DISTRICT SURVEY REPORT
OF
DARJEELING DISTRICT

(For Mining of Minor Minerals)
As per Notification No. S.O.3611 (E) New Delhi
Dated 25th of July 2018 and Enforcement & Monitoring Guidelines for Sand Mining (EMGSM) January 2020, Issued by Ministry of Environment, Forest and Climate Change (MoEF&CC)

Government of West Bengal

(Work Order No: MDTC/PM-5/160/66, Dated: 20.01.2020)

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CONSULTANT

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1 Preface

The need for District Survey Report (DSR) have been necessitated by MoEF & CC vide there Notification No. 125 (Extraordinary, Part II Section 3, Sub-section ii), S.O. 141 (E), dated 15th January 2016. The notification was addressed to bring certain amendments with respect to the EIA notification 2006 and in order to have a better control over the legislation. District level committee's have been introduced in the system. As a part of this notification, preparation of District Survey Reports has been introduced. Subsequently, MOEF & CC has published Notification No. 3611 (E), dt. 25th July, 2018 regarding inclusion of the "Minerals Other than Sand" and format for preparation of the DSR has been specified. Monitoring Guidelines for Sand Mining (EMGSM) January 2020, Issued by 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 also 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 time to time as well as the requirement specified in WBMMCR, 2016.

The purpose of District Survey Report (DSR) is to identify the mining potential areas where mining can be allowed; and also to distinguish areas where mining will not be allowed due to proximity to infrastructural structures and installations, areas of erosion, areas of environmental sensitivities etc. The DSR would also help to estimate the annual rate of replenishment wherever applicable.

Preparation of this DSR involved 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 district survey report of Darjeeling district also describes the general geographical profile of the district, distribution of natural resources, livelihood, climatic condition and sources of revenue generation.

Darjeeling District is the northernmost district of the state of West Bengal. The district is famous for its hill station and Darjeeling tea. Geographically, the district can be divided into two broad divisions: the hills and the plains. The entire hilly region covers the three hill subdivisions namely; Darjeeling, Kurseong and Mirik and Siliguri subdivision constitutes plan land of the district. The district is having a total population of 18,46,823 numbers distributed over 92-gram panchayats. The district covers around 2090 sq. km. area confined between the Teesta and the Jaldhaka watersheds. The District is having enriched biodiversity and its temperate climate favours agro-horticultural activities. The district has a rich diversification with respect to forest resources. Extensive tea plantation in the district along with the forest resources generates considerable amount of revenue every year.

Drainage system of Darjeeling district is highly topographic controlled, numerous rivulets coming down from the mighty Himalayas in the North and flowing to the Terai region in the South and South-East. The major rivers of the district are Teesta and Mahananda. Mechi, Greater Rangil, and Balason are the prominent rivers in the district. Because of its hilly topography the district witness several landslides and flooding during monsoons.

The whole district falls under Zone IV as per the earthquake zonation map of India. Most of the downhill areas of the district are susceptible to landslides as because of weathered and unconsolidated formations. Therefore, mining in the hilly areas should be taken with utter most care for sustainable development.

Geologically the district made up of rocks of ages ranging from pre-Cambrian to Quaternary. The Sub-Himalaya is made up of Siwalik deposits of the Tertiary age. The geological formation of Darjeeling District indicates the presence major minerals which include coal, lead, zinc, copper, limestone, graphite, iron ore, nickel, mica, and minor minerals such as building and ornamental stones and silica sand. However, mineral resources of the district are needed to be studied further through detail exploration. 15 million tonne of inferred resources of coal has been identified in Dalingkot coalfield. A talc lens sandwiched between overlying Daling quartzite and underlying Daling phyllite has been identified ate village Singla. GSI has also established copper deposits at Peshok in Darjeeling district.

The district is currently generating revenue from mining of minor minerals such as sand, stone and gravels from the riverbed. However, in-stream mining directly alters the channel geometry and bed elevation. Therefore, mining of riverbed should be carried out scientifically and based on statutory guidelines for conservation of land, river channels and sustainable development of the society.

As per the data received from Department of Mines and Minerals, Siliguri, total 75 blocks have been allotted for mining of river sand in the district. Out of which 34 blocks are allotted in Balason, 12 blocks are allotted in Mahananda, 12 blocks in Mechi, 12 blocks in Chengi and 5 blocks are allotted in small rivers. Total allotted block area for 75 blocks is 279.12 Ha and estimated reserve is around 9375933.87 CuM. Revenue generated in the district of Darjeeling from Minor minerals in the FY 2019-20 is Rs. 6.35 Crores.

The occurrence of riverbed sand and gravel in the district has been established by Directorate of Mines and Minerals, Government of West Bengal and others in previous instances. It requires further systematic and scientific approach to quantify the resource along with their grade assessment. This report also recommends to undertake detail exploration (G1 & G2 level) program to assess the mineral occurrences in the major rivers of the district and should have a proper development and production plan for the specified minerals. The potential sand mining zones are identified and shown in the relevant section of the report.

2 Introduction

The District Survey Report of Darjeeling 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.

Preparation of District Survey Report (DSR) of Darjeeling District was awarded to Global Management and Engineering Consultant (GMEC) International vide tender Ref NIT No: MDTC/PM-5/160/1147, Dt: 20.11.2019 and subsequent work order no MDTC/PM-5/160/66, dated 20.01.2020.

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 the sand mining, the DSR also include the potential development scope of in-situ minor minerals.

The objectives of the District Survey Report are as following

1. Identification and Quantification of Mineral Resource and its optimal utilization.
2. To regulate the Sand & Gravel Mining in the Country, identification of site specific end-use consumers and reduction in demand & supply gaps.
3. Use of information technology (IT) & latest scientific method of mining for surveillance of the sand mining at each step.
4. District Survey report shall enable Environmental Clearance for cluster of Sand & Gravel Mines. It shall assist concern Department during post Environmental Clearance Monitoring.
5. To control the instance of illegal mining.
6. To control the flood in the area.
7. To maintain the livelihood of aquatic habitat.
8. To protect the incursion of ground water in the area. Limiting extraction of material in floodplains to an elevation above the water table generally disturbs more surface area than allowing extraction of material below the water table.
9. To keep accumulated data records viz. details of Mineral Resource, potential area, lease, approved mining plan, co-ordinates of a district at one place.
10. To maintain the records of revenue generation.

11. In-stream extraction of gravel from below the water level of a stream generally causes more changes to the natural hydrologic processes than limiting extraction to a reference point above the water level, hence the DSR can be useful to design ultimate pit limit and scientific Mining plan.
12. In-stream extraction of gravel below the deepest part of the channel generally causes more changes to the natural hydrologic processes than limiting extraction to a reference point above the thalweg.
13. Excavating of sand and gravel from a small straight channel with a narrow floodplain generally will have a greater impact on the natural hydrologic processes than excavations on a braided channel with a wide floodplain.
14. Extracting of sand and gravel from a large river or stream will generally create less impact than extracting the same amount of material from a smaller river or stream. In this DSR, location of sand blocks are plotted on river bed which will enable the competent authority to understand the nature and sensitivity of the sand deposit before new block allotment.
15. A concise guideline can be framed considering the point discussed in the DSR for sand and or minor mineral mining in the district.

The District Survey report (DSR) is comprised of secondary data published and endorsed by various departments and websites about geology of the area, mineral resources, climate, topography, land form, forest, rivers, soil, agriculture, road, transportation, irrigation etc. Data on lease and mining activities in the district, revenue etc. are collected and collated from concern district DL& LRO office and West Bengal Mineral Development Corporation Limited.

2.1 Statutory Framework

2.1.1 Evolution of the Environmental Regulatory 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 are tabulated in Table 2.1.

Table 2.1: Requirement of District Survey Report & its year wise modification of Guidelines

Year	Particulars
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 preview of EIA, the MoEF&CC has issued EIA Notification SO 1533 (E), dated 14th 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.
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.
2016	West Bengal Minor Minerals Concession Rules,2016 amended the Mines and Minerals (Development and Regulation) Act, 1957 (Act 67 of 1957), to make the rules regulating the grant of mining licenses, prospecting license-cum-mining leases and mining leases in respect of minor minerals by auction process. The rule also incorporates EIA 2016 also includes SSMG

Year	Particulars
	2016 for minor mineral mining.
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.

2.1.2 Other Guidelines for Sand Mining in India:

The West Bengal Minor Minerals Concession Rules (WBMMCR), 2016

1) (a) No person shall undertake mining operation in any area prohibited by the 'Stale Government in the public interest by notification in the *Official Gazette*.
Provided that nothing in the sub-rule shall affect any mining operation undertaken in any area in accordance with the terms and conditions of a mining lease or mineral concession already granted.
(b) No person shall transport or store or cause to be transported or stored any mineral otherwise than in accordance with the provisions of these rules and the West Bengal Minerals (Prevention of Illegal Mining, Transportation and Storage) Rules, 2002.

(2) No minor mineral coming out in course of digging of wells or excavation of tanks Shall be disposed of by the person digging or excavating without informing the District Authority as well as the Executive Officer of the *Panchayat Samiti* or the Executive Officer of the Municipality concerned, as the case may be, about such occurrence.
Provided that disposal of such minor mineral may be allowed on pre-payment of prices of such minor mineral at the prevailing market rate as determined on the basis of the rates published by the Public Works Department / concerned department of the State Government for the concerned area from time to time.

(3) No mining of river bed occurrences shall be allowed within 300 meters, upstream and downstream, measured from the centre line of any bridge, regulator or similar hydraulic structure and from the end point of bank protection works.

(4) No river bed mining shall be allowed beneath 3 meters of the river bed or ground water Ievel, whichever is less.

(5) No mining operation in case of river bed occurrence shall be done within a distance of three (3) kilometers of a barrage axis or dam on a river unless otherwise permitted by the concerned Executive Engineer or Revenue Officer or authorized officer and such distance shall be reckoned across an imaginary line parallel to the 'barrage, or dam axis, as the case maybe.

(6) No extraction of river bed occurrence shall 'be allowed beyond the central one third of the river bed, or keeping a distance of 100 meter from the existing bank line whichever is less, unless otherwise permitted by the concerned Executive Engineer or Revenue Officer.

(7) No extraction of minerals other than river bed occurrence shall be allowed within fifty (50) meters from any road, public structure, embankment, railway line, bridge canal, road and other public works or buildings.

(8) No mining lease shall be granted without proof of existence of mineral contents in the area for which the application for a mining lease has been made in accordance with such parameters as may be prescribed by the Government from time to time.

N.B- The aforesaid application for mining lease shall succeed the competitive bidding for mining lease for a specified mineral(s).

Sustainable Sand Mining Management Guidelines (SSMMG), 2016by 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.

a) 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.

b) 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.

c) Sand and gravel may be extracted across the entire active channel during the dry season.

d) 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.

e) 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.

f) Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.

g) 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.

h) Sand and gravel shall not be extracted within 200 to 500 meter 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.

h) 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.

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.

i) Alternatively, off-channel or floodplain extraction is recommended to allow rivers to replenish the quantity taken out during mining.

j) The Piedmont Zone (Bhabhar area) particularly in the Himalayan foothills, where riverbed material is mined, 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.

k) Mining depth should be restricted to 3 meter and distance from the bank should be 3 meter or 10 percent of the river width whichever less.

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.

l) 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)

The 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.

a) 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.
b) 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.
c) Sand and gravel may be extracted across the entire active channel during the dry season.
d) 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.
e) 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.
f) Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.
g) 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.
h) Sand and gravel shall not be extracted 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 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.
i) 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 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.
j) 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.
k) 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.

l) The Piedmont Zone (Bhabhar area) particularly in the Himalayan foothills, where riverbed material is mined, 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.

m) Mining depth should be restricted to 3 meters and distance from the bank should be ¼th or river width and should not be less than 7.5 meters.

n) 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 center-to-center should be left in the borrow pits.

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

p) A buffer distance /un-mined 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.

q) 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.

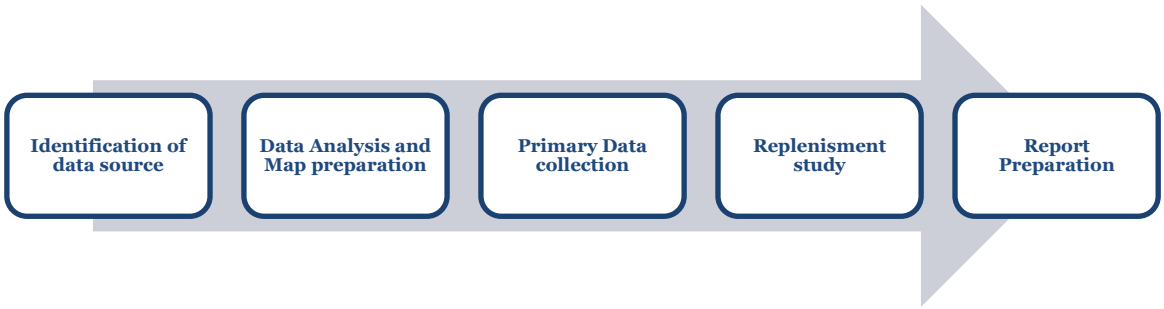
r) River bed sand mining shall be restricted within the central 3/4th width of the river/rivulet or 7.5 meters (inward) from river banks but up to 10% of the width of the river, as the case may be and decided by regulatory authority while granting environmental clearance in consultation with irrigation department. Regulating authority while regulating the zone of river bed mining shall ensure that the objective to minimize the effects of river bank 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.

s) 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 depth 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.

2.2 Methodology of DSR Preparation

During the preparation of District Survey Report, database related to district profile, geology, mineralization, mining activities are found as sketchy and disjointed. There are multiple data sources, which are in the public domain, as well as in websites. Hence, after collating available data base, extensive work has been undertaken to verify and analyze the data base. Preparation of this DSR has undergone through several steps as stated below:



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. This 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 and or fromthe published report in reputed journal. Information related to district profile has been taken from District Census report,2011 and District Statistical Handbook published by the Govt. of West Bengal. 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: Dataset which are captured during the report preparation, are gone through detail analysis work. District Survey Report involves the analytical implication of the captured dataset to prepare relevant maps.

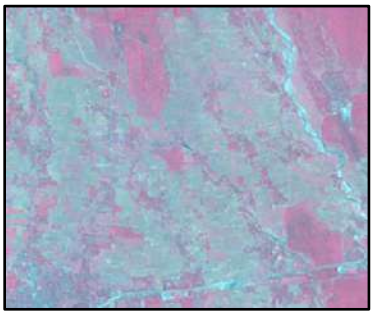
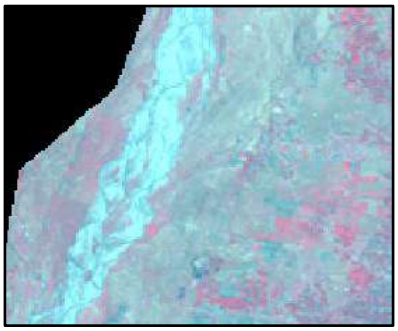
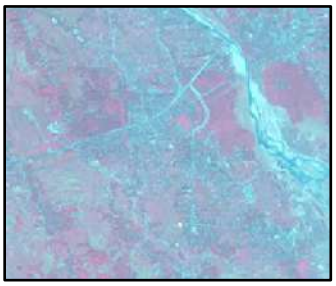
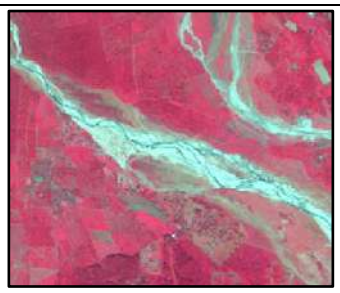
Methodology adopted for preparation of relevant maps is explained below.

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 may include determination of a suitable classification system via Visual Image Interpretation, selection of training samples, Satellite image (FCC-False Colour Composition)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.

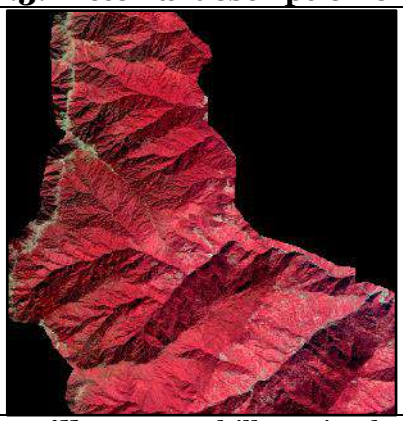
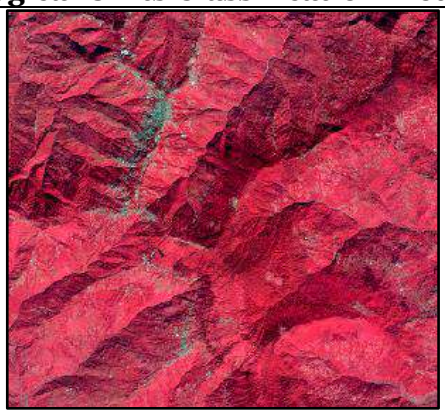
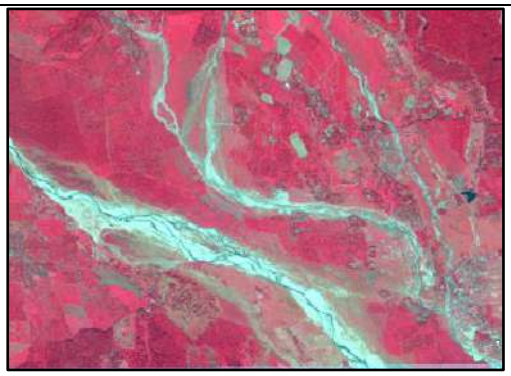
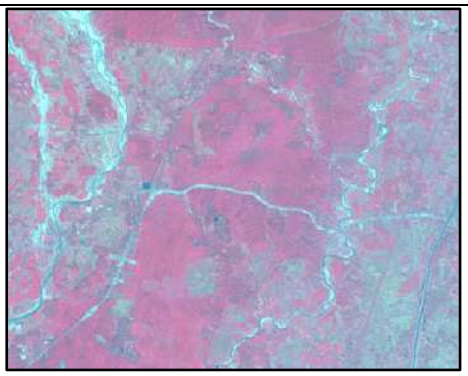
According to the Visual Image Interpretation (Tone, Texture, Colour etc.) training set of the pixel has been taken.

Table 2.2: Pictorial description of Land Use Classification methods

	
Agricultural Land - Based on their Geometrical shape, Red and Pink colour tone, Agricultural Land has been identified.	**Vegetation Covered Area** - Based on their continuous Red colour tone, Vegetation Covered Area has been identified.
	
Agricultural Fallow Land - Based on their Geometrical shape, Light and dark cyanwith light pink colour tone, Agricultural Land has been identified.	**Bad Land Topography**- Light Yellowish mixed with cyan colour has been identified as Bad Land Topography.
	
Settlement – Area with Cyan Colour including geometrical shape has been recognised as Settlement Area.	**Water Bodies –** Dark blue colour has been classified as Water Bodies.

Geomorphological Map: The major steps of preparing Geomorphological Map is identifying features like – Alluvial Fan, Alluvial Plain, Hilly Region etc. from Satellite Imagery (FCC-False Colour Composition) 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.

Table 2.3: Pictorial description of Geomorphological Units Classification methods

	
Upper Hills – Upper hilly region has been identified based on their high elevation and sharp edges of the land.	**Lower Hills** – Lower hilly has been identified based on their elevation and sharp edges which is comparatively less in height than upper hilly region.
	
Alluvial Fan- A fan-based deposition formed by stream where the velocity is abruptly decreased. In Satellite Imagery the flat area has been identified as Alluvial Fan just below the Lower hilly region.	**Alluvial Plain**- Alluvial plain is a largely flat landform created by the deposition of sediment over a long period. In satellite Imagery the flat land just below the Alluvial Fan has been identified as Alluvial Plain.

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).**
- 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.**
- 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 collected from **ENVIS Centre on Wildlife & Protected Areas.**
- Data has been geo-referenced using GIS software.
- Digitization of Wildlife Sanctuary& 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, capturing primary data or field data has also been carried out in the district. Field study involves assessment of the mineral resources of the district by means of pitting / trenching in specific interval. This provide clear picture of mineral matters characterization and their distribution over the area.

Replenishment study: One of the principal causes of environmental impacts from in-stream mining is the removal of more sediment than the system can replenish. It is therefore need for replenishment study for riverbed sand in order to nullify the adverse impacts arising due to excess sand extraction. The annual rate of replenishment carried out on every river of the district to have proper assessment of the sand reserve for mining purposes.

Physical survey has been carried out by GPS/DGPS/ Total Station 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.

Report Preparation: District Survey Report has been prepared to fulfill the purpose of identification of mining area both for major and minor mineral and their impact on environment. Report provides details of the major and mineral potential zones. Assessing mining prospect with respect to minor minerals. Replenishment study details includes in the report. Report also provides the socio environmental study for establishing minor minerals in the district.

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.
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 is way weaker and lesser in weight than blocks made of clay mixed with sand.

3 General Profile of the district

3.1 General Information

The district of Darjeeling is the northern most district of the State of West Bengal. Lying on the foot hills of the Himalayas, the district is the gateway to the State of Sikkim and the bordering countries of Bhutan and Nepal. Geographically, the district can be divided into two broad divisions: the hills and the plains. The entire hilly region covers the three hill subdivisions of Darjeeling, Kurseong and Mirik. The foothills of Darjeeling Himalayas, which comes under the Siliguri subdivision, is known as the Terai (Source: District census handbook 2011).

Darjeeling district is bounded on the north by the State of Sikkim, on the south by Uttar Dinajpur district; on the east by Kalimpong district of west Bengal and on the west by Nepal. Geographically the district is situated between 26°27' and 27°13' N and between 87°59' and 88°30'E (Figure 3.1). The district covers an area of 2090 sq.km.

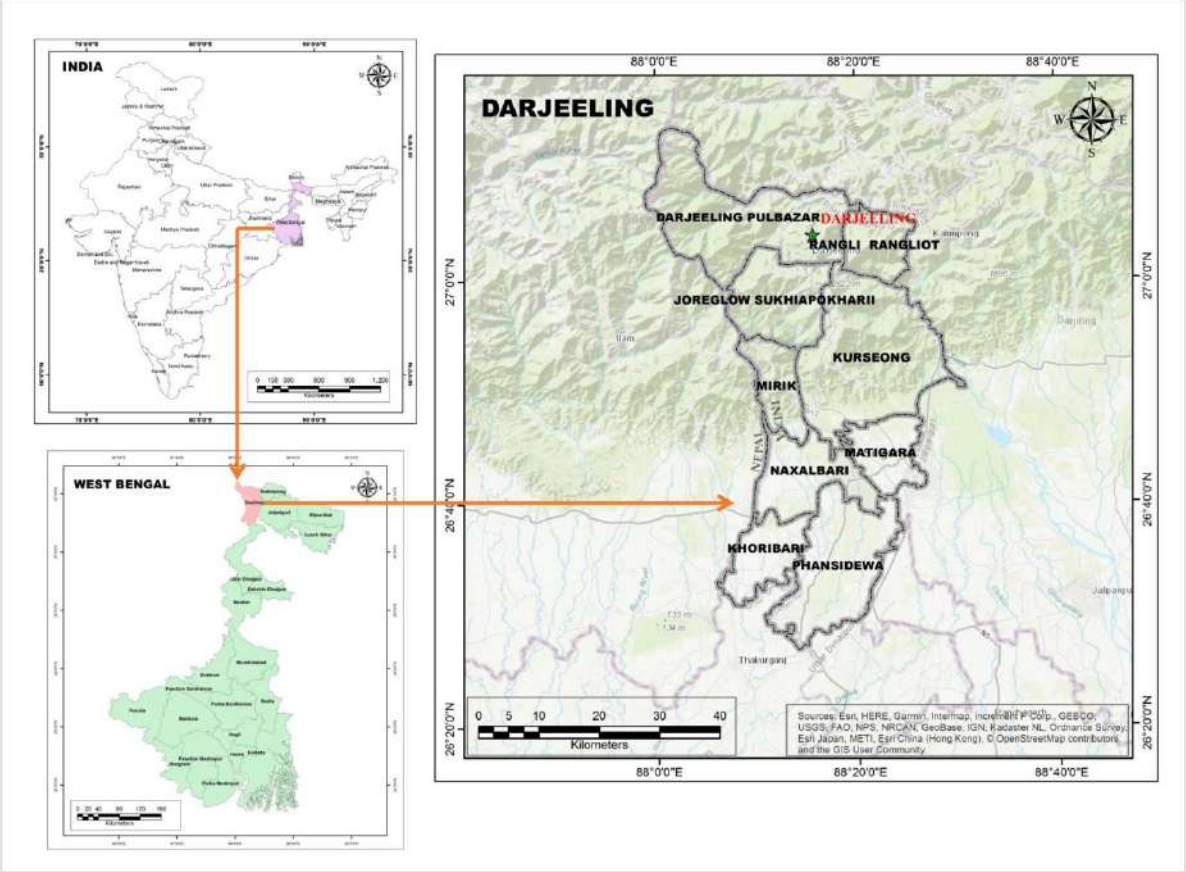


Figure 3.1: Location Map of Darjeeling
(Source: National Information Center and ESRI Base Map)

Darjeeling district comprises of four sub-divisions, namely Sadar sub-division, Kurseong sub-division, Mirik and Siliguri sub-division (Table 3.1). The Darjeeling hills area is spread over the first three sub-divisions. Siliguri subdivision is in the plains. Darjeeling is the district headquarters. There are 9 block in the district. Sadar sub-division is divided in three blocks, namely Darjeeling - Pulbazar, Rangli - Rangliot and Jorebunglow-Sukhiapokharii. Siliguri sub-division has four blocks, Matigara, Naxalbari, Khoribari and Phansidewa. Other two blocks are Kurseong and Mirik (Figure 3.2).

Table 3.1: Block distribution of Darjeeling District

Sub-Division	CD block	Headquarters	Distance from District HQ (km)	No of Gram Panchayat	Area (km^2)
Sadar Sub-Division	Darjeeling Pulbazar	Bijanbari	7.94	23	416.00
	Jorebunglow-Sukhiapokhri	Sukhiapokhri	10.94	16	222.12
	Rangli-Rangliot	Takdah	9.35	11	272.99
Kurseong Sub-Division	Kurseong	Kurseong	17.85	14	377.35
Mirik Sub-Division	Mirik	Mirik	19.13	6	125.68
Siliguri Sub-division	Naxalbari	Naxalbari	40.75	6	181.88
	Kharibari	Kharibari	55.05	4	144.88
	Phansidewa	Phansidewa	51.15	7	312.15
	Matigara	Bairatisal	36.95	5	143.00

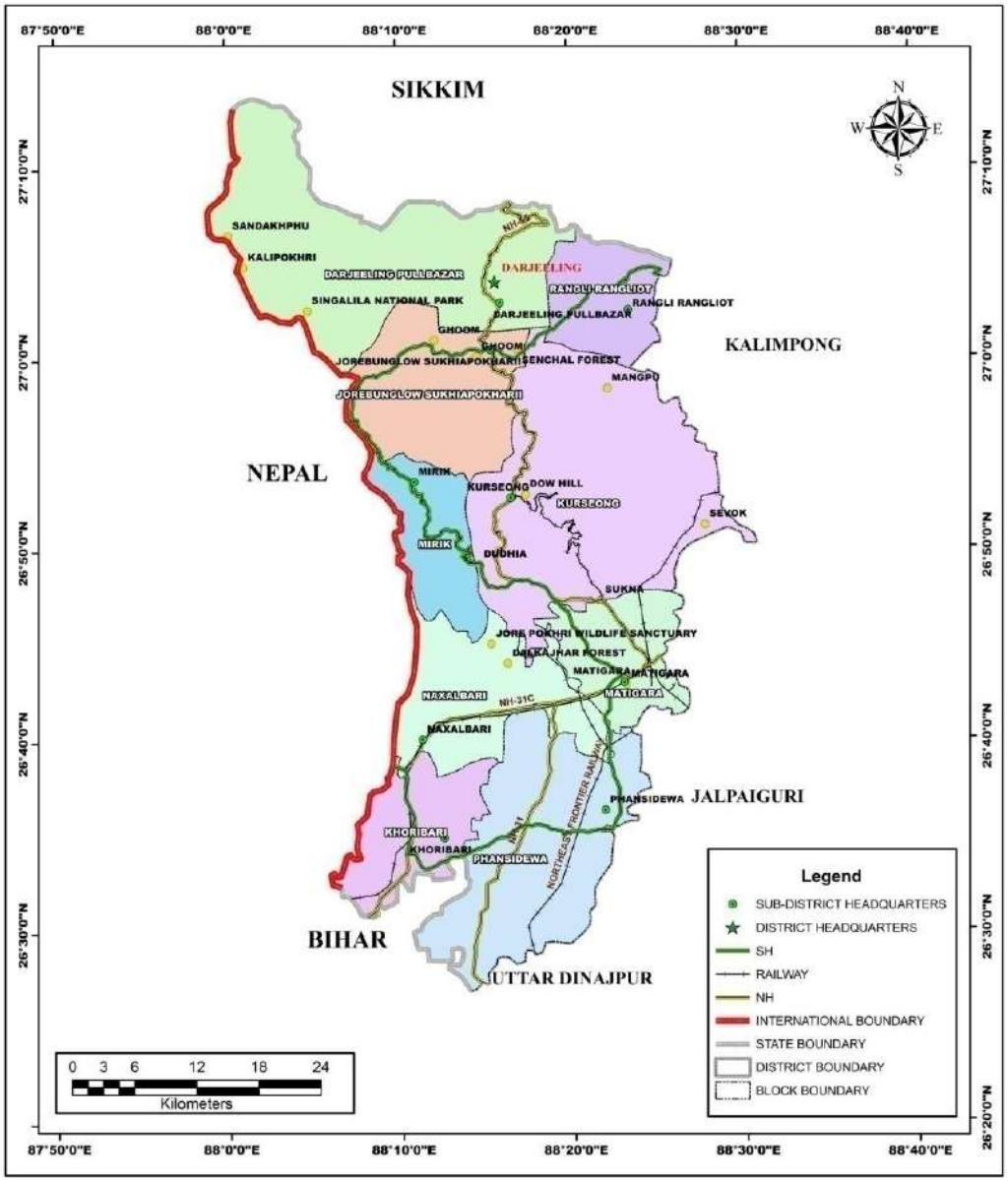


Figure 3.2: Block divisional map of Darjeeling

(Source: National Information Center)

3.2 Climate Condition

Darjeeling district has two different climatic conditions due to its distinctive topographical features having hills in a larger portion of the district and plain-lands of Terai towards South and South-Eastern part. The Hills have a temperate weather condition, with pleasant summer and cold winter with occasional snowfall. On the other hand, the marshy tract of Terai is humid and warm, showing typical Tropical and Sub-Tropical climatic conditions depending upon the elevation (Source: District census handbook 2011).

3.2.1 Temperature

The temperature in the hilly areas of Darjeeling district varies from 25°C to near freezing points. The maximum temperature is usually reached during monsoon and the lowest temperature is reached during the cold winter, between December to March. The lowest temperature of the district remains around 10°C to (-) 3°C, depending on elevation (Source: District census handbook 2011).

The average maximum and minimum temperature recorded around Darjeeling Town during preceding five years is as follows:

Table 3.2: Monthly average temperature distribution of Darjeeling District

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Avg. Temperature (°C)	6.6	8.1	11.7	14.7	16.1	17.3	17.8	17.8	17.5	15.3	11.5	8.4
Min. Temperature (°C)	3.3	4.6	7.9	10.9	13	14.9	15.5	15.5	14.8	11.6	7.5	4.6
Max. Temperature (°C)	9.9	11.6	15.5	18.6	19.2	19.7	20.2	20.2	20.2	19	15.6	12.3

(Source: Climate-Data.Org)

3.3 Rainfall and Humidity

The rainy season in the district commence from June and lasts till September. The average annual rainfall is 2973 mm (Figure 3.3). The maximum rainfall in the area as per IMD data was recorded in the month of July followed by August and September. The following table shows the annual total rainfall recorded for Darjeeling district along with the month(s) while maximum precipitation is recorded over 5 years from 2014-2018 (Table 3.3).

Table 3.3: Annual rainfall recorded in Darjeeling District

Month	2014	2015	2016	2017	2018	Average
Jan	0.1	5	6.5	0.9	0.7	2.64
Feb	10.3	11.8	3	4.6	6	7.14
Mar	20.5	44.3	46.3	79.1	40.4	46.12
Apr	26.9	146.5	34	61.3	79.9	69.72
May	310	296.1	191.4	276.1	241.9	263.1
Jun	744.1	537.8	727.9	531	408.2	589.8
Jul	490.1	581.3	1168.3	760.2	592.9	718.56
Aug	825.4	691.7	310.9	767.9	558.7	630.92
Sept	453.4	556.2	535	531	579.7	531.06

Oct	56.8	50.4	306.2	63.8	59.4	107.32
Nov	4.9	5.2	0	7.6	1.7	3.88
Dec	0.9	3.8	0	0	11.3	3.2
Yearly Total	2943.4	2930.1	3329.5	3083.5	2580.8	2973.46

Source: Website of Indian Meteorological Department, Govt. of India

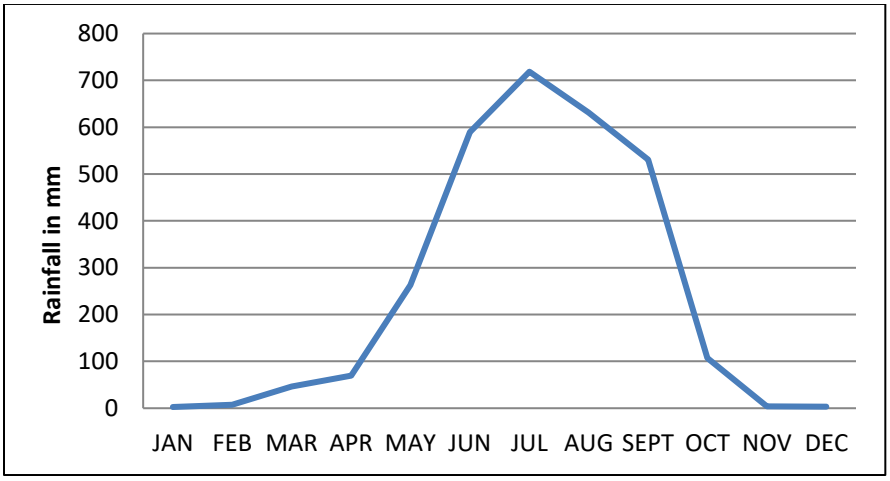


Figure 3.3: Graphical representation of Darjeeling District Rainfall

3.3.1 Relative Humidity, Wind speed & Wind direction

The entire Darjeeling Himalaya experiences a high relative humidity that is spread uniformly. Generally the north facing slopes are colder and remain humid throughout the whole year. The relative humidity is higher towards the higher altitudes (above 2000 m) ranging from 85 - 99% during the monsoons, and the relative humidity generally decreases towards the lower elevations. The drier months of March and April are less humid with the relative humidity ranging between 45% - 60%.

The winds over the Himalaya are predominantly westerly during November to May. At the upper level, these winds are invariably strong and may attain to the intensity hurricane. With the setting in of the Monsoon (in early June), the westerly wind is replaced by the South and S.E. monsoon winds.

Surface winds of Darjeeling District are generally from the east. But during winter months the prevailing wind direction is E-NE. During the monsoon (June to September), the prevailing direction is from E-SE. At Darjeeling, the average wind speed does not generally exceed 10 Km/hour. The mean velocity is lower in the Terai. Local storms, however, occur in all parts of the District.

3.4 Topography and Terrain

Physiographically Darjeeling district can be broadly divided into Hills and Plain land (Figure 4.4). The natural slope of the land is from North to South. Numerous rivers and springs flow South-wards emerging from the hills at the North, the most important being river Teesta. The district further sub divided into region based on topography.

Darjeeling Himalayas region bears the highest elevation and lies at the Northern-most portion of the district. The Singalila range is the highest mountain range of district Darjeeling lies in this region. The two highest peaks of West Bengal lie in the Singalila Range which are Sandakphu with an elevation of 3,636 metres and Phalut with an elevation of 3,600 metres. Tonglu (3,036 metres) and Sabargram (3,543 metres) are two other important peaks (Source: District census handbook 2011).

Western Dooars region is mainly spread over the foot-hills of the Himalayas and primarily is a plain land gently sloping from North to South. General elevation of land is 80 metres to 300 metres. Mahananda Tract, known as Terai region, is the primarily plan land of the district situated to the South of Western Dooars and having elevation of 100 to 150 metres (Source: District census handbook 2011).

