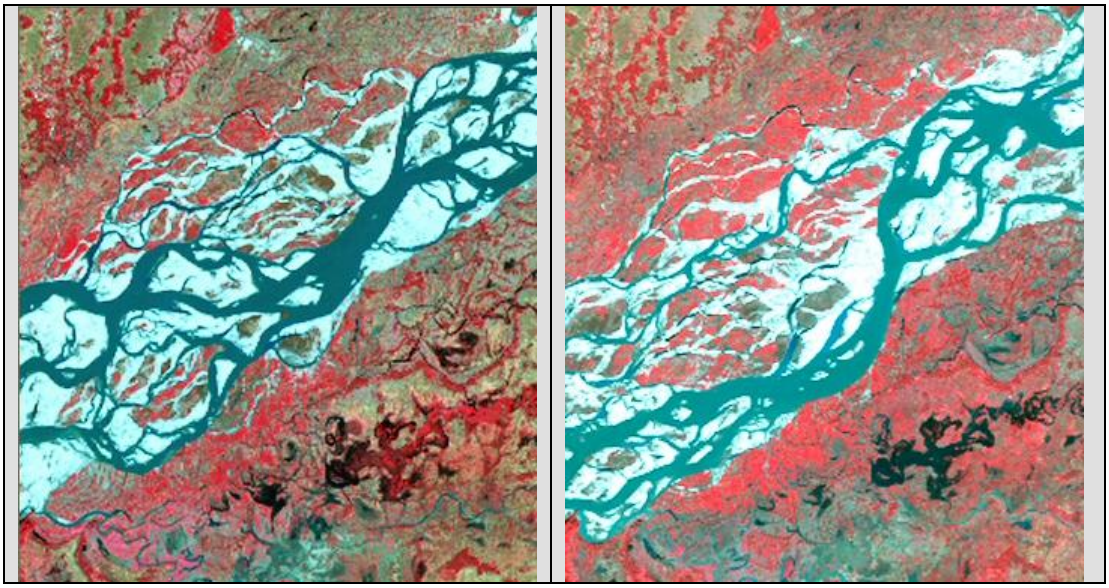
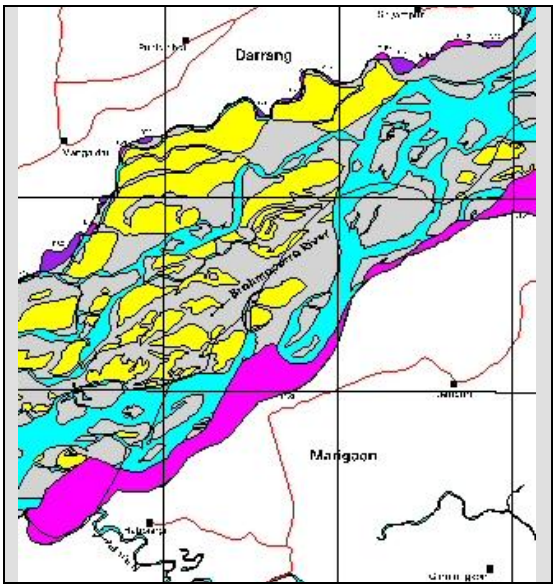
Identification and Estimation of River Bank Erosion along Brahmaputra and Barak Rivers in Assam during 1996-2002 using Satellite Remote Sensing Techniques.





December 2004

Prepared by

Water Resources Division
RS & GIS Applications Area
National Remote Sensing Agency
Hyderabad

Prepared for

Superintending Engineer
Hydrological Observation Circle
Central Water Commission
Guwahati, Assam.

Study Team

Smt. P.Manjusree
Scientist / Engineer "SD"
Water Resources Division

Shri.T.Kiran Kumar
Scientist / Engineer "SD"
Water Resources Division

Shri.G.Srinivasa Rao
Scientist / Engineer "SE"
Water Resources Division

Shri.V.Bhanu Murthy
Head, Water Resources Division

Contents

1.0 Introduction

1.1 Monitoring of river bank erosion

1.2 Satellite Remote Sensing

1.3 Genesis of the study

1.4 Objective of the study

2.0 Study Area

2.1 Satellite data

3.0 Methodology

3.1 Preparation of map base

3.2 Rectification of satellite data

3.3 Preparation of ancillary layers

3.4 Preparation of River and Bank lines

3.5 Generation of Statistics

3.6 Preparation of outputs

3.6.1 Generation of photo products

3.6.2 Generation of bank erosion maps

4.0 Observations

List of Tables, Figures and Annexures

List of Tables

Table-1: Geo-graphical extent of the study area
Table-2: Satellite data
Table-3: Projection parameters of the satellite data
Table-4: District-wise erosion and deposition statistics

List of Figures

Figure-1: Study area

Figure-2: Schematic representation of the methodology

Figure-3: Satellite data of the study area for the year 1996

Figure-4: Flowchart of the methodology

List of Annexures

Annexure-I: Erosion and Deposition statistics at different pockets
Annexure-II: Erosion map plates

Plate-1: Erosion map showing Brahmaputra River in part of Tinsukia district
Plate-2: Erosion map showing Brahmaputra River in part of Tinsukia district
Plate-3: Erosion map showing Brahmaputra River in part of Tinsukia and Dhemaji districts
Plate-4: Erosion map showing Brahmaputra River in part of Dibrugarh, Tinsukia and Dhemaji districts
Plate-5: Erosion map showing Brahmaputra River in part of Dibrugarh, Tinsukia and Dhemaji districts
Plate-6: Erosion map showing Brahmaputra River in part of Dibrugarh and Dhemaji districts
Plate-7: Erosion map showing Brahmaputra River in part of Dibrugarh district

Plate-8: Erosion map showing Brahmaputra River in part of Dhemaji and Dibrugarh districts

Plate-9: Erosion map showing Brahmaputra River in part of Dhemaji and Dibrugarh districts

Plate-10: Erosion map showing Brahmaputra River in part of Dhemaji and Dibrugarh districts

Plate-11: Erosion map showing Brahmaputra River in part of Jorhat, Sibsagar, Dhemaji and Dibrugarh districts

Plate-12: Erosion map showing Brahmaputra River in part of Jorhat, Sibsagar, Dhemaji and Dibrugarh districts

Plate-13: Erosion map showing Brahmaputra River in part of Jorhat, Sibsagar, Dhemaji and Lakhimpur districts

Plate-14: Erosion map showing Brahmaputra River in part of Jorhat and Lakhimpur districts

Plate-15: Erosion map showing Brahmaputra River in part of Golaghat, Jorhat and Lakhimpur districts

Plate-16: Erosion map showing Brahmaputra River in part of Golaghat, Sonitpur and Lakhimpur districts

Plate-17: Erosion map showing Brahmaputra River in part of Golaghat, and Sonitpur districts

Plate-18: Erosion map showing Brahmaputra River in part of Nowgong, Karbi Anglong and Golaghat districts

