protection of Infrastructure:

- Mining activities shall not be done for mine lease where mining can cause danger to site of flood protection works, places of cultural, religious, historical, and archaeological importance.
- For carrying out mining in proximity to any bridge or embankment, appropriate safety zone should be worked out on case-to-case basis, taking into account the structural parameters, location aspects and flow rate, and no mining should be carried out in the safety zone so worked out.

Mining shall not be undertaken in a mining lease located in 300-500 meter of bridge, 300 meter upstream and downstream of water supply / irrigation scheme, 100 meters from the edge of National Highway and railway line, 50 meters from a reservoir, canal or building, 25 meters from the edge of State Highway and 10 meters from the edge of other roads except on special exemption by the Sub-Divisional level Joint Inspection Committee.

CHAPTER 13: SUGGESTED RECLAMATION PLAN FOR ALREADY MINED OUT AREAS

As per statute all mines/quarries are to be properly reclaimed before final closure of the mine. Reclamation plans should include:

1. Baseline survey of river cross section. The study of cross section is basis for delineating channel form. Cross-sections must be surveyed between two monumented endpoints set on the river banks, and elevations should be referenced based on benchmark set in the area;
2. The proposed mining cross-section data should be plotted over the baseline data to illustrate the vertical extent of the proposed excavation;
3. The cross-section of the replenished bar should be the same as the baseline data. This illustrates that the bar elevation after the bar is replenished will be the same as the bar before extraction;
4. A planimetric map showing the aerial extent of the excavation and extent of the riparian buffers;
5. Planting plan developed by a plant ecologist familiar with the flora of the river for any areas such as roads that need to be restored;
6. Each EC holder shall have to undertake plantation of trees over at least 20% of the total area of the plot or plots of land as subject to such working in accordance with a plan approved by the concerned Divisional Forest Officer holding jurisdiction, provided further the competent authority i.e., The Divisional Forest Officer may fix up norms for plantation of trees in a particular area regarding choice of species, spacing, nos of trees and maintenance etc.
7. A monitoring plan has to establish.

CHAPTER 14: RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

Risk analysis is the systematic study of risks encountered during various stages of mining operation. Risk analysis seek to identify the risks involved in mining operations, to understand how and when they arise, and estimate the impact (financial or otherwise) of adverse outcomes. The sand mining operation in the district is mainly done manually.

14.1. Identification of risk due to river sand mining

There is no land degradation due to mining activities as mining is done only on river bed dry surface. There will be no OB or waste generation as the sand is exposed in the river bed and is completely saleable. There will be neither any stacking of soil nor creation of OB dumps. The mining activity will be carried out up to a maximum depth of 3m below the surface level. So, there is no chance of slope failure, bench failure in the mines. However, there are some identified risks in the mining activity which are as follows:

1. Accident during sand loading and transportation
2. Inundation/ Flooding
3. Quick Sand Condition

14.2. Mitigation measures

14.2.1. Measures to prevent accidents during loading and transportation:

- ❖ During the loading, trucks should be brought to a lower level so that the loading operation suits the ergonomic condition of the workers.
- ❖ The workers will be provided with gloves and safety shoes during loading.
- ❖ Opening of the side covers of the truck should be done carefully and with warning to prevent injury to the loaders.
- ❖ Mining operations will be done during daylight only.
- ❖ The truck will be covered with tarpaulin and maintained to prevent any spillage.
- ❖ To avoid danger while reversing the trackless vehicles especially at the embankment and tipping points, all areas for reversing of lorries should be made man free as far as possible.
- ❖ All transportation within the main working will be carried out directly under the supervision and control of the management.
- ❖ Overloading should not be permitted and the maximum permissible speed limit should be ensured.

- ❖ There will be regular maintenance of the trucks and the drivers will have valid driving license

14.2.2. Measures to prevent incidents during Inundation/ Flooding:

- ❖ To minimize the risk of flooding/ inundation following measures should be under taken:
- ❖ Mining will be completely closed during the monsoon months.
- ❖ Proper weather information, particularly on rain should be kept during the operational period of mines so that precautionary measures will be undertaken.

14.2.3. Measures for mitigation to quick sand condition:

- ❖ Quicksand zone and deep-water zone will be clearly demarcated and all the mine workers will be made aware of the location.
- ❖ Mining will be done strictly as per the approved mining plan.