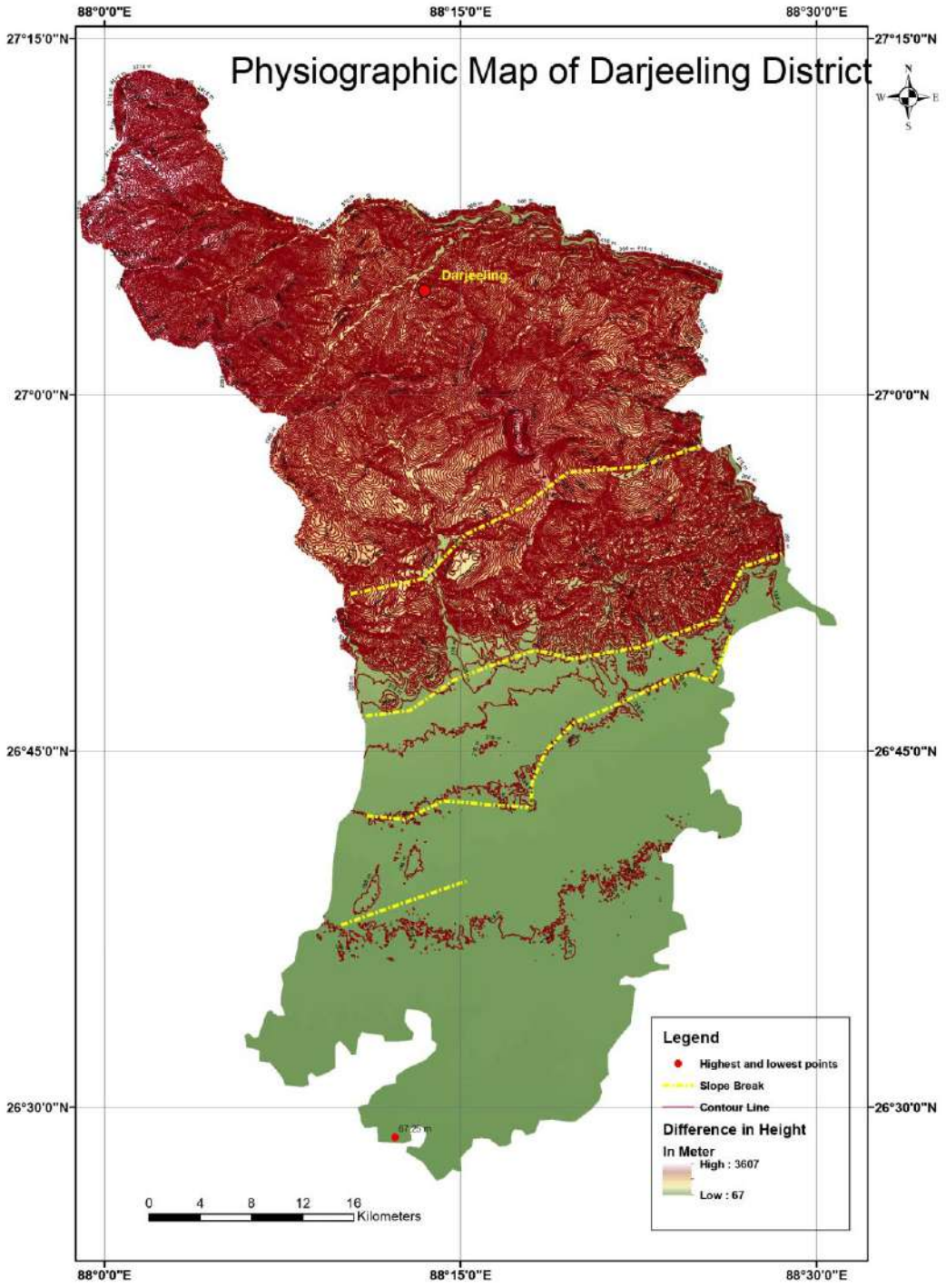


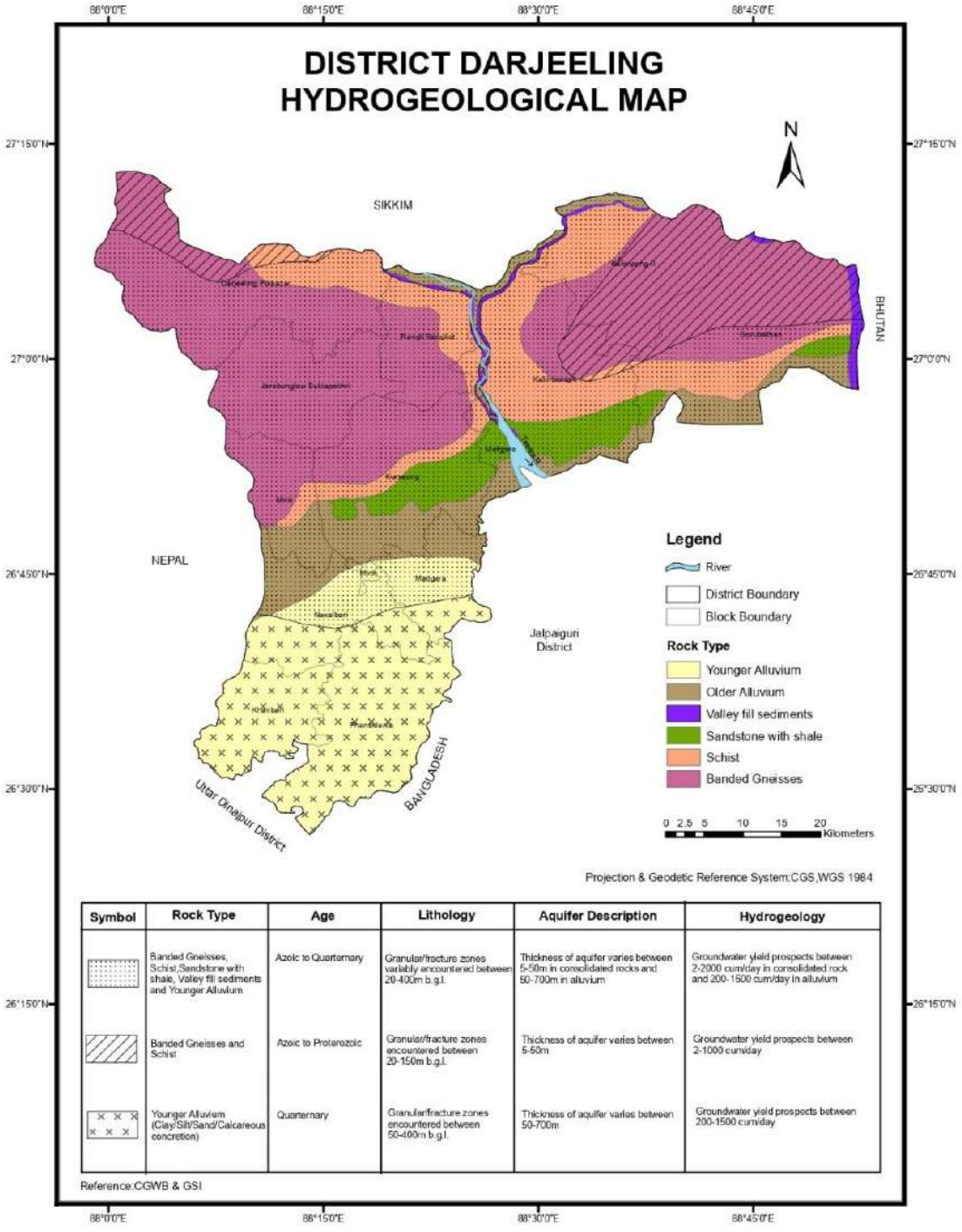
Figure 3.4: Physiographic map of Darjeeling District
(Source: Cartosat-1, Bhuvan India)

3.5 Water courses and Hydrology

The district is covered by three major geological formations viz, the Precambrian crystallines, the Vindhyans and the Gondwanas. Besides, the tertiary laterite and alluvium also cover part of the district. Ground water occurs mostly under phreatic condition in all the lithological units and locally under semi-confined and confined condition (Source: District census handbook 2011).

Figure 4.5 represents hydrogeological map of the district which includes Kalimpong district. Rock type of the Darjeeling district mainly consist of Banded Gneisses, Schist, Sandstone with shale, valley fill sediments and younger Alluvium of Azoic to Quaternary age. This rock group chiefly comprises the district profile. Northern hilly and doors region is the part of this. Thickness of the aquifer varies between 5 to 50m in consolidated rocks which poses yield of 2-2000 cum/day and the thickness of alluvium in this part varies between 50-700m. Groundwater yield of the alluvium is 200-1500 cum/day.

Sothern flat land of the district comprises mainly of younger Alluvium of Quaternary age. Thickness of the rock type varies between 50 to 700m and having yield value of 200-1500 cum/day.



Symbol	Rock Type	Age	Lithology	Aquifer Description	Hydrogeology
	Banded Gneisses, Schist,Sandstone with shale, Valley fill sediments and Younger Alluvium	Azoic to Quarternary	Granular/fracture zones variably encountered between 20-400m b.g.l.	Thickness of aquifer varies between 5-50m in consolidated rocks and 50-700m in alluvium	Groundwater yield prospects between 2-2000 cum/day in consolidated rock and 200-1500 cum/day in alluvium
	Banded Gneisses and Schist	Azoic to Proterozoic	Granular/fracture zones encountered between 20-150m b.g.l.	Thickness of aquifer varies between 5-50m	Groundwater yield prospects between 2-1000 cum/day
	Younger Alluvium (Clay/Silt/Sand/Calcareous concretion)	Quarternary	Granular/fracture zones encountered between 50-400m b.g.l.	Thickness of aquifer varies between 50-700m	Groundwater yield prospects between 200-1500 cum/day

Figure 3.5: Hydrogeological map of Un-divided Darjeeling district

3.6 Ground water development

Depth of water in wells measured by CGWB at 32 locations in district varied from 1.46 to 14.24 m bgl during pre-monsoon period with an average of 4.6m and 1.01 to 9.6 m bgl during post-monsoon period with an average of 3.2m in the year 1996 to 2018 (Source: CGWB Website). Figure 4.6 represents water level fluctuation graph for two CGWB monitor wells, one from Bagdogra area and another from Phansidewa area.

Over all stage of ground water development in the area is 6% indicating sufficient scope of development (Source: Dynamic Groundwater Resources Assessment of India – 2017, CGWB).

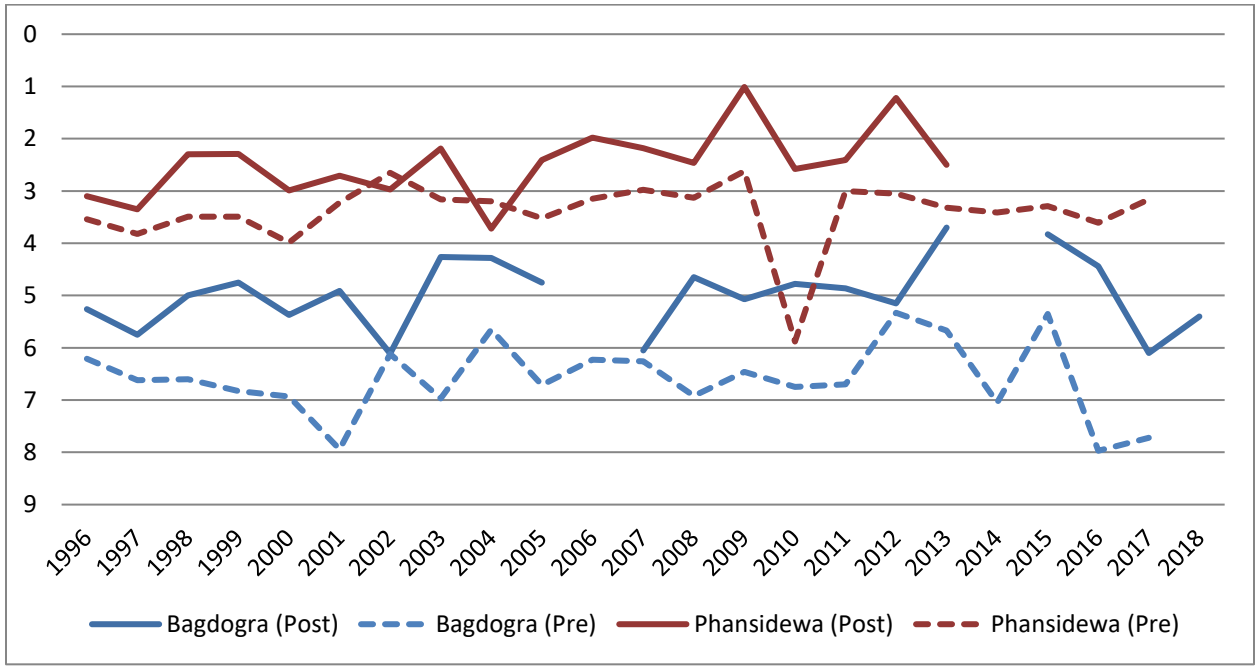


Figure 3.6: Graphical representation of pre-monsoon and post-monsoon data of two wells

3.7 Drainage System

Mahananda, Teesta, Mechi, Greater Rangil, and Balasan are the prominent rivers draining the district (Figure 3.7). Tributaries of Teesta namely Lish, Mauza, Taipu, Lachka, etc. flow through the district in different ways. All the major rivers originate from the Himalayas and are perennial in nature, being fed by the melting snow of the glaciers. Due to shallow beds, they become turbulent during the monsoons, after heavy precipitation in catchment areas (Source: District Industry profile, MSME, GoI).

The drainage system of the district consists of two major watersheds, namely, the Brahmaputra and the Ganga the two most important drainage basins. The Brahmaputra system

is represented in the area by its Teesta sub-system and the Ganga system is represented by the Mahananda sub-system. Drainage system of Darjeeling explained in detail in Chapter 7.2.

Table 3.4: Rivers and tributaries in Darjeeling District

Watershed	Sub-Watershed	Flow Regime	Rivers & Tributaries	Length in Darjeeling (km)
Brahmaputra	Teesta	Middle	Teesta	37
			Great Rangit	18.57
			Rammam	39.78
			Rangpoo	9.66
Ganga	Mahananda	Upper	Mahananda	91.70
			Balason	48.40
			Mechi	63.21

Source: Cajee L, 2018

A Drainage map of Darjeeling District is furnished as Figure 3.7 and as in Annexure 1.

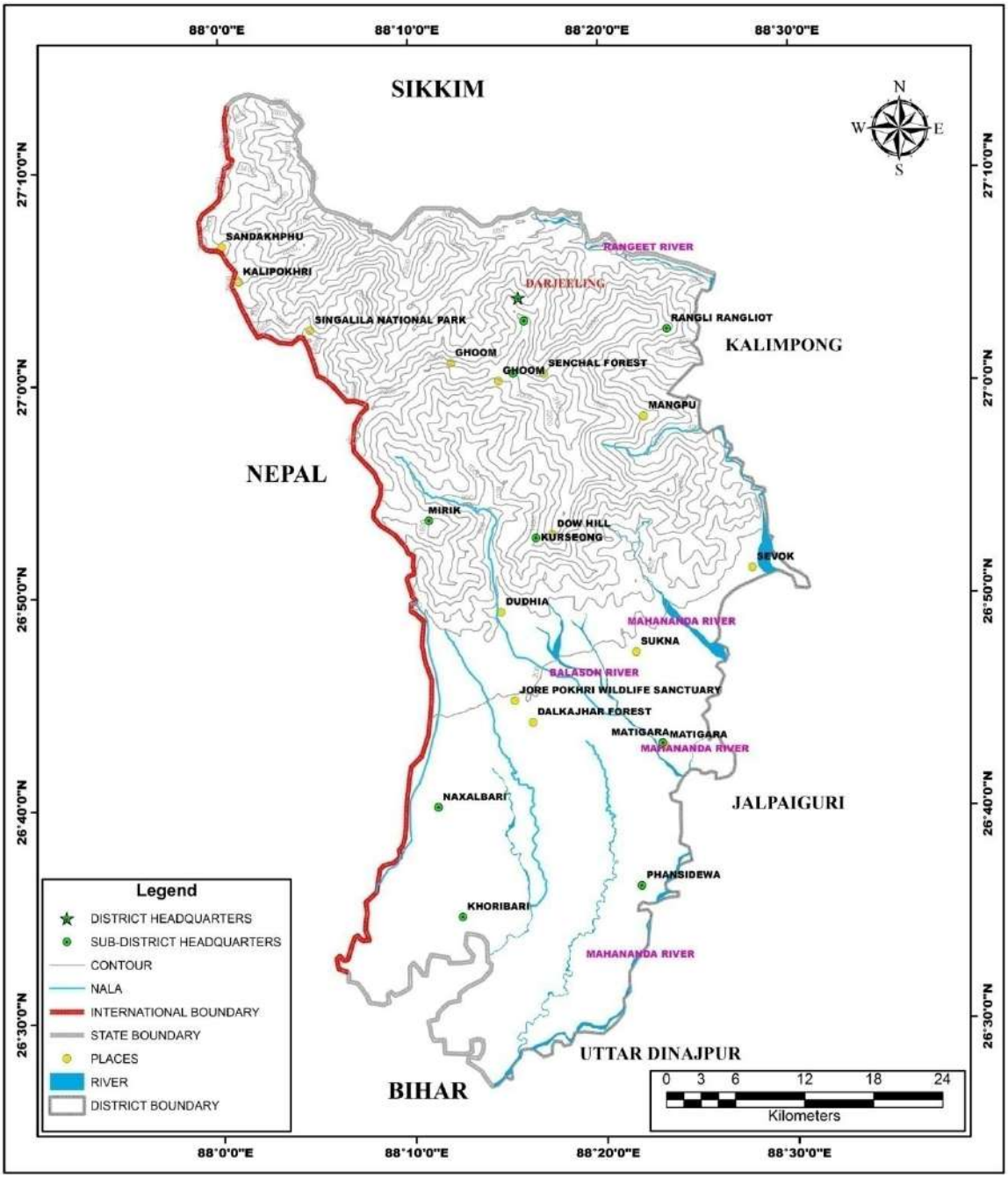


Figure 3.7: Drainage map of Darjeeling District

(Source: National Information Center)

3.8 Demography

According to 2011 census, the district encompasses a geographical area of 3149 sq km and has a population of 18,46,823 (persons) including 9,37,259 (males) and 9,09,564 (females). The district has a sex ratio of 970 (females for every 1000 males). The major religions in the district are Hindu (74.00%) and Buddhist (11.33%) of the total population respectively. The literacy rate in the district is 79.56% (persons), 85.61% (males) and 73.33% (females).

In 2014, Kalimpong sub-division of Darjeeling district has been declared as Kalimpong district. Table 3.5 representing Darjeeling district demographic profile modified based on 2011 census. Total area of district comes around 2232.31 sq.km and total population of the district after 2014 is 1595181. Among the four block of the district, Darjeeling Sadar is highest in literacy rate. Based on census 2011, Darjeeling Municipality area is having 93.85% literacy rate. Figure 3.8 and 3.9 representing block wise population distribution and literacy rate respectively for Darjeeling district.

Table 3.5: Demographic distribution of Darjeeling District

Sub-Division/ C.D.Block/MC/M	Area (Sq.Km.)	Number of households	Male	Female	Population	Literacy (%)	Percent of population to district population
Sadar Sub-Division	**918.25**	**90024**	**214272**	**215109**	**429381**	**84.89**	**26.92**
Darjeeling (M)	7.43	21,782	59,187	59,618	1,18,805	93.85	7.45
Darjeeling Pulbazar	416	27,470	63,828	63,107	1,26,935	80.78	7.96
Jorebunglow Sukiapokhri	221.83	25,468	56,232	57,284	1,13,516	82.54	7.12
Rangli Rangliot	272.99	15,304	35,025	35,100	70,125	80.50	4.4
Kurseong Sub-Division	**390.36**	**27508**	**68453**	**68340**	**136793**	**82.30**	**8.58**
Kurseong (M)	7.85	6,616	21,423	21,023	42,446	93.73	2.66
Kurseong	382.51	20,892	47,030	47,317	94,347	81.15	5.91
Mirik Sub-Division	**125.89**	**12427**	**29082**	**28805**	**57887**	**82.40**	**3.63**
Mirik (NA)	6.5	2,465	5,688	5,825	11,513	88.38	0.72
Mirik	119.39	9,962	23,394	22,980	46,374	80.84	2.91
Siliguri Sub-Division	**797.81**	**209970**	**497002**	**474118**	**971120**	**75.56**	**60.88**
Siliguri (MC)	20.1	66,062	1,51,535	1,43,011	2,94,546	86.43	18.46
Matigara	132.61	42,666	1,01,023	96,255	1,97,278	74.78	12.37
Naxalbari	188.12	35,752	85,054	80,469	1,65,523	75.47	10.38
Kharibari	144.88	23,352	55,671	53,580	1,09,251	67.37	6.85
Phansidewa	312.1	42,138	1,03,719	1,00,803	2,04,522	64.46	12.82
TOTAL	**2232.31**	**339929**	**808809**	**786372**	**1595181**	**79.56**	**100**

(Source: Census of India, 2011)

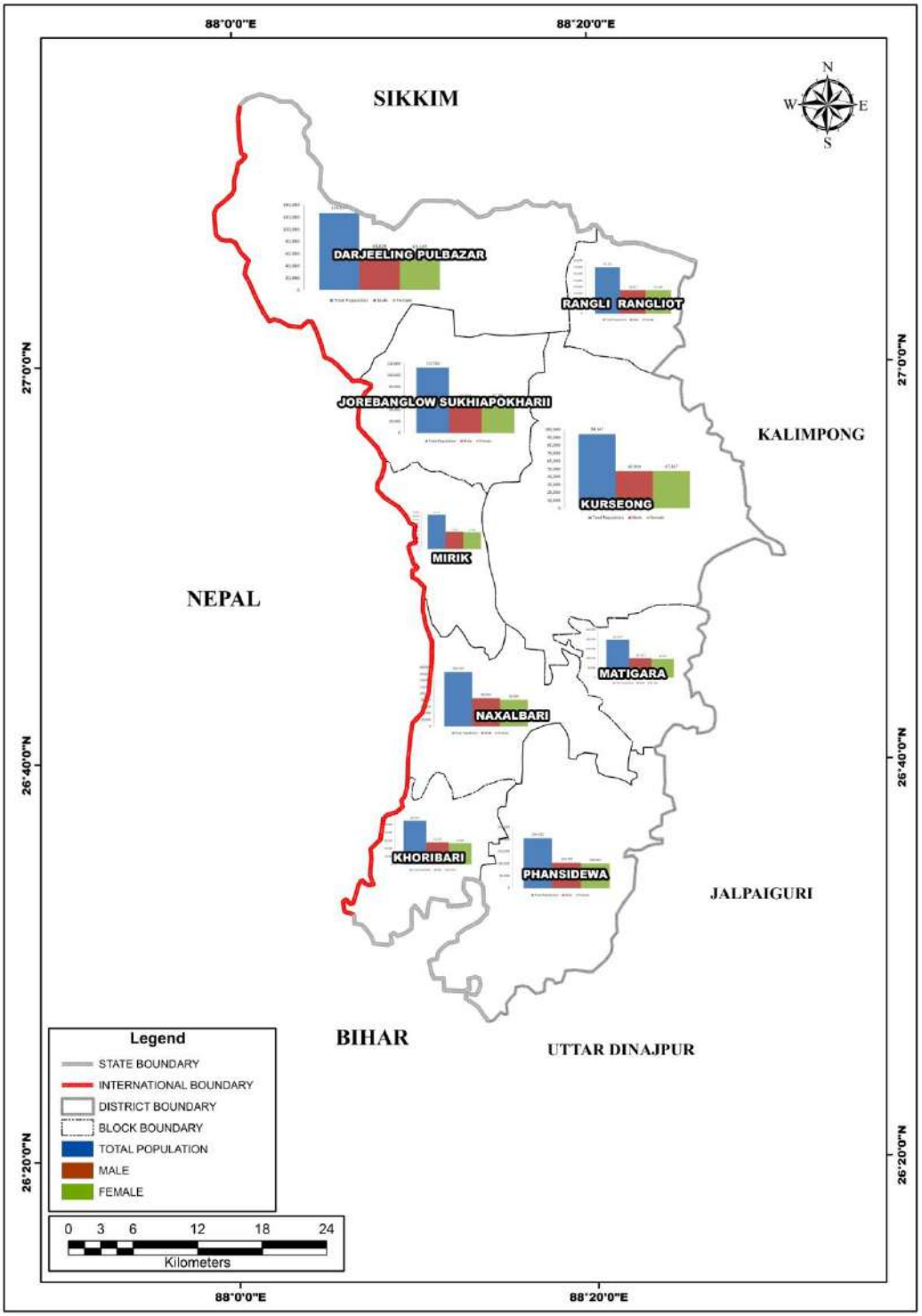


Figure 3.8: Block-wise population distribution in Darjeeling District

(Source: Census of India, 2011)

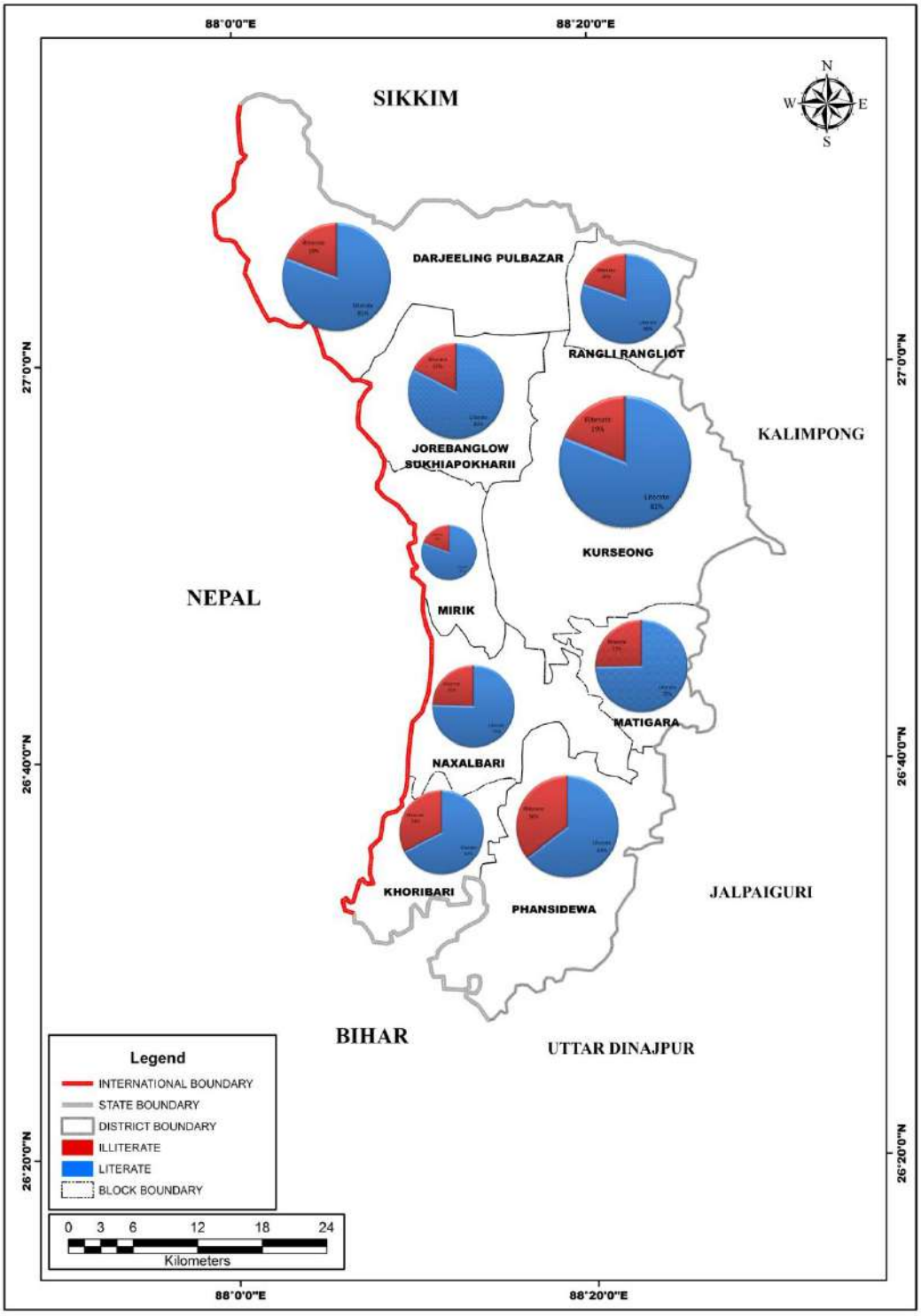


Figure 3.9: Demographic map showing Block-wise Literacy rate of Darjeeling District

(Source: Census of India, 2011)

3.9 Cropping pattern

The crops of Darjeeling district broadly fall into two groups - (a) plantation crops like tea, orange, cinchona and (b) non-plantation crops like rice, wheat, maize, jute, potato, vegetables etc.

Tea production form the most important part of the district economic scenario. Rice, jute and potato cultivated at the plain-lands under the Terai and Dooars. Jute is also cultivated in the plains. Maize (Corn) and ginger are cultivated primarily in the sloping lands at the foot of the hills. Fruits like Orange, Pomegranate, Pineapple, Mandarin Orange, Banana, Lichee, different Citrus fruits; different vegetables and medicinal herbs like Cucumber, Brinjal, Cabbage, Cauliflower, Cardamom, Chillies, Turmeric, Ginger, Dar-haldi (Daru-Haridra in Sanskrit), Khayer, Cumin, Mint, Potato are cultivated in the district.

3.10 Land Form and Seismicity

Darjeeling district is dominated by hilly topography in the north and plain land in the southern part. The hilly region of the district is very prone to landslide due to poor water retention capacity of the soil clubbed with steep land slope (from North to South, and South-East).

The seismic hazard map of India was updated in 2000 (Figure 3.10) by the Bureau of Indian Standards (BIS). There are no major changes in the zones in West Bengal with the exception of the merging of Zones I and II in the 1984 BIS map. Western sections of the northern districts of Jalpaiguri and Coochbehar lie in Zone V. The remaining parts of these two districts, along with the districts of Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, Maldah, 24 North Parganas and 24 South Parganas lie in Zone IV. The rest of the state along with the city of Kolkata lies in Zone III.

The whole district falls under the Seismic Zone IV (in a scale of I to V in ascending order of propensity f Seismic Activity), indicating very prone to the earthquakes (Source: District census handbook 2011). However, no major earth quake event has been recorded with its epicenter in Darjeeling district. Many earthquake shocks experienced in the district have been recorded.

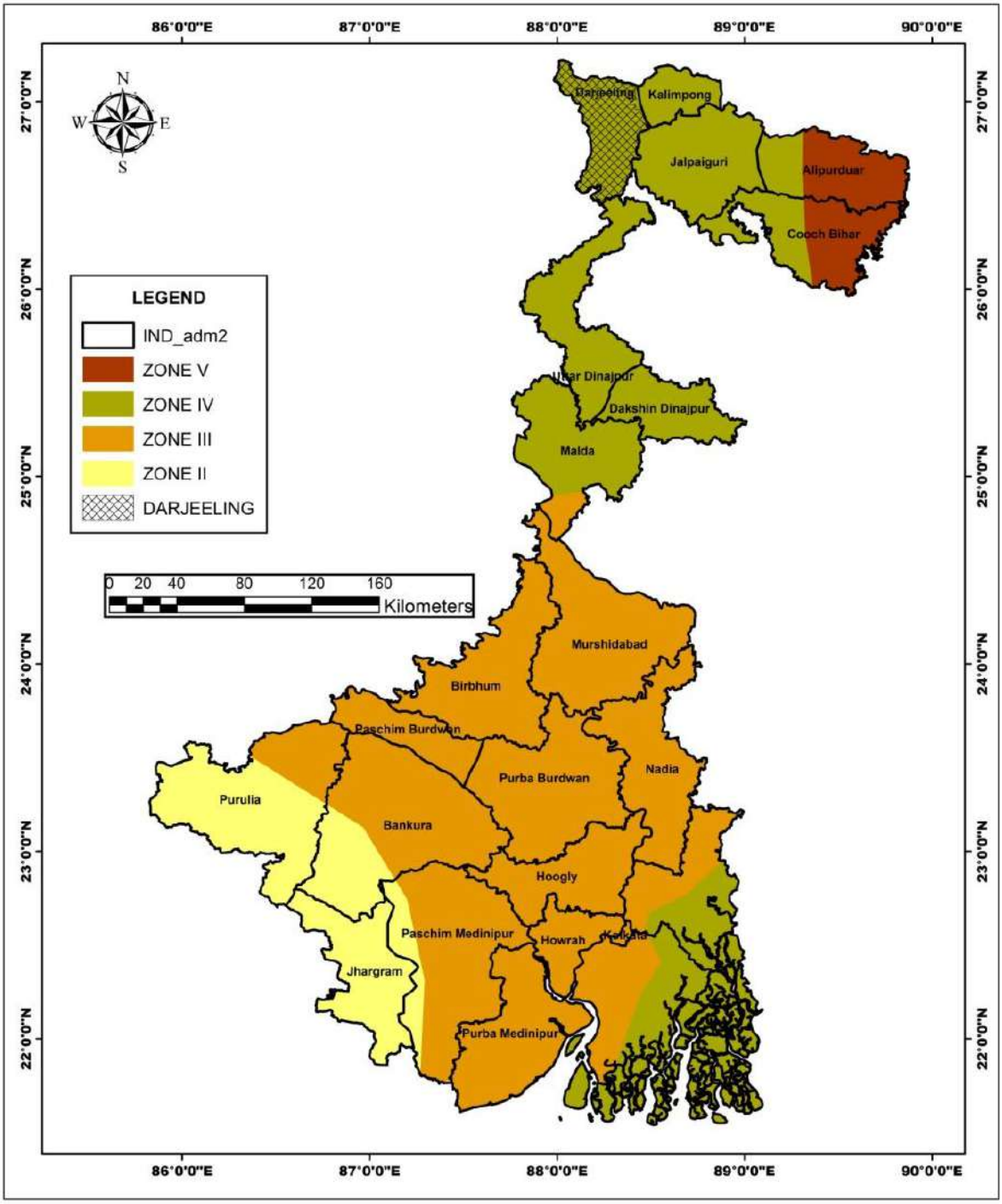


Figure 3.10: Earthquake zonation map of West Bengal highlighting the Darjeeling district position

(Source: Ministry of Earth Science)

3.10.1 Earthquake:

Earthquake shocks experienced in the district have been recorded since, 1842. Two sharp shocks, felt on the 27th and 28th February 1849, caused many well-built walls to crack. During the Cachar Earthquake of 10 January 1869, smart shocks were recorded at Darjeeling, Kurseong, Pankhabari and Siliguri. The district fell within the higher isoseismic zone of the earthquake with its focus near Cherrapunji; the quake reached Darjeeling within minutes and caused massive devastation. Cracks appeared in several buildings of Darjeeling town and Kalimpong due to the Dhubri earthquake of 3rd July 1930. The Bihar-Nepal earthquake of 15th January 1934 was, severely felt in the district, the worst affected parts being Darjeeling town and its neighboring spurs and the railway station at Tindharia. Kurseong and Kalimpong escaped with minor cracks in buildings but landslides occurred at several places in the Tista valley below Kalimpong. The September 18, 2011 earthquake left a trail of devastation in Sikkim and Darjeeling hilly area damaging roads, building and other structures, uprooting mobile phone towers and snapping communication and power lines. The impact of the quake in Darjeeling hills was felt mainly in Kalimpong and Kurseong subdivisions (Source: Mili J, 2012).

On 25th April and 12th May 2015, Nepal and its surrounding area were hit by earthquakes which are considered to be the most devastating in the living memory of the inhabitants of these affected areas. The 7.9 magnitude quake was the strongest to hit Nepal for 81 years. It was the most horrible natural disaster to hit Nepal since the 1934 Nepal–Bihar border earthquake. Earthquakes are often followed by landslides and rock avalanches and glacier avalanches in Himalayan hilly areas. Landslides also blocked the river channels, sewage and other communication system in Darjeeling district. Mud wall, buildings and boundary walls in different locations of Siliguri and Jalpaiguri had collapsed because of the tremors (Source: Dey S, 2015).

3.10.2 Landslide:

In Darjeeling district, occurrences of landslides are prominent from a long time of history. As per the landslides records available, in September 1899 landslide 72 lives were lost in Darjeeling town. Kalimpong, Kurseong, Ghum, Tindharia of the Darjeeling Himalaya were also affected by this disaster. In January of 1934, the landslides is mainly affected in Darjeeling, Ghum and Kurseong town. A massive landslide occurred in June 1950, in which 127 lives were lost along with the loss of several properties including roads and Siliguri-Kalimpong railways line. 667 lives were lost along with the destruction of a tea garden due to October 1968 landslides. The affected areas of the landslide were Darjeeling town, Manpuri, Lebong, Kalimpong, Tista Bazar, etc. Again, Rimbik, Lodhama, Darjeeling Town, Bijanbari, Lebong, Ghum, Happy Valley were affected by the landslides that occurred on September 1980. Several landslide disasters happened in the year of 1991, 1993, 2003, 2004, 2005, and 2006. All of the slides occurred in the Darjeeling Town, Kalimpong, Kurseong, Pulbazar, Rongtong, Tindharia, etc. The landslide of June 2011 was the subsequent effects of high rainfall of about 152 mm at Darjeeling and 60 mm rainfall in about 3 hours at Kalimpong, Kurseong. In this landslide, no

such significant casualties had occurred. In the same year, in September, the landslides occur due the subsequent effect of Sikkim earthquake but the Darjeeling Himalayas has been less affected than the Sikkim Himalayas (Source: Biswas and Pal 2015).

Heavy rain has triggered landslides at Mirik, Darjeeling, Kalimpong and Kurseong during June-July, 2015, causes the loss of several lives and properties. Thus, the landslide disaster of 2015 triggers severely the natural environment of the Darjeeling Himalayas. Geological survey conducted for the Darjeeling Landslide by the Survey of India and the report says that the Nepal earthquake has a significant role in the occurrence of the Darjeeling landslide. However, historical record suggests that intense rainfall is the key factor for the June-July, 2015 landslide. As the developmental activity is increased in the mountainous region, thereby, the land use management is significant to reduce the vulnerability of the landslides (Source: Biswas and Pal 2015).

The mitigational measures to tackle the landslide hazard in the district are (Source: Nad, 2015)-

- ✓ Structural measures: The stability of a vulnerable slope may be increased either by reducing the volume at the head or by expanding the volume at the toe.
- ✓ Drainage Corrections: The streams and temporary water resources particularly at the head of the slides are diverted from the slide area.
- ✓ Proper land use measures: proper scientific land use planning and Ban on non-biodegradable materials in hazard areas.
- ✓ Afforestation: Afforestation programmed lunched for minimize the breakdown situation of environmental equilibrium. The grass cover must not be disturbed unnecessarily in the hilly area.
- ✓ Public Awareness: Village wise Training Programmed, Landslide Management Education from School Level.
- ✓ Settlement policy: Restricting Development in Landslide Prone Areas, Protection of Existing Development, Monitoring and Warning System.

3.10.3 Critical landslide prone area:

The primary risk inclined territories of landslides prone areas tabulated as per research work by Deepak and Pradeep, 2019:

Table 3.6: Critical landslide prone areas of Darjeeling Himalaya

Level of Landslide Prone Area	Hazard Areas
Very high (Severe) landslide prone area	Small patch on the north-eastern part of the Darjeeling district
High landslide prone area	Darjeeling sadar sub-division on the right side of Teesta river

Level of Landslide Prone Area	Hazard Areas
Moderately high zone of landslide hazard	North-west and south-east below high zone in sadar sub-division
Moderate zone of landslide hazard	Largest part of Darjeeling hills where there remain a chance of at least one landslide/ km²
Low landslide hazard prone area	North-west corner of sadar sub-division and southern most end of Kurseong sub-division

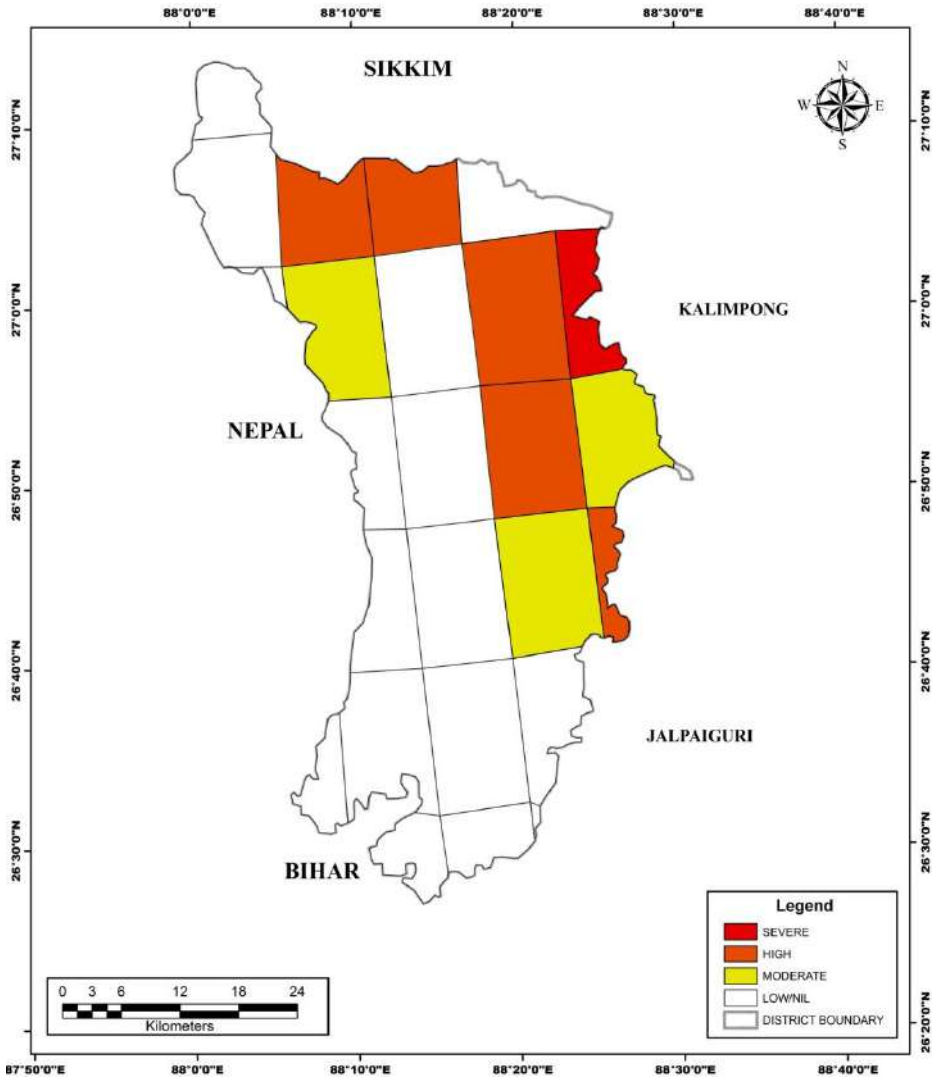


Figure 3.11: Landslide Hazard Zonation Map of Darjeeling District

(Source: Nad, 2015)

3.11 Flora

The major portion of the southern plain area is mostly covered by tea gardens with some protected and reserved forests. Hilly terrains toward the north are thickly forested. The forest consists of trees essentially of Sal, Teak, Bamboo, Pine, Cane etc. Moreover, thick under-growths and plenty of creepers, thorns and bushes make forest difficult to penetrate. Orchids and medicinal plants are available in this hilly region.

A wide range of vegetation structures with extremely rich plant and animal diversity developed in the district due to the extreme climatic, edaphic and physiographic variations. Plants of diverse forms, such as trees, shrubs, climbers, lianas, annual and perennial herbs, geophytes, epiphytes, parasites, and saprophytes, are evenly distributed. The estimated vascular flora for Darjeeling district is 2,912.