Plate-19: Erosion map showing Brahmaputra River in part of Nowgong, Karbi Anglong and Sonitpur districts

Plate-20: Erosion map showing Brahmaputra River in part of Nowgong and Sonitpur districts

Plate-21: Erosion map showing Brahmaputra River in part of Nowgong and Sonitpur districts

Plate-22: Erosion map showing Brahmaputra River in part of Marigaon, Nowgong, Darrang and Sonitpur districts

Plate-23: Erosion map showing Brahmaputra River in part of Marigaon and Darrang districts

Plate-24: Erosion map showing Brahmaputra River in part of Kamrup, Marigaon and Darrang districts

Plate-25: Erosion map showing Brahmaputra River in part of Kamrup and Darrang districts
Plate-26: Erosion map showing Brahmaputra River in part of Kamrup and Nalbari districts
Plate-27: Erosion map showing Brahmaputra River in part of Kamrup, Barpeta and Nalbari districts
Plate-28: Erosion map showing Brahmaputra River in part of Kamrup, Golpara and Barpeta districts
Plate-29: Erosion map showing Brahmaputra River in part of Golpara, Bongaigaon and Barpeta districts
Plate-30: Erosion map showing Brahmaputra River in part of Golpara, Bongaigaon , Barpeta and Dhubri districts
Plate-31: Erosion map showing Brahmaputra River in part of Golpara, Bongaigaon and Dhubri districts
Plate-32: Erosion map showing Brahmaputra River in part of Golpara and Dhubri districts
Plate-33: Erosion map showing Brahmaputra River in part of Dhubri district
Plate-34: Erosion map showing Brahmaputra River in part of Dhubri district
Plate-35: Erosion map showing Barak River in part of Cachar, Hailakhandi and Karimganj districts
Plate-36: Erosion map showing Barak River in part of Cachar district
Plate-37: Erosion map showing Barak River in part of Cachar district
Plate-38: Erosion map showing Brahmaputra River on 1:700,000 scale
Plate-39: Erosion map showing Brahmaputra and Barak Rivers on 1:700,000 scale
Plate-40: Erosion map showing Brahmaputra and Barak Rivers on 1:1,000,000 scale

Introduction

1.0 Introduction

The Brahmaputra in Assam is one of the largest rivers in the world and carries over 30% of the total water resources of the country. The channel of the river is characterized by rapid aggradations, dramatic channel shifts and excessive bank line recession. In the foothill region, alluvial fans and braided channels exist filled with deposition of coarse alluvial materials due to sudden change in gradient of the rivers.

Bank erosion in one of the most commonly experienced effects due to high inflows, excessive sediment charge and channel shift of the river on either side. As the discharge of the stream increases, the depth and the mean velocity increases, due to which river banks are subjected to greater erosive action. An increase in the discharge increases high stream power of the flow that would cause more bank erosion. As the severity and effect of hydraulic forces increase manifold during the flood, the rate of erosion increases rapidly.

Excessive sediment load is mainly due to the frequent seismic disturbances of low magnitudes and earthquake of disastrous nature in combination with the deforestation in upper catchment area of the river basins. In a braided river like the Brahmaputra, short time channel migration is quite drastic.

The tributaries flowing through Sikkim and North Bengal have steep slopes and bring down large quantity of the silt with high velocity, resulting in aggradations of riverbeds, erosion of banks and changing of the river course. Deforestation, cutting in hillside for developmental works like roads and shifting cultivation cause further problem by way of soil erosion and quick runoff. The heavy silt load results in cross channels and formation of shoals and bars, braiding and erosion of banks.

1.1 Monitoring River Bank Erosion

There are direct and indirect methods for monitoring the river bank erosion. The direct method is taking measurements from the field in terms of linear rates of erosion, volumes of erosion and channel cross section. The indirect method is by analyzing the archival sources that exist at various timescales with the sediment records. The archive sources can be conventional survey maps, aerial photos or satellite images.

1.2 Satellite Remote Sensing

In the recent years, Satellite Remote Sensing Technology has successfully proven itself as a valuable information generator for various river engineering studies. The potential of remote sensing data is that it is highly reliable, accurate and cost effective. Using high-resolution data of LISS-III/IV and PAN sensors aboard Indian Remote Sensing (IRS) satellites like IRS-1C, 1D & P6, the latest river

configuration, shift in the river courses, formation of new channels/oxbow lakes, bank erosion/deposition, drainage-congested areas, etc. can be mapped at different scales. Since accurate river configuration is obtained, it can be used for laying models for conducting river behavior studies. Information derived from remote sensing can be used for other river morphological application studies like monitoring the existing flood control works and identification of vulnerable reaches, planning bank protection works, planning drainage improvement works etc. The changes in the river configuration can be monitored at regular intervals of time.

1.3 Genesis of the study

Central Water Commission is a premier Technical Organization in the country in the field of Water Resources under Ministry of Water Resources and is responsible for various water management activities throughout the country for purpose of Flood Control, Irrigation, Navigation, Drinking Water Supply and Water Power Development etc. in consultation with the State Governments concerned. It is also involved in Flood Management and Development and Operation of Flood Forecasting System and river morphological studies, schemes for bank/coastal protection and preparation of relevant status reports and manuals.

Central Water Commission (CWC), Guwahati has approached National Remote Sensing Agency (NRSA), Department of Space, Govt. of India, to study the river bank erosion in the main Brahmaputra and Barak river system. In this connection the concerned officials of CWC Guwahati visited NRSA during Jan 2003 and had discussions to take up the study. The user was interested to procure the high resolution satellite images of 1996 and 2002 besides bank erosion maps during the years 1996 – 2002 on 1:50,000 scale. Accordingly a project proposal was prepared and the cost of the project was estimated to be Rs.18.38 Lakhs. The duration of the execution of the project was estimated to be about 8 months.

1.4 Objective of the study

- To provide annotated satellite images on 1:50,000 scale covering main Brahmaputra River and Barak River in Assam for the post flood seasons of 1996 and 2002.

- To provide maps showing location and extent of river bank erosion on 1:50,000 scale along the main Brahmaputra and Barak rivers in Assam during the years 1996 – 2002 both in hard and soft copies.

Study Area

2.0 Study Area

The study area is the main Brahmaputra reach from Sunpura in Tinsukia district to Patakata in Dhubri district and Barak River from Rabipur in Cachar district to Katakhal in Karimganj district in Assam as shown in Figure-1. The Geo-graphical extent of the study area is shown in Table-1. The study area is covered in about 50 topomaps on 1:50,000 scale. The entire study area is covered in thirty seven plates on 1:50,000 scale and 2 plates on 700,000 scale and in one plate on 1Million scale for a complete overall view. A total of 80 satellite image plates were designed both for 1996 and 2002 years respectively and 40 erosion maps were designed showing the river bank erosion during 1996-2002.