14.3. Disaster Management Plan

As the depth of mining will be maximum of 3m below the surface level considering local condition, the risk related to mining activity is much less. The mining operation will be carried out under the supervision of experienced and qualified Mines Manager having Certificate of Competency to manage the mines granted by DGMS. All the provisions of Mines Act 1952, MMR 1961 and Mines Rules 1955 and other law applicable to mine will strictly be complied. During heavy rainfall and during the monsoon season the mining activities will be closed. Proper coordination with Irrigation Department should be maintained so that at the time of releasing water, if any, from the dam suitable warning/information is given in advance. Special attention and requisite precautions shall be taken while working in areas of geological weakness like existence of slip, fault etc. The mining site will be supplied with first aid facilities and the entire mines worker will have access to that.

CHAPTER 15: CONCLUSION & RECOMMENDATIONS

15.1 CONCLUSION

Sand mining or River Bed Minerals mining (used here as a generic term that includes mining of any riverine aggregates regardless of particle size) is a global activity that is receiving increasing media attention due to perceived negative environmental and social impacts. As calls grow for stronger regulation of mining, there is a need to understand the scientific evidence to support effective management. This paper summarizes the results of a structured literature review addressing the question, the review found that most investigations have focused on temperate rivers where sand or river bed mineral mining occurred historically but has now ceased. Channel incision was the most common physical impact identified; other physical responses, including habitat disturbance, alteration of riparian zones, and changes to downstream sediment transport, were highly variable and dependent on river characteristics. Ecosystem attributes affected included macro invertebrate drift, fish movements, species abundance and community structures, and food web dynamics. Studies often inferred impacts on populations, but supporting data were scarce. Limited evidence suggests that rivers can sustain extraction if volumes (weight) are within the natural sediment load variability. Significantly, the countries and rivers for which there is science-based evidence related to sand or river bed mineral mining are not those where extensive sand mining or gravel, pebbles, boulder extraction is currently reported. The lack of scientific and systematic studies of mining in these countries prevents accurate quantification of mined volumes (weight) or the type, extent, and magnitude of any impacts. Additional research into how river bed mining is affecting ecosystem services, impacting biodiversity and particularly threatened species, and how mining impacts interact with other activities or threats is urgently required.

The rapid rise in urbanization and construction of large-scale infrastructure projects are driving increasing demands for construction materials globally. United Nations Environment Programme (UNEP; 2014) estimated that between 32 and 50 billion tonnes of sand and gravel are extracted globally each year with demand increasing, especially in developing countries (Schandl et al., 2016). Rivers are a major source of sand and gravel for numerous reasons: cities tend to be located near rivers so transport costs are low; river energy grinds rocks into gravels and sands, thus eliminating the cost of mining, grinding, and sorting rocks; and the material produced by rivers tends to consist of resilient minerals of angular shape that are preferred for construction (whereas wind-blown deposits in deserts are rounder and less suitable). Sand mining or river bed minerals mining activities are one of many recognized pressures affecting riverine ecosystems, where biodiversity is already in rapid decline (World Wildlife Fund, 2018). Increasingly, there are media reports about the negative environmental and social impacts of river bed mining, and as calls grow for stronger regulation of mining (Schandl et al., 2016), there is a need to understand the scientific evidence of mining impacts to underpin management.

Impacts of sand mining or river bed mineral mining on rivers may be two types such as direct or indirect. Direct impacts are those in which the extraction of material is directly responsible for the ecosystem impact, such as due to the removal of flood plains habitat. Indirect impacts are related to ecosystem changes that are propagated through the system due to physical changes in the river system resulting from sand extraction. For example, the removal of material from a river can alter the channel, river hydraulics, or sediment budget which in turn can alter the distribution of habitats and ecosystem functioning. These types of impacts can be difficult to attribute to river bed mining, as they may require long time frames to emerge, and

other interventions can result in similar changes. The situation is further complicated by the existence of geomorphic thresholds in river systems (Schumm, 1979). Alterations linked to removal of sand, gravel, pebbles, boulder from rivers may not be gradual and/or linear, and only limited changes may be observed for an extended period, but once a threshold is reached, change may become rapid and irreversible. Whether the impacts of sand or river bed mineral mining are positive, neutral, or negative depends on the situation and perceptions of different stakeholders.