Table 3.7: Vascular flora in Darjeeling

Taxa	Estimated number of Species
Angiosperms (dicots)	1900
Angiosperms (monocots)	750
Gymnosperms	12
Pteridophytes	250

(Source: Das, 2008)

Darjeeling district has four protected areas – two national parks and two sanctuaries. The biodiversity elements of these protected areas are presented in the following sections (Source: Das, 2008).

Singhalila National Park (SNP): With an area of 79 sq.km, Singhalila National Park lies in the extreme northwestern part of Darjeeling district. The altitude ranges from 2,400 to 3,660m. Thick bamboo, oak, magnolia and rhododendron forest between 2000 and 3600 m cover the Singalila Ridge. There are two seasons of wildflower bloom - one in spring (March and April) when the rhododendrons bloom, and another in the post-monsoon season (around October), when the lower forests bloom (Primula, Geranium, Saxifraga, Bistort, Senecio, Cotoneaster, and numerous orchids). Sandakphu is known as the "mountain of poisonous plants" due to the large concentration of Himalayan cobra lilies (Arisaema) which grow there.

Mahananda Wildlife Sanctuary: Shrubs, lianas, climbers, and epiphytes are abundant but grasses and herbaceous growth are scarce. The major deciduous species include Shorea robusta, Tectona grandis, Lagerstroemia parviflora, Terminalia alata, Albizia procera, Phyllanthus urinaria, Alstonia scholaris, Litsea monopeltata, and Macaranga pustulatac. The

subtropical zone (500-1,000m) contains forest affected by a seasonal climate of dry winter and wet monsoon. The forests are deciduous and semi-evergreen and the dominant species are Duabanga grandiflora, Schima wallichii, Terminalia alata, Michelia champaca, Mallotus philippensis, Phyllanthus emblica, Quercus glauca, Cinnamomum bejolghota, Phoebe lanceolata, Litsea cubeba, Pterospermum acerifolum, and many others.

Senchal Wildlife Sanctuary: The area is important because of interesting floristic composition. The background vegetation is temperate broad-leaved forest with dominant species such as, Rhododendron arboreum, Rhododendron grande, Castanopsis hystrix, Ilex sikkimensis, Magnolia campbellii, Alcimandra cathcartii, Exbucklandia populnea, and Prunus cerasoides. Climbers and scramblers include Rubus paniculatus, Senecio diversifolius, Rubia manjith, Codonopsis viridis, and Edgaria darjeelingensis. The undershrubs and herbs are dominated by Aconogonum molle, Cautleya lutea, Globba hookeri, Artemisia vulgaris, Urtica dioica, and Gerardiana heterophylla. The secondary grassland on Tiger Hill is home to innumerable sun-loving herbaceous plants. Being an area with very high humidity, almost all trees, including planted conifers, are covered with thick epiphytic vegetation, including Begonia gemipara, Agapetes serpens, A. hookerii, Pilea ternifolia, Chamabainia cuspidata, and Hymenodictyon flaccidum. The sanctuary is also home to numerous medicinal plants such as Swertia chirayita, S. pedicillata, Panax pseudoginseng, Hypericum uralaum, and Valleriana hardwickii.

Jore Pokhri Wildlife Sanctuary: The Sanctuary was established in 1985 on an area of 0.04 sq.km. The sanctuary is surrounded by some intact patches of oak and temperate broad-leaved forest and is home to numerous mammals, birds, and reptiles.

Endangered Floral Species:

Table 3.8: Threatened Plants of Darjeeling District, West Bengal

Scientific Name	Family	Status	Distribution sites and Avg. altitude
Acer hookeri	Aceraceae	Endangered	Darjeeling, 600-1500 m
Acer osmastonii	Aceraceae	Endangered	Darjeeling (endemic), Salombong, Birch hill
Pimpinella tongloensis	Apiaceae	Endangered	Endemic to Singaleela range in the Darjeeling-Sikkim Himalaya
Phoenix rupicola	Arecaceae	Rare	450 m
Begonia scutata	Begoniaceae	Rare	Darjeeling, Peninsular India. 1000-1500 m
Codonopsis affinis	Campanulaceae	Rare	Darjeeling and Sikkim Hiamalaya. 1830-3335 m
Bulleyia yunnanensis	Orchidaceae	Rare	Darjeeling hills

Scientific Name	Family	Status	Distribution sites and Avg. altitude
Diplomeris hirsuta	Orchidaceae	Vulnerable	Darjeeling. 1500-2000 m
Christiopteris tricuspis	Polypodiaceae	Indeterminate	Darjeeling
Ophiorrhiza lurida	Rubiaceae	Rare	Darjeeling. 300-1500 m
Christella clarkei	Thelypteridaceae	Vulnerable	Darjeeling. 4000 m

(Source: India Biodiversity Portal)

3.12 Fauna

Darjeeling district possess a rich variety of fauna. There are about 90 species of mammals in the Darjeeling District. Among the large carnivores, Wild Leopard, Clouded Leopard, Leopard-Cats are seen both in the hills and jungles of the Terai region. The Jackal, Indian Fox are also normal residents of the forests. The Himalayan Black Bear, Common Indian Sloth Bear and Malayan Sun-Bear are the species belonging to Ursidae family which can still be found, although in very limited number, in forests. Among the herbivore, Elephant is very common. Several wild Elephants, sometimes in herds, sometimes singly can often be seen, mainly near the forest areas in the vicinity of river streams and in the Terai. Among the less challenging smaller herbivore, the Gaur, Sambar, Spotted-Deer, Barking-Deer and Hog-Deer can also be occasionally observed. Among the goats, Serow and Ghoral can still be seen in the forests. The Red-Tailed Rabbit, Hispid Hare, Squirrels, Porcupines, Moles, Rats, Mice, wide variety of poisonous and non-poisonous Snakes, Martens and numerous other small animals are the common residents here. (Source: District census handbook 2011).

Darjeeling District is very rich in Bird life containing about 550 species. Nearly one quarter of the species of birds found in India, is found here. More than half of the species are passerine birds, the largest families being the Timaliinae (Laughing-Thrushes, Babblers) with 61 species; the Sylviinae (Warblers) with 60 species; the Turdinae (Chats, Robins, Thrushes) with 56 species; the Muscioa-pmas (Fly-catchers) with 27 species; the Fringillinae (Finches) with 22 species. There are plenty of Minivets, Orioles, Sunbirds, Malay Tree Sparrow. The best represented families in the Coraciformes are the Picidae (Woodpeckers) with 15 species; the Cuculidae (cuckoos) with 16 species and Asionidae (owls) with 14- species. There are five species of King-fisher of which the tiny Indian three-toed Kingfisher (Ceyx e. enthaca) a forest species, is the most beautiful one. Accipitrine birds number about 40 and include the fine Himalayan Lammergeyer (Gypaetus barbatus hemachalanus), Hodgson's Feather-toed Hawk Eagle (Spizaetus n. nipalensis), the Himalayan Rufous bellied Hawk-Eagle (Lophotnorohis k. kienerl) and the handsome bold miniature Falcon, the Himalayan Red-legged Falconet (Microphierax c. coerulscens). There are about a dozen species of pigeon and doves, some being only found at high elevations. Only Bengal Green-Pigeon (Crocopus p. phoenicopterus) is found m the plains.

The Green-Pigeon (Sphenocercus s. spenurus) and the Himalayan Pintailed Green-Pigeon (Sphenocercus a. apicandus) are common in the hills.

Endangered Fauna: There has been a depletion of natural fauna of this region to a certain degree due to human interference on animal kingdom. Because of unnecessary shooting and poaching, extension of tea cultivation and spread of human settlements on the fringe of forests and even setting up of settlements on the seasonal migration routes of some animals like elephants, there has been considerable depletion of fauna in this district. All of these have made conservation of wild life an urgent need of the district for the maintenance of ecological balance. In 1955, Mahanadi Wild Life Sanctuary has been setup for the protection of gaur (Indian bison).

Mahananda Wildlife Sanctuary: Located on the foothills of the Himalayas and is sprawling across 158 sq km of forest area over different altitudes. This wildlife sanctuary is mainly to protect the Indian Bison and Royal Bengal Tiger, which were facing the threat of extinction.

Jore Pokhri Wildlife Sanctuary: This wildlife sanctuary is the habitat of some high-altitude animals like the Himalayan Salamander which is known as Gora in the local language and it is also home to a few other local animals like the tiger, rhino and different species of birds.

Senchal Wildlife Sanctuary: It is one of the oldest wildlife sanctuaries of India and covers an area of 38.6 km^2. The elevation ranges from 1,500 to 2,600 m. It provides habitat for barking deer, wild boar, Himalayan black bear, Indian leopard, jungle cat, rhesus monkey, Assam macaque, Himalayan flying squirrel. The sanctuary is also rich in bird life.

Singhalila National Park (SNP): The Park is home to about 22 species of mammals, of which three are threatened; there are more than 250 species of birds, of which four are threatened. Some of the important wildlife include red panda (Ailurus fulgens), leopard cat (Prionailurus bengalensis), serow (Naemorhedus sumatraensis), common leopard (Panthera pardus), Himalayan thar (Hemitragus jemlahicus), Himalayan black bear (Ursus thibetanus), tragopan (Tragopan satyra), and monal pheasant (Lophophorus impejanus). Floristic exploration of the park is now in progress; preliminary assessments indicate a high proportion of endemics.

Location of Wild Life Sanctuary and National Parks are shown in the Map of West Bengal (Figure 3.12). As per the map of ENVIS Centre on Wildlife and Protected Areas, there is one National Park and four Sanctuaries situated within the Darjeeling district.

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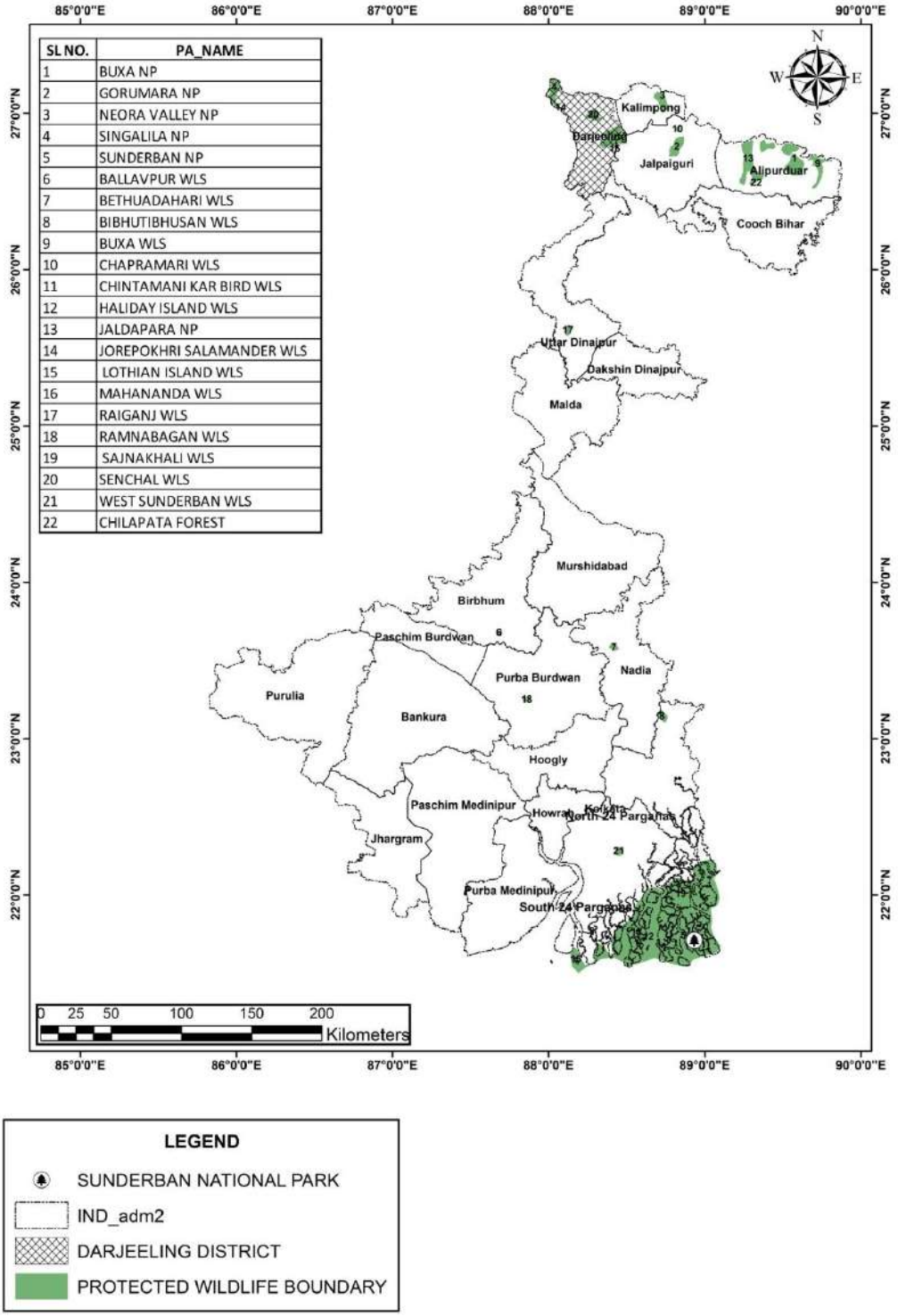

SL NO.	PA_NAME
1	BUXA NP
2	GORUMARA NP
3	NEORA VALLEY NP
4	SINGALILA NP
5	SUNDERBAN NP
6	BALLAVPUR WLS
7	BETHUADAHARI WLS
8	BIBHUTIBHUSAN WLS
9	BUXA WLS
10	CHAPRAMARI WLS
11	CHINTAMANI KAR BIRD WLS
12	HALIDAY ISLAND WLS
13	JALDAPARA NP
14	JOREPOKHRI SALAMANDER WLS
15	LOTHIAN ISLAND WLS
16	MAHANANDA WLS
17	RAIGANJ WLS
18	RAMNABAGAN WLS
19	SAJNAKHALI WLS
20	SENCHAL WLS
21	WEST SUNDERBAN WLS
22	CHILAPATA FOREST

Figure 3.12: District location with respect to Wild Life Sanctuary of West Bengal
(Source: ENVIS Centre on Wildlife and Protected Areas)

4 Geomorphology of the district

4.1 General Landforms

Darjeeling Himalaya rises abruptly from the North Bengal plain, the elevation changing rapidly from 100-130 m above sea level (a.s.l) to 2000-3000 m a.s.l within a distance of few kilometers. The hilly areas of Darjeeling are a part of the Siwalik Range or Outer Himalayas. The general slopes of the hills are from north to south. Narrow ridges separated by closely-spaced V-shaped valleys, where the slope varies between 15°and 40°.The region is highly prone to landslides, often causing disruptions to socio-economic activities as well as destruction of life and properties (Source: Geomorphological Field Guide Book, IGI).

The complex landform of the district has been form due to different geomorphic processes, each of which has developed its own characteristic assemblage. The geomorphic configuration of the hilly tract is the joint product of geologic foundation and fluvial processes; although slope-wash, in particular mass-movements and related phenomena play a significant role in the final shaping of the landform. The region is characterized by a myriad of ridges and valleys because of the spurs ramifying into lateral spurs which give off lesser ones and these in turn cut the terrain into ridges and valleys, creating a mosaic of micro-topographical units (Cajee 2018).

Lower hills: This region is bounded by contour heights of approximately 200 - 800 m and covers most of the central section of the district. The rivers are mostly south-flowing and cut deep gorges and V-shaped valleys. The landscape is characterized by narrow ridges, deep incisions and numerous mass-movement scars. The average slope in this zone varies between 10° - 30°, with slope length sometimes exceeding 800 m. These lower hills are the most dissected and eroded tract in the Darjeeling Himalaya.

Middle hills: This is a rather narrow zone, sandwiched between the upper and lower hills and bounded by 800 m and 1400 m contours. Most of the western and north eastern part of the district falls under this category. These hill slopes are mostly used by tea plantations.

Upper hills: The upper hills lie above the 1400 m contour line and have been identified along the Mahaldiram-Bagora region and above the Ghum-Sonada ridge. It is most prominent along the extreme north-western boundary of the region along the Singalila ridges with peaks like Sandhakphu and Phalut towering over the region.

Beyond the hill region in the North, starts the flat plain at South and South-East part of the district. This foothills zone is called the “Terai”, where the wider valley floors are frequently filled up with large boulders transported by debris flow. A number of rivers, i.e., Teesta, Balason, Mahananda originate in the Darjeeling Himalaya, and have formed braided courses on the plains, which are overloaded with sediments. These streams form smaller fans, the apex part of

which could be noticed at the entrance of the mountains. Fragments of higher fan levels with well-develop soil profile are preserved between the alluvial fans. The shape of the terraces and the fan systems on the Terai piedmont zone is irregular, and are partly controlled by tectonics (Source: Geomorphological Field Guide Book, IGI).

4.2 Soil and rock pattern

The Darjeeling hill area is formed of comparatively recent rock structure that has a direct bearing on landslides. Heavy monsoon precipitation contributes to the landslides. Soils of Darjeeling hill areas are extremely varied, depending on elevation, degree of slope, vegetative cover and rock type.

The soil of district Darjeeling falls under Warm Perhumid Eco-Region under the Eastern Himalayas Agro Ecological Sub Region (Source: District census handbook 2011). Soils in the highlands stretching from the west to the east of the district along most of the inter fluvial areas are mainly mixed sandy loam and loamy, while those on the southern slopes of Mirik and Kurseong are mainly clayey loam and reddish in color. Sandy soils are mainly found in the east of the river Teesta (Source: Geomorphological Field Guide Book, IGI).

Figure 4.1 is showing soil pattern of the district Darjeeling. Soil type of the district mainly divided based on Brown Forest Soil and Terai soil and their subtype as explained below table (Table 4.1).

Table 4.1: Description of District soil type

MAP SYMBOL	DESCRIPTION
HILLS AND SIDE SLOPES (BROWN FOREST SOILS)	
W001	Shallow, excessively drained, gravelly loamy soils occurring on very steep side slopes with gravelly loamy surface and severely eroded, associated with rock outcrops.
W002	Moderately shallow, excessively drained, coarse loamy soils occurring on steep side slopes with gravelly loamy surface, severe erosion and strong rockiness associated with moderately shallow, well drained, gravelly loamy soils with loamy surface and moderate erosion.
W003	Deep well drained, fine loamy soils occurring on steep side slopes with gravelly loamy surface, moderate erosion and moderate rockiness, associated with moderately shallow, excessively drained, coarse loamy soils with loamy surface, severe erosion and moderate rockiness.
W004	Moderately shallow, well drained, gravelly loamy soils occurring on steep side slopes with gravelly loamy surface, moderate erosion and moderate rockiness associated with moderately shallow, somewhat excessively drained, gravelly loamy soil with loamy surface, moderate erosion and moderate rockiness.
PIEDMONT PLAIN (TERAI SOILS)	

MAP SYMBOL	DESCRIPTION
W006	Very deep, imperfectly drained, coarse loamy soils occurring on very gently sloping upper piedmont plains with loamy surface and moderate erosion associated with very deep, imperfectly drained, fine loamy soils
W007	Very deep, imperfectly drained, fine loamy soils occurring on very gently sloping lower piedmont plain with loamy surface and moderate erosion associated with very deep, imperfectly drained, coarse loamy soils.
W009	Very deep, imperfectly drained, coarse loamy soils occurring on nearly level lower piedmont plain with loamy surface associated with very deep, imperfectly drained, fine loamy soils.

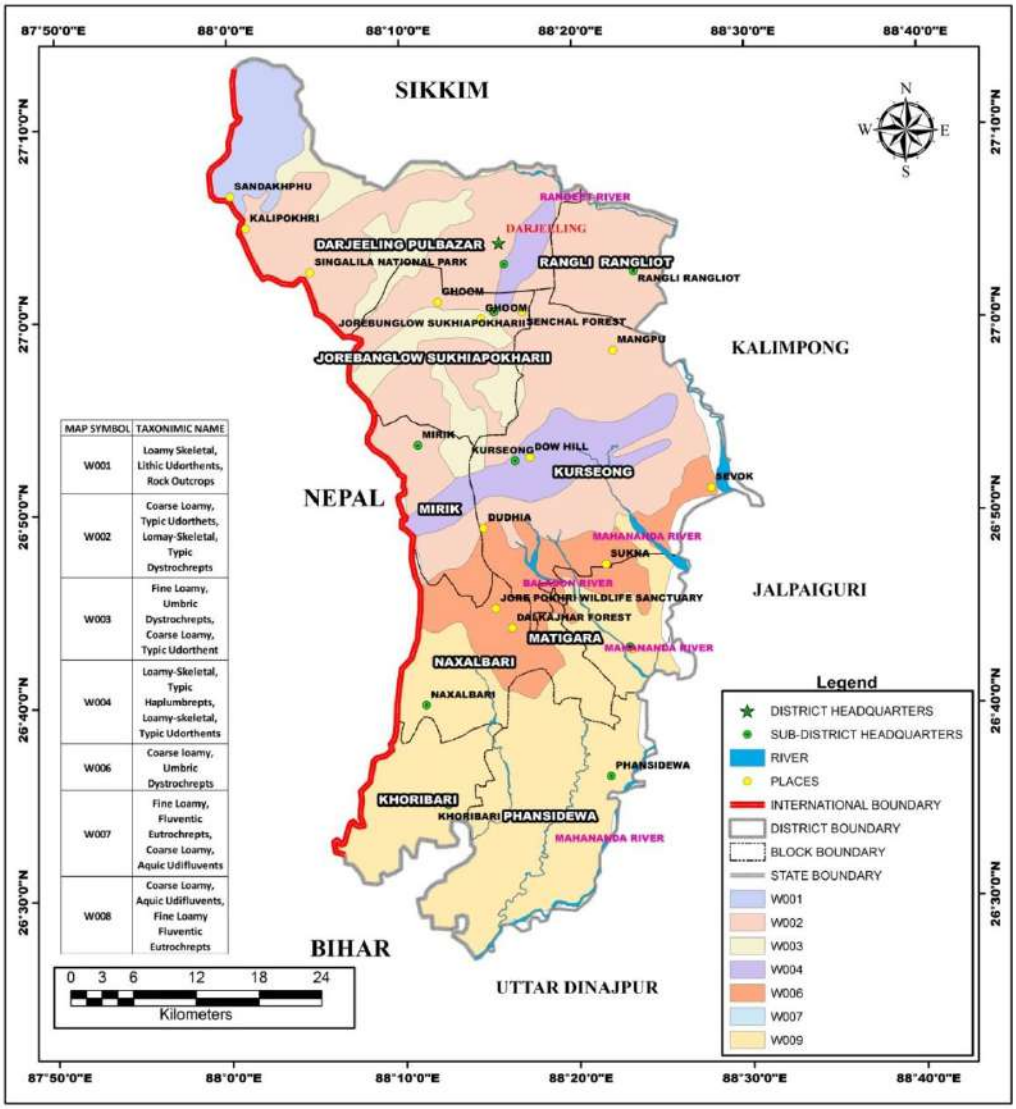

Figure 4.1: Soil Map of Darjeeling District
(Source: National Bureau of Soil Survey and Land Planning)

The rock formations from north to south consist of the moderately resistant Darjeeling Gneisses, the Daling Metamorphics of varying resistant (i.e., phyllite to quartzite), and the Damuda Shales with coal beds. Tertiary sandy molass deposits of Siwalik unconformably overlie the Damuda formation. The overall rock type of the district is mainly consisting of Granite, Gneiss, Shales, and most importantly Sandstone and solidified but poorly consolidated clutter of Conglomerate formations.

Rock type of the district may be divided into four tracts, which are, from north to south, the hard rock area, the Bhabar belt, the Terai belt and the alluvial plains. The Bhabar belt comprises rock fragments, big boulders and fine grained clastics derived from the hard- rock area is characterized by gentle slope, boulder surface and forest of tall trees. These are the coarse alluvial zone below the Siwalik Hills (outermost foothills of the Himalayas) where streams disappear into permeable sediments. The Terai belt is the zone of rejected recharge and, as such has developed swampy condition and is composed mostly of coarse granular materials alternating with finer clastics. The alluvium consists of succession of layers of sand, silt and clay with occasional gravel beds and lenses of peaty organic matter (Source: Mili J, 2012).

4.3 Different geomorphology units

Geomorphologically the Darjeeling district can be broadly divided into Hills and Plain land form. The hilly areas of Darjeeling are a part of the Siwalik Range. Darjeeling Himalayas has an elevation range of 2000-3000 m, and occurs as the foreland of the Kanchenjunga massif. Geological foundations of the Darjeeling hills consist of Precambrian slates, schist, phyllite, quartzite, gneisses, lower Gondwana and Siwalik sandstones and recent to sub-recent alluvium.

The foothills of Darjeeling Himalayas, which comes under the Siliguri subdivision, is known as the Terai. This is primarily a plain land having elevation of 100 to 150 meters. Geological formations of these plains are Alluvium, Older Alluvium and Laterite Siwalik System.

Figure 5.2 below represent the Geomorphological variation of Darjeeling district. Map shows the position of upper hills in the north-western part of the district where Singalila range is situated. Central region of the northern hilly area is also part of upper hills. Lower and middle ranges are demarcated by Lower hill region. Southern part of the district fall under Alluvial Plain region. In between Plan and hill, there is Alluvial Fan, characteristic of hilly terrain where river off load sediments from narrow canyon to plan land.

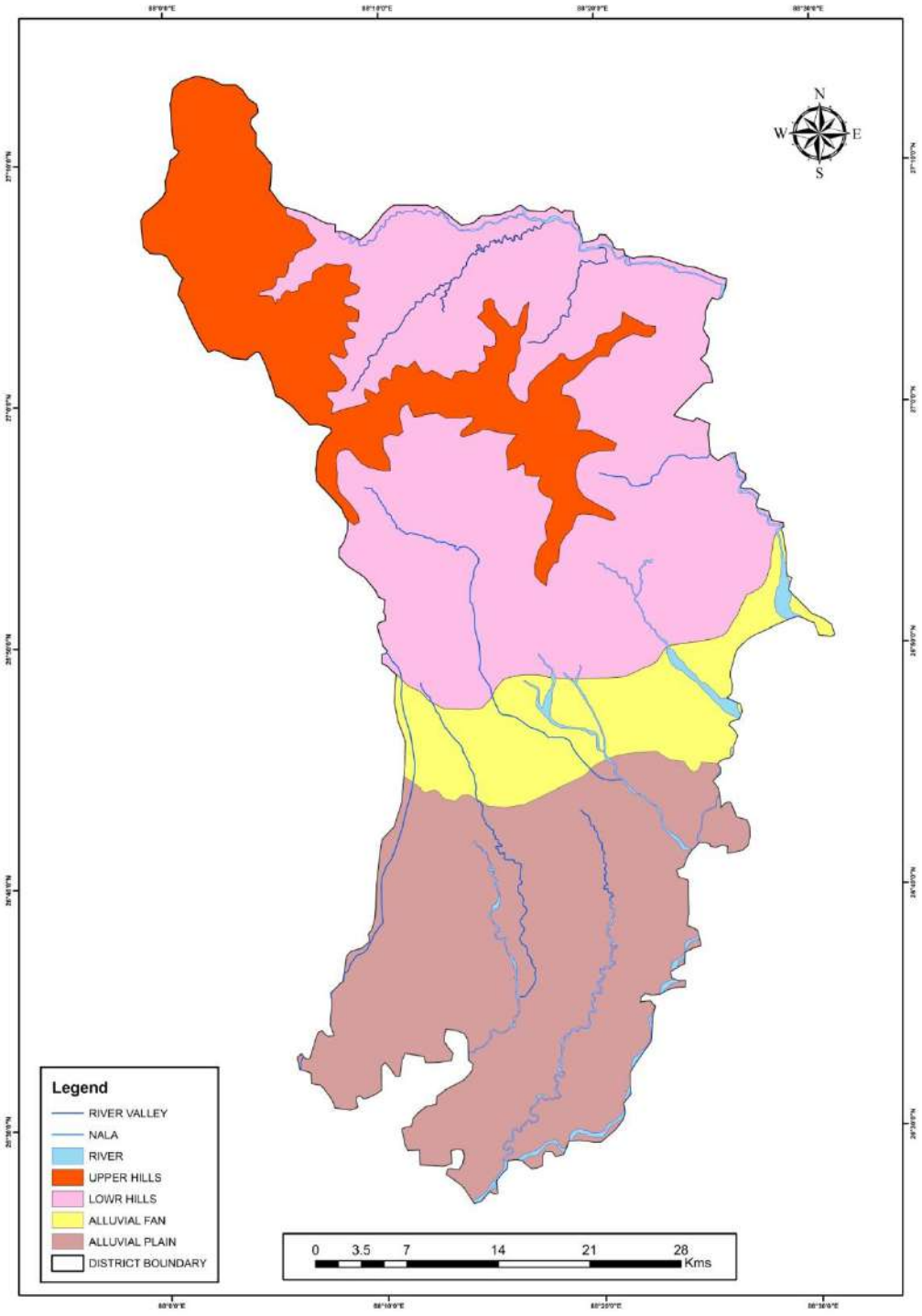

Figure 4.2: Geomorphological map of Darjeeling District

(Source: Resourcesat-1&2 – Liss-3, Bhuvan India)

5 Land use pattern of the district

The land share of district Darjeeling is modest in comparison to other districts in the state. Due to its mountainous terrain, fortunately, for a large proportion of land there is still a forest cover. Total forest land is 124.58 thousand hectares. Total land for agricultural use is 160 thousand hectares. Table 5.1 gives land utilization static of Darjeeling district. Figure 6.1 is pie diagram representing broad land use pattern of the district and Figure 5.2 is Land Use Land Cover map of the district.

Table 5.1: Classification of Land Utilisation Statistics in the district

(In thousand hectares)

Year	2008-09	2009-10	2010-11	2011-12	2012-13
Reporting Area (In Thousand Hectares)	325.47	325.47	325.47	325.47	325.47
Forest Area	124.57	124.57	124.57	124.57	124.58
Area under Non-agricultural use	39.88	40.16	40.53	38.62	39.21
Barren & unculturable land	2.48	2.14	2.46	2.57	2.33
Permanent pastures & other grazing land	0.87	1.13	0.83	0.57	0.5
Land under Misc. tree groves not included in Net area sown	2.21	2.33	2.35	2.64	2.78
Culturable waste land	1.67	1.55	1.49	1.31	1.12
Fallow land other than Current fallow	3.75	3.65	3.22	3.18	2.93
Current fallow	17.53	17.67	16.44	17.36	16.55
Net area sown	132.51	132.27	133.58	134.65	135.47

Source: Directorate of Agriculture (Evaluation), Govt. of W.B.

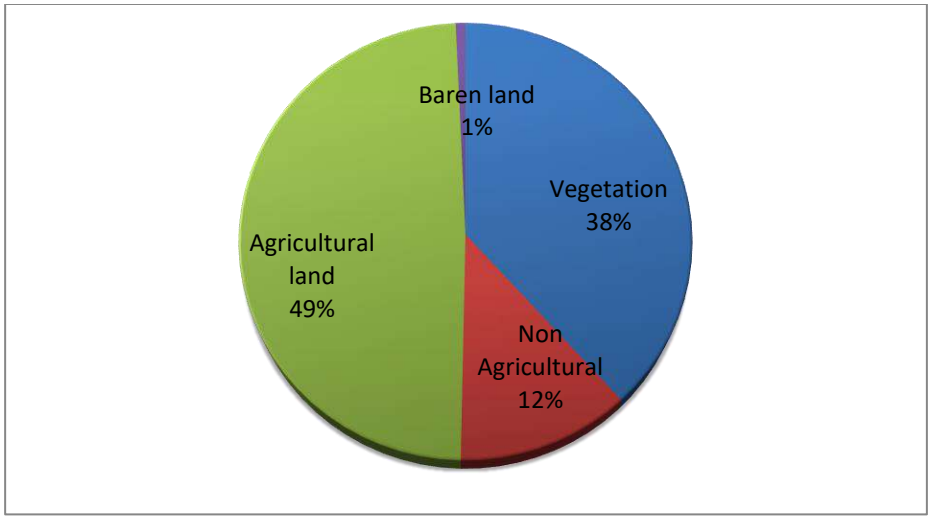

Figure 5.1: Land use pattern of Darjeeling District

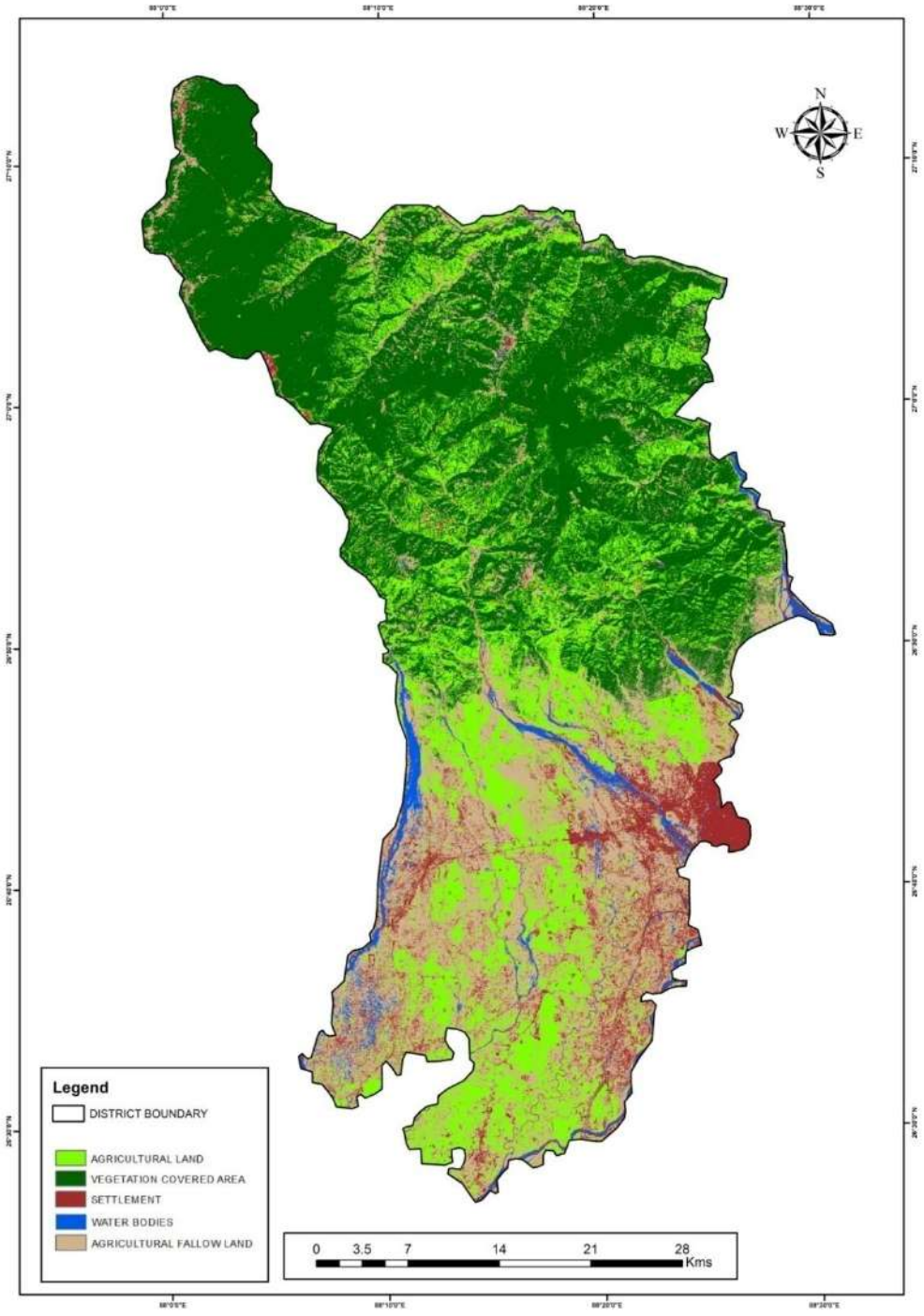

Figure 5.2: Land Use Land Cover map of Darjeeling District
(Source: Resourcesat-1&2 – Liss-3, Bhuvan India)

5.1 Forest -detail of the area

The natural forest resources of Darjeeling district can be classified into the following five categories (Source: District census handbook 2011; Report on Forest Resource, FSI 1997):

The Tropical Semi-Evergreen Forests of district Darjeeling is generally spread over the foothills of the Himalayan mountain range. The important species are Micheliachampaca, Terminalia myriocarpa, Ailanthus grandis, and Phoebe species. All these species yield valuable commercial timbers.

Tropical Moist Deciduous Forest of Sal (Shorearobusta) is the most abundant species of plant in this vegetation. Other important deciduous evergreen plants and trees of shorter height like Michelia (Champa), Magnolia, Needlewood Tree (Chilauni), Black Cutch (Khayer), Silk Cotton (Simul), Banana, Plantains, Bamboo can also be seen in great numbers.

Sub-Tropical Hill Forest can usually be seen at smaller hills up to the height of six thousand feet. It is alternatively known as Sub-tropical Broad-leaved Hill Forest. The main vegetation include tall and large trees like Himalayan Alder, Nepali Alder, Himalayan Birch (Bhurja-Patra tree) etc.

Eastern Himalayan Wet Temperate Forest usually grows at an altitude of six thousand to eight thousand feet, which may extend up to an altitude of ten thousand feet. Typical vegetation consists of Fern, Mosses, Epiphytic Orchids, Magnolias, Rhododendrons, Olive, Wild Ginger and large coniferous trees like Himalayan Alpine Fir, Himalayan Hemlock, Chestnut, Wormwood, Walnut, Birch etc.

Alpine forests can be seen in at a height of eight to ten thousand feet and more. The forest area includes mainly of Pine, Juniper, Willows, Himalayan Silver Fir, Conifers, Oak, Chestnut, Walnut, Laurel, Maple etc. with deciduous and evergreen shrubs of genus Berberis, dwarf Rhododendron, Magnolia, etc.

As per the data made available in the District Statistical Hand Book of Darjeeling published by Government of West Bengal, 1,04,373 Hectares of the district forest land are under Reserved Forest category and 1,752 Hectares are under Protected Forest category. As on 2010-11, Unclassed State Forest in the district is spread over 5,760 Hectares (Source: District census handbook 2011).

Table 5.2: Classification of Forest Area, Out-turn of Forest Produce, Revenue and Expenditure of Forest Department

Item	Unit	2006-07	2007-08	2008-09	2009-10	2010-11
1. Area by class of forest:	-	-	-	-	-	
Reserved forest	hectare	104373.00	104373.00	104373.00	104373.00	104373.00
Protected forest	"	1752.30	1752.30	1752.30	1752.30	1752.30
Unclassed state forest	"	5759.87	5759.87	5759.87	5759.87	5759.87
Total		**111885.17**	**111885.17**	**111885.17**	**111885.17**	**111885.17**
2. Forest Produce:	-	-				
Timber	thousand cu. metre	96.75	98.29	91.35	93.10	93.45
Fuel	"	22.56	18.27	15.30	17.20	17.10
Pole	Number	-	-	17	14	18
3. Revenue & Expenditure:	-					
Revenue	Rs. in thousand	184292.00	222943.00	87698.00	82921.00	88767.00
Expenditure	"	188930.00	113070.00	74521.00	78701.28	80874.00

(Source: D.F.O., Wild life Division, Division Office, W.B. Darjeeling, Kurseong; Div.Manager, W.B.F.D.C., Kalimpong; D.F.O., D.G.H.C., Forest Deptt.)

5.2 Agriculture & Irrigation

Agriculture not only dominates the economy of Darjeeling District but it is also varied in nature due to variations in altitude, climate and soils. It is imperative to cut terraces for farming due to steep slopes. The steep slope again encourages soil erosion, thereby affecting the cropping pattern. The influence of temperature and heavy rain is also well-marked on the cropping pattern of the district.

The two distinct divisions of the district are mountainous region to the north forming the greater part and the alluvial plains to the south. Most of the area in the district is under forest. Cultivation is suitable between 300m and 600m in the hill areas. The lower hills are mainly used for plantation crops like Tea, Cinchona and Rubber. The net cultivated area is 49% of the total area of the district.

The plain-lands under the Terai and Dooars region are favourable for cultivation of rice, jute and potato. Maize (Corn) and ginger are cultivated primarily in the sloping lands at the foot of the hills. Organised sugarcane cultivation in the district has been accelerated after 2006-07.