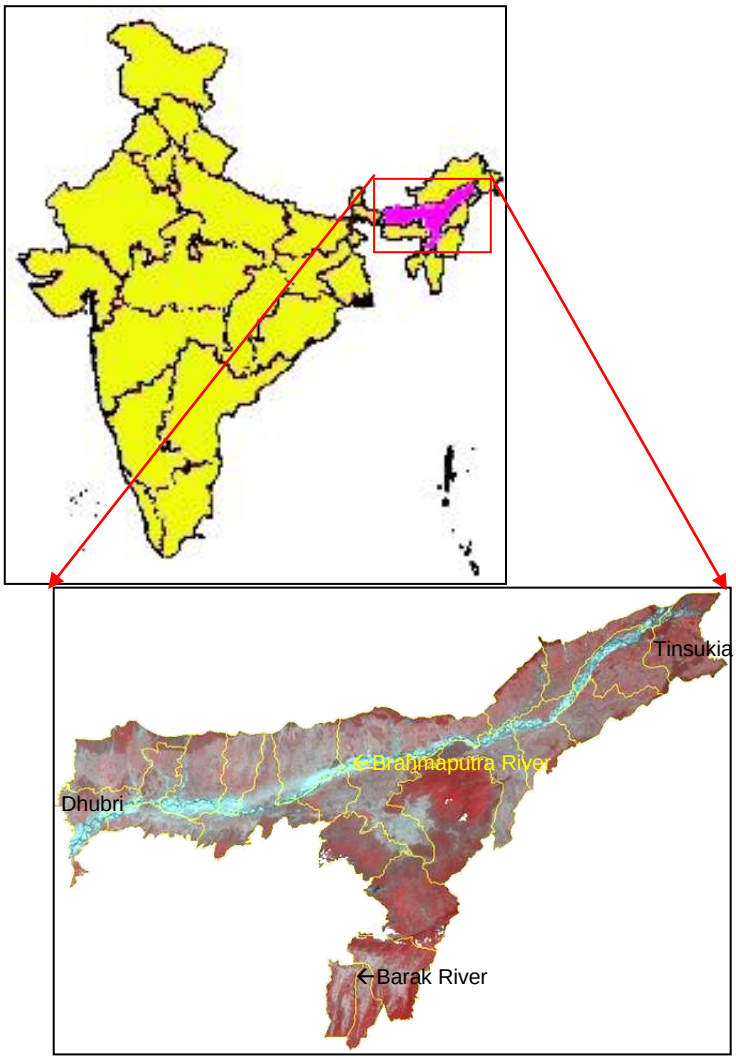


Figure-1: Location of the study area

S. No	River	From		To	
		Long(E)	Lat(N)	Long(E)	Lat(N)
1	Brahmaputra	89 49 53	25 43 33	95 51 54	27 49 55
2	Barak	92 29 53	24 42 42	93 04 28	24 52 39

Table: 1 Geo-graphical extent of the study area

2.1 Satellite data

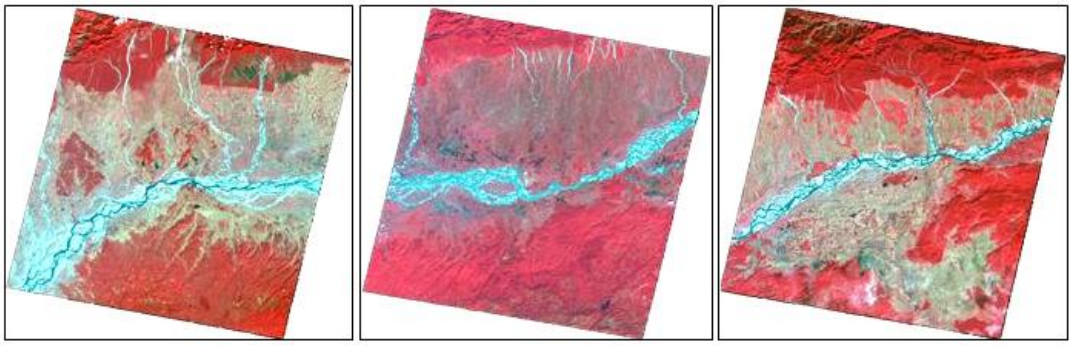
IRS-1C and IRS-1D satellites which were launched during December 1995 and September 1997 respectively have LISS-III sensor, whose characteristics were shown in Table-2. Post flood season satellite data of IRS-1C/1D LISS-III sensor which has a spatial resolution of 23m was procured to carry out the study. Wherever post flood season satellite data during November/December was not available, January and February data of the succeeding year was procured as shown in Table-3. Resampled images of the satellite data of different paths and row for the year 1996 are shown in Figure-2.

S.No	Sensor parameters	Value
1	Spectral resolution	4 bands Band2: (0.52-0.59micrometers)- Green Band3: (0.62-0.68 micrometers)- Red Band4: (0.77-0.86 micrometers)- Near Infrared Band5: (1.55-1.7 micrometers)- SWIR
2	Spatial resolution	23.5 m (visible and near IR region) 70.5 m (SWIR)
3	Swath	141 Km (visible and near IR region) 148 Km (SWIR)
4	Repetitivity	24 days

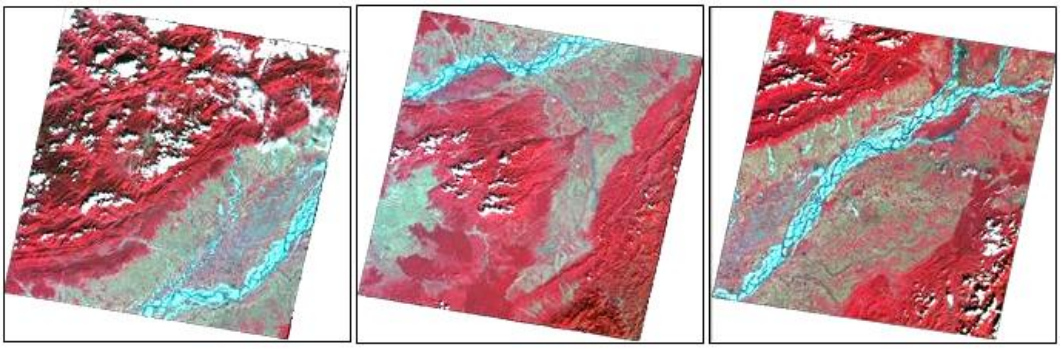
Table: 2 Characteristics of IRS-1C LISS-III sensor

S.No.	Date of pass	Satellite/Sensor	Path/ Row
1	11-Jan-97	IRS - 1C/LISS-III	109-52
2	05-Nov-96	IRS - 1C/LISS-III	110-53
3	04-Dec-96	IRS - 1C/LISS-III	111-52
4	09-Dec-96	IRS - 1C/LISS-III	112-52
5	09-Dec-96	IRS - 1C/LISS-III	112-53
6	10-Mar-97	IRS - 1C/LISS-III	111-54
7	19-Feb-97	IRS - 1C/LISS-III	112-54
8	14-Dec-96	IRS - 1C/LISS-III	113-52
9	28-Nov-02	IRS – 1D/LISS-III	109-53
10	25-Nov-02	IRS – 1D/LISS-III	110-53
11	22-Nov-02	IRS – 1D/LISS-III	111-53
12	14-Dec-02	IRS – 1D/LISS-III	112-52
13	19-Jan-03	IRS – 1C/LISS-III	112-52
14	02-Feb-03	IRS – 1D/LISS-III	112-54
15	08-Dec-02	IRS – 1D/LISS-III	114-52