During the preparation of the present report prominent rivers/ streams has been studied in detail. These mineral concessions shall also reduce demand load and will be helpful to minimize illegal extraction of minerals, failure of which may result in to illegal mining at odd hours and shall be haphazard and more detrimental to the local ecology. Irrespective of it following geo-scientific considerations are also suggested to be taken into account during the river bed mining in a particular area:

1. Abandoned stream channels or terrace and inactive floodplains may be preferred rather than active channels and their deltas and floodplains.
2. Stream should not be diverted to form inactive channel.
3. Mining below subterranean water level should be avoided as a safeguard against environmental contamination and over exploitation of resources.
4. Mining area should be demarcated on the ground with Pucca pillars so as to avoid illegal unscientific mining.

15.2 Recommendation:

1. The mining lease distribution for the district must be carried out by involving a district level committee constituted with inter-disciplinary members of various departments including irrigation and waterways, DL&LRO, forest, biodiversity, wetland management, SWID or any other relevant department which the district authority may find suitable to include.
2. While recommending for Mining Leases, the District Level Committee should ensure the protection of Biodiversity Zones as recorded by relevant Government Agenesis from time to time.
3. It is recommended to have a periodical review along with primary data collection during pre- and post-monsoon periods to record the seasonal variance of the sedimentation rate on annual basis and update replenishment rate of the district.
4. Efforts should be given to restrict distribution of mining leases along the confluence zone of the rivers where rich aquatic habitats are reported.

CHAPTER 16: REFERENCES

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ANNEXURE – I

- **Details of Sand / M – Sand Source**
 - a) **Rivers,**
 - b) **De-siltation location: (Lakes/Ponds/Dams etc.)**
 - c) **Patta Lands/khatedari Land**
 - d) **M-Sand Plants**

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a) Rivers:

Sl. No.	River Name / M-Sand plant	Total stretch of River (in Km)	Type Of River
1	Digaru River	41.9	Perennial
2	Kolong / Kapili River	17.2	Perennial
3	Brahmaputra River	45.9	Perennial

b) List of De-siltation location (Lake, Pond, Dams, River)

Name	Maintain / Controlled by Sate Govt./PSU etc.	Location	District	Lake/Pond/Dams/River/Canal	Tehsil	Village	Size (Ha)	Existing /Proposed
NA								

c) List of Patta Lands / Khatedari land

Owner	Sr. No.	Area	District	Tehsil	Village	Agricultural Land (Yes / No)
Keshab Tumung	1	1.2 ha	Kamrup Metro	Sonapur	Sonaigaon	No
Prasanta Boro	2	1.0 ha	Kamrup Metro	Sonapur	Kamalajari	No
Jaladha Mikir	3	1.4 ha	Kamrup Metro	Sonapur	Sonaigaon	No

d) M-Sand plants with location:

Sl. No.	Plant Name	Owner	District	Tehsil	Village	Geolocation		Quantity (Tonnes /Annum)
						Latitude	Longitude	
NA								

ANNEXURE – II

➤ **List of Potential Mining Leases (existing)**

- **Rivers**
- **Patta Lands/Khatedari Land:** (existing)
- **De-Siltation Location:** (Lakes/Ponds/Dams etc.) (existing)
- **M-Sand Plants:** (existing)

DISTRICT SURVEY REPORT OF KAMRUP METROPOLITAN DISTRICT, ASSAM

a) List of existing mining zones of the district with location, area, period for each minor mineral

Sl. No.	River Details	Name of the mines or Desilting sites	Lease Details	Area (Ha)	Geolocation		Distance in (km) from PA/BR/WC	Distance from Forest Area (in km)	Mining Leases within 500 meters (if yes cluster area)	Production as per EC (MT)	Mineral to be mined (Sand/Bajri/RBM etc)	Existing / Proposed
					Latitude	Longitude						
1	Digaru River	Digaru Sand Permit Area No. 4	2 years	3.0 Ha.	26° 4'45.219"N 26° 4'39.232"N 26° 4'40.916"N 26° 4'47.100"N	91°56'2.142"E 91°56'22.072"E 91°56'21.322"E 91°56'1.600 E	11 km	4 km approx...	No	20,000 m ³	Sand	Existing

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b) List of Patta Lands / Khatedari land

Owner	Sr. No.	Area	District	Tehsil	Village	Total Reserve (cum)	Total Mineral to be mined (cum)	Existing / Proposed
Keshab Tumung	1	1.2 ha	Kamrup Metro	Sonapur	Sonaigaon	36,000	21,600	Existing
Prasanta Boro	2	1.0 ha	Kamrup Metro	Sonapur	Kamalajari	30,000	18,000	Existing
Jaladha Mikir	3	1.4 ha	Kamrup Metro	Sonapur	Sonaigaon	42,000	25,200	Existing

c) List of De-siltation location (Lake, Pond, Dams, River)