Among the vegetables, production of Cucurbits like Squash, Pumpkin, Zucchini, Gourds etc. are maximum in the district, followed by Cabbage, Cauliflower, Tomato, Bringaletc (Source: District census handbook 2011).

The crops of Darjeeling district broadly fall into two groups - (a) plantation crops like tea, orange, cinchona and (b) non-plantation crops like rice, wheat, maize, jute, potato, vegetables etc.

These two may again be conveniently grouped under the following broad categories;-

(1) Subsistence Farming — Paddy, maize, millet, soyabean, wheat, barley etc.
(2) Cash Crop Raising — Potato and vegetables, ginger, cardamom etc.
(3) Plantation Agriculture — Tea, medicinal plants and pineapples.
(4) Miscellaneous categories — Horticulture, floriculture, orchid culture, sericulture and production of mushrooms.

Tea production form the most important part of the district economic scenario. Fruits like Orange,Pomegranate, Pineapple, Mandarin Orange, Banana, Lichee, different Citrus fruits; different vegetables and medicinal herbs like Cucumber, Brinjal, Cabbage, Cauliflower, Cardamom, Chillies, Turmeric, Ginger, Dar-haldi (Daru-Haridra in Sanskrit), Khayer, Cumin, Mint, Potato are cultivated in the district. Food Crops like Rice, Maize, and Wheat etc. are cropped mainly in the Terai region. Jute is also cultivated in the plains (Source: District census handbook 2011).

In Darjeeling, agro-forestry is an integral part of the farming system, where trees are integrated extensively with crop and livestock production. Two type of agro-forestry is practiced in the district. The large cardamom based agro-forestry system which accelerates the nutrient cycling, increases the soil fertility and productivity, reduces soil erosion and also provides aesthetic values for the mountain societies. Another is alder-based jhum system, a unique and highly productive form of jhuming (shifting cultivation or slash and burn agriculture). This system is usually practice at high altitude of Rimbhik and Lava region only by lepchas. Normally a jhum farmer cultivates the jhum fields for two years within a nine-year cycle (1:4 ratio of cropping to fallow). But the alder system allows two harvests in two out of every four to five years (1: 1 ratio of cropping to fallow) (Source: Mukherjee D, 2012).

Agriculture is a way of life to the people of Darjeeling as it is the source of livelihood, employment and raw materials to leading industries. In Darjeeling district about 7.6% of the total working population are cultivators, 4.7% are agricultural laborers and 29.96% are engaged in allied agricultural activities. The leading agro-based large-scale industry of the district is tea. Among the small-scale industries sericulture, fruit-processing, phyto-chemical, wheat grinding, flour crushing, rice milling are worth mentioning. The major cash crops of the district are orange, ginger, pine-apple, cardamom, potato and even vegetables.

Table 5.3 shows the crop production capacity of the un-divided Darjeeling district.

Table 5.3: Production of Principal Crops in the district of Darjeeling (thousand tonnes)

Crops	2006-07	2007-08	2008-09	2009-10	2010-11
(1)	(2)	(3)	(4)	(5)	(6)
Foodgrains :					
1. **Rice**	**58.7**	**59.5**	**68.7**	**75.4**	**77.8**
Aus	8.9	6.2	5.9	7.6	8.2
Aman	46.6	49.6	59.6	64.4	65.6
Boro	3.2	3.7	3.2	3.4	4.0
2. Wheat	3.2	3.8	2.8	3.4	3.5
3. Barley	-	-	-	-	-
4. Maize	30.8	38.2	42.9	39.6	40.8
5. Other Cereals	14.4	14.3	14.3	14.3	14.2
Total Cereals	**107.1**	**115.8**	**128.7**	**132.7**	**136.3**
6. Gram	-	-	-	-	-
7. Tur	(b)	(b)	(b)	(b)	(b)
8. Other Pulses	1.2	0.7	0.7	0.6	0.7
Total Pulses	**1.2**	**0.7**	**0.7**	**0.6**	**0.7**
Total Foodgrains	**108.3**	**116.5**	**129.4**	**133.3**	**137.0**
Oil Seeds :					
1. Rapeseed & Mustard	0.1	0.1	0.1	0.1	0.2
2. Linseed	(b)	(b)	(b)	(b)	(b)
3. Other Oil seeds	8.0	0.2	0.2	0.1	0.2
Total Oil seeds	**8.1**	**0.3**	**0.3**	**0.2**	**0.4**
Fibres :					
1. Jute	31.4	28.3	33.9	36.8	30.2
2. Mesta	-	-	-	-	-
3. Other Fibres	-	-	-	-	-
Total Fibres	**31.4**	**28.3**	**33.9**	**36.8**	**30.2**
Miscellaneous crops :					
1. Sugarcane	-	2.3	0.9	0.3	0.3
2. Potato	110.4	109.2	124.0	149.4	126.7
3. Tobacco	-	-	-	-	-
4. Tea(P)	88.9	75.2	77.1	72.2	73.9
5. Chillies (dry)	0.3	1.1	0.6	0.6	0.6
6. Ginger	6.3	6.7	6.8	6.9	6.9
Total Miscellaneous crops	**205.9**	**194.5**	**209.4**	**229.4**	**208.4**

(Source: Directorate of Agriculture, Govt. of W.B.; B.A.E.& S., Govt. of W.B.)

5.3 Horticulture

A large variety of fruits such as Pine apples, Oranges, Plums, Peaches, Apples etc. are grown in the valleys and on the slopes under moderate rainfall. The Oranges are of excellent quality. The better orangeries usually occur at elevations of 650 m to 1300m. The traditional orange orchards cover about 3.82 sq.km. of area. Mirik is supposed to be the most flourishing orange growing area in the district (Source: Report on Forest Resource, FSI 1997).The production of Darjeeling Mandarin Oranges and other variety of Citrus fruits are around 37,770 Metric Tonnes as on 2010-11.Pineapples are the highest growing fruit variety in the district with an annual production of 1,31,900 Metric Tonnes in 2010-11 (Source: District census handbook 2011).

Table 5.4: Production of Fruits and Vegetables in the district

Name of Fruits / Vegetables		Production (Thousand tonnes)				
		2006-07	2007-08	2008-09	2009-10	2010-11
A.	**Fruits**					
	Mango	0.17	0.17	0.17	0.17	0.19
	Banana	3.30	3.53	3.94	3.94	3.94
	Pineapple	124.93	126.40	126.90	126.90	131.90
	Papaya	2.80	2.99	2.99	2.99	3.01
	Guava	1.44	1.45	1.45	1.45	1.45
	Jackfruit	2.10	2.56	2.57	2.57	2.57
	Litchi	2.92	0.55	0.55	0.55	0.55
	Mandarin Orange	0.46	35.98	35.98	36.23	36.53
	Other Citrus	5.69	1.24	1.24	1.24	1.24
	Sapota	-	-	-	-	-
	Others	32.55	32.75	32.75	32.73	32.76
	Total	**176.35**	**207.62**	**208.54**	**208.77**	**214.14**
B.	**Vegetables**					
	Tomato	13.26	13.47	13.47	14.47	14.66
	Cabbage	29.17	30.08	30.08	30.08	30.50
	Cauliflower	26.19	26.62	26.62	26.62	26.97
	Peas	12.19	12.22	12.22	12.22	12.59
	Brinjal	46.39	24.57	24.57	24.57	20.64
	Onion	0.49	0.46	0.46	0.46	0.48
	Cucurbits	64.98	80.59	80.59	78.59	81.37
	Ladies Finger	7.93	6.05	6.05	6.05	6.23
	Radish	13.59	13.92	13.92	13.92	9.73

Name of Fruits / Vegetables		Production (Thousand tonnes)				
		2006-07	2007-08	2008-09	2009-10	2010-11
	Others	23.70	26.68	26.68	26.68	36.80
	Total	**237.90**	**234.66**	**234.66**	**233.66**	**239.97**

(Source: Directorate of Food Processing Industries and Horticulture, Govt. of W.B.)

Table 5.5: Production of Flowers in the district

Name of Flowers	Production				
	2006-07	2007-08	2008-09	2009-10	2010-11
Rose	1.099	1.525	1.525	1.525	1.525
Chrysanthemum	1.870	1.770	1.770	1.770	1.770
Gladiolus	19.015*	20.910	20.910	20.910	20.930
Tuberose	-	-	-	-	-
Marigold	..	0.110	0.110	0.110	0.110
Jasmine	0.048	0.018	0.018	0.018	0.018
Seasonal Flower	0.102	0.102	0.102	0.102	0.103
Misc. Flower	0.066	0.078	0.078	0.078	0.078

* crore Spike

(Source: Directorate of Food Processing Industries and Horticulture, Govt. of W.B.)

5.4 Mining

Darjeeling district is not exposed to mining activity at large scale. Collection of sand, stone and gravels from the river-bed are the main mineral sources. These materials are primarily utilized for construction purpose. Revenue generated in the district of Darjeeling from Minor minerals in the FY 2019-20 is Rs. 6.35 Crores.

6 Geology

The Sikkim-Darjeeling Himalaya contains the stretch of tectonically active Eastern Himalaya. It is composed of three main tectonic units: the Higher Himalaya, the Lower Himalaya and the Siwaliks separated by thrusts, but joined by great fluvial system of the Teesta River. The Higher Himalaya with relief up to 2,000–4,000 m was uplifted by about 2,000 m in the Quaternary rising above the snowline. Its mountain massifs previously had fluvial relief which later had been totally transformed by glacial processes. The Lower Himalaya dissected 1,000–2,000 m locally with remains of mature relief fragments are continuously in the forest belt. The Siwaliks in this part of the Himalayan Range are reduced to a narrow belt, which blend with the Lower Himalaya. Along the Frontal Fault it rises above 1,000 m directly over the alluvial plains of the Sub-Himalayan foredeep, which is still active and split into blocks of various tectonic tendencies (Singh and Keyho, 20014).

Darjeeling-Sikkim Himalaya is one of the important fault thrust belt in the Himalaya covering the rocks of Central Crystalline Gneissic Complex, Daling Phyllite, Gondwana, Buxa and Siwaliks from north to south. Quaternary rock delimits the Himalaya in the southern part. A number of thrust namely MCT, MBT, MFT and also Daling Thrust are reported in this fault thrust belt (Singh and Keyho, 20014).

The geological formations of the Darjeeling Himalaya consist essentially of unaltered sedimentary rocks. The Sub-Himalaya is made up of Siwalik deposits of the Tertiary age. North of the Siwaliks is the coal-bearing lower Gondwana formations. The Daling series (Pre-Cambrian) follows and is succeeded by the Darjeeling gneiss further north (Cajee L, 2018).

Table 6.1: Geological succession of Darjeeling Himalaya

Age	Series	Lithological Characteristics
Recent to Sub-recent	Alluvium	Younger flood plain deposits of rivers consisting of sands, pebbles, gravels, boulders etc.
Pleistocene to Lower Pleistocene (Lower Tertiary)	Siwalik	Micaceous sandstone with siltstone, clay, lignite lenticles, etc.
Thrust (Main Boundary Fault)		
Permian	Damuda (Lower Gondwana)	Quartzitic sandstone with slaty bands, seams of graphitic coal, lampophyre silt and minor bands of limestone.
Thrust (Fault Of Nappe Qutlier)		
Pre-Cambrian	Daling series	Slate, chlorite-sericite schist, chlorite- quartzschist.
	Darjeeling Gneiss	Golden silvery mica-schist, carboniferous mica-schist, coarse grained gneiss.

Source: Cajee L, 2018

Darjeeling Sub Himalaya: The Terai and the foothills were given their present form after the final upheaval of the Himalayan orogeny and consist of almost horizontal layers of unconsolidated sand, silt, pebbles and gravel. The Sub Himalaya is made up of the Siwalik deposits of the Tertiary and good Siwalik exposure is met along the Teesta River.

Damuda Series: Along the foothills of Darjeeling, the Siwaliks are steeply over-thrust by the Damuda formations (Lower Gondwana). The thrust zone is badly exposed and appears to dip at 60° – 70° towards the North. This thrust coincides with the well-known main boundary fault, occurring throughout the entire Himalayan range. The sandstones are micaceous, feldspathic and brownish, often weathered in exposed thrust zones, with coal bearing detrital rocks. Frequently, the sandstones have been converted to quartzites; the shales into splinter-shales and the carboniferous shales to graphitic shales; while the coal has been altered to anthracite. There is a thin discontinuous band of limestone from Kalijhora to Rongtong.

Daling Series: Northwards, the Damuda Series is succeeded by the very uniform and characteristic Dalings. They border the Damudas with a very sharp thrust contact, dipping steeply towards the north. The Daling consist mainly of slates and phyllites, with silvery mica schists representing transition rocks. Feldspars and quartz layers are found lying alternate to each other.

Darjeeling Gneiss: The Darjeeling gneiss occupies a greater part of the region and is found along the higher reaches of the hills. The Darjeeling gneiss consists of garnetiferous mica-schists, quartzites, biotite-kyanite and sillimantic gneiss. The Darjeeling gneiss is met with traverses along SukhiaPokhri - ManeyBhanjang - Tonglu- Sandhakphu-Phalut Road and also along the Phalut-Rammam-Rimbick-Jhepi-Pulbazar-Darjeeling Road. The gneisses are well foliated, much folded and crumpled and are well- jointed (40°-70° E-W) rocks.

7 Mineral wealth

7.1 Overview of mineral resources

The geological formation of Darjeeling District indicates the presence of quite a number of major minerals such as coal, lead, zinc, copper, limestone, graphite and minor minerals such as building and ornamental stones and silica sand. Of these major minerals, resource of coal is well established along with lead-zinc, copper-gold and limestone deposits. Deposits of Sand and Building stones are explored economically.

7.2 Details of Resources

7.2.1 Sand and other riverbed minerals:

I. Drainage System

Drainage system of the district is controlled by following river courses:

River Teesta (also spelt as Tista) is the most important river of Darjeeling district. The main stream of the river is originated from Cholamoo (Tso Lhamo) Lake in Tibet. Passing through the mighty Himalayas during its early path, the river reaches the plain land at Sevoke near Siliguri and expands in the plains after entering Jalpaiguri district. River Teesta is fed by numerous smaller tributaries from East and large but fewer tributaries from West bank throughout its journey from Sikkim to Bangladesh through Darjeeling and Jalpaiguri. Inside Darjeeling district, the principal tributary of river Teesta are river Rangpo to the left bank which creates a natural boundary between Darjeeling and Sikkim for some distance and rivers Great Rangeet (Bari Rangeet/Rangeet Chhu) and Rammam joins Teesta from the right bank forming the district boundary with Sikkim. The River Teesta is primarily a snow-fed river in its upper course and fed by heavy rainfall during the month of June to September in its lower course. Like all other hilly rivers in the region the river bed almost remains dry in other seasons.

River Mahananda is also known as Mahanadi or Mahaldi. It is originated from the Mahaldiram Hills at East of Kurseong from an elevation 6,900 ft. and flows in a North-South direction through the district up to Siliguri. Mechi, Balason, Ratwa and Kankai are main tributaries of Mahananda. Like all other rivers of North Bengal, Mahananda is fed by numerous small streams of rivulets flowing from the mighty Himalayas. Trinai, Ranochondi, Chokor and Dauk are notable among them.

The river Rammam and river Rangeet forms the natural Northern boundary of the Darjeeling district with the state of Sikkim. Rangeet is originated from a glacier of Mt. Kabru at the lower Kanchenjunga region towards North and meets with river Rammam near Jorethang of Sikkim which ultimately meets river Teesta. The river Rammam is originated from the Singalila range in Darjeeling and flows towards East before meeting Rangeet. River Rammam is fed by its

main tributary Lodhoma and numerous small streams before reaching its confluence with Rangeet.

River Balason is originated from Lepcha Jagat at the Senchal Hills South- West of Darjeeling. It is a tributary of river Mahananda and flows in North-South direction. There are two notable tributaries of river Balason, one is Rinchintong on the left bank and the other is Rangbong on the right bank. The stones, gravels and sand found in the hilly terrain of the river-bed of Balason are used for construction purpose and are considered of having impressive quality.

River Mechi is originated from Mahabharat range of Nepal and flows from North to South and enters Darjeeling district at Mirik C.D. Block. It is the Western-most tract of Darjeeling district forming the Western boundary (international boundary) with Nepal. River Mechi is a tributary of river Mahananda.

(Source: District census handbook 2011)

Table 7.1: Drainage system with description of main rivers

S.No.	Name of the River	Area drained (Sq.km)	% Area drained in the district
1	Balason River	19.69	0.94%
2	Teesta River	9.02	0.43%
3	Rangeet River	2.74	0.13%
4	Mechi River	16.60	0.79%
5	Mahananda River	11.67	0.56%

Table 7.2: Salient Features of important rivers and streams

S.No.	Name of the River or Stream	Total Length in the District (in Km)	Place of origin	Altitude at Origin
1	Balason River	48.40	Lepchajagat at the Senchal Hills	2361m
2	Teesta River	37.00	Tso Lhamo Lake, Sikkim	5100m
3	Rangeet River	18.57	Glacier of Mt. Kabru, lower Kanchenjunga	5330m
4	Mechi River	63.21	Mahabharat range	4000m

S.No.	Name of the River or Stream	Total Length in the District (in Km)	Place of origin	Altitude at Origin
			of Nepal	
5	Mahananda River	91.70	Paglajhora Falls on Mahaldiram Hill	2100m

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 include following parameter:

i) Place of Origin

Name of the River or Stream	Place of origin
Balason River	Lepchajagat at the Senchal Hills
Teesta River	Tso Lhamo Lake, Sikkim
Rangeet River	Glacier of Mt. Kabru, lower Kanchenjunga
Mechi River	Mahabharat range of Nepal
Mahananda River	Paglajhora Falls on Mahaldiram Hill

ii) Catchment Area

River Teesta and Mahananda are forming the main drainage system of Darjeeling district. Teesta River is a 315 km long river that rises in the eastern Himalayas, flows through the Indian states of Sikkim and West Bengal through Bangladesh and enters the Bay of Bengal. Mahananda River originated from the Mahaldiram Hills at East of Kurseong from an elevation 6,900 ft. and flows in a North-South direction through hilly catchment area of the district up to Siliguri.

iii) General profile of river stream

River profile has been studied along the cross section lines which was chosen based on the drastic variation of the river widths, proximity of the operating sand Ghats and the position of the sand bars. Relative disposition of rivers in Darjeeling district along with the distribution of the section lines are shown in Figure 7.1.

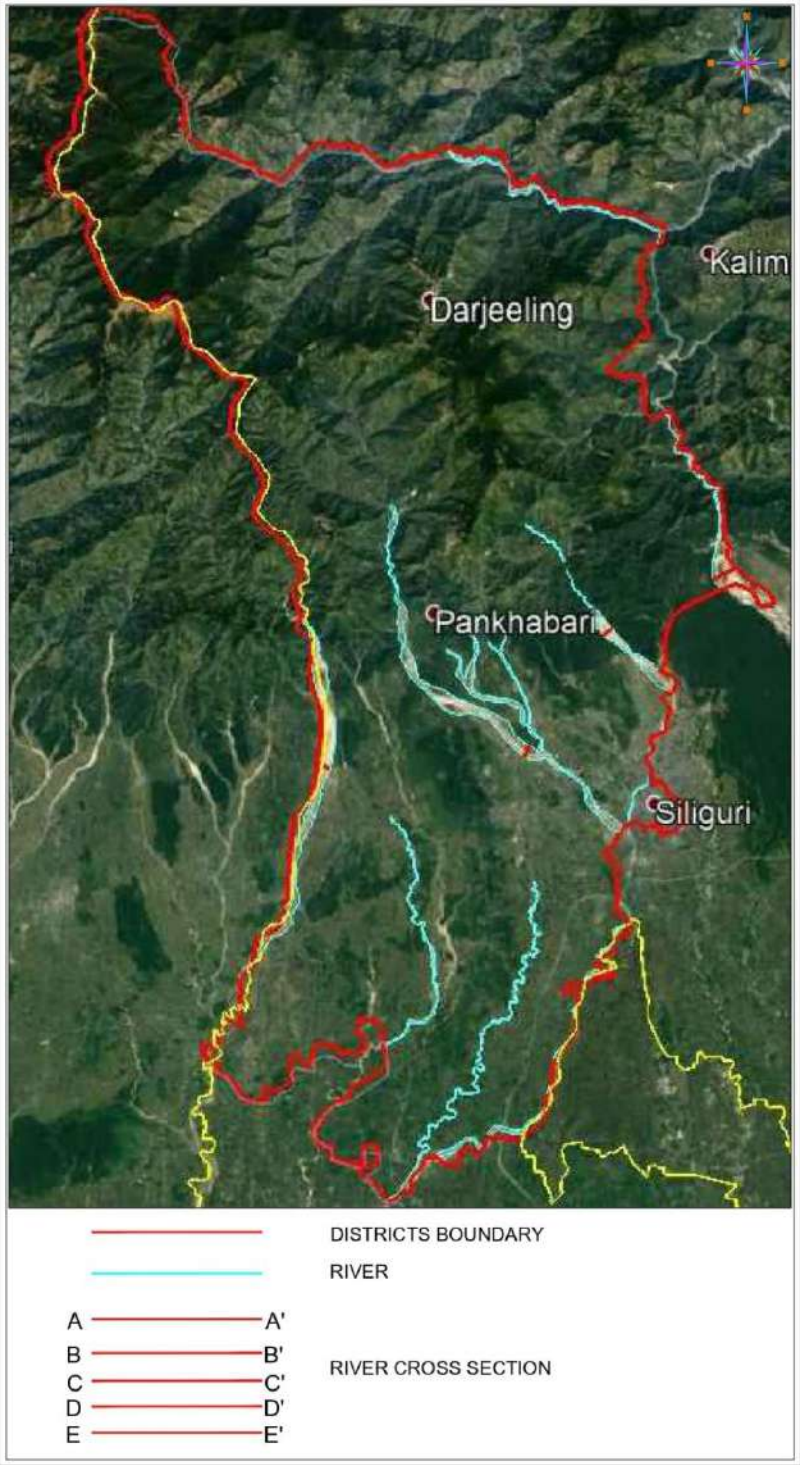

Figure 7.1: Plan showing the major rivers along with the distribution of Section Lines

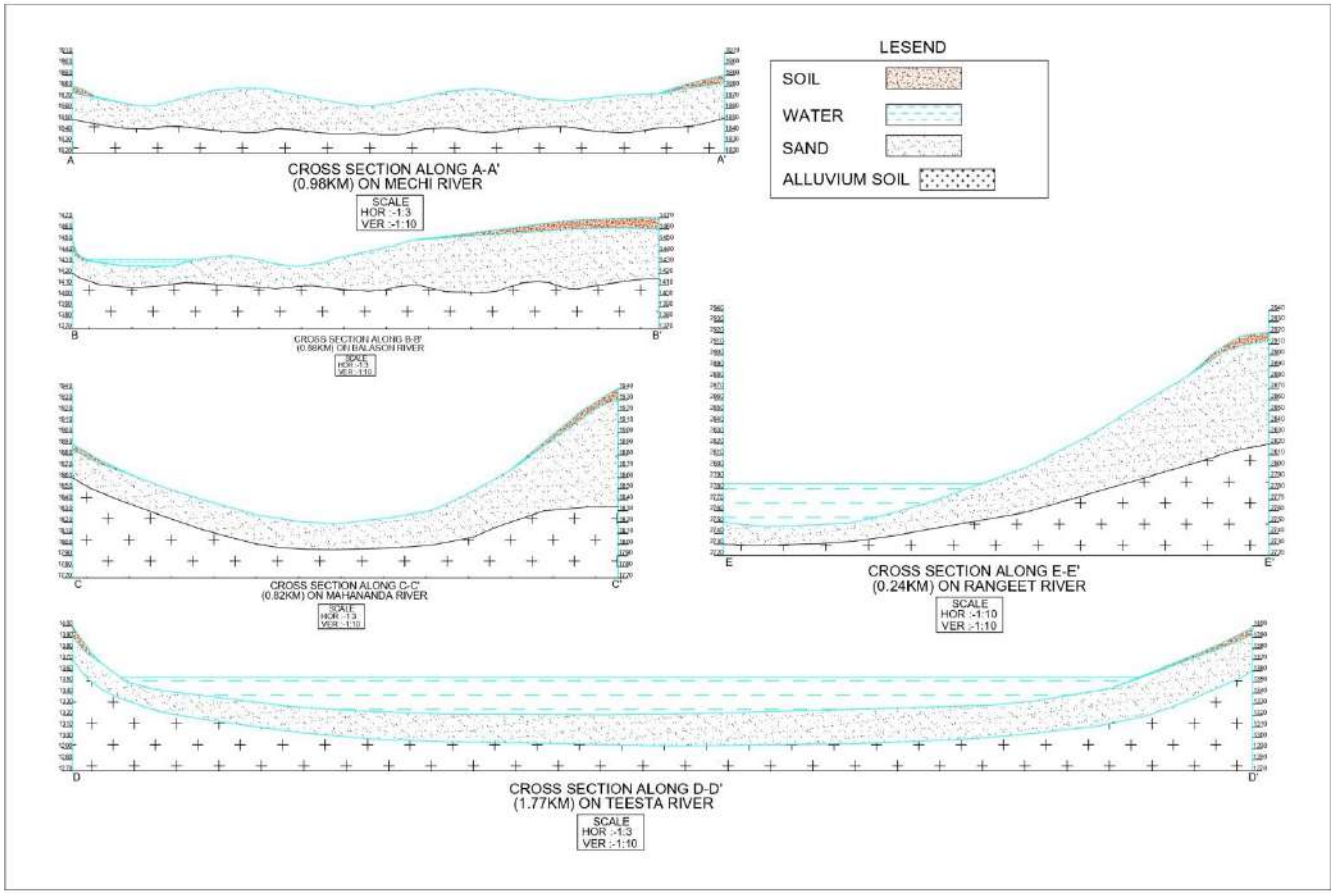

Figure 7.2: Cross section of rivers during pre monsoon period

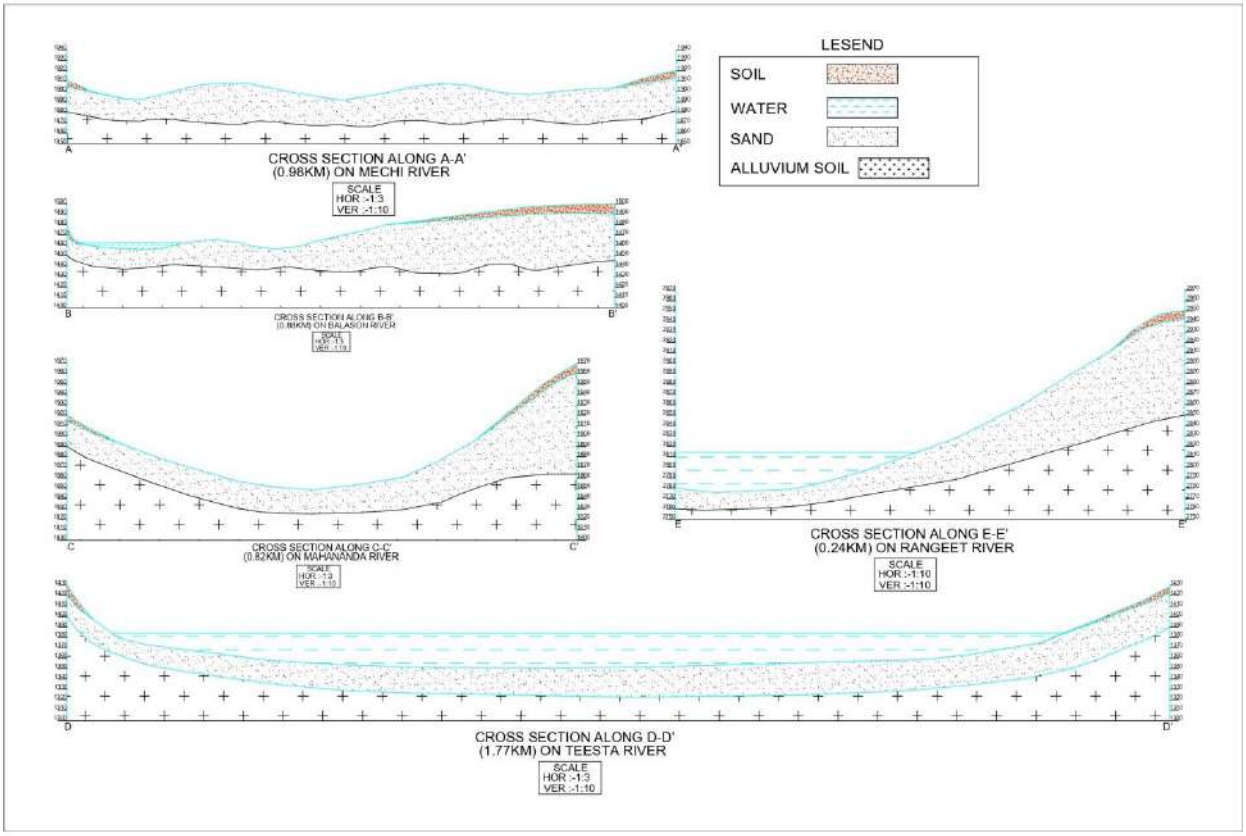

Figure 7.3: Cross section of rivers during post monsoon period

iv) Annual deposition factor

Annual deposition of riverbed materials depends on various factors, such as process of deposition, mode of sediment transport, sediment transport rate, sedimentation yield of the river.

1. Process of deposition

Deposition is the processes where material being transported by a river is deposited. Deposition occurs when the forces responsible for sediment transportation are no longer sufficient to overcome the forces of gravity and friction, creating a resistance to motion; this is known as the null-point hypothesis. This can be when a river enters a shallow area or towards its mouth where it meets another body of water.

The principle underlying the null point theory is due to the gravitational force; finer sediments remain in the water column for longer durations allowing transportation outside the surf zone to deposit under calmer conditions. The gravitational effect or settling velocity

determines the location of deposition for finer sediments, whereas a grain's internal angle of friction determines the deposition of larger grains on a shore profile.

Deposition of non-cohesive sediments: Large-grain sediments transported by either bedload or suspended load will come to rest when there is insufficient bed shear stress and fluid turbulence to keep the sediment moving; with the suspended load this can be some distance as the particles need to fall through the water column.

Deposition of cohesive sediments: The cohesion of sediment occurs with the small grain sizes associated with silts and clays, or particles smaller than 4Φ on the phi scale. If these fine particles remain dispersed in the water column, Stokes law applies to the settling velocity of the individual grains. The face of a clay platelet has a slight negative charge where the edge has a slight positive charge when two platelets come into close proximity with each other the face of one particle and the edge of the other are electrostatically attracted, and then have a higher combined mass which leads to quicker deposition through a higher fall velocity.

2. Mode of sediment transport in rivers

Sediment transport in rivers provides a dynamic linkage between flow and channel form. Mainly there are three processes by which sediment load is transported and these are rolling or traction, in which the particle moves along a sedimentary bed but is too heavy to be lifted from it; saltation; and suspension, in which particles remain permanently above the bed, sustained there by the turbulent flow of the water.

Another name for sediment transport is sediment load. The total load includes all particles moving as bedload, suspended load, and wash load.

Bed load: Bedload is the portion of sediment transport that rolls, slides or bounces along the bottom of a waterway. This sediment is not truly suspended, as it sustains intermittent contact with the streambed, and the movement is neither uniform nor continuous. Bedload occurs when the force of the water flow is strong enough to overcome the weight and cohesion of the sediment. While the particles are pushed along, they typically do not move as fast as the water around them, as the flow rate is not great enough to fully suspend them. Bedload transport can occur during low flows (smaller particles) or at high flows (for larger particles). Approximately 5-20% of total sediment transport is bedload. In situations where the flow rate is strong enough, some of the smaller bedload particles can be pushed up into the water column and become suspended.

Suspended load: While there is often overlap, the suspended load and suspended sediment are not the same thing. Suspended sediment are any particles found in the water column, whether the water is flowing or not. The suspended load, on the other hand, is the amount of sediment carried downstream within the water column by the water flow. Suspended loads require moving water, as the water flow creates small upward currents (turbulence) that

keep the particles above the bed. The size of the particles that can be carried as suspended load is dependent on the flow rate. Larger particles are more likely to fall through the upward currents to the bottom, unless the flow rate increases, increasing the turbulence at the streambed. In addition, suspended sediment will not necessarily remain suspended if the flow rate slows.

Wash load: The wash load is a subset of the suspended load. This load is comprised of the finest suspended sediment (typically less than 0.00195 mm in diameter). The wash load is differentiated from the suspended load because it will not settle to the bottom of a waterway during a low or no flow period. Instead, these particles remain in permanent suspension as they are small enough to bounce off water molecules and stay afloat. However, during flow periods, the wash load and suspended load are indistinguishable.

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's 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 Qs.

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, qt = qb + qs. 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 qs.

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 over the full width of the flow section.

Dandy Bolton formula is often used to calculate the sedimentation yield. But use of these equations to predict sediment yield for a specific location would be unwise because of the wide variability caused by local factors not considered in the equations development. However, they

may provide a quick, rough approximation of mean sediment yields on a regional basis. 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. Sedimentation Yield

All of 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 study for a river solely depends on estimation of sediment load for any river system and the estimation is a time consuming and should be done over a period. The process in general is very slow and hardly measurable on season to season basis except otherwise the effect of flood is induced which is again a cyclic phenomenon. Usually replenishment or sediment deposition quantities can be estimated in the following ways as given below:

A. Direct measurement of the sand bar upliftment, monitoring of the new sand bars created in the monsoon within the channel, elimination of sand bars during the monsoon etc. With systematic data acquisition, over a period, regression equations can be developed for modeling of the sediment yield and annual replenishment with variable components.
B. In this report, for volume estimation of sand, “Depth x Area” has been followed. The sand bars are interpreted with the help of satellite imageries. Ground truthing done for 100% of the total identified sand bars. While ground truthing, width and length of each segment were physically measured. It has also been observed that in few cases, sand bars have attained more than 3 meters height from the average top level of the river beds. Considerations of sand resources have been restricted within 3 meters from the average top surface of the river bed. Thus, in few occasions, heights for sand reserve estimation are found to be more than 3 meters.
C. The replenishment estimation based on a theoretical empirical formula with the estimation of bed-load transport comprising of analytical models to calculate the replenishment estimation.

Sedimentation in any river is dependent on sediment yield and sediment yield depends on soil erosion in river's catchment area. Catchment yield is computed using Strange's Monsoon runoff tables for runoff coefficient against rainfall return period. Peak flood discharge calculated by using Dickens, Jarvis and Rational formula at 25, 50 and 100 years return period. The estimation of bed load transport using Ackers and White Equation.

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

1. **Field data collation**

Field data collation was carried out during May- June for all the river ghats on continuous basis for pre monsoon period and October- November for all the river ghats on continuous basis for post monsoon period. However, the nonoperational areas were covered through traverses. In both the cases, relative elevation levels were captured through GPS/DGPS/ Electronic Total Station. Thickness of the sand bars was measured through sectional profiles. In few instances, sieve analysis of the sands was carried out to derive the size frequency analysis.

Figure 7.4: Figure Showing Site View of Balason River

2. Selection of Study profiles:

Study profiles are selected based on the occurrence of the sand bars 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 blocks.

3. Data Compilation:

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

- Elevation levels of the different sand Ghats and Sand Bar's as measured at site.
- Extents of the sand bars are measured from the pre monsoon satellite imageries.
- Sand production data of the district.

All these data were compiled while estimation of the replenished sand in the Darjeeling district.

4. 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.

The major sand producing rivers of the Darjeeling district are Mechi, Balason, Rangeet, Mahananda and Teesta rivers. Planning has been done for systematic sand mining in the rivers.

From the ground survey and satellite imageries study in the pre monsoon period, altogether 168 sand bars are identified in Darjeeling district of which 64 are falling in Balason river, 31 are falling in Mechi River, 25 are falling in Teesta river, 9 are falling in Mahananda river, 10 sandbar is falling in Rangeet River, 23 sand bars in Chenga River, 5 sand bars in Manja River and remaining 1 in Teri River.

In the post monsoon period, altogether 158 sand bars are identified in Darjeeling district of which 60 are falling in Balason River, 25 are falling in Mechi River, 22 are falling in Teesta river, 14 are falling in Mahananda river, 10 sandbar is falling in Rangeet River, 20 sand bars in Chenga River, 6 sand bars in Manja River and remaining 1 in Teri River.

While calculation of the areas of sand bar, a classification system has been adopted with three categories of land identified within the channel areas. the class which followed for classification are as follows:

a. The untapped Sand Bars.
b. The Sand bars worked in the pre-monsoon period.
c. Main channel course within the channel.

Details of each sand bars along with their sand resources in pre monsoon and post monsoon period are provided in Table 7.3.