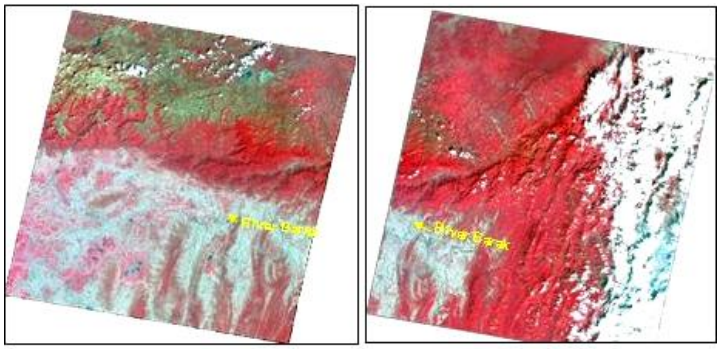
Table: 3 Satellite data



109-52 11-Jan-1997 110-53 05-Nov -1996 111-52 04- Dec -1996



112-52 09- Dec -1996 112-53 09 -Dec -1996 113-52 14 -Dec -1996



111-54 10 -Mar-1997 112-54 19 -Feb-1997

Figure-2: Satellite data of the study area for the year 1996

Methodology

3.0 Methodology

The methodology can be broadly categorized into five major steps as shown in Figure-3. The steps followed in the analysis of the study are shown as flowchart in Figure-4.

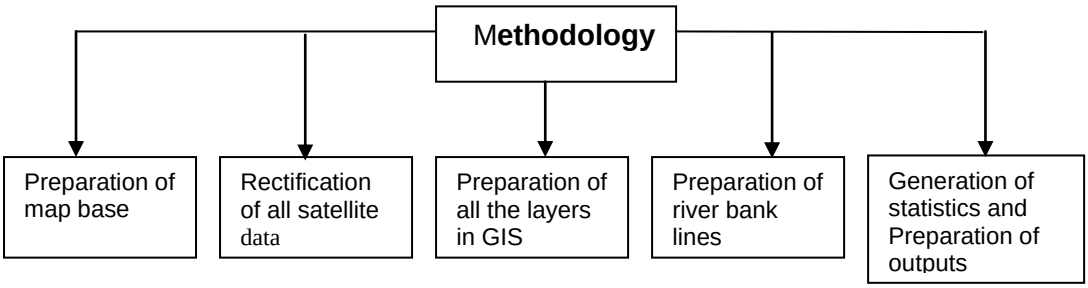


Figure-3: Schematic representation of the methodology

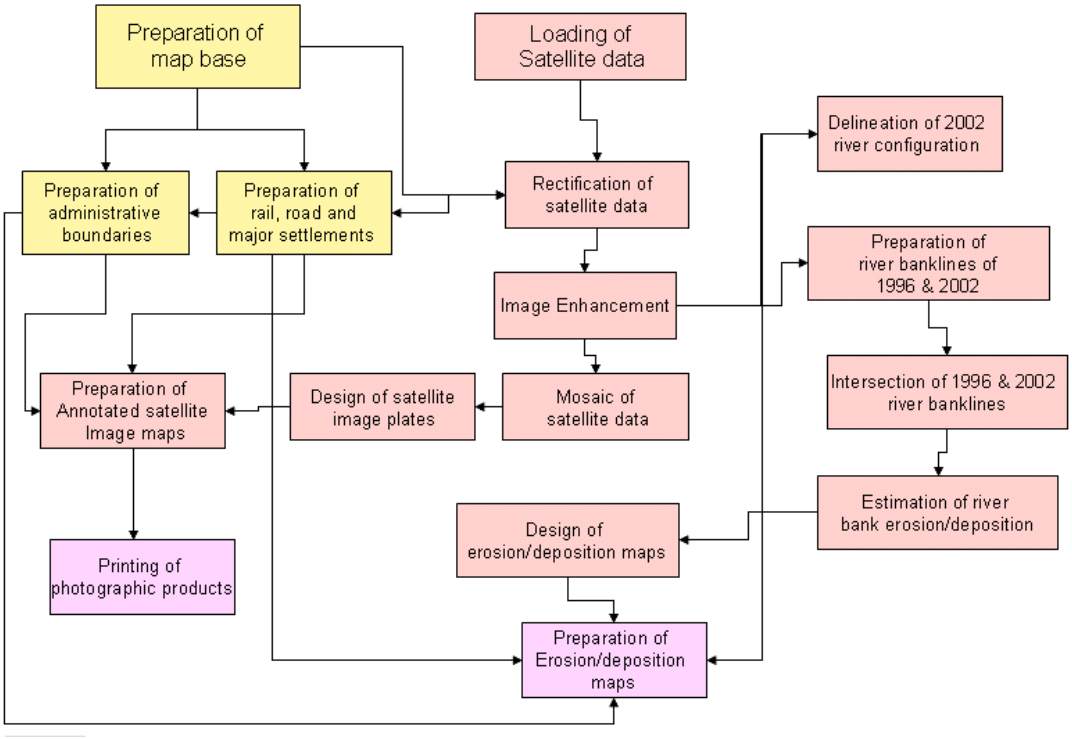


Figure-4: Flowchart of the methodology

3.1 Preparation of map base

ERDAS/Imagine imaging software was used to carry out the satellite data analysis. Using the available maps, a rectified master database was prepared with the projection Lambert Conformal Conic (LCC) and the parameters as shown in Table-3.

S.No	Parameter	Value
1	Spheroid Name	Modified Everest
2	Datum Name	Modified Everest
3	Latitude of 1st standard parallel	23:02:30.000000 N
4	Latitude of 2nd standard parallel	28:12:30.000000 N
5	Longitude of central meridian	92:45:00.000000 E
6	Latitude of origin of projection	25:38:04.000000 N
7	False easting at central meridian	1000000.000000 meters
8	False easting at origin	1000000.000000 meters

Table-3: Characteristics of the LCC projection

3.2 Rectification of satellite data

All the satellite data of 1996 and 2002 were geometrically rectified to the master map base for positional accuracy and the ground control points (GCP's) were appropriately chosen so that Root Mean Square (RMS) error was less than half a pixel (<12m). Image enhancement techniques were applied on all the individual satellite data scenes to obtain better contrast among the features especially between land and water. It is also worth mentioning that efforts were made to maintain a common Look-Up-Table (LUT) for all the satellite data, to maintain uniformity in the enhancement over entire study area. The satellite data was mosaiced for the individual years of 1996 and 2002.