Name	Maintain / Controlled by Sate Govt./PSU etc.	Location	District	Tehsil	Village	Size (Ha)	Quantity (MT/Year)	Existing / Proposed
NA								

d) M-Sand plants with location

Sl. No.	Plant Name	Owner	District	Tehsil	Village	Geolocation		Quantity (Tonnes /Annum)
						Latitude	Longitude	
NA								

ANNEXURE – III

- **list of Cluster and Contiguous Clusters**
 - **Clusters:**
 - **Contiguous Clusters:**

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• **Cluster details**

River Name	Cluster No.	Lease No.	Location (Riverbed/Patta Land)	Village	Area (in Ha)	Total Excavation (Ton)	Total Mineral Excavation (Ton)
NA							

• **Contiguous Cluster details**

River Name	Contiguous Cluster No.	Cluster No.	Number of leases in the cluster	Location (Riverbed/Patta Land)	Distance between clusters	Village	Area of Cluster (Ha)	Total Mineral Excavation (Ton)
NA								

ANNEXURE – IV

- **Transportation Routes for Individual leases and leases in Cluster**

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➤ **Transportation Routes for individual leases details:**

Lease No.	Transportation Route No.	Number of tippers /days of lease	Number of tippers /days of all the lease on route	Length of the Route in Km	Type of Road (black Topped/ unpaved)	Recommendation for road (Black Topped/ unpaved)	The road will be constructed by Govt. / Lease Owner	Route Map & Location
NA								

➤ **Transportation Routes for leases in Cluster details:**

Cluster No.	Transportation Route No.	Number of tippers / days of cluster	Number of tippers / days of all the clusters on route	Length of Route in km	Type of Road (Black Topped / unpaved)	Recommendation for road (Black Topped / unpaved)	The road will be Constructed by Govt. / Lease Owner	Route Map & Location
NA								

ANNEXURE – V

- **Final list of Potential Mining Zones :** (Proposed)
- **Final list of Patta land:** (Proposed)
- **De-siltation Location:** (Lakes/Ponds/Dams etc.)(Proposed)
- **Final list of Sand/M – Sand Source:** (Proposed)

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➤ **Final List of potential Mining zones: (River Bed)**

Sl. No.	Lease Details (Zone Code)	River Details	Area (In Ha)	Latitude	Longitude	Depth	Distance (In Km) From PA/BR/W C	Distance From Forest Area (In Km)	Mining Leases Within 500 meters (if Yes cluster area In Ha)	Total Excavation in (CUM/Yr) (Mine Depth max as 3m)	Mineable Reserve (cum)	Mineral to be mined (Sand/Bajri/RBM etc.)	Existing / Proposed
1	KRPM_PRO_01	Digaru River	15	26°5'3.05"N 26°5'1.60"N 26°4'24.85"N 26°4'24.10"N	91°56'48.21"E 91°56'48.92"E 91°55'39.83"E 91°55'41.85"E	3	No PA/BR/W C available in 500m	No forest available in 500m	No	450000	270000	SAND	Proposed
2	KRPM_PRO_01 A	Digaru River	12.4	26°5'10.98"N 26°5'11.17"N 26°5'1.39"N 26°4'59.97"N	91°57'38.87"E 91°57'40.75"E 91°57'0.75"E 91°56'59.78"E	3	No PA/BR/W C available in 500m	No forest available in 500m	No	372000	223200	SAND	Proposed
3	KRPM_PRO_01 B	Digaru River	12	26°6'9.66"N 26°6'9.91"N 26°5'17.73"N 26°5'16.70"N	91°58'39.44"E 91°58'40.81"E 91°57'54.34"E 91°57'55.68"E	3	No PA/BR/W C available in 500m	No forest available in 500m	No	360000	216000	SAND	Proposed
4	KRPM_PRO_01 C	Digaru River	11.3	26°8'18.18"N 26°8'18.52"N 26°7'23.42"N 26°7'23.99"N	91°59'22.62"E 91°59'24.09"E 91°58'49.47"E 91°58'48.08"E	3	No PA/BR/W C available in 500m	No forest available in 500m	No	339000	203400	SAND	Proposed
5	KRPM_PRO_01 D	Digaru River	28	26°11'13.45"N 26°11'14.32"N 26°8'47.57"N 26°8'48.20"N	91°59'36.00"E 91°59'36.99"E 91°59'36.36"E 91°59'35.02"E	3	No PA/BR/W C available in 500m	No forest available in 500m	No	840000	504000	SAND	Proposed
6	KRPM_PRO_01 E	Digaru River	37.9	26°4'14.79"N 26°4'13.57"N 26°3'35.48"N 26°3'33.84"N	91°55'33.09"E 91°55'32.76"E 91°53'3.24"E 91°53'3.32"E	3	No PA/BR/W C available in 500m	No forest available in 500m	No	1137000	682200	SAND	Proposed
TOTAL			116.6							3498000	2098800		