Table 7.3: Estimation of Sand Resources in Pre monsoon & Post monsoon period in sand bars

Pre monsoon						Post monsoon					
S L No	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**	**S L No**	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Mechi River											
1	PR_DR_MR_MC_01	350.00	386140.1387	2.00	0.77	1	PO_DR_MR_MC_01	350	374956.9415	2.00	0.75
2	PR_DR_NB_MC_02	280.00	1501995.484	2.00	3.00	2	PO_DR_NB_MC_02	280	1795652.821	2.00	3.59
3	PR_DR_NB_MC_03	201.00	5691296.847	2.00	11.38	3	PO_DR_NB_MC_03	201	6279377.47	2.00	12.56
4	PR_DR_NB_MC_04	155.00	934161.7372	2.00	1.87	4	PO_DR_NB_MC_04	155	986233.0705	2.00	1.97
5	PR_DR_NB_MC_05	141.00	665677.8321	2.00	1.33	5	PO_DR_NB_MC_05/06	141	938723.5328	2.00	1.88
6	PR_DR_NB_MC_06	0.00	186971.6953	2.00	0.37					2.00	0.00
7	PR_DR_NB_MC_07	135.00	121177.0302	2.00	0.24	6	PO_DR_NB_MC_07	135	121177.0302	2.00	0.24
8	PR_DR_NB_MC_08	129.00	12604.33188	2.00	0.03	7	PO_DR_NB_MC_08	129	12604.33188	2.00	0.03
9	PR_DR_NB_MC_09	128.00	17067.21784	2.00	0.03	8	PO_DR_NB_MC_09	128	29393.50138	2.00	0.06
10	PR_DR_NB_MC_10	128.00	22705.90718	2.00	0.05	9	PO_DR_NB_MC_10	128	73433.45369	2.00	0.15
11	PR_DR_NB_MC_11	126.00	25493.57395	2.00	0.05	10	PO_DR_NB_MC_11	126	38125.45158	2.00	0.08
12	PR_DR_NB_MC_12	125.00	48112.47387	2.00	0.10	11	PO_DR_NB_MC_12	125	46132.81913	2.00	0.09
13	PR_DR_NB_MC_13	124.00	7984.026945	2.00	0.02	12	PO_DR_NB_MC_13	124	57658.12334	2.00	0.12
14	PR_DR_NB_MC_14	124.00	11592.76512	2.00	0.02	13	PO_DR_NB_MC_14	124	48258.72629	2.00	0.10
15	PR_DR_NB_MC_15	122.00	5883.888336	2.00	0.01	14	PO_DR_NB_MC_15	122	34465.42943	2.00	0.07
16	PR_DR_KB_MC_16	121.00	21449.85319	2.00	0.04	15	PO_DR_NB_MC_16	121	32174.41896	2.00	0.06
17	PR_DR_KB_MC_17	118.00	33721.2256	2.00	0.07	16	PO_DR_KB_MC_17	118	53582.35639	2.00	0.11
18	PR_DR_KB_MC_18	118.00	74159.39451	2.00	0.15	17	PO_DR_KB_MC_18	118	84331.60207	2.00	0.17

Pre monsoon						Post monsoon					
S L No	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**	**S L No**	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**
19	PR_DR_KB_MC_19	116.00	151675.5106	2.00	0.30	18	PO_DR_KB_MC_19	116	171608.0484	2.00	0.34
20	PR_DR_KB_MC_20	114.00	6006.396421	2.00	0.01	19	PO_DR_KB_MC_20_21_22_23	114	253442.076	2.00	0.51
21	PR_DR_KB_MC_21		107187.5744	2.00	0.21					2.00	0.00
22	PR_DR_KB_MC_22		15381.56424	2.00	0.03					2.00	0.00
23	PR_DR_KB_MC_23		6909.456023	2.00	0.01					2.00	0.00
24	PR_DR_KB_MC_24	110.00	50612.50042	2.00	0.10	20	PO_DR_KB_MC_24	110	99432.09374	2.00	0.20
25	PR_DR_KB_MC_25	109.00	5197.843057	2.00	0.01		PO_DR_KB_MC_25		0	2.00	0.00
26	PR_DR_KB_MC_26	109.00	51061.37004	2.00	0.10	21	PO_DR_KB_MC_26_27	109	79579.19554	2.00	0.16
27	PR_DR_KB_MC_27		13521.39241	2.00	0.03					2.00	0.00
28	PR_DR_KB_MC_28	107.00	40091.64604	2.00	0.08	22	PO_DR_KB_MC_28	107	40807.15973	2.00	0.08
29	PR_DR_KB_MC_29	106.00	20073.82487	2.00	0.04	23	PO_DR_KB_MC_29_30	106	130865.3075	2.00	0.26
30	PR_DR_KB_MC_30		68856.54452	2.00	0.14					2.00	0.00
31	PR_DR_KB_MC_31	104.00	62257.11784	2.00	0.12	24	PO_DR_KB_MC_31	104	73873.21073	2.00	0.15
	PR_DR_KB_MC_32		0	2.00	0.00	25	PO_DR_KB_MC_32	104	46922.08166	2.00	0.09
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Chenga River											
1	PR_DR_MR_CG_01	235.80	149016.8751	2.00	0.30	1	PO_DR_MR_CG_01	236	149016.8751	2.20	0.33
2	PR_DR_MR_CG_02	219.80	11272.42398	2.00	0.02	2	PO_DR_MR_CG_02	220	11272.42398	2.20	0.02
3	PR_DR_MR_CG_03	212.80	18835.62187	2.00	0.04	3	PO_DR_MR_CG_03	213	45826.30901	2.20	0.10
4	PR_DR_MR_CG_04	206.80	17645.18586	2.00	0.04	4	PO_DR_MR_CG_04	207	17457.28248	2.20	0.04
5	PR_DR_NB_CG_05	201.80	20810.97352	2.00	0.04	5	PO_DR_NB_CG_05	202	39673.28957	2.20	0.09
6	PR_DR_NB_CG_06	184.80	27961.52546	2.00	0.06	6	PO_DR_NB_CG_06	185	27961.52546	2.20	0.06
7	PR_DR_PD_CG_07	125.80	17593.9112	2.00	0.04	7	PO_DR_PD_CG_07	126	17593.9112	2.20	0.04
8	PR_DR_PD_CG_08	115.80	38929.13182	2.00	0.08	8	PO_DR_PD_CG_08	116	24929.2005	2.20	0.05
9	PR_DR_PD_CG_09	113.80	23519.87231	2.00	0.05	9	PO_DR_PD_CG_09	114	13585.44219	2.20	0.03
10	PR_DR_PD_CG_10	108.80	39130.90264	2.00	0.08	10	PO_DR_PD_CG_10	109	49704.60976	2.20	0.11
11	PR_DR_PD_CG_11	102.80	146754.979	2.00	0.29	11	PO_DR_PD_CG_11_12	103	249283.8867	2.20	0.55
12	PR_DR_PD_CG_12		27974.3195	2.00	0.06					2.20	0.00

Pre monsoon						Post monsoon					
S L No	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**	**S L No**	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**
13	PR_DR_PD_CG_13	97.80	174584.4266	2.00	0.35	12	PO_DR_PD_CG_13	98	34372.027	2.20	0.08
14	PR_DR_PD_CG_14	95.80	52266.93401	2.00	0.10	13	PO_DR_PD_CG_14	96	55340.04873	2.20	0.12
15	PR_DR_PD_CG_15	94	15243.50607	2.00	0.03		PO_DR_PD_CG_15		0	2.20	0.00
16	PR_DR_PD_CG_16	93	41877.62784	2.00	0.08		PO_DR_PD_CG_16		0	2.20	0.00
17	PR_DR_PD_CG_17	89.80	17539.43885	2.00	0.04	14	PO_DR_PD_CG_17	90	17539.43885	2.20	0.04
18	PR_DR_PD_CG_18	87.80	10353.02705	2.00	0.02	15	PO_DR_PD_CG_18	88	10353.02705	2.20	0.02
19	PR_DR_PD_CG_19	87.80	19464.56591	2.00	0.04	16	PO_DR_PD_CG_19	88	19464.56591	2.20	0.04
20	PR_DR_PD_CG_20	86.80	13820.4434	2.00	0.03	17	PO_DR_PD_CG_20	87	13820.4434	2.20	0.03
21	PR_DR_PD_CG_21	85.80	69773.2671	2.00	0.14	18	PO_DR_PD_CG_21	86	57007.45881	2.20	0.13
22	PR_DR_PD_CG_22	85.80	24178.93956	2.00	0.05	19	PO_DR_PD_CG_22	86	24178.93956	2.20	0.05
23	PR_DR_PD_CG_23	84.80	8332.067015	2.00	0.02	20	PO_DR_PD_CG_23	85	28338.45711	2.20	0.06
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Manja River											
1	PR_DR_PD_MJ_01	109.00	6982.540847	1.50	0.01	1	PO_DR_PD_MJ_01_02	109	29682.99647	1.50	0.04
2	PR_DR_PD_MJ_02		8741.82696	1.50	0.01						
3	PR_DR_PD_MJ_03	103.00	119415.7963	1.50	0.18	2	PO_DR_PD_MJ_03	103	110117.0527	1.50	0.17
4	PR_DR_PD_MJ_04	99.00	10427.18819	1.50	0.02	3	PO_DR_PD_MJ_04	99	8197.118949	1.50	0.01
	PR_DR_PD_MJ_04A		0	1.50	0.00	4	PO_DR_PD_MJ_04A	97	31254.30521	1.50	0.05
5	PR_DR_PD_MJ_05	91.00	13696.40396	1.50	0.02	5	PO_DR_PD_MJ_05	91	13696.40396	1.50	0.02
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Tari River											
1	PR_DR_KB_TA_01	92.00	42360.42288	1.00	0.04	1	PO_DR_KB_TA_01	92	41470.00566	1.00	0.04
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Balason River											
1	PR_DR_KS_BS_01	241.90	587841.9225	2.90	1.70	1	PO_DR_KS_BS_01	242	532484.3762	3.00	1.60
2	PR_DR_KS_BS_02	228.90	38826.31253	2.90	0.11	2	PO_DR_KS_BS_02	229	38826.31253	3.00	0.12
3	PR_DR_KS_BS_03	212.90	85031.9871	2.90	0.25	3	PO_DR_KS_BS_03	213	85031.9871	3.00	0.26
4	PR_DR_KS_BS_04	212.90	78793.70037	2.90	0.23	4	PO_DR_KS_BS_04	213	78793.70037	3.00	0.24
5	PR_DR_KS_BS_05	203.90	13960.32138	2.90	0.04	5	PO_DR_KS_BS_05_06	204	72137.56893	3.00	0.22
6	PR_DR_KS_BS_06		33380.44311	2.90	0.10					3.00	0.00

Pre monsoon						Post monsoon					
S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum	S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum
7	PR_DR_KS_BS_07	198.00	13426.66741	2.90	0.04	6	PO_DR_KS_BS_07		0	3.00	0.00
8	PR_DR_KS_BS_08	194.90	134824.3046	2.90	0.39	7	PO_DR_KS_BS_08	195	78826.83453	3.00	0.24
9	PR_DR_KS_BS_09	194.90	120096.2076	2.90	0.35	8	PO_DR_KS_BS_09	195	151868.449	3.00	0.46
10	PR_DR_KS_BS_10	189.90	166185.4849	2.90	0.48	9	PO_DR_KS_BS_10	190	177682.3498	3.00	0.53
11	PR_DR_KS_BS_11	182.90	25418.67763	2.90	0.07	10	PO_DR_KS_BS_11	183	134311.0883	3.00	0.40
12	PR_DR_KS_BS_11A		0	2.90	0.00	11	PO_DR_KS_BS_11A	182	59481.29561	3.00	0.18
13	PR_DR_KS_BS_12	182.00	8330.549815	2.90	0.02	12	PO_DR_KS_BS_12		0	3.00	0.00
14	PR_DR_KS_BS_13	181.90	35296.32955	2.90	0.10	13	PO_DR_KS_BS_13	182	35296.32955	3.00	0.11
15	PR_DR_KS_BS_14	181.90	17759.61213	2.90	0.05	14	PO_DR_KS_BS_14	182	17759.61213	3.00	0.05
16	PR_DR_KS_BS_15	176.90	131734.3963	2.90	0.38	15	PO_DR_KS_BS_15	177	131750.3718	3.00	0.40
17	PR_DR_KS_BS_16	174.90	104011.6317	2.90	0.30	16	PO_DR_KS_BS_16	175	152965.8039	3.00	0.46
18	PR_DR_KS_BS_17	165.90	244715.1847	2.90	0.71	17	PO_DR_KS_BS_17	166	324409.7074	3.00	0.97
19	PR_DR_NB_BS_18	158.90	113335.9098	2.90	0.33	18	PO_DR_NB_BS_18	159	72900.28369	3.00	0.22
20	PR_DR_NB_BS_19	156.90	49908.57086	2.90	0.14	19	PO_DR_NB_BS_19	157	98704.0894	3.00	0.30
21	PR_DR_NB_BS_20	154.90	37630.2674	2.90	0.11	20	PO_DR_NB_BS_20	155	48716.17657	3.00	0.15
22	PR_DR_NB_BS_21	152.90	39633.16304	2.90	0.11	21	PO_DR_NB_BS_21_22	153	115309.2928	3.00	0.35
23	PR_DR_NB_BS_22		49122.03895	2.90	0.14					3.00	0.00
24	PR_DR_MT_BS_23	151.90	41838.69885	2.90	0.12	22	PO_DR_NB_BS_23	152	38799.61021	3.00	0.12
25	PR_DR_MT_BS_24	146.90	508170.0666	2.90	1.47	23	PO_DR_MT_BS_24	147	541482.9003	3.00	1.62
26	PR_DR_MT_BS_25	143.90	24835.23287	2.90	0.07	24	PO_DR_MT_BS_25	144	111975.976	3.00	0.34
27	PR_DR_MT_BS_26	139.90	19765.36701	2.90	0.06	25	PO_DR_MT_BS_26	140	57552.61059	3.00	0.17
28	PR_DR_MT_BS_27	140.90	44453.87976	2.90	0.13	26	PO_DR_MT_BS_27	141	44453.87976	3.00	0.13
29	PR_DR_MT_BS_28	139.00	9467.031073	2.90	0.03	27	PO_DR_MT_BS_28		0	3.00	0.00
30	PR_DR_MT_BS_29	134.90	55866.90274	2.90	0.16	28	PO_DR_MT_BS_29_30	135	297581.9556	3.00	0.89
31	PR_DR_MT_BS_30		76304.83613	2.90	0.22					3.00	0.00
32	PR_DR_MT_BS_31	141.90	11490.60213	2.90	0.03	29	PO_DR_MT_BS_31	142	11490.60213	3.00	0.03

Pre monsoon						Post monsoon					
S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum	S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum
33	PR_DR_MT_BS_32	141.90	40819.8789	2.90	0.12	30	PO_DR_MT_BS_32	142	40819.8789	3.00	0.12
34	PR_DR_MT_BS_33	135.00	12908.85198	2.90	0.04	31	PO_DR_MT_BS_33		0	3.00	0.00
35	PR_DR_MT_BS_34	130.00	5235.225524	2.90	0.02	32	PO_DR_MT_BS_34		0	3.00	0.00
36	PR_DR_MT_BS_35	129.90	18784.00988	2.90	0.05	33	PO_DR_MT_BS_35	130	37559.37117	3.00	0.11
37	PR_DR_MT_BS_35A	127.90		2.90	0.00	34	PO_DR_MT_BS_35A	128	52209.44582	3.00	0.16
38	PR_DR_MT_BS_36	125.90	147637.3023	2.90	0.43	35	PO_DR_MT_BS_36	126	115172.0576	3.00	0.35
39	PR_DR_MT_BS_37	121.90	11736.13458	2.90	0.03	36	PO_DR_MT_BS_37	122	11736.13458	3.00	0.04
40	PR_DR_MT_BS_38	121.90	38240.02384	2.90	0.11	37	PO_DR_MT_BS_38	122	38240.02384	3.00	0.11
41	PR_DR_MT_BS_39	116.90	69556.59073	2.90	0.20	38	PO_DR_MT_BS_39	117	69556.59073	3.00	0.21
42	PR_DR_MT_BS_40	116.90	79637.25605	2.90	0.23	39	PO_DR_MT_BS_40_41	117	325857.6498	3.00	0.98
43	PR_DR_MT_BS_41		62633.27197	2.90	0.18					3.00	0.00
44	PR_DR_MT_BS_42	116.00	65485.82206	2.90	0.19	40	PO_DR_MT_BS_42		0	3.00	0.00
45	PR_DR_MT_BS_43	116.00	199938.009	2.90	0.58	41	PO_DR_MT_BS_43		0	3.00	0.00
46	PR_DR_NB_BS_44	109.90	5876.887874	2.90	0.02	42	PO_DR_NB_BS_44	110	5876.887874	3.00	0.02
47	PR_DR_PD_BS_45	107.90	3671.742335	2.90	0.01	43	PO_DR_PD_BS_45	108	3671.742335	3.00	0.01
48	PR_DR_PD_BS_46	106.90	3454.728011	2.90	0.01	44	PO_DR_PD_BS_46	107	20346.8051	3.00	0.06
49	PR_DR_PD_BS_47	104.90	6303.916058	2.90	0.02	45	PO_DR_PD_BS_47	105	6303.916058	3.00	0.02
50	PR_DR_PD_BS_48	102.90	6744.945166	2.90	0.02	46	PO_DR_PD_BS_48	103	6744.945166	3.00	0.02
51	PR_DR_PD_BS_49	101.90	5883.888336	2.90	0.02	47	PO_DR_PD_BS_49	102	5883.888336	3.00	0.02
52	PR_DR_PD_BS_49A		0	2.90	0.00	48	PO_DR_PD_BS_49A	102	8370.614064	3.00	0.03
53	PR_DR_PD_BS_50	99.90	4504.797316	2.90	0.01	49	PO_DR_PD_BS_50	100	4504.797316	3.00	0.01
54	PR_DR_PD_BS_51	99.90	3748.747417	2.90	0.01	50	PO_DR_PD_BS_51	100	10597.17901	3.00	0.03
55	PR_DR_PD_BS_51A		0	2.90	0.00	51	PO_DR_PD_BS_51A	100	8110.137629	3.00	0.02
56	PR_DR_PD_BS_52	98.90	8999.093939	2.90	0.03	52	PO_DR_PD_BS_52	99	8999.093939	3.00	0.03
57	PR_DR_PD_BS_53	96.90	5066.006522	2.90	0.01	53	PO_DR_PD_BS_53	97	5066.006522	3.00	0.02
58	PR_DR_PD_BS_54	94.90	4193.276756	2.90	0.01	54	PO_DR_PD_BS_54	95	4193.276756	3.00	0.01

Pre monsoon						Post monsoon					
S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum	S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum
59	PR_DR_PD_BS_55	93.90	7539.497606	2.90	0.02	55	PO_DR_PD_BS_55	94	7539.497606	3.00	0.02
60	PR_DR_PD_BS_55A		0	2.90	0.00	56	PO_DR_PD_BS_55A	94	6261.913286	3.00	0.02
61	PR_DR_PD_BS_56	92.90	12947.35452	2.90	0.04	57	PO_DR_PD_BS_56	93	12947.35452	3.00	0.04
62	PR_DR_PD_BS_57	91.90	20392.34589	2.90	0.06	58	PO_DR_PD_BS_57	92	20392.34589	3.00	0.06
63	PR_DR_PD_BS_58	91.90	15415.01739	2.90	0.04	59	PO_DR_PD_BS_58	92	15415.01739	3.00	0.05
64	PR_DR_PD_BS_59	90.90	5169.841209	2.90	0.01	60	PO_DR_PD_BS_59	91	5169.841209	3.00	0.02
65	PR_DR_PD_BS_60	90.90	13255.37485	2.90	0.04	61	PO_DR_PD_BS_60	91	13255.37485	3.00	0.04
66	PR_DR_PD_BS_60A		0	2.90	0.00	62	PO_DR_PD_BS_60A	91	8551.064369	3.00	0.03
67	PR_DR_PD_BS_60B		0	2.90	0.00	63	PO_DR_PD_BS_60B	90	15555.02663	3.00	0.05
68	PR_DR_PD_BS_61	89.90	14196.937	2.90	0.04	64	PO_DR_PD_BS_61	90	14196.937	3.00	0.04
69	PR_DR_PD_BS_62	87.90	7350.485131	2.90	0.02	65	PO_DR_PD_BS_62	88	7350.485131	3.00	0.02
70	PR_DR_PD_BS_63	87.90	7448.491599	2.90	0.02	66	PO_DR_PD_BS_63	88	7448.491599	3.00	0.02
71	PR_DR_PD_BS_64	87.90	16454.586	2.90	0.05	67	PO_DR_PD_BS_64	88	16454.586	3.00	0.05
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Mahananda River											
1	PR_DR_KS_MH_01	168.90	1760564.451	2.90	5.11	1	PO_DR_KS_MH_01	169	1617157.915	3.00	4.85
2	PR_DR_MT_MH_02	131.90	246724.212	2.90	0.72	2	PO_DR_MT_MH_02	132	246724.212	3.00	0.74
3	PR_DR_MT_MH_03	125.00	71799.95059	2.90	0.21	3	PO_DR_MT_MH_03		0	3.00	0.00
4	PR_DR_MT_MH_04	111.90	17286.76593	2.90	0.05	4	PO_DR_MT_MH_04	112	17286.76593	3.00	0.05
5	PR_DR_PD_MH_04A		0	2.90	0.00	5	PO_DR_PD_MH_04A	100	18844.54713	3.00	0.06
6	PR_DR_PD_MH_05	97.90	65454.31998	2.90	0.19	6	PO_DR_PD_MH_05	98	65454.31998	3.00	0.20
7	PR_DR_PD_MH_06	96.90	48373.40787	2.90	0.14	7	PO_DR_PD_MH_06	97	48373.40787	3.00	0.15
8	PR_DR_PD_MH_07	96.90	114401.5505	2.90	0.33	8	PO_DR_PD_MH_07	97	148616.6717	3.00	0.45
9	PR_DR_PD_MH_08	94.90	137068.5961	2.90	0.40	9	PO_DR_PD_MH_08	95	98836.89014	3.00	0.30
10	PR_DR_PD_MH_08A		0	2.90	0.00	10	PO_DR_PD_MH_08A	96	9488.779412	3.00	0.03
11	PR_DR_PD_MH_09	94.90	43258.69882	2.90	0.13	11	PO_DR_PD_MH_09	95	43258.69882	3.00	0.13
12	PR_DR_PD_MH_10		0	2.90	0.00	12	PO_DR_PD_MH_10	90	21690.83813	3.00	0.07
13	PR_DR_PD_MH_11		0	2.90	0.00	13	PO_DR_PD_MH_11	86	35073.18814	3.00	0.11

Pre monsoon						Post monsoon					
S L No	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**	**S L No**	**Sand Bar_Code**	**RL (m)**	**Area in sq.m.**	**Sand Thickness in m.**	**Sand Volume in M. Cum**
14	PR_DR_PD_MH_12		0	2.90	0.00	14	PO_DR_PD_MH_12	86	39361.93651	3.00	0.12
15	PR_DR_PD_MH_13		0	2.90	0.00	15	PO_DR_PD_MH_13	85	26036.32737	3.00	0.08
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Teesta River											
1	PR_DR_KS_TS_01	150.90	23287.03694	2.90	0.07	1	PO_DR_KS_TS_01	151	37900.65133	3.00	0.11
2	PR_DR_KS_TS_02	147.90	10392.04587	2.90	0.03	2	PO_DR_KS_TS_02	148	10392.04587	3.00	0.03
3	PR_DR_KS_TS_03	146.90	11583.80453	2.90	0.03	3	PO_DR_KS_TS_03	147	11583.80453	3.00	0.03
4	PR_DR_KS_TS_04	142.90	23173.29613	2.90	0.07	4	PO_DR_KS_TS_04	143	23173.29613	3.00	0.07
5	PR_DR_KS_TS_05	142.90	22506.76544	2.90	0.07	5	PO_DR_KS_TS_05	143	31437.86902	3.00	0.09
6	PR_DR_KS_TS_05A		0	2.90	0.00	6	PO_DR_KS_TS_05A	141	17836.11681	3.00	0.05
7	PR_DR_KS_TS_05B		0	2.90	0.00	7	PO_DR_KS_TS_05B	141	12452.17212	3.00	0.04
8	PR_DR_KS_TS_06	137.90	61723.72652	2.90	0.18	8	PO_DR_KS_TS_06	138	76714.02965	3.00	0.23
9	PR_DR_KS_TS_07	137.90	813336.7827	2.90	2.36	9	PO_DR_KS_TS_07_08	138	921983.5031	3.00	2.77
10	PR_DR_KS_TS_08		8610.988324	2.90	0.02					3.00	0.00
11	PR_DR_KS_TS_09	137.90	40826.69456	2.90	0.12	10	PO_DR_KS_TS_09	138	27045.79337	3.00	0.08
12	PR_DR_KS_TS_10	134.90	60585.49864	2.90	0.18	11	PO_DR_KS_TS_10	135	125552.9512	3.00	0.38
13	PR_DR_KS_TS_11	134.90	208806.2812	2.90	0.61	12	PO_DR_KS_TS_11	135	316259.9218	3.00	0.95
14	PR_DR_KS_TS_12	133.90	40739.18878	2.90	0.12	13	PO_DR_KS_TS_12	134	40739.18878	3.00	0.12
15	PR_DR_KS_TS_13	132.90	22250.96856	2.90	0.06	14	PO_DR_KS_TS_13	133	22250.96856	3.00	0.07
16	PR_DR_KS_TS_13A		0	2.90	0.00	15	PO_DR_KS_TS_13A	133	16048.5592	3.00	0.05
17	PR_DR_KS_TS_14	131.90	24110.7113	2.90	0.07	16	PO_DR_KS_TS_14_15	132	81661.99929	3.00	0.24
18	PR_DR_KS_TS_15		20567.07742	2.90	0.06					3.00	0.00
19	PR_DR_KS_TS_16	131.90	17690.44757	2.90	0.05	17	PO_DR_KS_TS_16	132	27192.8123	3.00	0.08
20	PR_DR_KS_TS_18	131.90	425733.0578	2.90	1.23	18	PO_DR_KS_TS_18	132	450719.1466	3.00	1.35
21	PR_DR_KS_TS_17	131.90	25125.49828	2.90	0.07	19	PO_DR_KS_TS_17_19_20_21_22	132	298868.0621	3.00	0.90
22	PR_DR_KS_TS_19		19681.93901	2.90	0.06					3.00	0.00
23	PR_DR_KS_TS_20		14804.71711	2.90	0.04					3.00	0.00
24	PR_DR_KS_TS_21		12402.9986	2.90	0.04					3.00	0.00

Pre monsoon						Post monsoon					
S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum	S L No	Sand Bar_Code	RL (m)	Area in sq.m.	Sand Thickness in m.	Sand Volume in M. Cum
25	PR_DR_KS_TS_22		200283.1453	2.90	0.58					3.00	0.00
26	PR_DR_KS_TS_22A		0	2.90	0.00	20	PO_DR_KS_TS_22A	130	52260.72032	3.00	0.16
27	PR_DR_KS_TS_23	127.90	211408.4842	2.90	0.61	21	PO_DR_KS_TS_23	128	439680.7282	3.00	1.32
28	PR_DR_KS_TS_24	126.90	71563.31692	2.90	0.21	22	PO_DR_KS_TS_24_25	127	262820.1684	3.00	0.79
29	PR_DR_KS_TS_25		74680.71017	2.90	0.22					3.00	0.00
Estimation of Sand Resources in Pre monsoon period & Post monsoon period in sand bar regions of Rangeet River											
1	PR_DR_DP_RG_01	358.00	171562.3999	2.00	0.34	1	PO_DR_DP_RG_01	358	171562.3999	2.00	0.34
2	PR_DR_DP_RG_02	288.00	109149.685	2.00	0.22	2	PO_DR_DP_RG_02	288	109149.685	2.00	0.22
3	PR_DR_DP_RG_03	267.00	13412.01019	2.00	0.03	3	PO_DR_DP_RG_03	267	13412.01019	2.00	0.03
4	PR_DR_DP_RG_04	271.00	11974.2903	2.00	0.02	4	PO_DR_DP_RG_04	271	11974.2903	2.00	0.02
5	PR_DR_DP_RG_05	268.00	28415.75044	2.00	0.06	5	PO_DR_DP_RG_05	268	28415.75044	2.00	0.06
6	PR_DR_DP_RG_06	264.00	20875.37777	2.00	0.04	6	PO_DR_DP_RG_06	264	20875.37777	2.00	0.04
7	PR_DR_DP_RG_07	262.00	3566.735404	2.00	0.01	7	PO_DR_DP_RG_07	262	3566.735404	2.00	0.01
8	PR_DR_DP_RG_08	263.00	9500.467029	2.00	0.02	8	PO_DR_DP_RG_08	263	9500.467029	2.00	0.02
9	PR_DR_DP_RG_09	263.00	9110.681304	2.00	0.02	9	PO_DR_DP_RG_09	263	9110.681304	2.00	0.02
10	PR_DR_RR_RG_10	237.00	30851.31618	2.00	0.06	10	PO_DR_RR_RG_10	237	30851.31618	2.00	0.06

Maps showing distribution of sand bars on rivers of the Darjeeling district during Pre and Post monsoon are depicted in Plate 2A & Plate 2B respectively.

Table 7.4: Sediment load comparison between Pre and Post Monsoon period for different rivers of Darjeeling district

River Name	Pre-Monsoon no of ghats	Post-Monsoon no of ghats	Pre-Monsoon Sediment Load (Mcum)	Post Monsoon Sediment Load (Mcum)	Variance (Mcum)	Variance (%)
Mechi	31	25	20.73	23.81	3.07	14.81
Chenga	23	20	1.97	1.99	0.02	1.07
Manja	5	5	0.24	0.29	0.05	21.15
Tari	1	1	0.04	0.04	0.00	-2.10
Balason	71	67	11.17	13.35	2.18	19.51
Mahananda	15	15	7.26	7.31	0.04	0.61

River Name	Pre-Monsoon no of ghats	Post-Monsoon no of ghats	Pre-Monsoon Sediment Load (Mcum)	Post Monsoon Sediment Load (Mcum)	Variance (Mcum)	Variance (%)
Teesta	29	22	7.15	9.91	2.76	38.63
Rangeet	10	10	0.82	0.82	0.00	0.00
Total =	185	165	**49.39**	**57.52**	**8.13**	**16.46**

Thus, in Darjeeling district, about 8.13 Million cum of sand has been found as an incremental volume when compared between pre and post monsoon sand reserve data. Percentage of difference comes to about 116.46%. Considering the quantum of sand accumulated in the year during monsoon, and also considering mining activity (@15%), a replenishment and aggradation rate for the year comes to about 98.99%.

vi) Total potential of minor mineral in the river bed

The major sand producing rivers of the Darjeeling district are Mechi, Balason, Rangeet, Mahananda and Teesta rivers. Planning has been done for systematic sand mining in the rivers.

B. Geological studies

i) Lithology of the catchment area

Darjeeling Himalaya consists essentially of unaltered sedimentary rocks. The Sub-Himalaya is made up of Siwalik deposits of the Tertiary age. The Terai and the foothills were given their present form after the final upheaval of the Himalayan orogeny and consist of almost horizontal layers of unconsolidated sand, silt, pebbles and gravel. The Darjeeling gneiss occupies a greater part of the region and is found along the higher reaches of the hills. The Darjeeling gneiss consists of garnetiferous mica-schists, quartzites, biotite-kyanite and sillimantic gneiss.

ii) Tectonics and structural behavior of rocks

The Sikkim-Darjeeling Himalaya contains the stretch of tectonically active Eastern Himalaya. It is composed of three main tectonic units: the Higher Himalaya, the Lower Himalaya and the Siwaliks separated by thrusts. Darjeeling-Sikkim Himalaya is one of the important fault thrust belt in the Himalaya covering the rocks of Central Crystalline Gneissic Complex, Daling Phyllite, Gondwana, Buxa and Siwaliks from north to south. Quaternary rock delimits the Himalaya in the southern part. A number of thrust namely MCT, MBT, MFT and also Daling Thrust are reported in this fault thrust belt.

C. Climate Factors

i) Intensity of rainfall

The average annual rainfall is 2973 mm. The maximum rainfall in the area as per IMD data was recorded in the month of July followed by August and September. The rainy season in the district commence from June and lasts till September. The intensity of rainfall due to depressions sometimes becomes very great and may cause enhanced soil erosion in the district.

ii) Climate zone

Darjeeling district has two different climatic conditions due to its distinctive topographical features having hills in a larger portion of the district and plain-lands of Terai towards South and South-Eastern part. The Hills have a temperate weather condition, with pleasant summer and cold winter with occasional snowfall. On the other hand, the marshy tract of Terai is humid and warm, showing typical Tropical and Sub-Tropical climatic conditions depending upon the elevation.

iii) Temperature variation

The temperature in the hilly areas of Darjeeling district varies from 25°C to near freezing points. The maximum temperature is usually reached during monsoon and the lowest temperature is reached during the cold winter, between December to March. The lowest temperature of the district remains around 10°C to (-) 3°C, depending on elevation.

Table 7.5: Annual deposition of Riverbed minerals

Sl. No.	River or Stream	Portion of the river stream recommended for mineral concession	Length of area recommended for mineral concession (in meter)	Average width of area recommended for mineral concession (in meters)	Area recommended for mineral concession (in Sqm)	Mineable mineral potential (in Mcum) (60% of total mineral potential
1	MECHI	95.31	25304.44	392.40	9929354.38	11.92
2	CHENGA	39.75	14380.87	57.81	831390.01	1.10
3	MANJA	11.68	1725.41	67.34	116195.52	0.10
4	TARI	40.34	846.51	34.87	29518.81	0.02
5	BALASON	48.04	31522.04	111.39	3511292.33	6.32
6	MAHANANDA	56.07	21316.12	81.19	1730736.12	3.12
7	TEESTA	50.60	9460.32	275.02	2601808.85	4.68
8	RANJEET	38.54	7524.74	44.62	335779.24	0.40

River Name	Considered Thickness (m)
MECHI	2
CHENGA	2.2
MANJA	1.5
TARI	1
BALASON	3
MAHANANDA	3
TEESTA	3
RANJEET	2

Sand bar area recommended for mineral concession in the above table is being calculated as per the Enforcement & Monitoring Guidelines for Sand Mining (EMGSM) 2020. As per guidelines, mining depth restricted to 3 meters depth and distance from the bank is ¼th of river width and not be less than 7.5 meters. Also mining is prohibitated 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 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.

III. Riverbed Mineral Potential

Sand is the important riverbed mineral found to be potential for mining. Considerable quantity of quality sands are found to occur in part of Balason, Mechi, Mahananda, Teesta and Rangeet rivers. Smaller patches are also available locally in the other smaller rivers as well. Sand mining can be developed on cluster approach with restricted usage of Machinery's for lifting of sands. The rivers in the north Bengal are filled by Gravels & boulders. Development of river bed material with huge boulders also requires usage of machinery's to increase more production in turn revenue.

Table 7.6: Resources of Potential Riverbed Mineral

Boulder (Mcum)	Pebbles/Gravel (Mcum)	Sand/White sand (Mcum)	Total Mineable, Mineral Potential (Mcum)
5.53	8.29	13.83	27.66

Table 7.7: Potential Zone of Riverbed Mineral

Sl. No	Rivers or Streams	Location of potential zones						Area within prohibited zone as per rule 3 of WBMMC Rules, 2016 (in sq.m)
		Administrative Block	Mouza	JL No.	Zone	Co-ordinates		
						Latitude	Longitude	
1	MECHI	NAXALBARI	Baramaniram,Madan	20,1	1	26.82867	88.169187	1597266.69
						26.65199	88.163528	
		KHORIBARI	Madan & Bajarpur Chat,Antaram,Bhulka	01,04,5,6	2	26.639	88.163102	121222.05
						26.60559	88.134069	
2	CHENGA	MIRIK	Gaziram	60	1	26.78501	88.209322	5967.81
						26.76264	88.227804	
		NAXALBARI	Gaziram	60	2	26.76264	88.227804	634.51
						26.74709	88.234262	
		PHANSIDEWA	Patharhirhira,Tentulguri	25,33	3	26.64672	88.272623	32455.32
						26.60829	88.282085	
		PHANSIDEWA	Tarabandha,Dhambhita	69,38	4	26.57425	88.266097	295.29
						26.55169	88.229627	
3	MANJA	PHANSIDEWA	Tantilguri,Tentulguri	33	1	26.62261	88.259984	23604.53
						26.60759	88.2661	
4	TARI	KHORIBARI	Bagilahagi & Chuchur	72,74	1	26.5857	88.222201	11951.20
						26.57873	88.22165	
5	BALASON	NAXALBARI	Radha	72	1	26.6567	88.339526	0.00
						26.65528	88.340923	
		PHANSIDEWA	Radha	72	2	26.65528	88.340923	2297.30
						26.65183	88.339017	
		PHANSIDEWA	Sirsia	71	3	26.63912	88.337699	653.20
						26.63587	88.337557	
		PHANSIDEWA	Nembutari	86	4	26.61615	88.339318	1639.77
						26.58903	88.3271	
		PHANSIDEWA	Kantivitta	87	5	26.57806	88.321921	2833.93
						26.53947	88.30042	
		KURSEONG	Mm Tarai,Bournivitar Chhat	78,82	6	26.80307	88.248349	305892.04
						26.75319	88.320903	
		MATIGARA	Bournivitar Chhat	82	7	26.77077	88.297074	19313.13
						26.76359	88.30898	

Sl. No	Rivers or Streams	Location of potential zones						Area within prohibited zone as per rule 3 of WBMMC Rules, 2016 (in sq.m)
		Administrative Block	Mouza	JL No.	Zone	Co-ordinates		
						Latitude	Longitude	
		NAXALBARI	Lalsara	62	8	26.75651	88.314609	46240.77
						26.74822	88.3219	
		MATIGARA	Lalsara,Dumriguri Chhat, Patanara Chat,Bataliguri, Panchkulguri,Nemai	62,49,61, 64,59,57	9	26.75319	88.320903	171633.46
						26.72376	88.37203	
		MATIGARA	Kalam	76	10	26.70957	88.381549	43173.65
						26.70247	88.386613	
6	MAHANANDA	KURSEONG	Purba Karaibari Chat	31	1	26.82888	88.384216	311262.67
						26.80969	88.405868	
		KURSEONG	Purba Karaibari Chat	31	2	26.80314	88.414772	1132.32
						26.79825	88.4202	
		MATIGARA	Duramarir Chhat	36	3	26.78806	88.43404	15822.54
						26.78066	88.439945	
		PHANSIDEWA	Purba Bansgaon	113	4	26.62751	88.400666	45160.08
						26.49605	88.327241	
7	TEESTA	KURSEONG	Pulundung	9	1	26.92629	88.455159	17321.00
						26.9051	88.472404	
		KURSEONG	Pulundung	9	2	26.87634	88.475511	238750.40
						26.8388	88.513117	
8	RANJEET	DARJEELING PULBAZAR	Pulundung	9	1	27.12767	88.283551	65672.79
						27.10697	88.335951	
		RANGLI RANGLIOT	Pulundung	9	2	27.0968	88.366277	6966.69
						27.09708	88.370251	

7.2.2 In-situ Minerals:

I. Mineral Reserve

Mineral resources of the district are still not well established. Reserve of Coal is only mentioned in the Mineral Year Book of West Bengal 2014. Occurrences of coal have been established over a stretch of 77 km between Pankhabari to the west of the Darjeeling district and Jaldhaka to the east of Kalimpong district. Coal reserves are found in Dalingkot coalfield, several

seam occur near Tindharia. A total of 15 million tonne of inferred resources of coal down to a depth of 300m has been estimated (Source: Glimpse of Geology of West Bengal, GSI Publication).

Coal bearing Dumuda series consisting of quartzitic and carbonaceous sandstone, shale and coal occur as a thin bed being sandwiched in between two thrusts viz. Daling thrust in the north against Daling rocks and Main Boundary Fault in the south against Siwalik rocks. As a result of thrusting, Daling rocks of Precambrian age are lying above the Damuda of Lower Gondwana (Permian) with a reverse succession. Generally the rocks striking in West-Southwest to East-Northeast direction have a steep (up to 80°) northerly dip. These Gondwana rocks are well exposed at Pankhabari, Tindharia, Kalijhora, Bagrakotx, Dalingkot and in the valley of Mahanadi and Teesta. The coal exposure beds are not continuous everywhere due to nature of thrusting. This coal bearing Damuda Series has been lithologically sub-divided into three units i.e., upper and a lesser coal bearing unit separated by a barren unit. The upper, middle and lower units are formally named as the Dalingkot, Chunabhati and Rongtong formation.

II. Mineral Potential

The Sikkim-Darjeeling area is dotted with as many as 40 base metal occurrences confined essentially to the Daling /Darjeeling Group of rocks with biotitic granites occurring as tongue-like bodies. Peshok in Darjeeling district copper deposits established which grades between 0.5% and 2.5% Cu (VE) (Source: Mineral Resources of India, GSI).

A talc lens sandwiched between overlying Daling quartzite and underlying Daling phyllite has been located on a hill slope in north-eastern part of the area at Darjeeling Gorkha Hill Council Forest beside Village Singla. The continuity of the talc lens has been traced down slope over a distance of about 120 m. The analyses of pure/impure talc bodies show 18.91-34.94% MgO with average of 31.63% MgO (Source: Mineral Year Book, WB 2014).

Graphite occurrences have been noted in the Daling Group along Rakti River and as carbonaceous material (mainly graphite) in Sukheapukh-Tanglu road.

A 1.6 Km. long lenticular ferruginous band of iron ore with maximum thickness of 36.57 m. occurs within Siwalik sandstones in the Lohagarh area south-west of Pankhabari. Ores available in the area is relatively poor in quality with only 30% iron content.

Table 7.8: In-situ Minerals Occurrences

Name of mineral	Name of associated minerals, if any	Host rock of mineralization	Area of mineralization	Depth of mineralization	Whether virgin or partially excavated	Name of land (whether free for mining/forest /agricultural	Mineral reserve (approximate) mentioning grade	Location of potential mineralized zones				Infrastructure available near the mineralized zone
								Administrative Block	Mouza	Plot No.s	Co-ordinates	
1	2	3	4	5	6	7	8	9				11
Coal	No associated minerals	Carbonaceous sandston, shale	Pankhabari	300m	Partially excavated	Forest/ agricultural land	15 million tonne	Kurseon block	Forest Mauza	NA	26°49'53" and 88°15'58"	Metalled road then foot track
Talc	talc-tremolite-calcite-quartz assemblage	Between overlying Daling quartzite and underlying Daling phyllite	Village Singla	2.5m wide and 120m extended mineralized zone identified	Virgin	Forest	54600 metrict tone (334 category) average grade of 31.63% MgO	Pulbazar C D block,	Darjeeling Gorkha Hill Council Forest	NA	bound by latitudes 27°05'00" to 27°08'00" and longitudes 88°14'00" to 88°17'15"	Metalled road then foot track
Copper	Lead-Zinc	chlorite schist of the Dalings group	Peshok	Surface exposure	Virgin	Peshok Tea garden area	between 0.5% and 2.5% Cu	Rangli Rangliot block	Peshok	NA	27° 03' 10" N and 27° 04'15" N and longitudes 88° 24'30" E and 88° 24'35" E	Metalled road then foot track

7.3 Exploration Requirement of the district

Geologically, the district holds good prospect with respect to base metals, coal and limestone deposits. However, due to lack to details investigation mineral prospect of the district has not been established. GSI has carried out exploration during 1970's to 2000's in search of base metals deposits of the district.