3.3 Preparation of ancillary layers

Different layers consisting of administrative boundaries (state, district) and transport network such as road, railway and major settlements were prepared in the GIS environment at 1: 50,000 scale. Since the transport network is dynamic in nature, the prepared layers were also superimposed on the satellite data and were updated accordingly. Sufficient care was taken while cleaning and building the topology of all the layers.

3.4 Preparation of River and Banklines

The procure satellite data was analysed and river configuration of the year 2002 was delineated along with major permanent water bodies. Three different symbology codes were provided for river water as "1", sand as "2" and island as "3". The active river channel and the permanent water bodies were given cyan color, sand was given grey

and island was given yellow. The banklines of the rivers for the year 1996 and 2002 were prepared. Both the banklines were intersected to identify and estimate the amount of erosion and deposition at different pockets along the main Brahmaputra and Barak river stretch. The final layer was again edited, cleaned and build and symbology codes were provided. The erosion code was given as 1 and deposition code as 2. The color code for erosion was magenta and violet for deposition. Nomenclature was provided to the erosion and deposition at different pockets of the river. Some of the erosion and deposition had been observed within the islands itself like in Majuli Island. Such areas have also been considered for representation.

3.5 Generation of Statistics

The amount of erosion and deposition at each pocket of the river stretch was calculated as shown in the annexure-I. The total amount of erosion and deposition in each district of Assam state during 1996-2002 was also estimated as shown in Table-4.

District Name	Area eroded (ha)	Area deposited (ha)
Barpeta	2098	146
Bongaigaon	316	142
Cachar	270	146
Darrang	1165	563
Dhemaji	2929	235
Dhubri	2876	377
Dibrugarh	1296	34
Golaghat	2277	219
Golpara	1429	103
Hailakhandi	9	4
Jorhat	1673	320
Kamrup	784	332
Karimganj	14	9
Lakhimpur	633	342
Marigaon	3328	77
Nalbari	206	124
Nowgong	711	357
Sibsagar	354	46
Sonitpur	3751	1689
Tinsukia	2143	589
Total	**28049**	**5854**

Table-4: District-wise erosion and deposition statistics

3.6 Preparation of outputs

80 map compositions were designed for providing the annotated satellite images for both the years of 1996 and 2002 and 40 map compositions for providing the erosion maps (see annexure-II). All the layers including river, sand, islands, state /district boundary, road, rail and major settlements were integrated in the map design. As per the user request, lat/long grids, title, legend, scale, plate reference

map, SOI reference map were provided in the map. A tabular column was provided showing the erosion and deposition statistics corresponding to the relevant plate. It is to be mentioned that erosion and deposition area less than 5 hectares had not been considered for tabulating. The plate reference map shows all the plates and the selected plate map. The SOI reference map denotes in which 50,000 scale topomap, the selected plate map covers.

Further, sample products were generated consisting of annotated satellite images of 1996 and 2002 and corresponding bank erosion map covering Guwahati city. These sample products were submitted to the user for concurrence and suggestions. As per the user requirement, the final products were generated.

3.6.1 Generation of photo products

The 80 annotated satellite image compositions were converted into image format and then submitted for generation of 80 photographic products.

3.6.2 Generation of bank erosion maps

The final 40 bank erosion map compositions were printed on a HP-designjet plotter to obtain the bank erosion maps.

Observations

4.0 Observations

The following observations were made based on the analysis of satellite data.

1. In Assam state, the amount of erosion due to Brahmaputra and Barak rivers during 1996-2002 is more than the amount of deposition.
2. The total area of erosion along Brahmaputra and Barak Rivers in the Assam state was found to be 28,262 hectares during 1996-2002.
3. The total area of deposition along Brahmaputra and Barak Rivers in the Assam state was found to be 5,854 hectares during 1996-2002.
4. The total area of erosion along Brahmaputra River only during 1996-2002 was found to be 27,756 hectares.
5. The total area of deposition along Brahmaputra River only during 1996-2002 was found to be 5695 hectares.
6. The total area of erosion along Barak River only during 1996-2002 was found to be 293 hectares.
7. The total area of deposition along Barak River only during 1996-2002 was found to be 159 hectares
8. Maximum erosion was found at 92^{o} 02' 24'' E and 26^{o} 17' 09'' N in Marigaon district as shown in Plate-23 and the eroded area was 2611 hectares
9. Maximum deposition was found at 92^{o} 32' 50'' E and 26^{o} 37' 15'' N in Sonitpur district as shown in Plate-21 and the deposited area was 469 hectares
10. The maximum amount of erosion along the main Brahmaputra River during 1996-2002 was found in Sonitpur district and the eroded area was about 3751 hectares.
11. The maximum amount of deposition along the main Brahmaputra River during 1996-2002 was found in Sonitpur district and the deposited area was about 1689 hectares.
12. The minimum amount of erosion along the main Brahmaputra River during 1996-2002 was found in Nalbari district and the eroded area was about 206 hectares.
13. The minimum amount of deposition along the main Brahmaputra River during 1996-2002 was found to be in Dibrugarh district and the deposited area was about 34 hectares.
14. Most of the erosion and deposition due to Barak River was found in Cachar district and the eroded and deposited area were 270 ha and 146 ha respectively.

Annexure-I

Annexure-I

Erosion and Deposition statistics during 1996-2002 at different pockets of River Brahmaputra and Barak in Assam

S.No	Erosion Code	Area(ha)	Deposition Code	Area(ha)
1	E2	108	D2	26
2	E3	114	D3	15
3	E4	95	D4	162
4	E5	69	D5	10
5	E6	90	D6	10
6	E7	11	D7	67
7	E8	28	D8	164
8	E9	7	D9	18
9	E10	13	D10	15
10	E11	49	D11	5
11	E12	19	D12	38
12	E13	10	D13	11
13	E14	10	D14	12
14	E16	100	D15	16
15	E17	50	D16	35
16	E19	638	D17	16
17	E20	54	D18	25
18	E21	7	D19-a	7
19	E22	46	D19-b	49
20	E23	29	D20	16
21	E24	17	D21	8
22	E25	1165	D22	9
23	E27	27	D23	7
24	E28	70	D24	14
25	E29	160	D25	31
26	E30	120	D26	8
27	E31	8	D27	27
28	E32	66	D28	12
29	E33	21	D29	35
30	E34	546	D30	12
31	E35	48	D31	8
32	E36	11	D32	8
33	E37	42	D33	29
34	E38	17	D34	12
35	E39	40	D35	66
36	E40	570	D36	69
37	E41	21	D38	7
38	E43	6	D39	6
39	E44	6	D40	83
40	E45	13	D41	214
41	E46	41	D42	15
42	E47	7	D43	10
43	E48	44	D44	107
44	E49	7	D45	31
45	E50	386	D46	56
46	E51	7	D47	58
47	E52	115	D48	215
48	E53	141	D49	109