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➤ **Final List of potential Mining zones: (In-Situ)**

SL. No.	Zone Code	Name of the Mineral	Area of Mineralization (Ha)	Depth of Mineralization (in Meter)	Geological Reserve (cum)	Mineable Reserve (cum)	Latitude	Longitude
1	KRPM_PRO_IS_01	ORDINARY EARTH/ROCK/CLAY	125	3	3750000	2250000	26° 5'34.70"N 26° 5'23.39"N 26° 5'25.74"N 26° 5'42.09"N 26° 6'0.57"N	92° 0'0.22"E 92° 0'14.68"E 92° 0'35.59"E 92° 1'4.94"E 92° 1'1.23"E
2	KRPM_PRO_IS_02	ORDINARY EARTH/ROCK/CLAY	22.6	3	678000	406800	26° 5'17.76"N 26° 5'29.85"N 26° 5'26.16"N 26° 5'12.07"N	92° 2'59.35"E 92° 3'23.24"E 92° 3'30.83"E 92° 3'3.63"E
3	KRPM_PRO_IS_03	ORDINARY EARTH/ROCK/CLAY	71.5	3	2145000	1287000	26° 4'16.55"N 26° 4'6.52"N 26° 4'22.95"N 26° 4'36.49"N	92° 4'7.04"E 92° 4'11.92"E 92° 5'8.36"E 92° 5'3.77"E
4	KRPM_PRO_IS_04	ORDINARY EARTH/ROCK/CLAY	43.1	3	1293000	775800	26° 3'8.52"N 26° 2'50.96"N 26° 2'40.36"N 26° 2'59.41"N	91°53'36.85"E 91°53'49.80"E 91°53'20.01"E 91°53'19.27"E
5	KRPM_PRO_IS_05	ORDINARY EARTH/ROCK/CLAY	41.6	3	1248000	748800	26° 1'54.87"N 26° 1'40.81"N 26° 1'25.95"N 26° 1'39.48"N	91°55'12.27"E 91°54'58.13"E 91°55'13.35"E 91°55'31.61"E
6	KRPM_PRO_IS_06	ORDINARY EARTH/ROCK/CLAY	50.2	3	1506000	903600	26° 2'15.07"N 26° 2'0.10"N	91°57'32.54"E 91°57'43.61"E

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							26° 2'6.57"N 26° 2'28.51"N 26° 2'31.85"N 26° 2'37.73"N	91°57'55.14"E 91°57'54.07"E 91°57'59.48"E 91°57'57.59"E
7	KRPM_PRO_IS_07	ORDINARY EARTH/ROCK/CLAY	49	3	1470000	882000	26° 3'20.28"N 26° 3'22.26"N 26° 3'2.17"N 26° 2'55.20"N 26° 3'9.70"N	92° 4'54.08"E 92° 5'6.73"E 92° 5'21.76"E 92° 5'9.22"E 92° 4'50.53"E
8	KRPM_PRO_IS_08	ORDINARY EARTH/ROCK/CLAY	74.2	3	2226000	1335600	26°10'26.28"N 26°10'8.94"N 26°10'17.98"N 26°10'34.70"N	91°56'0.74"E 91°56'25.75"E 91°56'58.82"E 91°56'53.80"E
9	KRPM_PRO_IS_09	ORDINARY EARTH/ROCK/CLAY	31.2	3	936000	561600	26° 6'6.34"N 26° 5'57.59"N 26° 6'3.29"N 26° 6'13.49"N 26° 6'15.29"N	91°56'43.34"E 91°56'49.98"E 91°57'12.20"E 91°57'12.13"E 91°56'57.92"E
10	KRPM_PRO_IS_10	ORDINARY EARTH	41.4	3	1242000	745200	26° 9'52.69"N 26° 9'55.85"N 26° 9'27.14"N 26° 9'25.67"N	91°57'54.53"E 91°58'16.04"E 91°58'16.12"E 91°58'4.06"E
11	KRPM_PRO_IS_11	ORDINARY EARTH	44.7	3	1341000	804600	26° 8'42.43"N 26° 8'35.67"N 26° 8'15.99"N 26° 8'24.33"N	92° 4'17.38"E 92° 4'33.49"E 92° 4'28.57"E 92° 4'1.13"E
12	KRPM_PRO_IS_12	ORDINARY EARTH	18.2	3	546000	327600	26° 4'25.27"N 26° 4'21.10"N 26° 4'13.47"N	91°35'17.30"E 91°35'17.00"E 91°35'43.09"E