In 2000-2001, GSI has detail investigation in the valley of Mangwa jhora (Peshok khola) for base metal deposits. In 0.35 sq. km area detailed mapping in 1:2000 scale and geochemical sampling was carried out. Evidences of sulphide mineralisation, particularly crystals of pyrite along with chalcopyrite, malachite and azurite have been identified in a band of quartz chlorite schist on the footwall up to 300 m strike length on surface and expected to extend further (Source: Shankar and Tarafdar, GSI progress report, FS 2000-2001).

Reconnaissance stage investigation was carried out by GSI during FS 2010-12, in collaboration with DMM, West Bengal. A talc bearing rock has been identified which is lying in-between overlying Daling quartzite and underlying Daling phyllite located on a hill slope in north-eastern part of the district at Darjeeling Village Singla. Three trenches have been dug to trace the strike extension of the talc lens. Trench 1 exposed 3.2 m wide, both lumpy and platy talc. Trench-2 (which lies 40 m west of T-1), exposed 2.5 m wide talc of above types with impurities like Fe, mud and clay. The continuity of the talc lens has been traced down slope over a distance of about 120 m toward SE of Trench-1, where 1.5 m of talc body of both platy and lumpy types has been exposed. The analyses of bed rock samples of pure/impure talc bodies show 18.91-34.94% MgO with average of 31.63% MgO (Mineral Year Book, WB, 2012).

8 Overview of mining activity in the district

8.1 General overview

Darjeeling district is not exposed to mining activity at large scale. Collection of sand, stone and gravels from the river-bed are the main mineral sources. These materials are primarily utilized for construction purpose.

8.2 List of existing mining leases of the districts

As per the data received from Department of Mines and Minerals, Siliguri, total 75 blocks have been allotted for mining of river sand in the district. Out of which 34 blocks are allotted in Balason, 12 blocks are allotted in Mahananda, 12 blocks in Mechi, 12 blocks in Chengi and 5 blocks are allotted in small rivers. Total allotted block area for 75 blocks is 279.12 Ha and estimated reserve is around 9375933.87 CuM. Revenue generated in the district of Darjeeling from Minor minerals in the FY 2019-20 is Rs. 6.35 Crores.

Table 8.1: Details of mining leases of the districts

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
1	Sand & Stone	Tika Prasad Sharma	Siliguri	Pradhan Nagar	Mahananda	Purba Karaibari Chat	31	15(P), 16(P), 18(P)	26^0 47' 45.9" N 26^0 47' 42.4" N	88^0 25' 21.6" E 88^0 25' 22.0" E	1.2100	20-10-2016
2	Sand & Stone	Lalchand Oraon	Siliguri	Pradhan Nagar	Mahananda	Karaibari	43 (39)	1094/1160, 1095, 1694(P)	26^0 47' 41.7" N 26^0 47' 37.3" N	88^0 25' 25.7" E 88^0 25' 31.1" E	3.3000	20-10-2016
3	Sand & Stone	Lalchand Oraon	Siliguri	Pradhan Nagar	Mahananda	Champasari	34	14, 16, 44, 46 to 52	26^0 47' 43.6" N 26^0 47' 32.6" N	88^0 25' 26.8" E 88^0 25' 37.1" E	4.1600	20-10-2016
4	Sand & Stone	Niranjan Basak	Siliguri	Phansidewa	Manja	Tantilguri	33	20, 32, 32/281, 33(P)	26^0 36' 37.3" N 26^0 37' 32.0" N	88^0 15' 56.4" E 88^0 15' 56.7" E	2.0200	20-10-2016
5	Sand & Stone	Subrata Basak	Siliguri	Kharibari	Chenga	Bhatagach	76	580, 581, 582, 606, 662, 663, 667	26^0 34' 16.7" N 26^0 33' 36.0" N	88^0 14' 49.8" E 88^0 14' 47.5" E	3.5200	20-10-2016
6	Sand & Stone	Bablu Jaiswal	Siliguri	Kharibari	Tari	Bagilahagi & Chuchur	72, 74	112(P), 568, 156(P), 161-163, 159, 150	26^0 35' 02.5" N 26^0 34' 67.0" N	88^0 13' 17.4" E 88^0 13' 10.1" E	3.0700	20-10-2016
7	Sand & Stone	Smt. Tamali Chakrabortty	Siliguri	Kharibari	Tari/Mechi	Madan & Bajarpur Chat	01, 04	76(P), 5(P), 6(P)	26^0 38' 10.1" N 26^0 38' 11.9" N	88^0 09' 35.7" E 88^0 09' 36.8" E	2.6300	20-10-2016
8	Sand & Stone	Smt. Shudha Chakrabortty	Siliguri	Matigara	Balason	Lalsara	62	10(P)	26^0 44' 49.4" N 26^0 44' 43.0" N	88^0 19' 31.9" E 88^0 19' 37.0" E	3.0400	20-10-2016
9	Sand & Stone	Smt. Dipti Rani Das	Siliguri	Matigara	Balason	Kalam	76	433, 434	26^0 42' 27.1" N 26^0 42' 15.1" N	88^0 23' 01.3" E 88^0 23' 07.5" E	3.0800	20-10-2016
10	Sand & Stone	Sudip Das	Siliguri	Matigara	Balason	Mathapari	101 (79)	206	26^0 42' 42.0" N 26^0 42' 17.2" N	88^0 22' 44.9" E 88^0 23' 00.0" E	3.0400	20-10-2016

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
11	Sand & Stone	Samrat Chakrabortty	Siliguri	Matigara	Balason	Patanara Chat	61	9(P), 18, 42(P)	26^0 44' 42.6" N 26^0 44' 38.9" N	88^0 20' 05.3" E 88^0 20' 10.5" E	2.9900	20-10-2016
12	Sand & Stone	Smt. Joli Das	Siliguri	Matigara	Balason	Panchkulguri	59	27(P), 281(P), 282(P)	26^0 44' 58.0" N 26^0 44' 56.6" N	88^0 20' 44.7" E 88^0 20' 44.7" E	4.0600	20-10-2016
13	Sand & Stone	Smt. Pramila Yadav	Siliguri	Matigara	Balason	Kalam	76	639	26^0 42' 04.4" N 26^0 41' 59.2" N	88^0 23' 21.3" E 88^0 23' 26.5" E	2.0000	20-10-2016
14	Sand & Stone	Smt. Mina Devi Giri	Siliguri	Matigara	Balason(Rakti)	Panchkulguri	59	38(P)	26^0 45' 02.3" N 260 44' 57.0" N	88^0 20' 40.0" E 880 20' 44.4" E	1.4700	20-10-2016
15	Sand & Stone	Shyamal Kumar Sanyal	Siliguri	Matigara	Balason	Tari, Guria, Baniakhari	68, 56, 55	1, 305(P), 306(P), 312, 313, 314, 316, / 281(P), 375(P), / 58(P), 59, 60, 63/172, 63, 173, 179(P), 180(P), 181(P)	26^0 43' 04.0" N 26^0 43' 22.2" N	88^0 22' 22.30" E 88^0 22' 22.9" E	39.2600	03-11-2016
16	Sand & Stone	Animesh Banerjee	Siliguri	Phasidewa	Chenga	Harivita	42	970(P), 974(P), 975(P), 976(P), 980(P)	26^0 35' 23.96" N 26^0 35' 28.60" N	88^0 16' 02.45" E 88^0 16' 10.59" E	1.6700	08-11-2016
17	Sand & Stone	Reba Mitra	Siliguri	Matigara	Balason	Patanara Chat	61	15(P), 16, 17, 25(P), 26, 41(P)	26^0 44' 21.1" N 26^0 44' 19.5" N	88^0 20' 12.5" E 88^0 20' 07.6" E	3.7400	08-11-2016
18	Sand & Stone	Smt. Sushmita Ghosh Gope	Siliguri	Phasidewa	Chenga	Tentulguri	33	135(P)	26^0 37' 17.77" N 26^0 37' 11.74" N	88^0 16' 39.74" E 88^0 16' 39.84" E	0.8400	14-12-2016
19	Sand & Stone	Smt. Sushmita Ghosh	Siliguri	Phasidewa	Manja	Tentulguri	33	45(P), 46(P)	26^0 36' 36.32" N 26^0 36' 32.57" N	88^0 15' 56.39" E 88^0 15' 56.63" E	0.7900	14-12-2016

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
		Gope										
20	Sand & Stone	Vivekananda Singh	Siliguri	Phasidewa	Chenga	Dhambhita	38	663, 667, 420	26^0 33' 57.0" N 26^0 33' 49.78" N	88^0 15' 04.0" E 88^0 14' 51.37" E	3.5000	30-11-2016
21	Sand & Stone	M/s Lorsen Toubro Ltd. (L&T)	Siliguri	Phasidewa	Chenga	Farabari	43	44, 45, 46	26^0 36' 19.19" N 26^0 36' 35.91" N	88^0 16' 55.43" E 88^0 16' 50.67" E	4.9300	30-11-2016
22	Sand & Stone	M/s Lorsen Toubro Ltd. (L&T)	Siliguri	Phasidewa	Chenga	Farabari	43	44, 45, 47	26^0 36' 35.99" N 26^0 36' 19.59" N	88^0 16' 48.02" E 88^0 16' 53.43" E	4.8700	30-11-2016
23	Sand & Stone	Khitish Biswas	Siliguri	Kharibari	Mechi	Bhulka	6	1, 2, 3, 4	26^0 37' 22.6" N 26^0 37' 17.6" N	88^0 16' 48.02" E 88^0 16' 53.43" E	2.5000	09-01-2017
24	Sand & Stone	Smt. Dipti Rani Das	Siliguri	Matigara	Balason	Kalam	76	433, 434	26.705552^0 N	88.384483^0 E	3.0800	19-12-2016
25	Sand & Stone	Sudip Das	Siliguri	Matigara	Balason	Mathapari	101(79)	206	26.711673^0 N 26.704791^0 N	88.379155^0 E 88.383339^0 E	10.1200	19-12-2016
26	Sand & Stone	Pravin Kumar Agarwal	Siliguri	Phasidewa	Balason	Radha	72	1108, 1110, 1104, 1105, 1103	26^0 38' 38.11" N 26^0 38' 32.41" N	88^0 20' 29.71" E 88^0 20' 27.62" E	0.4500	28-12-2016
27	Sand & Stone	Krishna Gopal Agarwal & Sons	Siliguri	Phasidewa	Balason	Tarabandha	69	354	26^0 34' 31.6" N 26^0 34' 28.8" N	88^0 15' 58.9" E 88^0 15' 56.8" E	0.3800	09-01-2017
28	Sand & Stone	Sampa Kundu Munsi	Siliguri	Naxalbari	Balason	Mm Tarai	78	223, 34	26^0 47' 11.2" N 26^0 47' 04.3" N	88^0 15' 24.9" E 88^0 15' 31.2" E	3.2200	10-01-2017
29	Sand & Stone	Krishna Gopal Agarwal & Sons	Siliguri	Matigara	Balason	Nemai	57	262(P), 264(P), 266(P), 281(P)	26^0 44' 23.9" N 26^0 44' 22.2" N	88^0 20' 50.3" E 88^0 20' 55.4" E	1.2000	10-01-2017
30	Sand & Stone	Roy & Roy Enterprise	Siliguri	Kharibari	Mechi	Antaram	5	8, 23, 25, 32, 72	26^0 37' 28.0" N 26^0 37' 24.8" N	88^0 09' 26.4" E 88^0 08' 59.1" E	3.8000	10-01-2017

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
31	Sand & Stone	Krishna Gopal Agarwal & Sons	Siliguri	Phasidewa	Balason	Bhusibhita	71	1306	26^0 37' 38.4" N 26^0 37' 28.4" N	88^0 20' 25.8" E 88^0 20' 29.7" E	0.4900	09-01-2017
32	Sand & Stone	Bidyut Ranjan Thakur	Siliguri	Phasidewa	Chenga	Ambari	40	88, 348(P), 351, 344	26^0 34' 31.6" N 26^0 34' 28.8" N	88^0 15' 58.9" E 88^0 15' 56.6" E	1.4900	09-01-2017
33	Sand & Stone	Khitish Biswas	Siliguri	Kharibari	Mechi	Antaram	5	8, 23, 25, 32, 72	26^0 37' 19.4" N 26^0 37' 21.3" N	88^0 08' 55.0" E 88^0 08' 48.1" E	3.8000	10-01-2017
34	Sand & Stone	Gautam Ghosh	Siliguri	Kharibari	Mechi	Antaram	5	8, 23, 25, 32, 72	26^0 37' 37.1" N 26^0 37' 32.8" N	88^0 09' 19.3" E 88^0 09' 11.1" E	3.8000	06-01-2017
35	Sand & Stone	Smt. Nitu Dubey	Siliguri	Kharibari	Mechi	Madan	1	170, 171, 163, 166	26^0 38' 57.8" N 26^0 39' 05.1" N	88^0 09' 51.4" E 88^0 09' 54.6" E	2.5000	06-01-2017
36	Sand & Stone	Prakash Thapa	Siliguri	Naxalbari	Manja	Bairbhita	91	106 - 110, 113 - 115, 97	26^0 40' 16.8" N 26^0 40' 09.5" N	88^0 15' 07.4" E 88^0 15' 10.5" E	0.9400	06-01-2017
37	Sand & Stone	Sanjoy Goyal	Siliguri	Naxalbari	Balason	Mm Tarai	78	223, 34	26^0 47' 18.1" N 26^0 47' 09.8" N	88^0 15' 24.9" E 88^0 15' 31.2" E	2.6200	06-01-2017
38	Sand & Stone	Smt. Anamika Roy	Siliguri	Matigara	Balason	Nemai	57	281(P), 282(P), 283(P), 288(P), 289(P)	26^0 44' 23.14" N 26^0 44' 15.02" N	88^0 20' 56.07" E 88^0 21' 4.48" E	2.9900	31-01-2017
39	Sand & Stone	M/s North Bengal Co. Labour Constract & Construction Society Ltd.	Siliguri	Naxalbari	Manja	Sirsia	71	19(RS), 42(LR)	26^0 38' 31.0" N 26^0 38' 38.0" N	88^0 20' 24.0" E 88^0 20' 27.0" E	1.2000	02-03-2017
40	Sand & Stone	Ankur Bio Chem. Pvt. Ltd.	Siliguri	Matigara	Mahananda	Palash	43	813 - 817	26^0 45' 15.62" N 26^0 45' 05.50" N	88^0 25' 57.15" E 88^0 25' 50.17" E	2.3000	11-04-2017

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
41	Sand & Stone	Ankur Bio Chem. Pvt. Ltd.	Siliguri	Matigara	Mahananda	Duramarir Chhat	36	39, 41, 44, 47	26^0 47' 20.50" N 26^0 47' 17.43" N	88^0 25' 54.81" E 88^0 25' 47.06" E	1.9000	11-04-2017
42	Sand & Stone	Ankur Bio Chem. Pvt. Ltd.	Siliguri	Matigara	Mahananda	Duramarir Chhat	36	39, 41, 44, 48	26^0 47' 9.34" N 26^0 47' 0.50" N	88^0 26' 11.28" E 88^0 26' 2.03" E	3.6000	11-04-2017
43	Sand & Stone	Ankur Bio Chem. Pvt. Ltd.	Siliguri	Matigara	Mahananda	Palash	43	813 - 817	26^0 45' 24.32" N 26^0 45' 14.65" N	88^0 26' 02.64" E 88^0 25' 54.63" E	2.3000	11-04-2017
44	Sand & Stone	Bidyut Ranjan Thakur	Siliguri	Phasidewa	Chenga	Mandilajhar	101	1084, 1081	26^0 30' 40.7" N 26^0 30' 36.2" N	88^0 11' 29.8" E 88^0 11' 28.9" E	1.1000	09-06-2017
45	Sand & Stone	Bidyut Ranjan Thakur	Siliguri	Matigara	Balason	Kawakhali	75	399, 407, 408, 410, 418	26^0 41' 41.6" N 26^0 38' 38.9" N	88^0 23' 58.3" E 88^0 23' 48.4" E	3.0000	09-06-2017
46	Sand & Stone	Goutam Dey	Siliguri	Kharibari	Balason	Tari	68	67, 72, 175, 177, 300 (RS)	26^0 43' 40.8" N 26^0 43' 30.5" N	88^0 22' 10.5" E 88^0 21' 55.1" E	2.2300	01-08-2017
47	Sand & Stone	Excelent India Build Construction	Siliguri	Matigara	Mechi	Bhulka	6	1(P), 2(P), 3(P), 4(P)	26^0 37' 11.30" N 26^0 37' 02.80" N	88^0 08' 38.40" E 88^0 08' 32.00" E	3.8000	01-08-2017
48	Sand & Stone	Pravin Kumar Agarwal	Siliguri	Matigara	Balason	Dumriguri Chhat	49	29(P), 30(P)	26^0 44' 41.1" N 26^0 44' 31.7" N	88^0 19' 55.0" E 88^0 19' 43.7" E	3.2000	01-08-2017
49	Sand & Stone	Ambey Abasan Pvt. Ltd.	Siliguri	Matigara	Balason	Kawakhali	75	408(P), 410(P), 418(P)	26^0 41' 53.4" N 26^0 41' 43.5" N	88^0 23' 48.3" E 88^0 23' 38.0" E	4.0000	02-08-2017
50	Sand & Stone	Ambey Abasan Pvt. Ltd.	Siliguri	Matigara	Balason	Kawakhali	75	399(P), 407(P), 408(P), 410(P), 418(P)	26^0 41' 47.5" N 26^0 41' 43.2" N	88^0 23' 52.1" E 88^0 23' 42.8" E	3.8000	02-08-2017
51	Sand & Stone	Santosh Kumar Singh	Siliguri	Matigara	Balason	Nemai	57	289(P), 290(P), 322(P), 321(P), 315(P)	26^0 44' 15.02" N 26^0 44' 08.22" N	88^0 21' 12.26" E 88^0 21' 04.47" E	2.7000	07-09-2017

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
52	Sand & Stone	Shyamal Kumar Sanyal	Siliguri	Matigara	Balason	Tari, Guria, Baniakhari	68, 56, 55	1, 305(P), 306(P), 312, 313, 314, 316, / 281(P), 375(P), / 58(P), 59, 60, 63/172, 63, 173, 179(P), 180(P), 181(P)	26^0 43' 04.0" N 26^0 43' 22.2" N	88^0 25' 22.30" E 88^0 22' 22.9" E	39.2600	03-11-2017
53	Sand & Stone	Rainbow Infrustructure & Housing Development Ltd.	Siliguri	Matigara	Balason	Patiram	77	291, 317, 318, 321, 329	26^0 41' 38.3" N 26^0 41' 31.9" N	88^0 24' 08.8" E 88^0 24' 02.0" E	2.5000	18-12-2017
54	Sand & Stone	Shivalaya Enterprise	Siliguri	Matigara	Balason	Pataner Chhat	61	13, 14, 15, 5, 8, 16	26^0 44' 34.0" N 26^0 44' 24.8" N	88^0 20' 05.9" E 88^0 19' 53.7" E	1.5200	28-12-2017
55	Sand & Stone	Bidyut Ranjan Thakur	Siliguri	Kharibari	Mechi	Madan	1	170(P)	26^0 39' 14.6" N 26^0 39' 06.3" N	88^0 09' 55.7" E 88^0 09' 51.5" E	2.5000	28-12-2017
56	Sand & Stone	Falcon Abason Pvt. Ltd.	Siliguri	Kharibari	Dumuria	Guabari	69	268, 291 - 293, 296, 297	26^0 35' 48.1" N 26^0 35' 39.2" N	88^0 13' 21.9" E 88^0 13' 17.5" E	2.1300	28-02-2018
57	Sand & Stone	Smt. Rina Dutta	Siliguri	Matigara	Balason	Bataliguri	64	267 - 276	26^0 44' 26.88" N 26^0 44' 20.92" N	88^0 20' 15.99" E 88^0 20' 5.50" E	2.7000	14-06-2018
58	Sand & Stone	Ajay Kumar Sharma	Siliguri	Naxalbari	Balason	Bournivitar Chhat	82	6, 8	26^0 46' 03.9" N 26^0 45' 54.5" N	88^0 18' 16.0" E 88^0 17' 50.1" E	4.3200	27-06-2018
59	Sand & Stone	Vivek Associates	Siliguri	Phasidewa	Balason	Nembutari	86	24, 26, 28, 30, 31	26^0 36' 33.9" N 26^0 36' 30.3" N	88^0 20' 02.7" E 88^0 19' 54.1" E	0.6960	23-04-2018
60	Sand & Stone	Surovi Scrap	Siliguri	Naxalbari	Chenga	Gaziram	60	51, 79, 387	26^0 42' 53.6" N 26^0 42' 41.1" N	88^0 14' 43.3" E 88^0 14' 33.2" E	2.8000	23-04-2018

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
61	Sand & Stone	Smt. Nitu Dubey	Siliguri	Kharibari	Mechi	Antaram	5	10(P), 11(P), 15(P), 16(P), 25(P)	26^0 37' 30.7" N 26^0 37' 22.6" N	88^0 09' 11.0" E 88^0 09' 01.7" E	3.8000	08-05-2018
62	Sand & Stone	Falcon Abason Pvt. Ltd.	Siliguri	Phasidewa	Chenga	Patharhirhira	25	180(P), 97(P)	26^0 38' 50.1" N 26^0 38' 37.6" N	88^0 16' 21.7" E 88^0 16' 13.3" E	4.9000	28-02-2018
63	Sand & Stone	Rainbow Infrustructure & Housing Development Ltd.	Siliguri	Matigara	Balason	Kawakhali-II	75	399(P), 407(P), 408(P), 410(P), 418(P)	26^0 41' 40.1" N 26^0 41' 34.4" N	88^0 23' 48.8" E 88^0 23' 42.4" E	4.0000	27-02-2018
64	Sand & Stone	Rainbow Infrustructure & Housing Development Ltd.	Siliguri	Matigara	Balason	Kawakhali-I	75	399(P), 407(P), 408(P), 410(P), 418(P)	26^0 41' 43.9" N 26^0 41' 38.1" N	88^0 23' 44.0" E 88^0 23' 37.4" E	3.8000	27-02-2018
65	Sand	Smt. Dipa Thapa	Siliguri	Naxalbari	Mechi	Baramaniram	20	681(P), 683, 686(P), 688(P)	26^0 41' 33.9" N 26^0 41' 29.0" N	88^0 10' 16.4" E 88^0 10' 12.2" E	2.0000	06-01-2017
66	Sand	Falcon Abason Pvt. Ltd.	Siliguri	Phasidewa	Chenga	Harivita	42	72(P), 74(P), 75(P), 392(P)	26^0 35' 28.1" N 26^0 35' 21.1" N	88^0 16' 06.5" E 88^0 16' 01.9" E	3.0000	28-02-2018
67	Sand	Shyamal Kumar Sanyal	Siliguri	Matigara	Balason	Nemai	57	400, 434, 433, 318, 319, 321, 311	26^0 44' 13.23" N 26^0 44' 13.23" N	88^0 21' 10.71" E 88^0 21' 10.71" E	3.5900	15-12-2016
68	Sand	Falcon Abason Pvt. Ltd.	Siliguri	Phasidewa	Chenga	Harivita	42	167(P), 181(P), 182(P), 184(P)	26^0 35' 35.0" N 26^0 35' 27.2" N	88^0 16' 36.2" E 88^0 16' 29.3" E	2.0000	28-02-2018
69	Sand	Premi Arora	Siliguri	Phasidewa	Mahananda	Purba Bansgaon	113	7638(P)	26^0 31' 44.5" N 26^0 31' 18.3" N	88^0 21' 24.8" E 88^0 21' 04.3" E	4.9700	24-05-2018

Sl. No.	Mineral Commodity	Name of Leasee	Name of Sub-Division	Name of Block	Name of River	Mouza	J.L. No.	Plot No.	Latitude	Longitude	Area (Hector)	Date of approval
70	Sand	Ambey Abasan Pvt. Ltd.	Siliguri	Phasidewa	Mahananda	Purba Bansgaon	113	7638(P)	26^0 31' 12.72" N 26^0 30' 33.65" N	88^0 21' 04.58" E 88^0 20' 52.28" E	4.9000	24-05-2018
71	Sand	Premi Arora	Siliguri	Phasidewa	Mahananda	Dhakpara	105	3794(P)	26^0 27' 36.89" N 26^0 27' 30.56" N	88^0 14' 41.47" E 88^0 14' 36.91" E	0.5018	19-07-2018
72	Sand	Premi Arora	Siliguri	Phasidewa	Mahananda	Dhakpara	105	3798(RS), 3870(LR)	26^0 27' 15.78" N 26^0 27' 11.66" N	88^0 14' 27.90" E 88^0 14' 23.08" E	0.8417	19-07-2018
73	Sand	Premi Arora	Siliguri	Phasidewa	Mahananda	Dhakpara	105	3941(RS), 4033(LR)	26^0 27' 6.44" N 26^0 27' 3.22" N	88^0 14' 8.99" E 88^0 14' 4.44" E	0.2711	19-07-2018
74	Sand	Sudarshan Mishra	Siliguri	Matigara	Mechi	Baramaniram	20	681(P), 683(P), 686(P), 688(P)	26^0 42' 29.4" N 26^0 42' 38.8" N	88^0 10' 55.4" E 88^0 10' 44.5" E	4.0000	15-06-2017
75	Earth Cutting	M/s Lorsen Toubro Ltd. (L&T)	Siliguri	Phasidewa	Balason	Kantivitta	87	136	26^0 34' 55.08" N 26^0 34' 50.81" N	88^0 19' 37.24" E 88^0 19' 40.85" E	0.4200	02-03-2017

8.3 Detail of production of sand and other minerals during last three years

Table 8.2: Details of production of sand as per mine plan in Darjeeling district

Sl. No.	Year	Name of mineral	Total Production
1	2017-2018	Not-Available	Not-Available
2	2018-2019	Not-Available	Not-Available
3	2019-2020	Not-Available	Not-Available

9 Details of revenue generated from mineral sector during last three years

Table 9.1: District revenue generation from mineral sector

(In Crores)

Year	Land Revenue and Cess	Minor Minerals	Total revenue
2017-2018	Not-Available	Not-Available	Not-Available
2018-2019	Not-Available	Not-Available	Not-Available
2019-2020	1.82	6.35	8.17

10 Transport (Railway, road)

Despite a hilly terrain and high altitude, district Darjeeling has a very wide spread road-network covering almost all areas of the district. Since the expansion of British territory in the early Nineteenth Century across the area, structured transformation of the hilly rural roads to metalled and non-metalled road took place and within the end of Nineteenth Century, owing to the important strategic location, all places of the district were well connected with Head Quarter at Darjeeling Town. Till date the most famous and prominent mode of transport in the district is the Darjeeling Himalayan Railway (The Toy Train of Darjeeling). Presently its journey starts from the New Jalpaiguri Railway Station near Siliguri and stretches up to Darjeeling Town travelling a distance of 78 Kilometers. In the journey the elevation level changes from 100 Metres above sea level to 2,200 Metres. However, owing to the factors like steep changes in elevation, existence of several Loops in the path and a journey through a landslide prone path, the services in the complete route is hindered. New Jalpaiguri, serving the town of Siliguri, is the major railway station near the district. New Jalpaiguri is well connected to major Indian cities, especially Kolkata.

The Road network of district Darjeeling is well built and several National and State Highways pass through the district. NH-31, NH-31A, NH-31C and NH-110 crosses the district and important locations are connected by SH-12 and SH-12A beside numerous medium, small and minor road networks.

Darjeeling does not have an airstrip. The nearest airport is Bagdogra airport (IXB), near Siliguri.

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

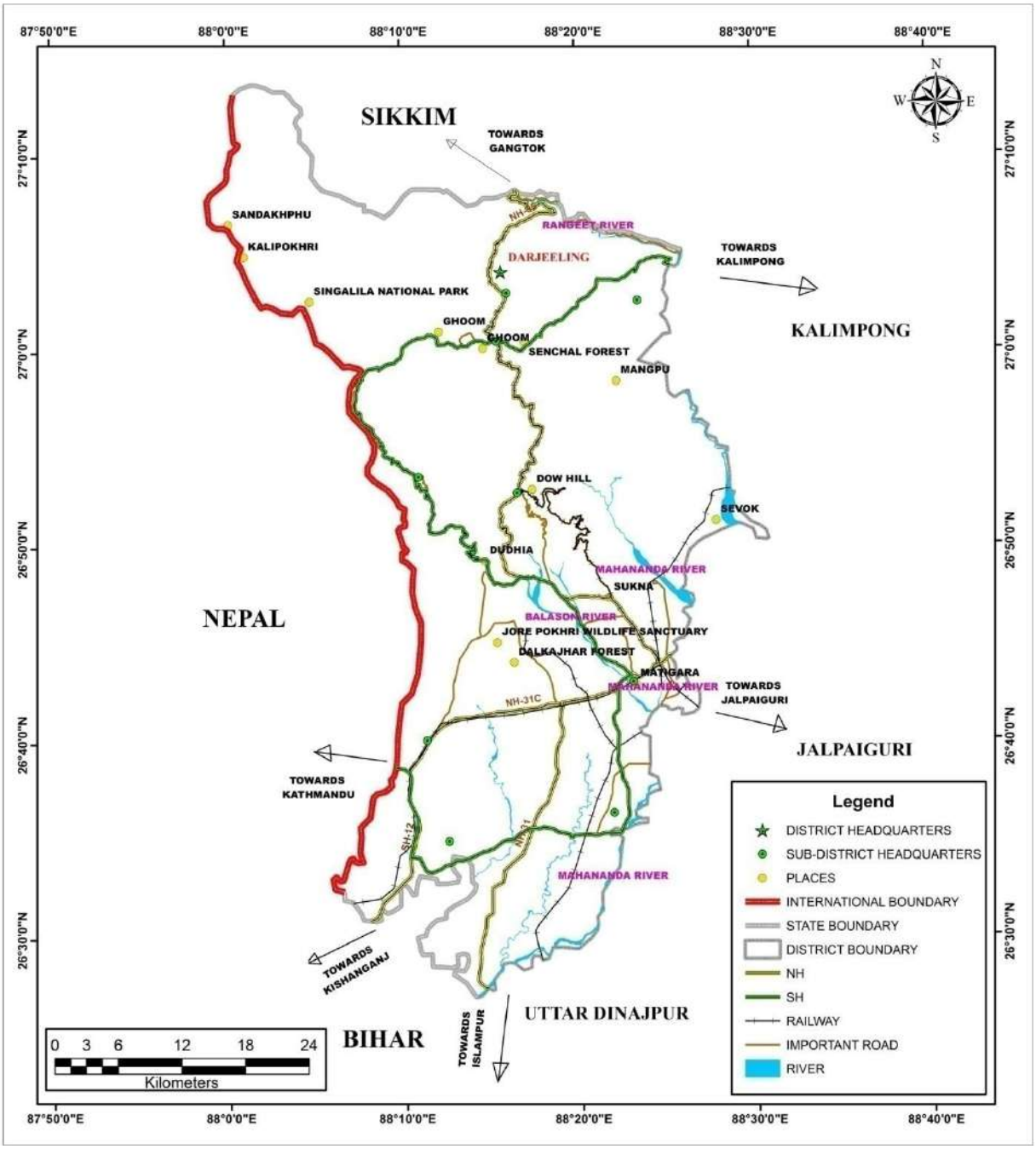

Figure 10.1: Transportation map of Darjeeling District

(Source: National Information Centre)

11 Remedial measure to mitigate the impact of Mining

11.1 Environmental Sensitivity

The Darjeeling Hill area represents a unique geo- environmental perception. The district has dense vegetation cover; almost 40% of the area is under forest cover. It has one national park and four sanctuaries which are rich in biodiversity.

The mountains of the district serve as the source of resources for the population residing in the hills as well as in the plains, the form of environmental degradation is quite extensive. Soil erosion and its conservation play an important role in the hill areas. Because of the presence of very thin soil cover plays an important role in the socio economic development. Landslide hazards, especially during rainy season have become a common factor to the people of the hill.

The district is not exposed to large scale mining. Only riverbed sand and gravel are being extracted and consumed in local market. Removal or extraction of too much sand from rivers leads to erosion shrinking of river banks. These destructive effects of sand mining ultimately results in loss of fertile land and property. It also destabilized the ground and causes the failure of engineering structures for civilization. In-stream mining directly alters the channel geometry and bed elevation. By removing sediment from the channel, in-stream material extraction disrupts the preexisting 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 tables and frequently leads to destruction of bridges and channelization structures (Source: Wiejaczka2018).The sand mining from natural barriers, made up of sand, causes flooding of the natural habitat. The sand mining activity destroys the aesthetic beauty of river bank and makes the ecosystem unstable. If there are popular tourist destination, tourism potential of such areas will lose. Therefore, mining of riverbed should be carried out scientifically and based on statutory guidelines for conservation of land, river channels and sustainable development of the society.

11.2 Sand 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 utilised 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 increase as population grows also urbanization with time. The high level of demands have offer led to the use of unsustainable sand mining process for speedy urbanisation resulted in illegal mining.

All though most jurisdictions have legal limit on the location and volume of sand that can be mined, illegal sand extraction is following in many parts of the country due to rapid urbanisation and industries. Removal or extraction of too much sand from rivers leads to erosion shrinking of river banks. Deltas can recede due to sand mining. These destructive effects of sand mining ultimately results in loss of fertile land and property. It also destabilized the ground and causes the failure of engineering structures for civilization.

In-stream mining directly alters the channel geometry and bed elevation. By removing sediment from the channel, in-stream material extraction disrupts the preexisting 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 tables and frequently leads to destruction of bridges and channelization structures (Source: Wiejaczka2018).

Sand Mining in beaches disturbs the ecosystem of different fauna of the beaches. The sand mining from natural barriers, made up of sand, causes flooding of the natural habitat. The sand mining activity destroys the aesthetic beauty o beaches and river bank and makes the ecosystem unstable. If there are popular tourist destination, tourism potential of such areas will lose.

It could be concluding that there has been little in depth research in to the environmental and social also political effect of land use practice and calls for urgent redressed by the competent authority.

11.3 Remedial measure

11.3.1 Sustainable Mining Practices:

- The depth of mining in Riverbed shall not exceed one meter or water level whichever is less, provided that where the Joint Inspection Committee certifies about excessive deposit or over accumulation of mineral.
- 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.

11.3.2 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.

11.3.3 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 to 7 pm.

11.3.4 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.

11.3.5 Bio-Diversity Protection:

- Restoration of flora affected by mining should be done immediately. Twice the number of trees destroyed by mining to be planted preferably of indigenous species. Each EC holder should plant and maintain for lease period at least 5 trees per hectare in area near lease.
- 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 turtle and bird habitats shall 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) have 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.

11.3.6 Management of Instability and Erosion:

- Removal, stacking and utilization of top soil in mining are should be ensured. 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.

11.3.7 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.

11.3.8 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.

11.3.9 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 archeological 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 200-500 meter of bridge, 200 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 meter 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.

12 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:

a) A baseline survey consisting of existing condition cross-section data. Cross-sections must be surveyed between two monumented endpoints set back from the top of bank, and elevations should be referenced bench mark set;

b) The proposed mining cross-section data should be plotted over the baseline data to illustrate the vertical extent of the proposed excavation;

c) 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;

d) A planimetric map showing the aerial extent of the excavation and extent of the riparian buffers;

e) A 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;

f) A monitoring plan has to establish.

13 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.

13.1 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 selable. There will be neither any stacking of soil nor creation of OB dumps. The mining activity will 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 risk in the mining activity which are as below:

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

13.2 Mitigation measures

13.2.1 Measures to prevent accidents during loading and transportation:

- During the loading truck would be brought to a lower level so that the loading operation suits to 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 takes place 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.

13.2.2 Measures to prevent incidents during Inundation/ Flooding:

To minimize the risk of flooding/ inundation following measures will 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.

13.2.3 Measures for mitigation to quick sand condition:

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

13.3 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 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 laws 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.

14 Conclusion

The District Survey Report for Darjeeling district has been prepared as per as per the guidelines issued by Ministry of Environment, Forests and Climate Change (MoEF& CC) time to time. The Guideline of WBMMCR, 2016 is also taken into consideration while preparation of this report.

Potential areas where mining can be allowed are identified and discussed in this DSR. This DSR would also help to estimate the annual rate of replenishment wherever applicable.

Preparation of this DSR involved 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 district survey report of Darjeeling district also describes the general geographical profile of the district, distribution of natural resources, livelihood, climatic condition and sources of revenue generation.

District physigraphy is divided in to two units, hills dominated in the north and plan in the southern part. These lead to the difference is climatic condition, soil pattern, cropping pattern of the district.

The Darjeeling District is holding mineral potentiality with respect to major and minor mineral. The district is currently generating revenue from mining of minor minerals such as sand, stone and gravels from the riverbed. In-stream mining directly alters the channel geometry and bed elevation. Therefore, mining of riverbed should be carried out scientifically and based on statutory guidelines for conservation of land, river channels and sustainable development of the society.

As per the data received from Department of Mines and Minerals, Siliguri, total 75 blocks have been allotted for mining of river sand in the district. Out of which 34 blocks are allotted in Balason, 12 blocks are allotted in Mahananda, 12 blocks in Mechi, 12 blocks in Chengi and 5 blocks are allotted in small rivers. Total allotted block area for 75 blocks is 279.12 Ha and estimated reserve is around 9375933.87 CuM. Revenue generated in the district of Darjeeling from Minor minerals in the FY 2019-20 is Rs. 6.35 Crores.

The district has an upside potential for development of Riverbed sand. The occurrence has been reported by Directorate of Mines and Minerals, Government of West Bengal and others in previous instances. It requires further systematic and scientific approach to quantify the resource along with their grade assessment. This report also recommends to undertake detail exploration (G1 & G2 level) program to assess the mineral occurrences in the major rivers of the district and should have a proper development and production plan for the specified minerals.