49	E54	80	D50	6
50	E55	39	D51	7
51	E56	39	D52	49
52	E57	12	D53	9
53	E58	7	D54	9
54	E59	30	D55	8
55	E60	13	D56	8
56	E61	9	D57	138
57	E62	40	D58	12
58	E63	10	D59	34
59	E64	30	D60	6
60	E65	34	D61	7
61	E66	10	D62	192
62	E67	13	D63	9
63	E68	6	D64	6
64	E69	357	D65	85
65	E70	528	D66	18
66	E71-a	266	D67	19
67	E71-b	60	D68	68
68	E72	12	D69	424
69	E73	64	D70	50
70	E74	13	D72	30
71	E75	7	D73	60
72	E76	23	D74	67
73	E77	78	D75	17
74	E78	22	D76	19
75	E79	26	D77	12
76	E80	27	D78	18
77	E81	6	D79	16
78	E82	73	D80	136
79	E84	74	D81	9
80	E85	27	D82	15
81	E86	88	D83	19
82	E87	19	D84	11
83	E88	6	D85	41
84	E89	76	D86	35
85	E90	35	D87	9
86	E91	224	D88	13
87	E92	215	D89	11
88	E93	105	D90	10
89	E94	35	D91	69
90	E95-a	164	D92	68
91	E95-b	10	D93	7
92	E96	61	D94	12
93	E97	111	D96	14
94	E98	98	D97	54
95	E99	31	D98	89
96	E100	25	D99	55
97	E101	12	D100	5
98	E102	38	D101	17
99	E103	23	D102	19
100	E104	36	D103	11
101	E105	125	D104	8
102	E106	50	D105	22
103	E107	53	D106	12

104	E108	25	D107	18
105	E109	82	D108	6
106	E110	50	D109	11
107	E111	192	D110	7
108	E112	278	D111	180
109	E113-a	183	D112	7
110	E113-b	8	D114	11
111	E114-a	25	D115	6
112	E114-b	156	D116	22
113	E115	446	D117	19
114	E116	763	D118	10
115	E117	139	D119	6
116	E119	32	D120	6
117	E120	764	D121	182
118	E121	259	D122	12
119	E122	7	D123	12
120	E123	135	D124	23
121	E124	800	D125	6
122	E125	19	D126	23
123	E126	494	D127	15
124	E127	80	D128	55
125	E128	21	D129	15
126	E129	9	D130	9
127	E130	7	D131	5
128	E131	50	D132	7
129	E132	26	D133	29
130	E133	23	D134	9
131	E134	360	D135	16
132	E135	239	D137	5
133	E136	70	D138	7
134	E137	955	D139	13
135	E138	10	D140	5
136	E139	12	D141	13
137	E140	82	D142	469
138	E141	7		
139	E142	37		
140	E143	7		
141	E144	17		
142	E145	48		
143	E146	129		
144	E147	38		
145	E148	38		
146	E149	78		
147	E150	455		
148	E151	1055		
149	E152	2611		
150	E153	12		
151	E154	15		
152	E155	7		
153	E156	9		
154	E157	17		
155	E158	23		
156	E159	24		
157	E160	31		
158	E161	22		

159	E162	7		
160	E163	8		
161	E164	50		
162	E165	10		
163	E166	88		
164	E167	62		
165	E168	26		
166	E169	19		
167	E171	15		
168	E172	135		
169	E173	6		
170	E174	164		
171	E175	29		
172	E176	441		
173	E177	22		
174	E178	89		
175	E179	121		
176	E180	257		
177	E181	31		
178	E182	963		
179	E183	46		
180	E184	12		
181	E185	8		
182	E186	198		
183	E187	190		
184	E188	23		
185	E189	21		
186	E190	165		
187	E191	29		
188	E192	48		
189	E193	14		
190	E194	26		
191	E195	121		
192	E196	45		
193	E197	13		
194	E198	214		
195	E199	9		
196	E200	321		
197	E201	16		
198	E202	7		
199	E203	769		
200	E204	6		
201	E205	309		
202	E206	105		
203	E207	27		
204	E208	7		
205	E209	51		
206	E210	11		
207	E211	58		
208	E212	252		
209	E213	506		
210	E214	158		
211	E215	70		
212	E216	926		
213	E217	29		

214	E218	172		
215	E219	28		
216	E220	8		
217	E221	37		
218	E222	6		
219	E223	8		
220	E224	8		
221	E225	12		
222	E226	10		
223	E227	6		
224	E228	8		
225	E229	5		
226	E230	11		
227	E231	17		
228	E232	5		
229	E233	6		
230	E234	17		
231	E235	8		
232	E236	11		
233	E237	6		