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							26° 4'23.46"N	91°35'45.10"E
13	KRPM_PRO_IS_13	ORDINARY EARTH/ROCK/CLAY	26.3	3	789000	473400	26°11'39.46"N 26°11'24.75"N 26°11'15.46"N 26°11'22.55"N	92° 2'12.85"E 92° 1'57.40"E 92° 2'9.98"E 92° 2'22.55"E
14	KRPM_PRO_IS_14	ORDINARY EARTH	44.9	3	1347000	808200	26° 9'0.37"N 26° 8'58.60"N 26° 8'35.42"N 26° 8'32.56"N	92° 6'8.92"E 92° 6'29.65"E 92° 6'26.88"E 92° 6'6.36"E
15	KRPM_PRO_IS_15	ORDINARY EARTH/ROCK/CLAY	25.9	3	777000	466200	26° 5'42.17"N 26° 5'55.90"N 26° 5'53.69"N 26° 5'41.80"N 26° 5'33.24"N	92° 7'12.01"E 92° 7'23.44"E 92° 7'34.62"E 92° 7'32.54"E 92° 7'22.09"E
TOTAL			709.8		21294000	12776400		

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➤ **Final List of proposed Patta Lands/Khatedari land**

Owner	Sl. No.	Area (hectare)	Latitude	Longitude	District	Tehsil	Village	Khasra No	Type of Material	Total Reserve (CUM)	Total Mineral to be mined (CUM)	Existing/ Proposed
NA												

➤ **Final List of Proposed De-siltation location (Lake, Pond, Dams, River):**

Name	Maintain/Controlled by Sate Govt./PSU etc.	Location	Khasra No.	District	Tehsil	Village	Size (Ha)	Quantity (CUM/Year)	Existing / Proposed
NA									

➤ **Final List of Proposed M-Sand Plants:**

Sl. No.	Plant Name	Owner	District	Tehsil	Village	Geolocation		Quantity / Capacity (Tonnes/Annum)	Existing / proposed
						Latitude	Longitude		
NA									

ANNEXURE – VI

- **Final list of Cluster and Contiguous Clusters**

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➤ **Cluster details (Riverbed)**

River Name	Cluster No.	Lease No.	Location (Riverbed/Patta Land)	Tehsil	Area (in Ha)	Total Excavation (CUM)	Total Mineable Mineral Excavation (CUM)
NA							

➤ **Contiguous Cluster details**

River Name	Contiguous Cluster No.	Cluster No.	Number of leases in the cluster	Location (Riverbed /Patta Land)	Distance between clusters	Tehsil	Area of Cluster (Ha)	Total Mineral Excavation (Ton)
NA								

- **Note: The final Cluster details shall be as per the approved mine plan and as per the environment clearance granted by the competent authority.**

ANNEXURE – VII

- **Final Transportation Routes for individual Zones and Zones in Cluster(s): (Proposed)**

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➤ **Transportation Routes for individual leases details (Riverbed)**

Lease No.	Transportation Route No.	Number of tippers /days of lease	Number of tippers /days of all the lease on route	Length of the Route in Km	Type of Road (black Topped/unpaved)	Recommendation for road (Black Topped/unpaved)	The road will be constructed by Govt. / Lease Owner	Route Map & Location
NA								

➤ **Transportation Routes for leases in Cluster details (Riverbed)**

Cluster No.	Transportation Route No.	Number of tippers / days of cluster	Number of tippers / days of all the clusters on route	Length of Route in km	Type of Road (Black Topped / unpaved)	Recommendation for road (Black Topped / unpaved)	The road will be Constructed by Govt. / Lease Owner	Route Map & Location
NA								

- **Note: The final transportation routes shall be as per the approved mine plan and as per the environment clearance granted by the competent authority.**