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Annexure 1: List of Brick Earth Mines in Darjeeling District

NA

PLATE 1

DRAINAGE MAP OF THE DISTRICT

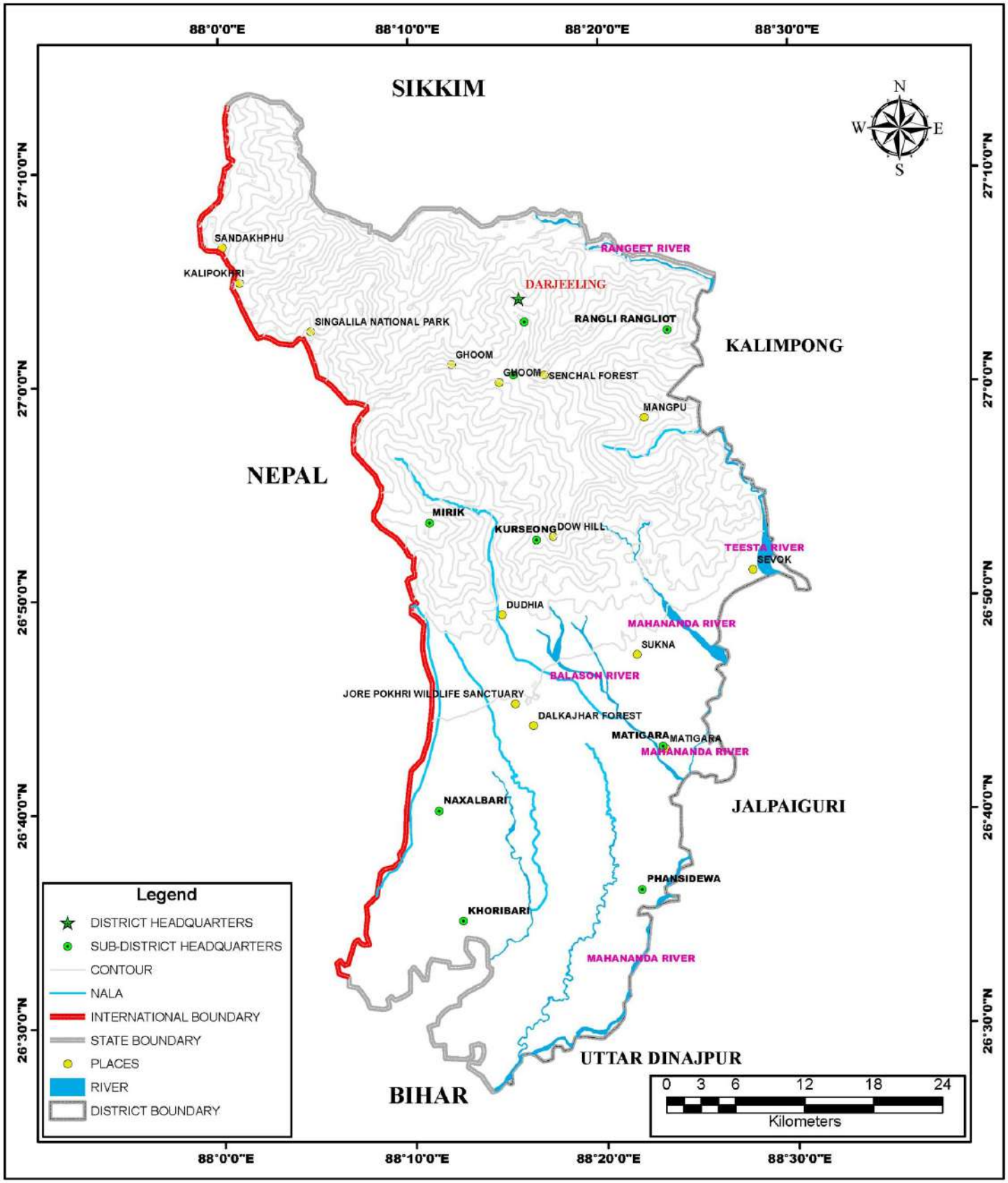

88°0'0"E
88°10'0"E
88°20'0"E
88°30'0"E
27°10'0"N
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
SIKKIM
N
W
E
S
SANDAKHPHU
KALIPOKHRI
RANGEET RIVER
DARJEELING
SINGALILA NATIONAL PARK
RANGLI RANGLIOT
KALIMPONG
GHOOM
GHOOM
SENCHAL FOREST
MANGPU
NEPAL
MIRIK
KURSEONG
DOW HILL
TEESTA RIVER
SEVOK
DUDHIA
MAHANANDA RIVER
SUKNA
BALASON RIVER
JORE POKHRI WILDLIFE SANCTUARY
DALKAJHAR FOREST
MATIGARA
MATIGARA
MAHANANDA RIVER
NAXALBARI
JALPAIGURI
PHANSIDEWA
KHORIBARI
MAHANANDA RIVER
UTTAR DINAJPUR
BIHAR
Legend
DISTRICT HEADQUARTERS
SUB-DISTRICT HEADQUARTERS
CONTOUR
NALA
INTERNATIONAL BOUNDARY
STATE BOUNDARY
PLACES
RIVER
DISTRICT BOUNDARY
0 3 6 12 18 24
Kilometers

PLATE 2A

DISTRIBUTION MAP OF SAND BARS ON RIVERS

DURING PRE-MONSOON PERIOD OF DARJEELING DISTRICT

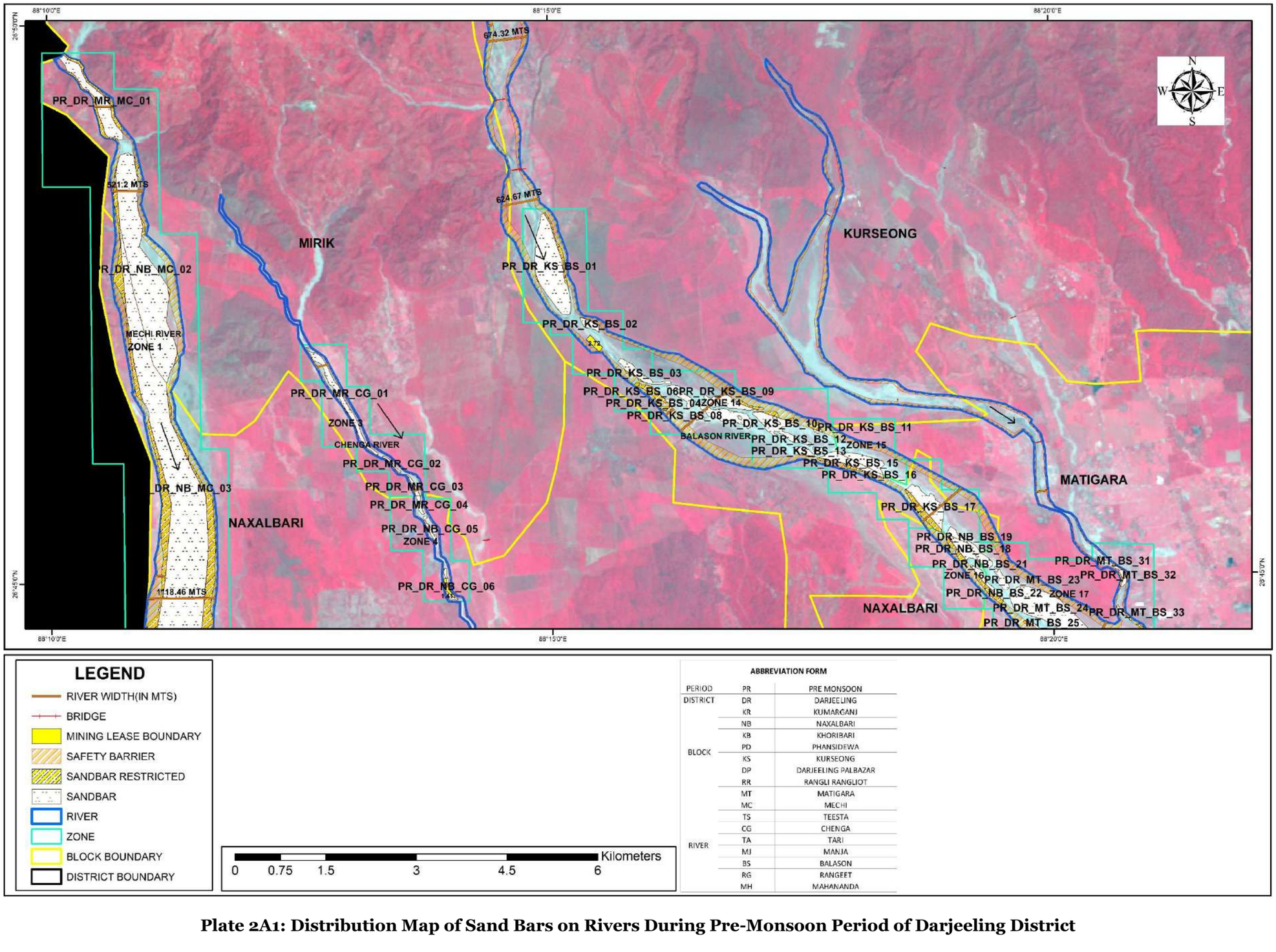


Plate 2A1: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

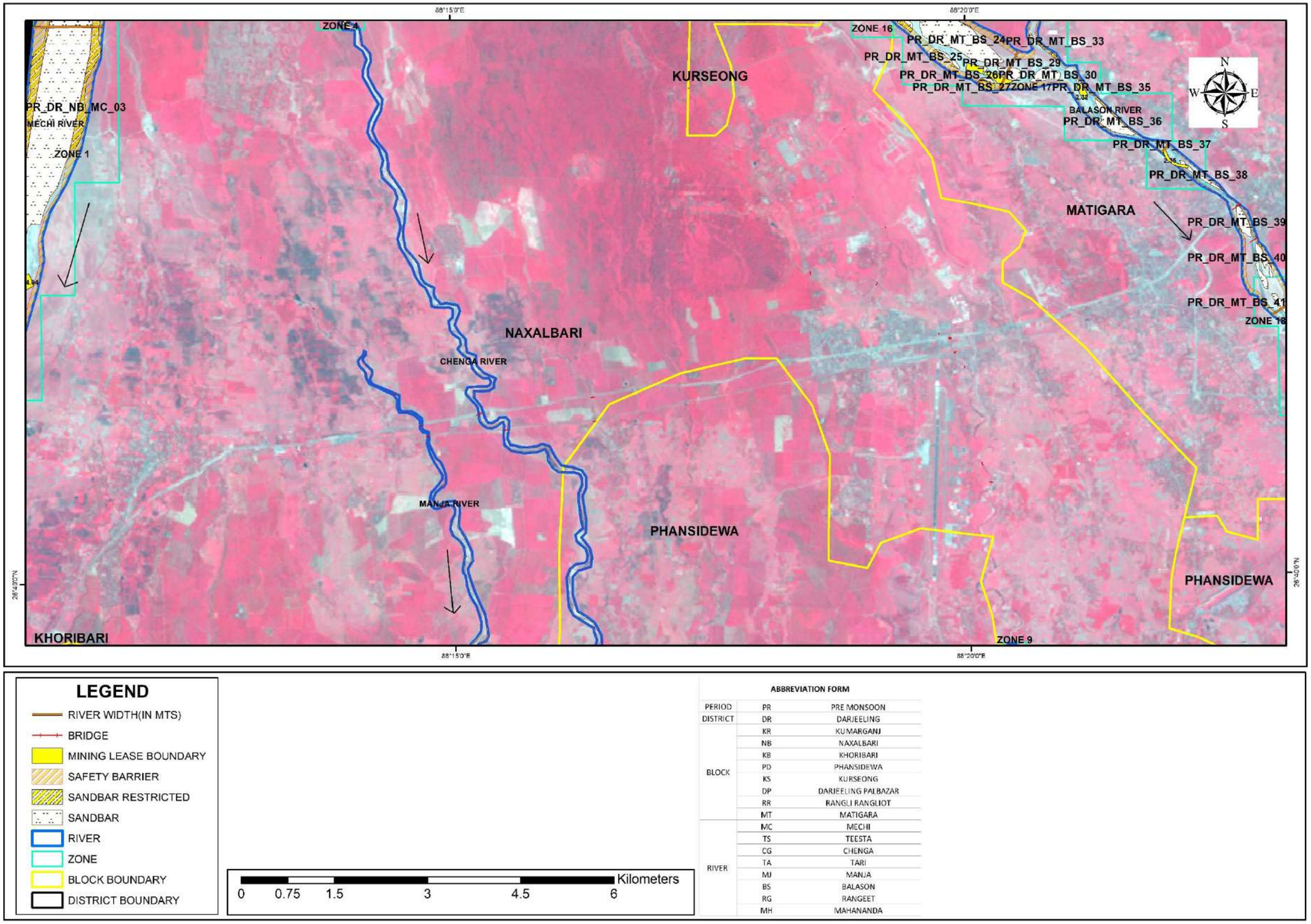


Plate 2A2: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

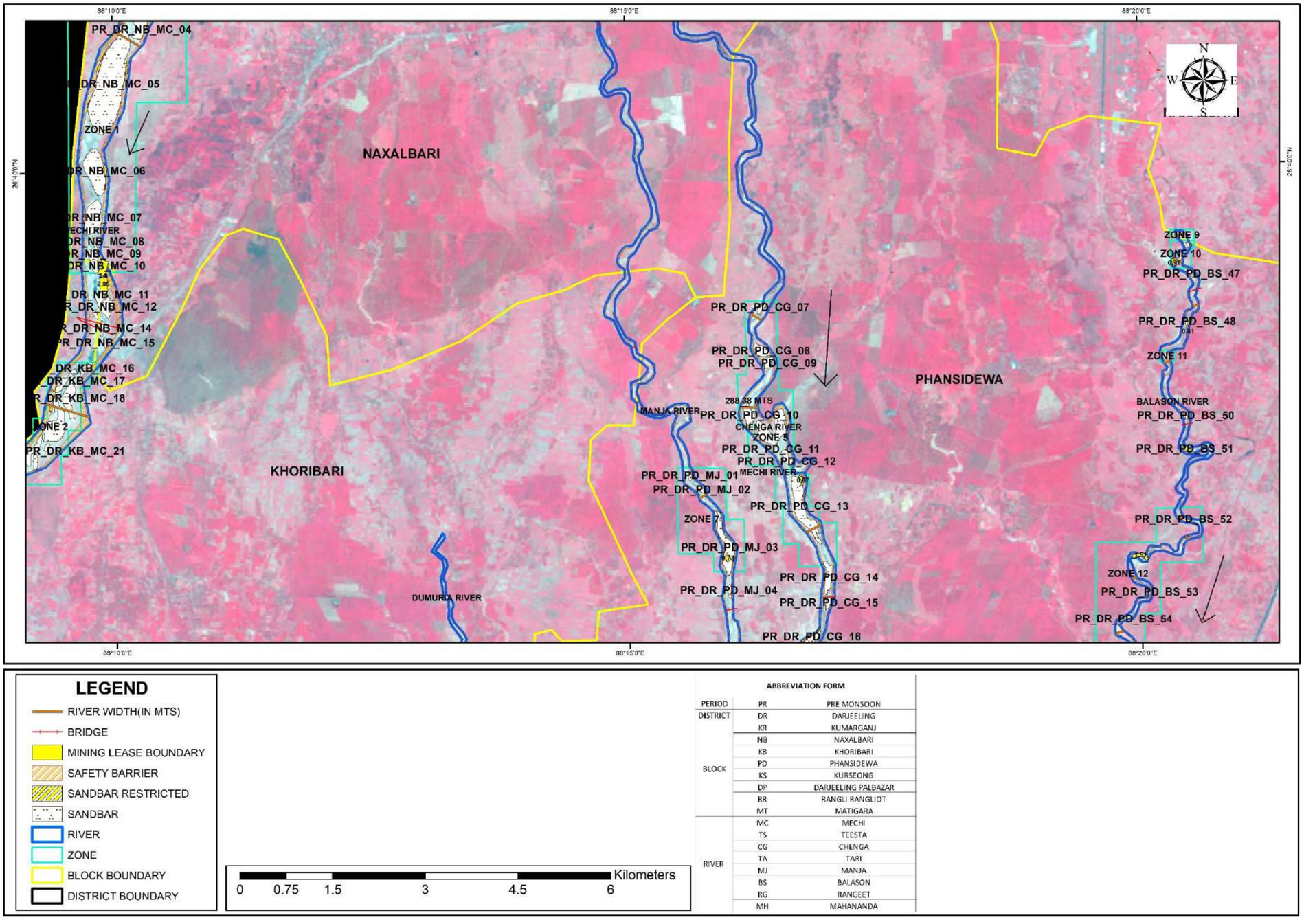


Plate 2A3: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

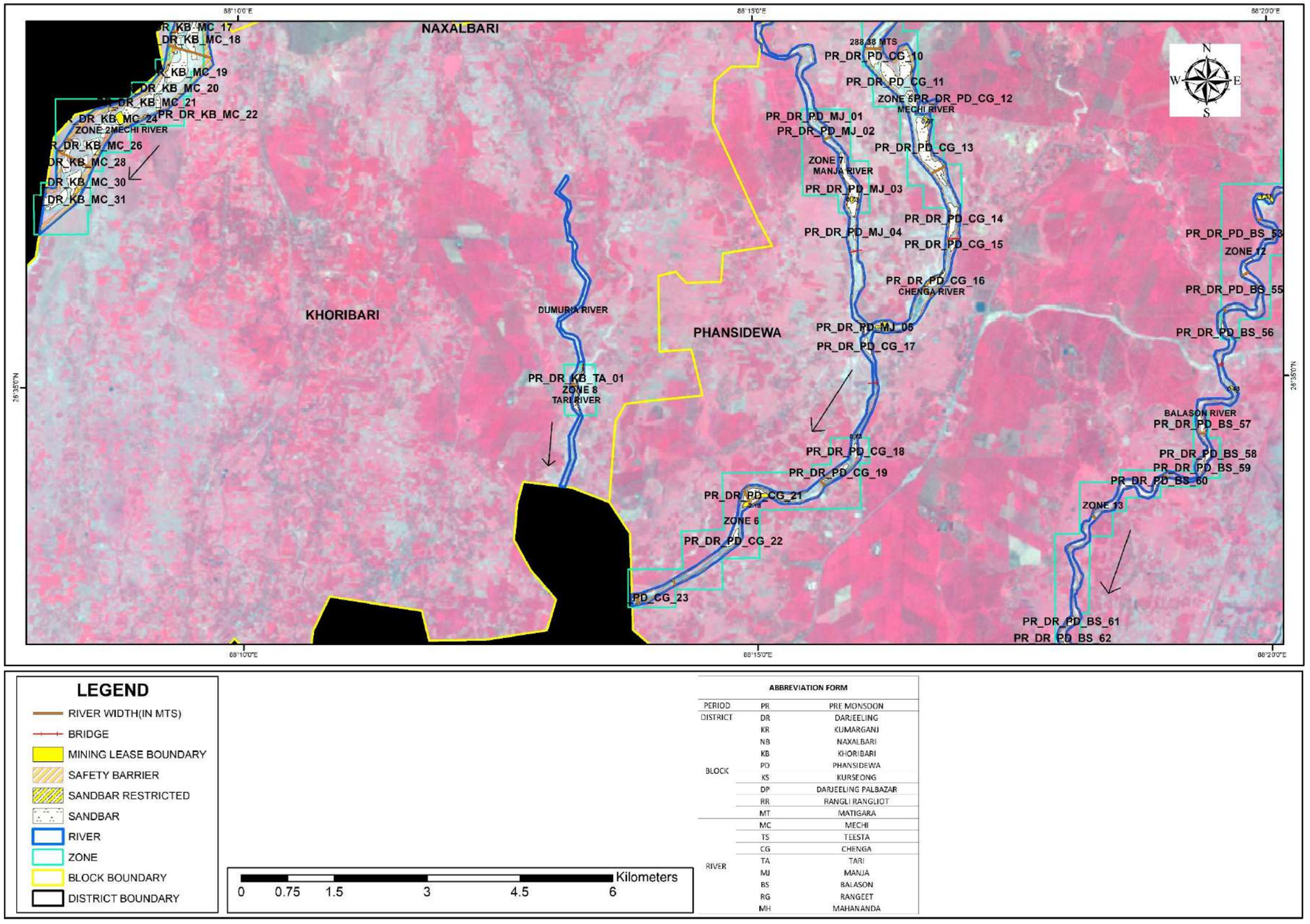


Plate 2A4: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

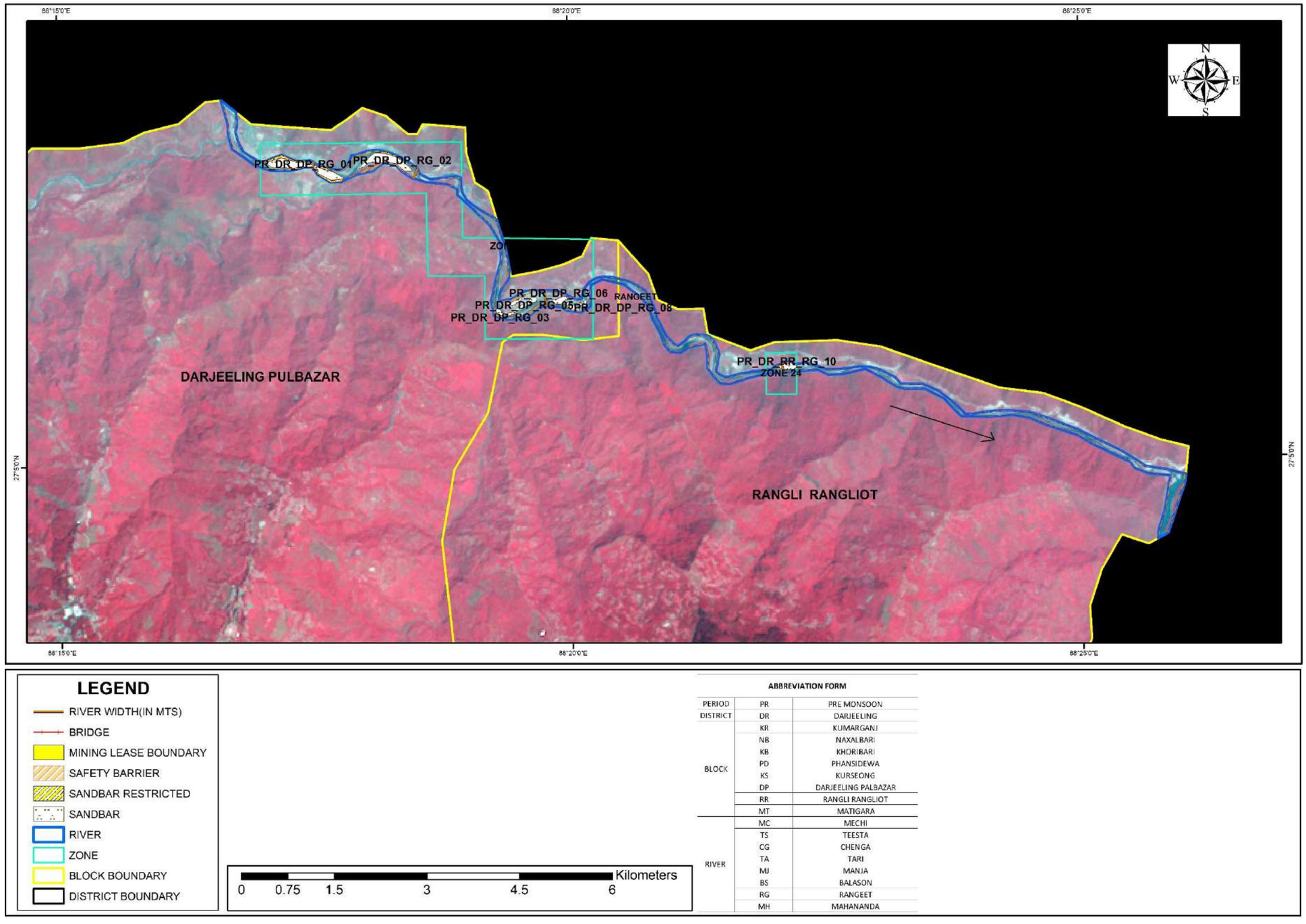
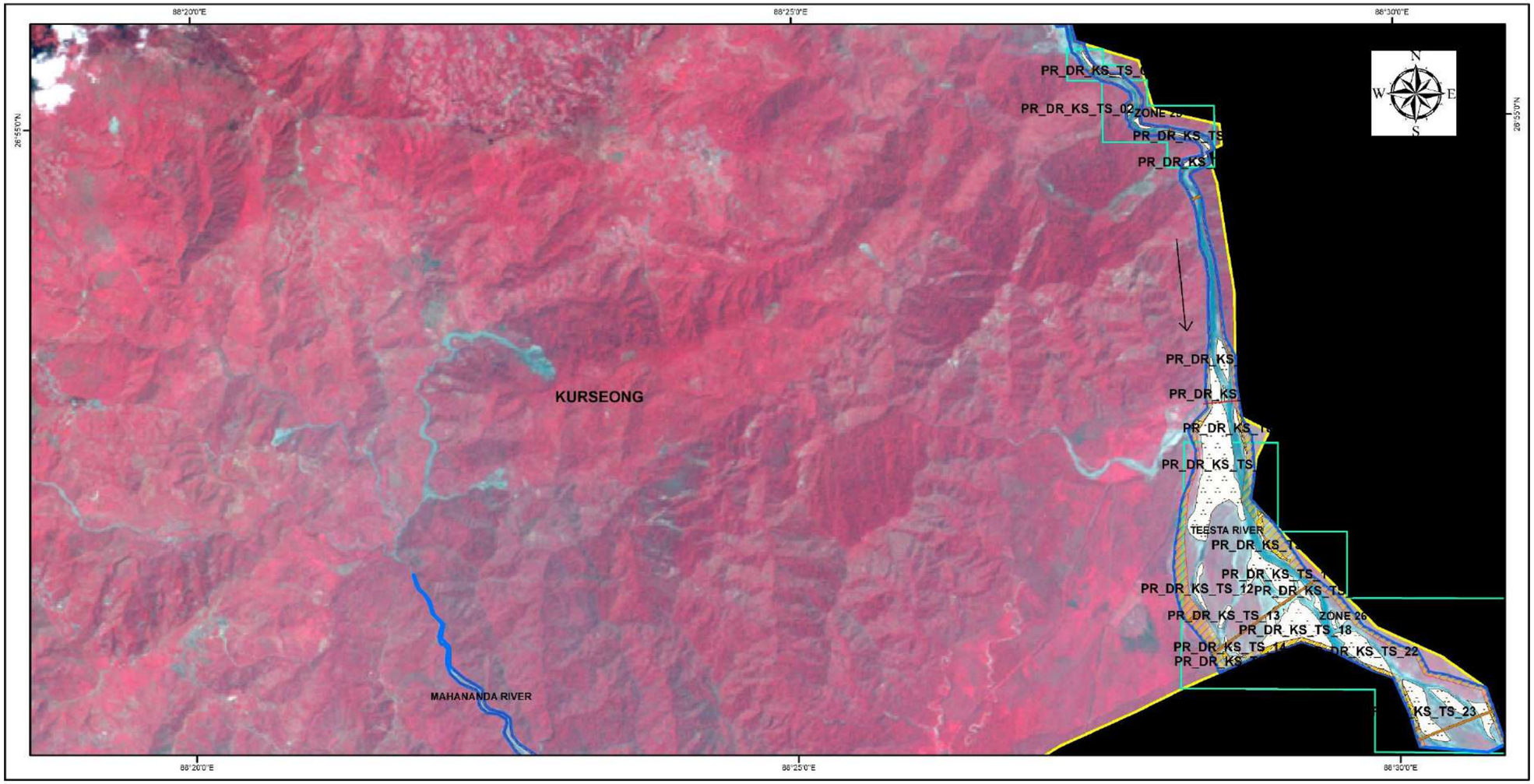


Plate 2A5: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District



ABBREVIATION FORM

PERIOD	PR	PRE MONSOON
DISTRICT	DR	DARJEELING
BLOCK	KR	KUMARGANJ
	NB	NAXALBARI
	KB	KHORIBARI
	PD	PHANSIDEWA
	KS	KURSEONG
	DP	DARJEELING PALBAZAR
	RR	RANGLI RANGLIOT
	MT	MATIGARA
RIVER	MC	MECHI
	TS	TEESTA
	CG	CHENGA
	TA	TARI
	MJ	MANJA
	BS	BALASON
	RG	RANGEET
	MH	MAHANANDA

Plate 2A6: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

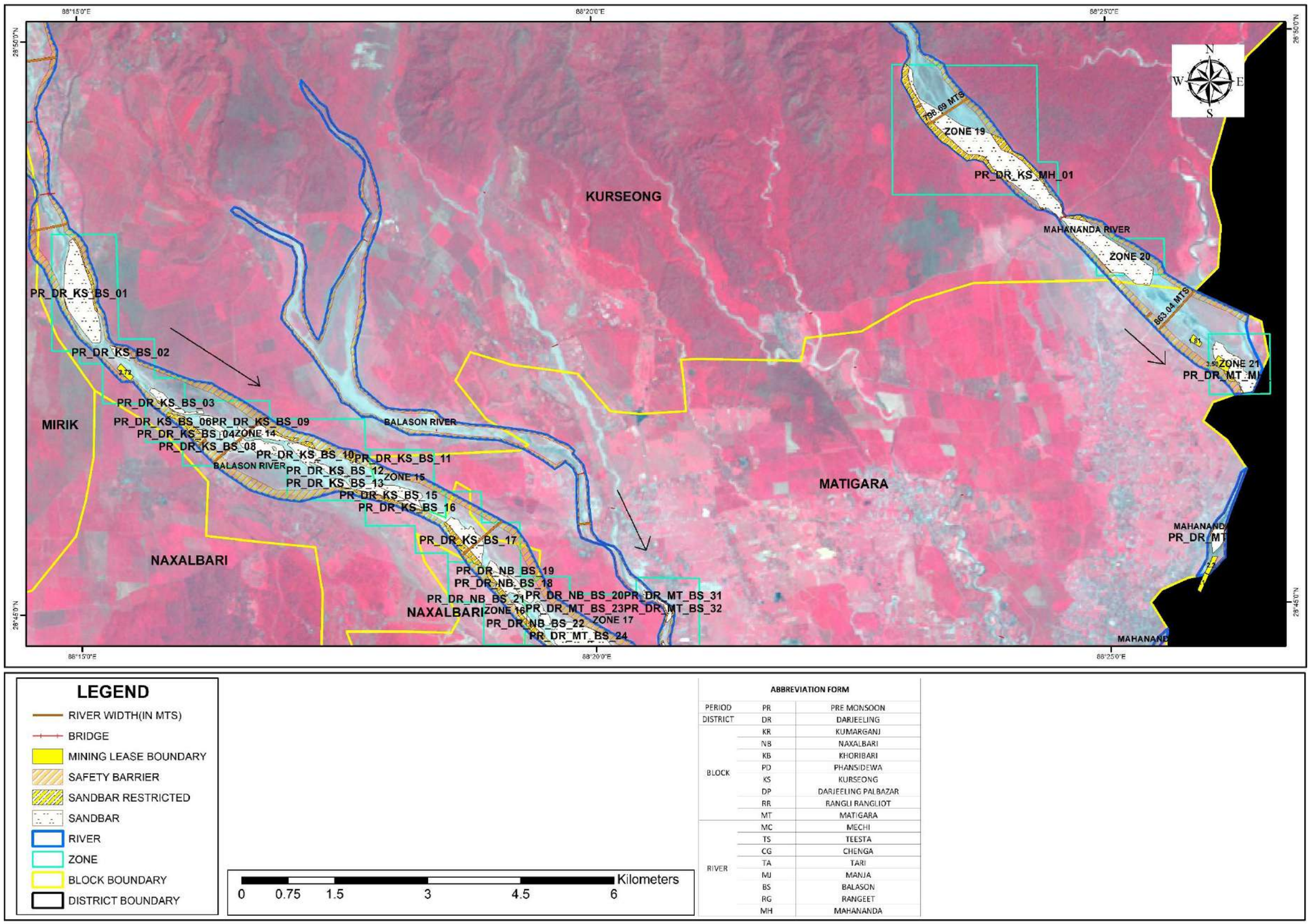


Plate 2A7: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

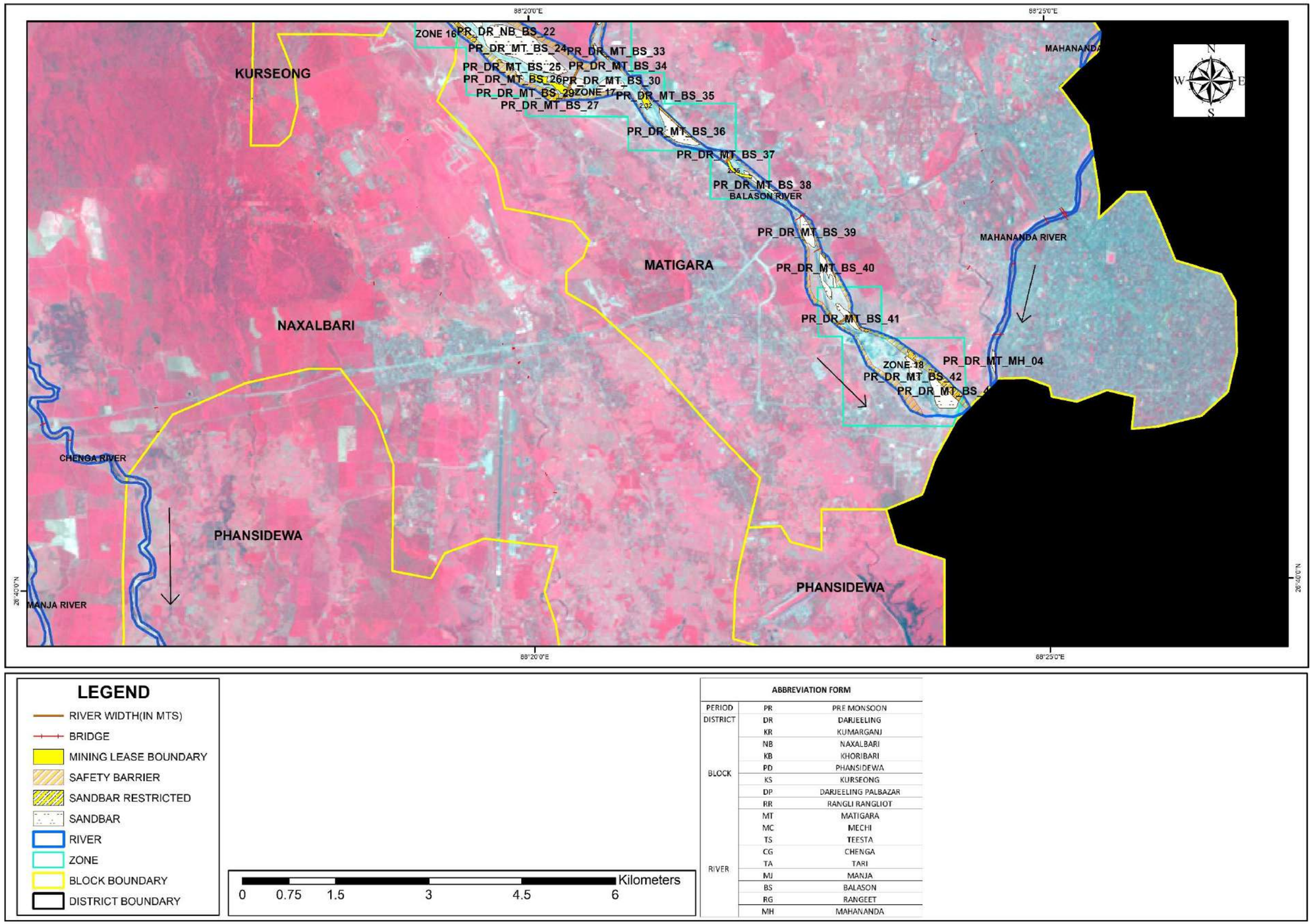


Plate 2A8: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

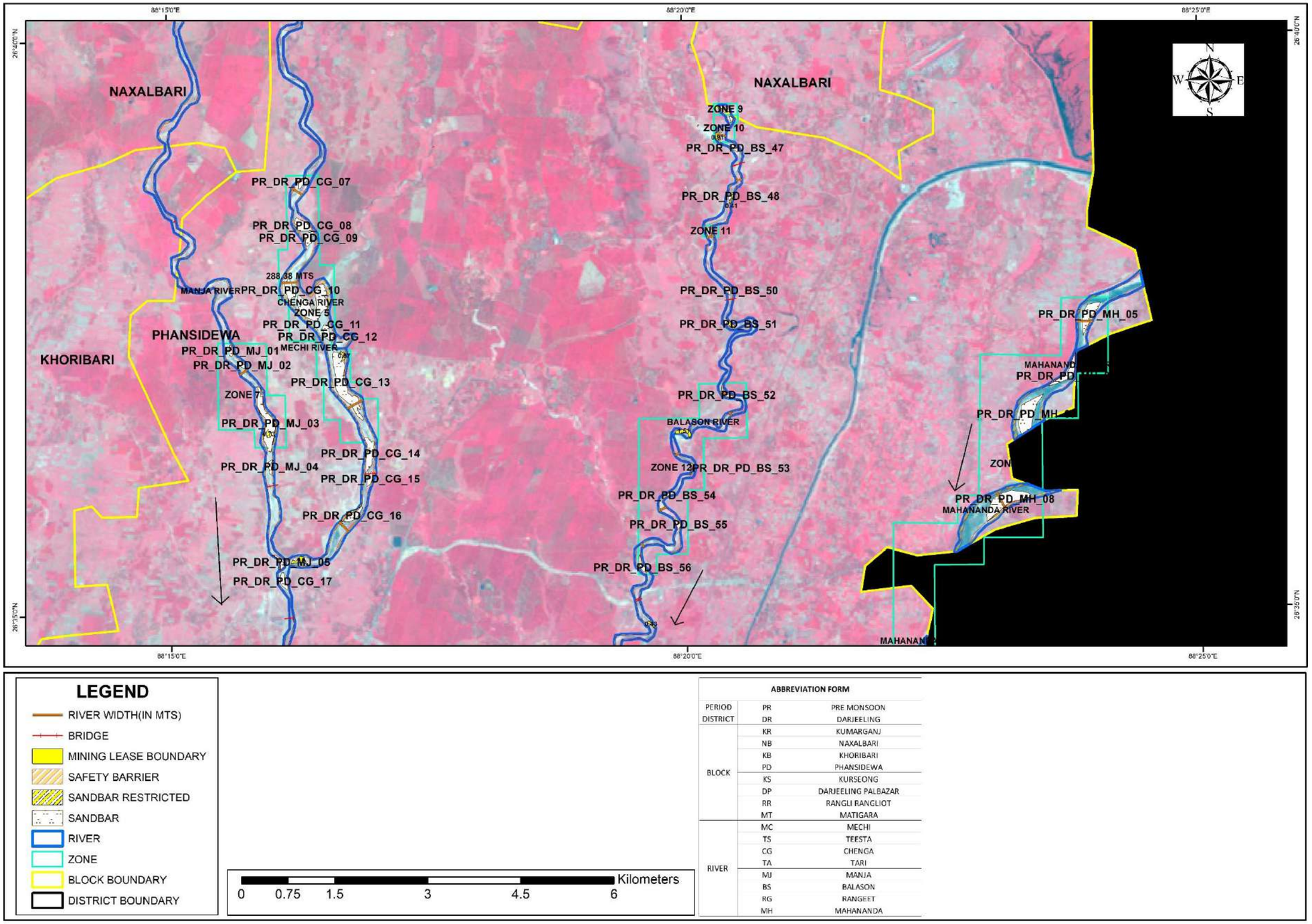


Plate 2A9: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

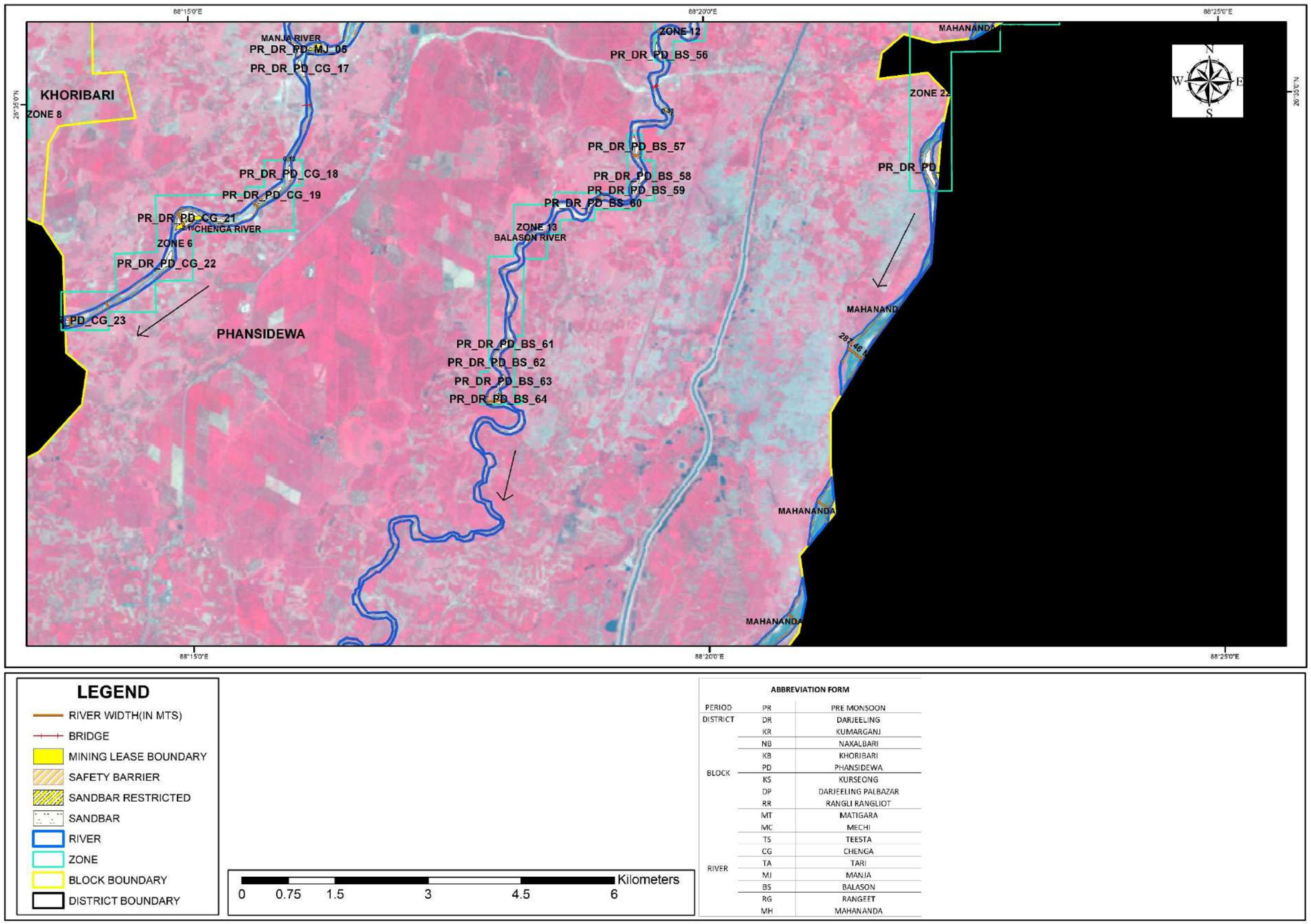
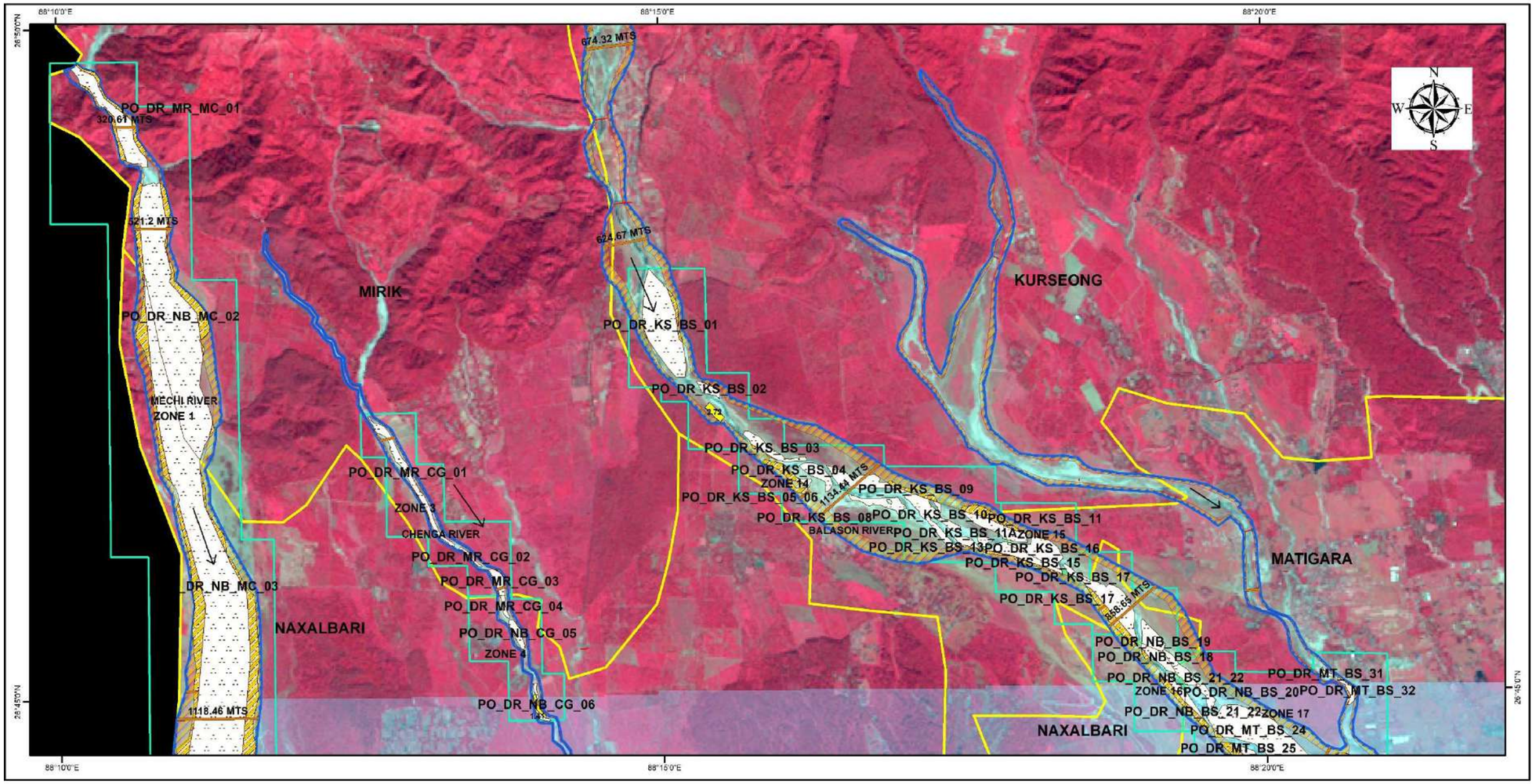