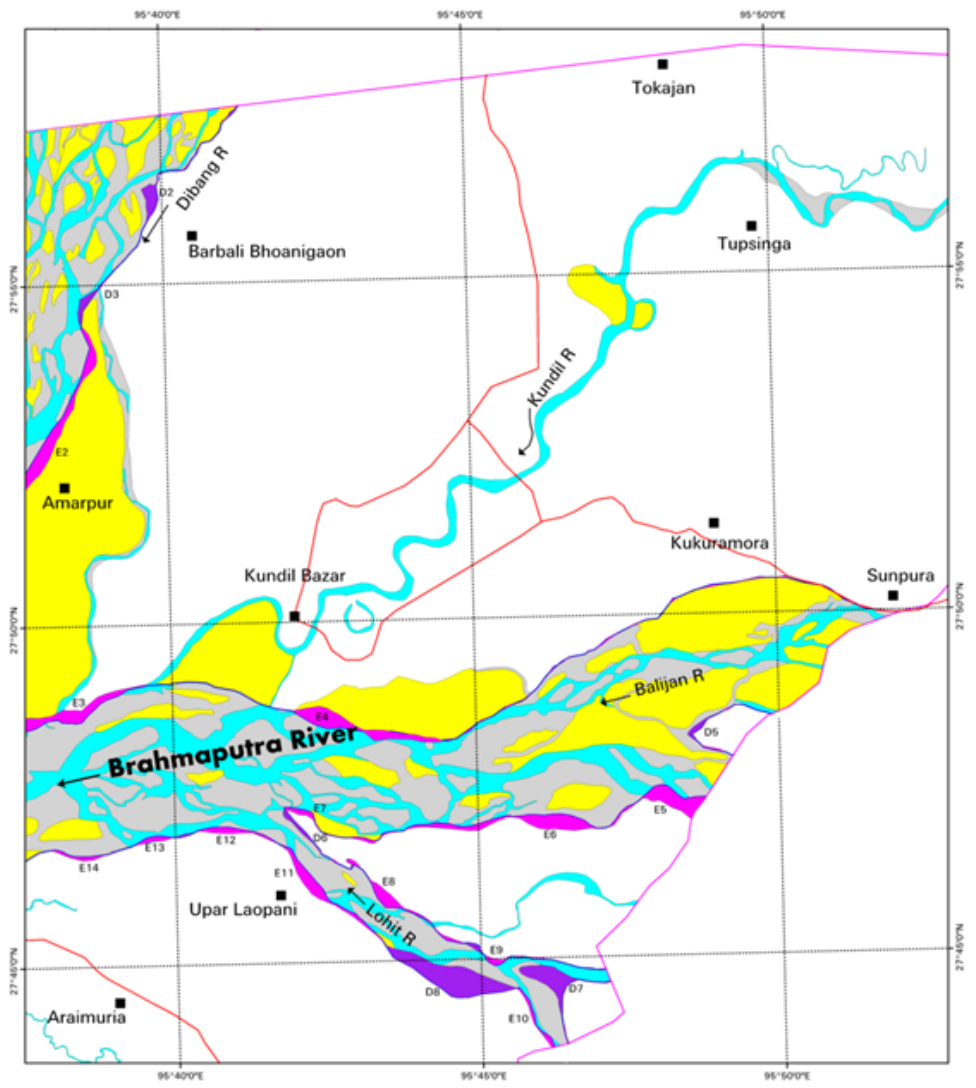
Annexure-II

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Tinsukia district

Map showing Erosion and Deposition during 1996-2002

Plate 1



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Areas less than 3 hectares not tabulated)

S.No	Location	Area (ha.)
1	E3	107.8
2	E3	114
3	E4	95
4	E5	69
5	E6	89.6
6	E7	10.3
7	E8	38.1
8	E9	7.1
9	E10	13
10	E11	49
11	E12	19
12	E13	9.7
13	E14	9.8
14	D3	35.9
15	D3	14.7
16	D5	9.3
17	D6	10.3
18	D7	67
19	D8	164

Prepared for

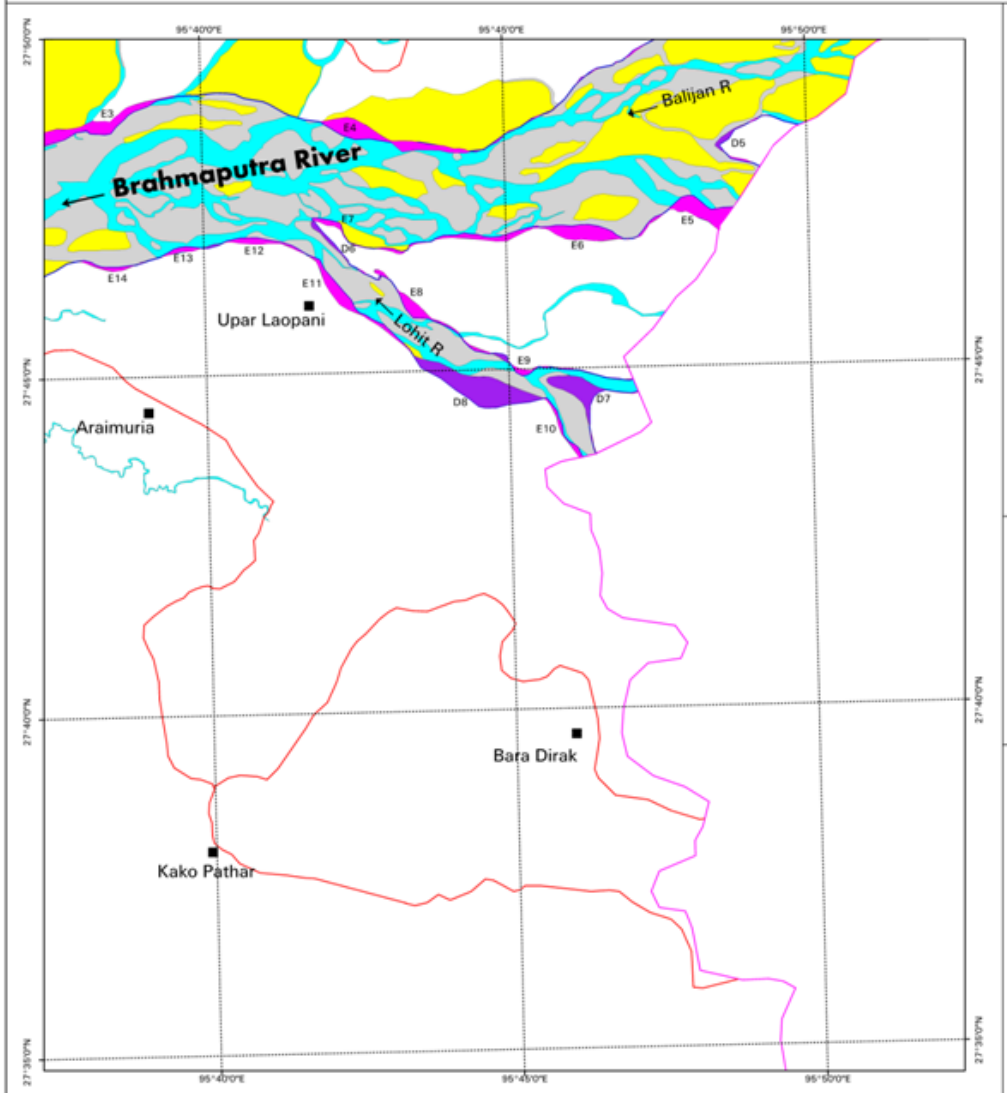
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Tinsukia district | **Map showing Erosion and Deposition during 1996-2002** | **Plate 2**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

N

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E3	114
2	E4	95
3	E5	69
4	E6	89.6
5	E7	10.5
6	E8	38.1
7	E9	7.1
8	E10	13
9	E11	49
10	E12	19
11	E13	9.7
12	E14	9.8
13	D5	9.5
14	D6	10.3
15	D7	67
16	D8	164