Plate 2A10: Distribution Map of Sand Bars on Rivers During Pre-Monsoon Period of Darjeeling District

PLATE 2B

DISTRIBUTION MAP OF SAND BARS ON RIVERS DURING POST-MONSOON PERIOD OF DARJEELING DISTRICT



LEGEND

- RIVER WIDTH(IN MTS)
- BRIDGE
- MINING LEASE BOUNDARY
- SAFETY BARRIER
- SANDBAR RESTRICTED
- SANDBAR
- RIVER
- ZONE
- BLOCK BOUNDARY
- DISTRICT BOUNDARY

0 0.75 1.5 3 4.5 6 Kilometers

ABBREVIATION FORM

PERIOD	PO	POST MONSOON
DISTRICT	DR	DARJEELING
	KR	KUMARGANJ
BLOCK	NB	NAXALBARI
	KB	KHORIBARI
	PD	PHANSIDEWA
	KS	KURSEONG
	DP	DARJEELING PALBAZAR
	RR	RANGLI RANGLIOT
	MT	MATIGARA
RIVER	MC	MECHI
	TS	TEESTA
	CG	CHENGA
	TA	TARI
	MJ	MANJA
	BS	BALASON
	RG	RANGEET
	MH	MAHANANDA

Plate 2A1: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

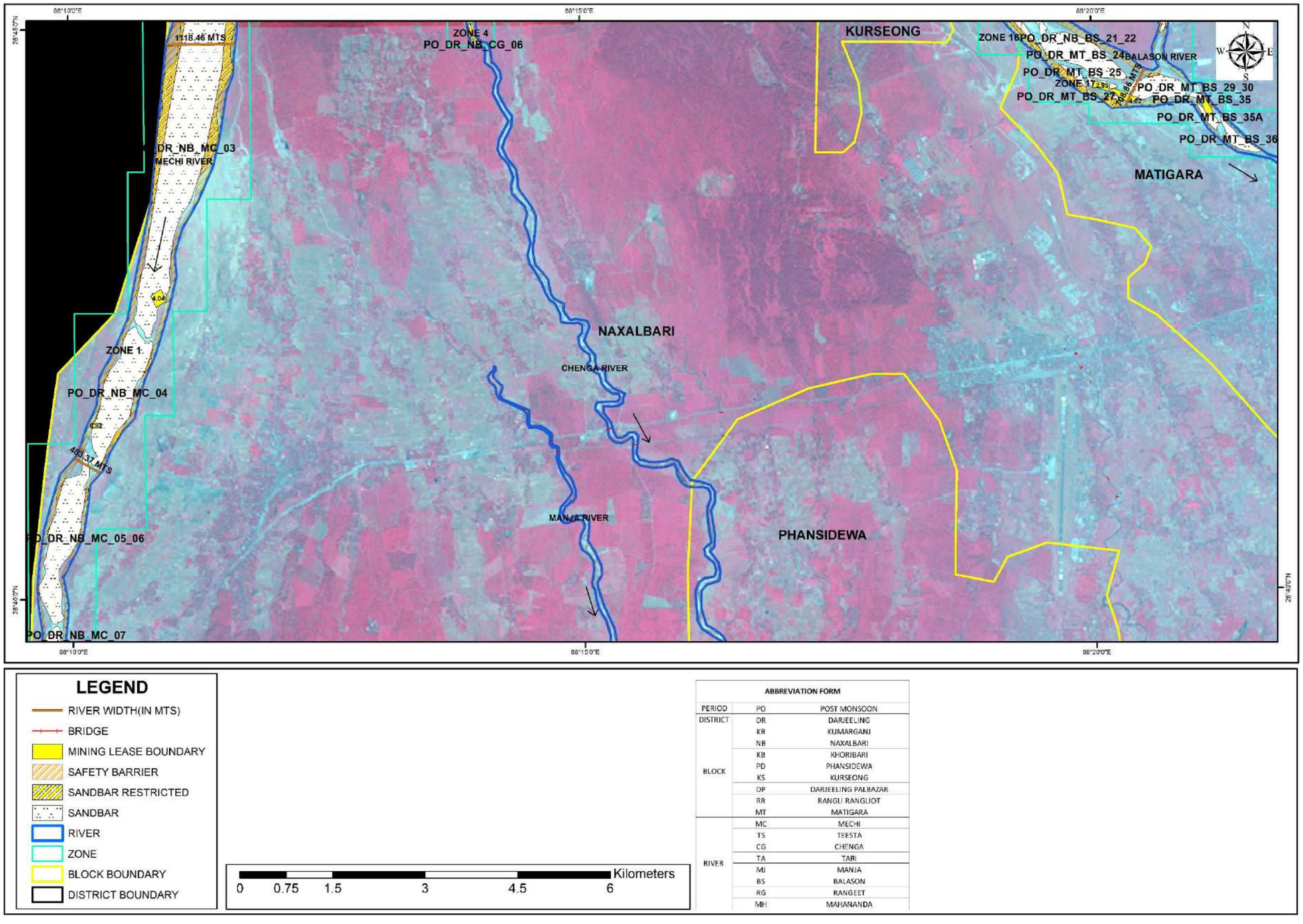


Plate 2A2: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

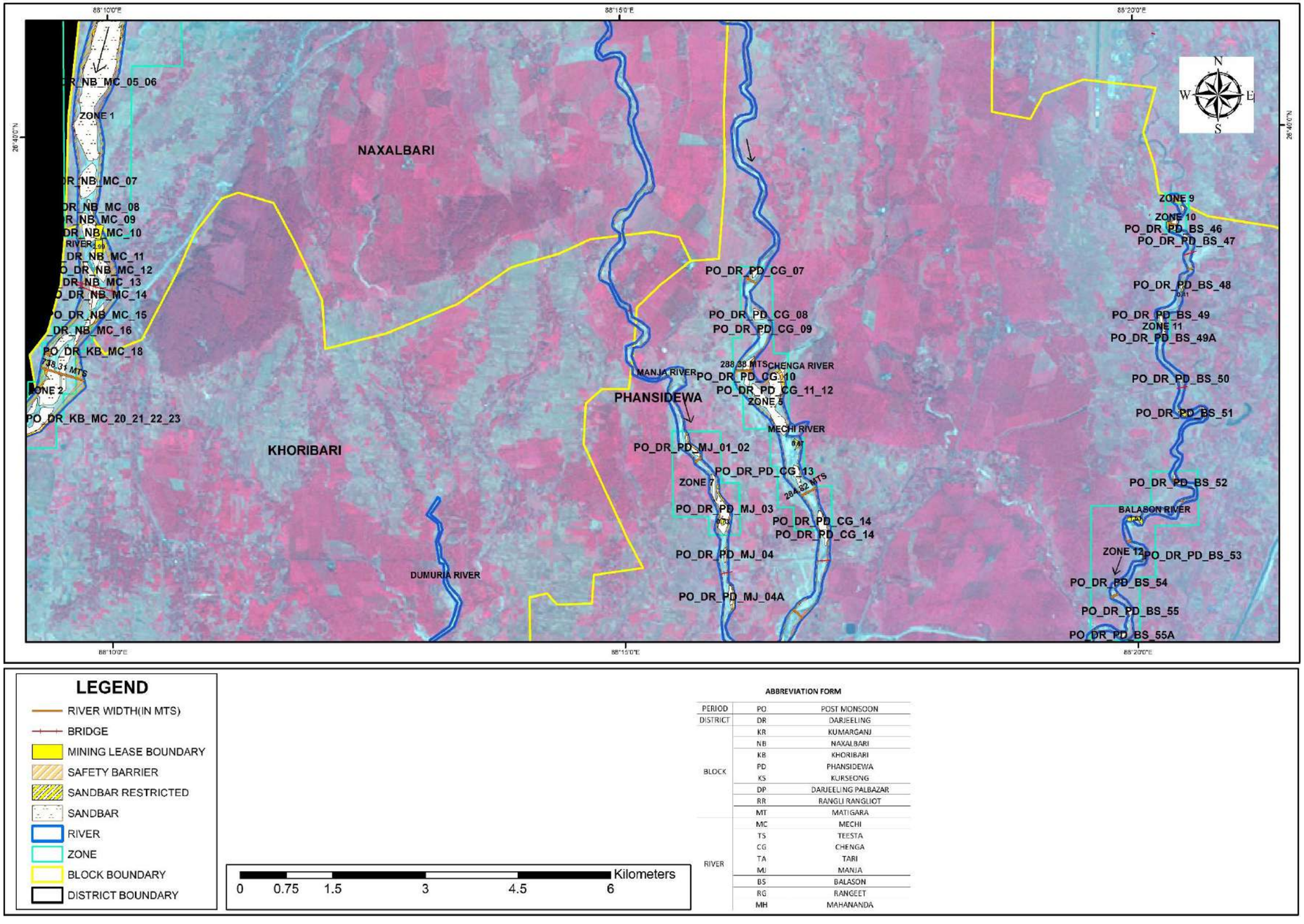


Plate 2A3: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

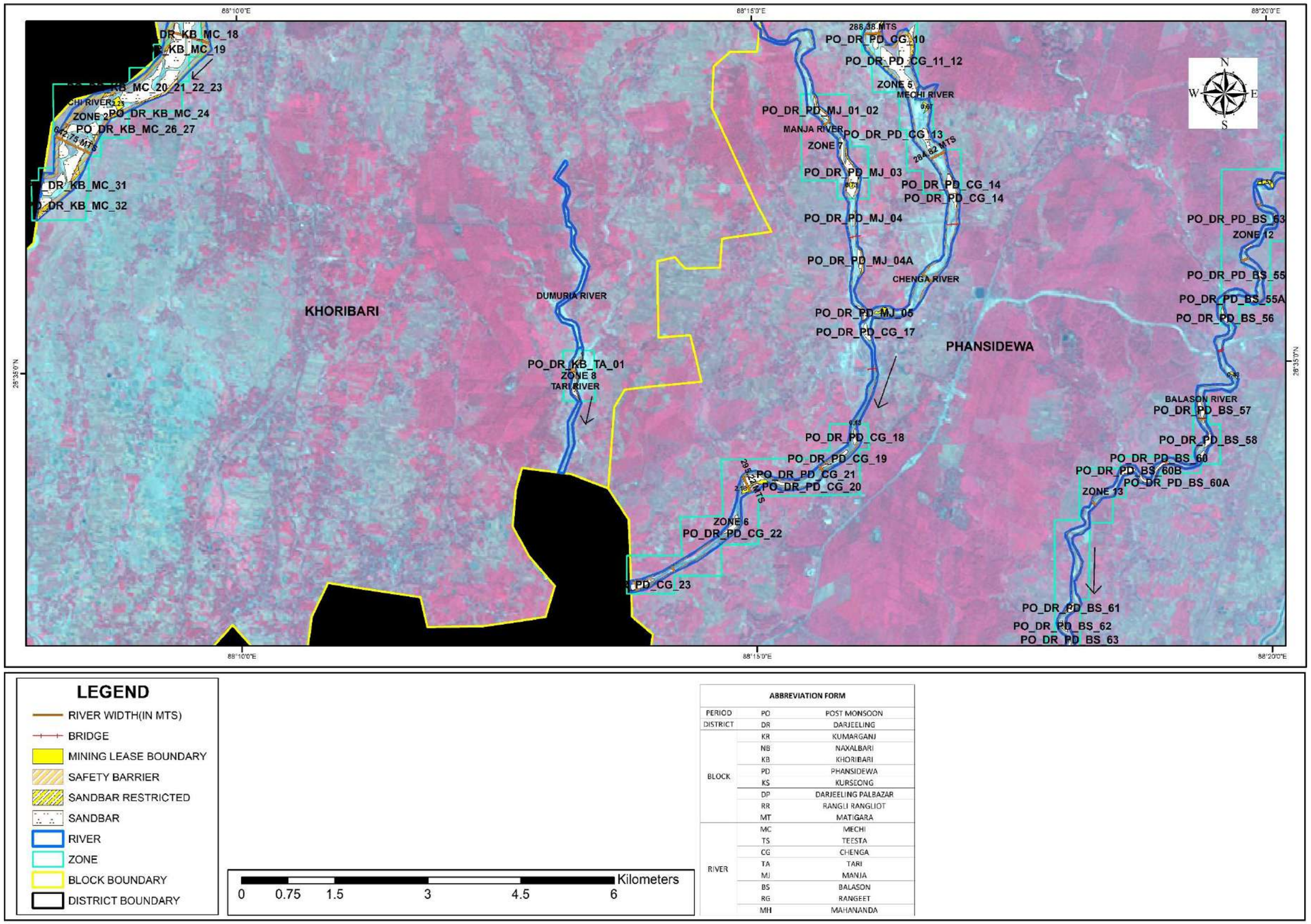


Plate 2A4: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

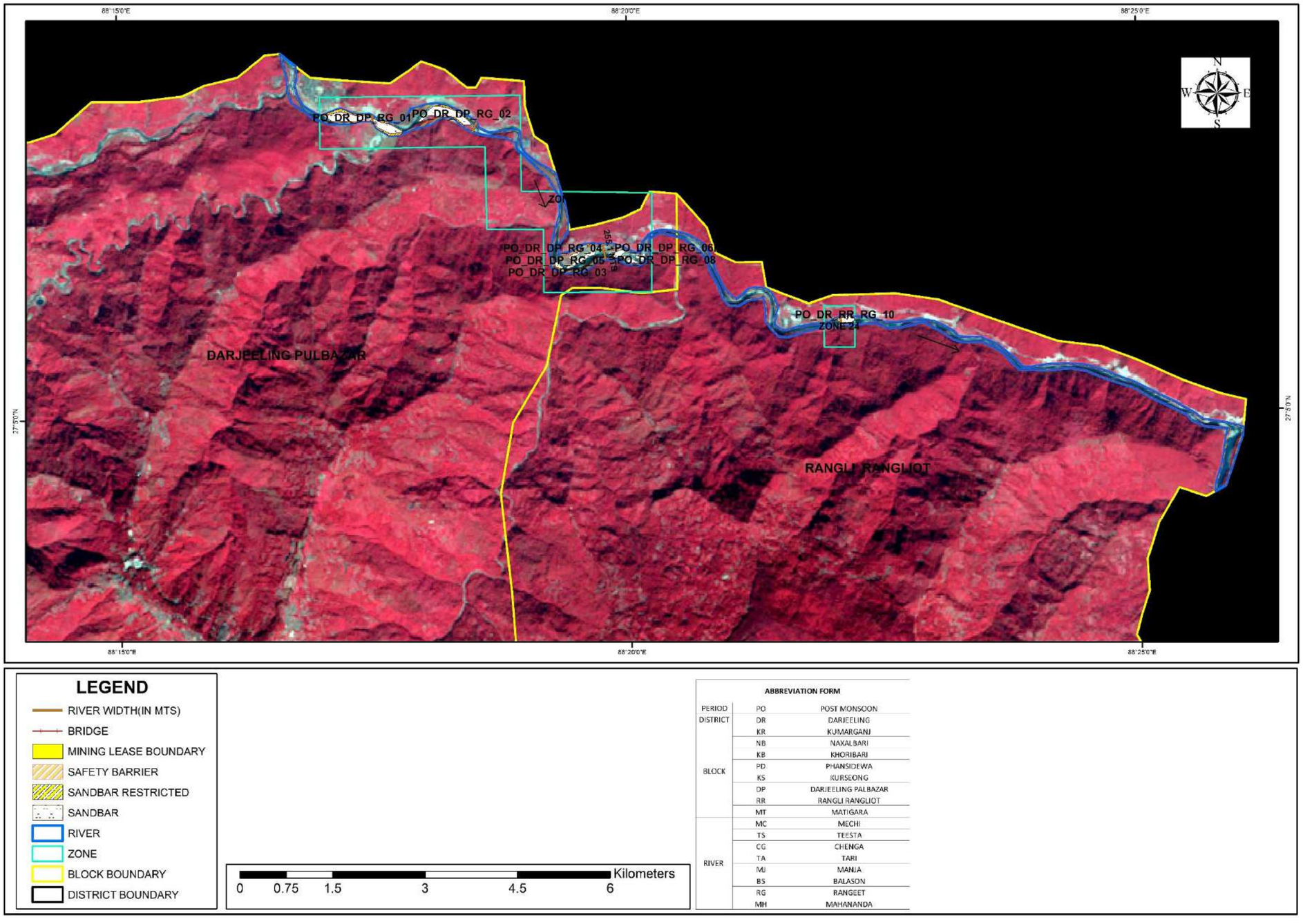


Plate 2A5: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

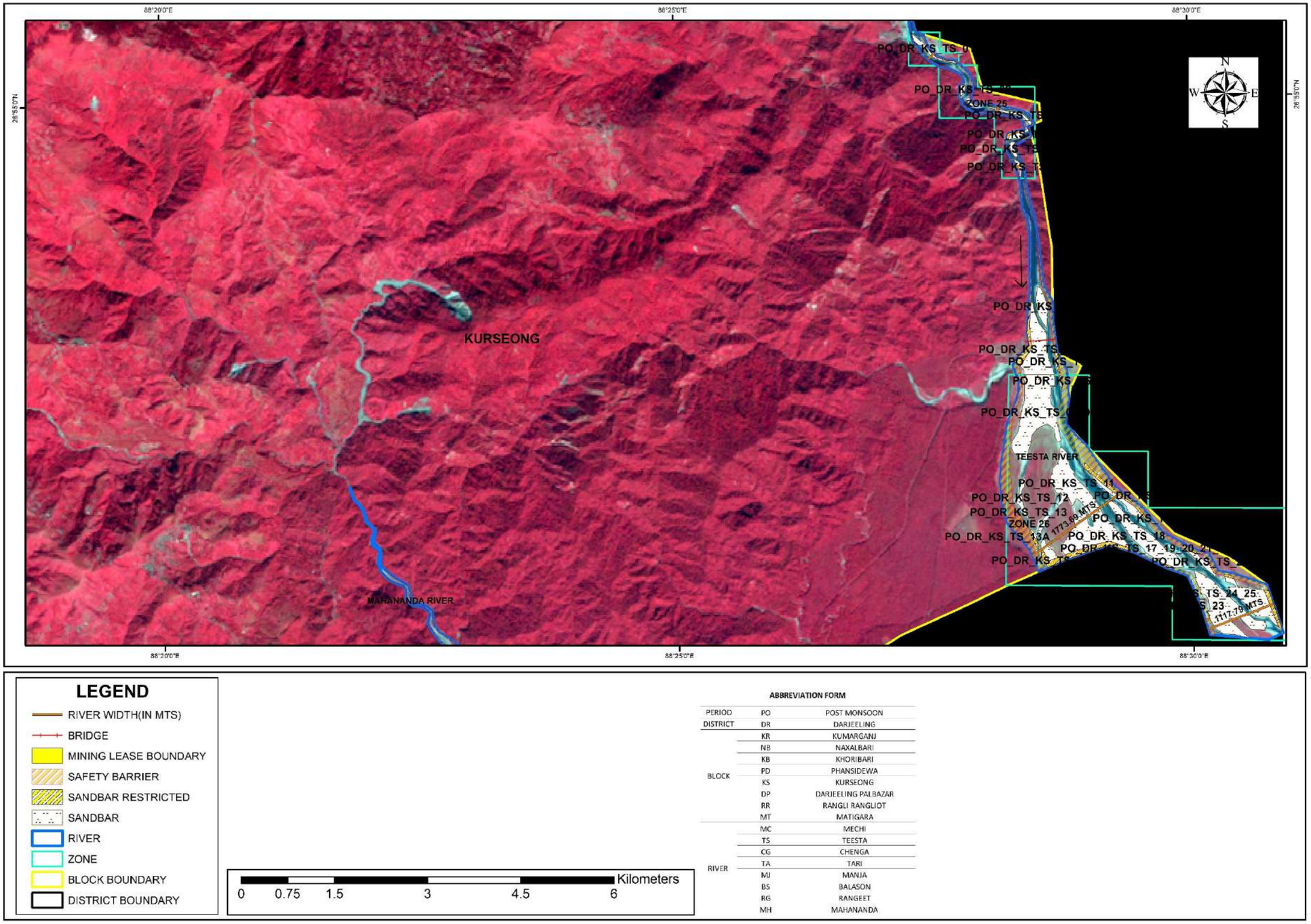
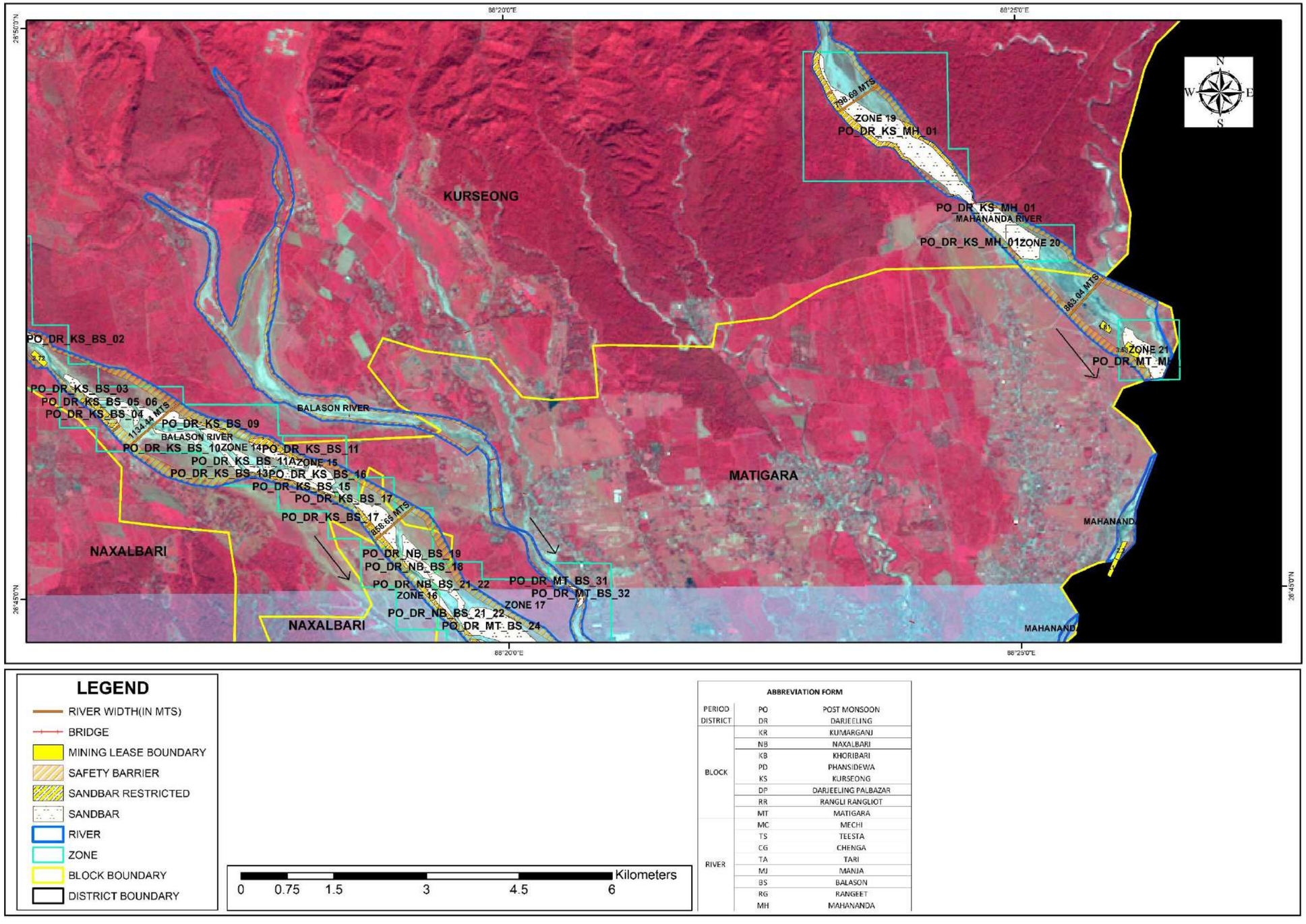


Plate 2A6: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District



LEGEND

- RIVER WIDTH(IN MTS)
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- MINING LEASE BOUNDARY
- SAFETY BARRIER
- SANDBAR RESTRICTED
- SANDBAR
- RIVER
- ZONE
- BLOCK BOUNDARY
- DISTRICT BOUNDARY

0 0.75 1.5 3 4.5 6 Kilometers

ABBREVIATION FORM

PERIOD	PO	POST MONSOON
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	KB	KHORIBARI
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	KS	KURSEONG
	DP	DARJEELING PALBAZAR
	RR	RANGLI RANGLIOT
	MT	MATIGARA
RIVER	MC	MECHI
	TS	TEESTA
	CG	CHENGA
	TA	TARI
	MJ	MANJA
	BS	BALASON
	RG	RANGEET
	MH	MAHANANDA

Plate 2A7: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

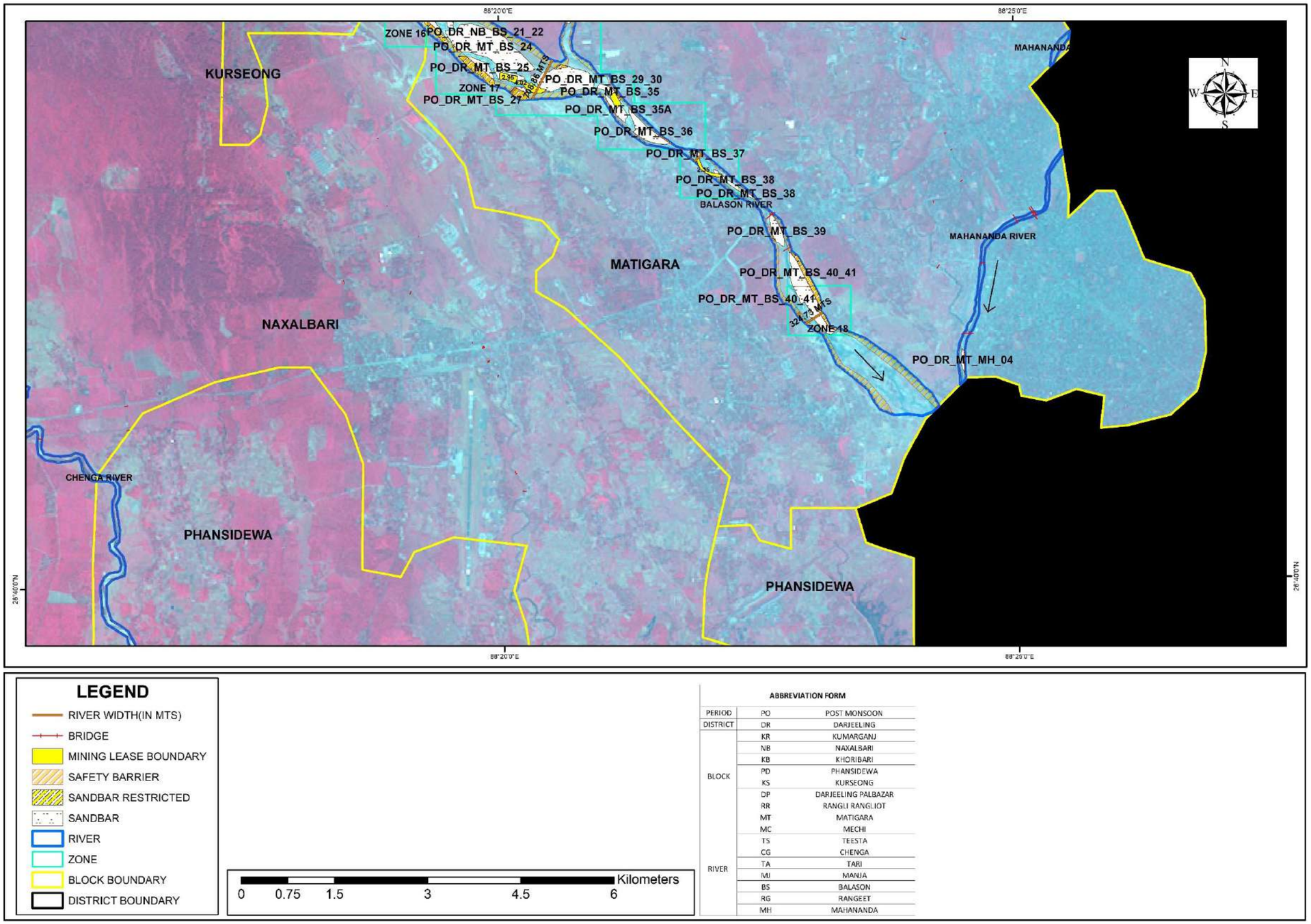

Plate 2A8: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

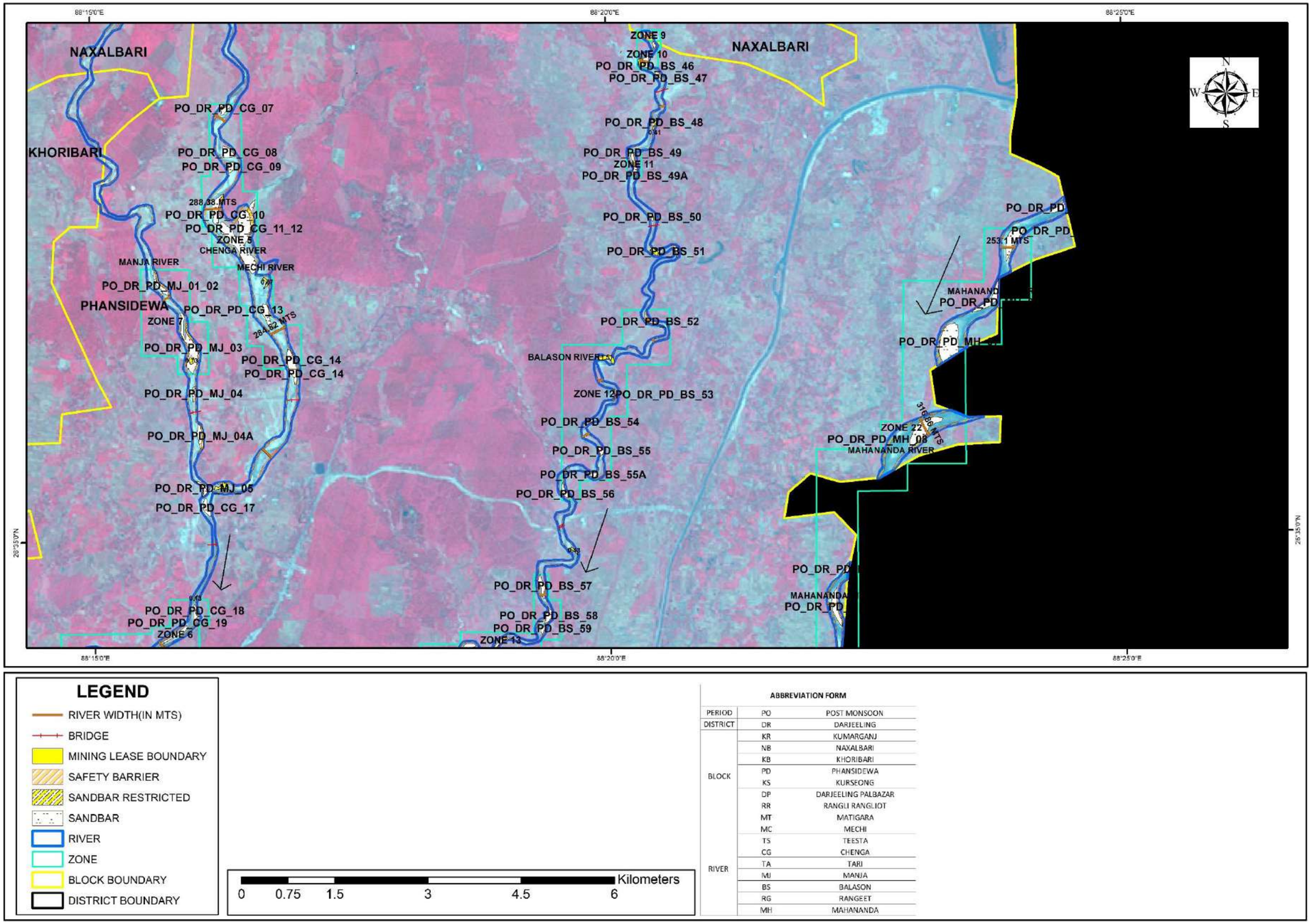

Plate 2A9: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District

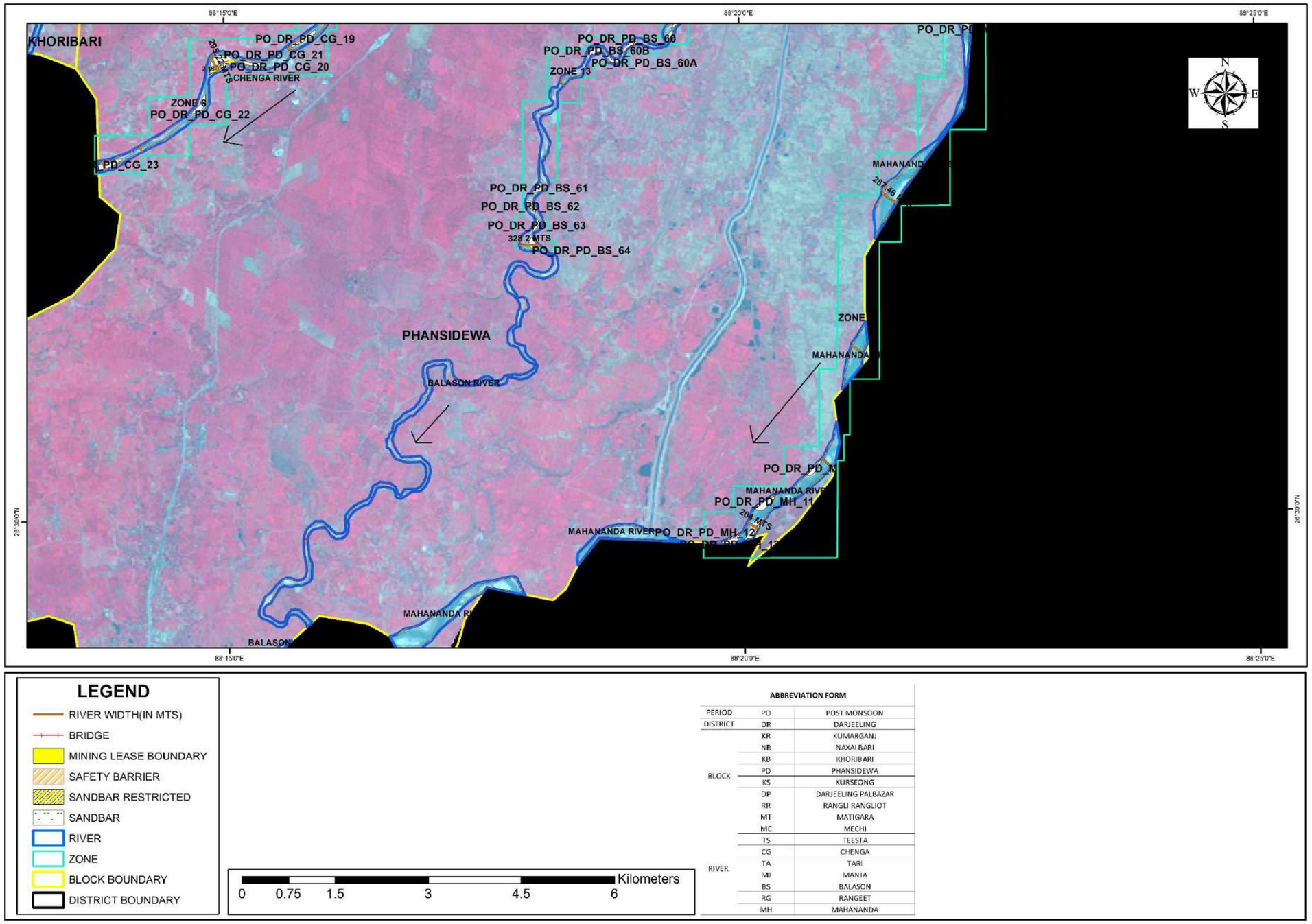

Plate 2A10: Distribution Map of Sand Bars on Rivers During Post-Monsoon Period of Darjeeling District