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

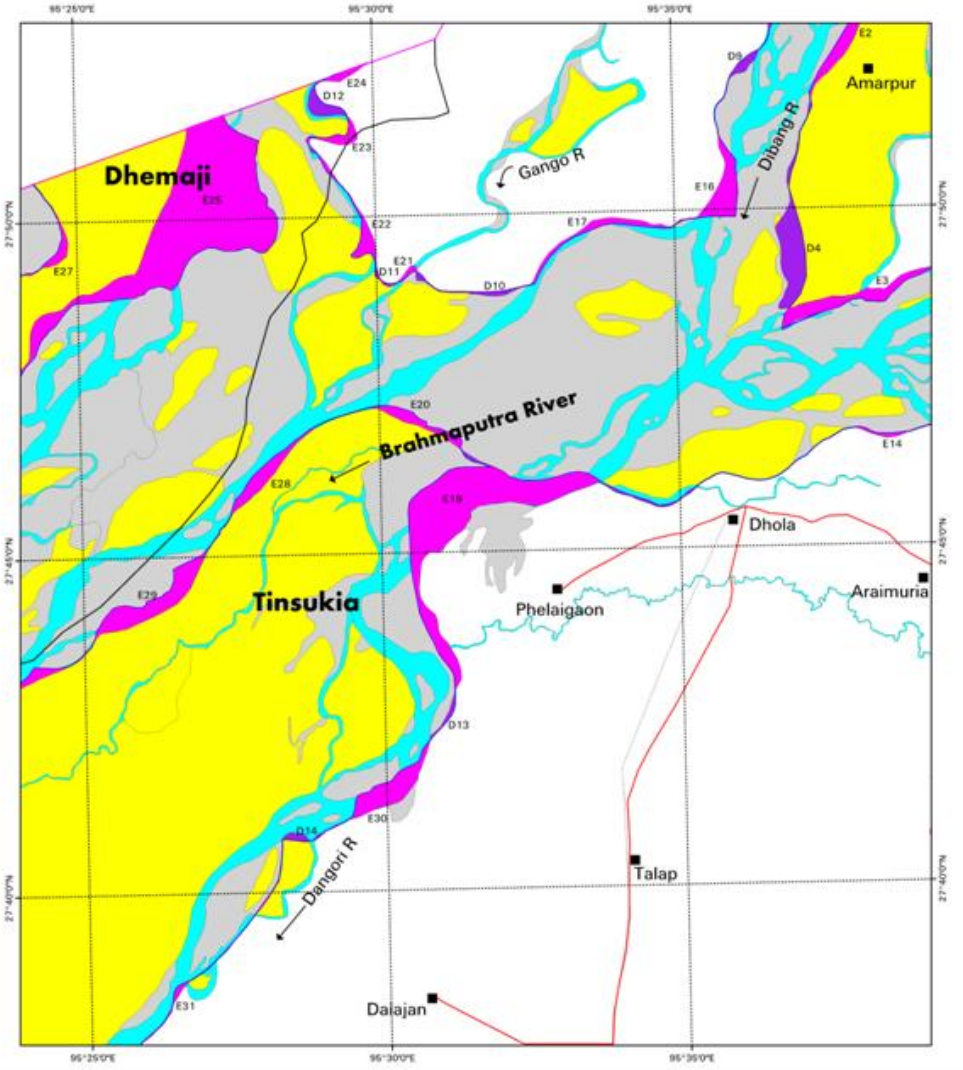
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Tinsukia and Dhemaji districts

Map showing Erosion and Deposition during 1996-2002

Plate 3



LEGEND

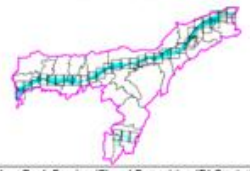
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

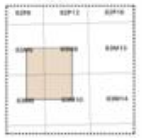
1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E2	114
2	E16	100
3	E17	30
4	E19	608
5	E20	53.3
6	E22	46
7	E23	39
8	E24	17
9	E25	1165
10	E27	57
11	E28	69.3
12	E29	160
13	E30	130
14	E31	7.7
15	D4	165
16	D9	18
17	D10	15
18	D11	5
19	D12	26
20	D13	10.6
21	D14	12

Prepared for

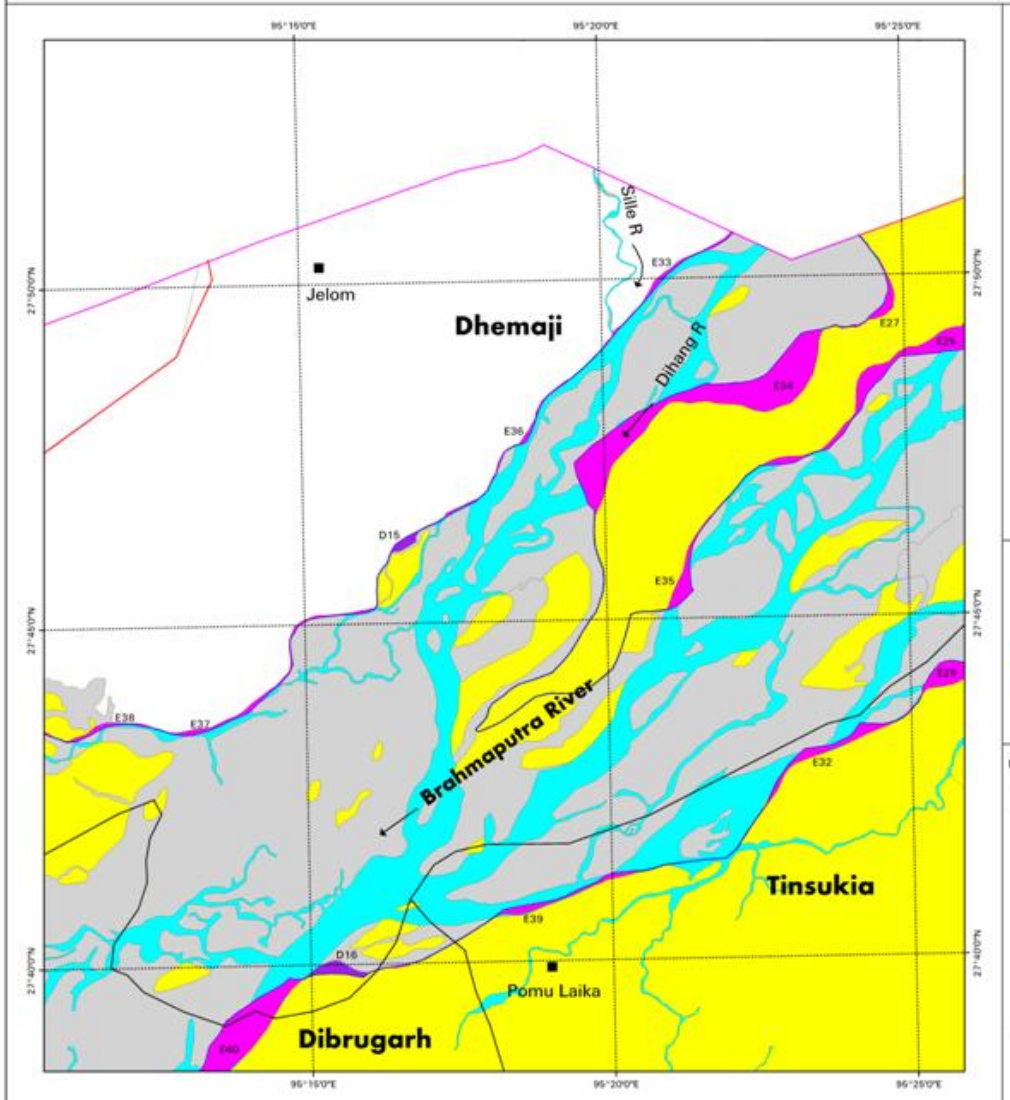
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space, Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dibrugarh, Tinsukia and Dhemaji districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 4**



LEGEND

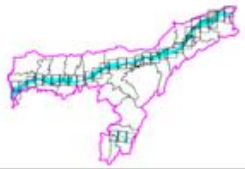
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E32	66
2	E33	31
3	E34	346
4	E35	48
5	E36	11
6	E37	43
7	E38	17
8	E39	40
9	D15	16
10	D16	35

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

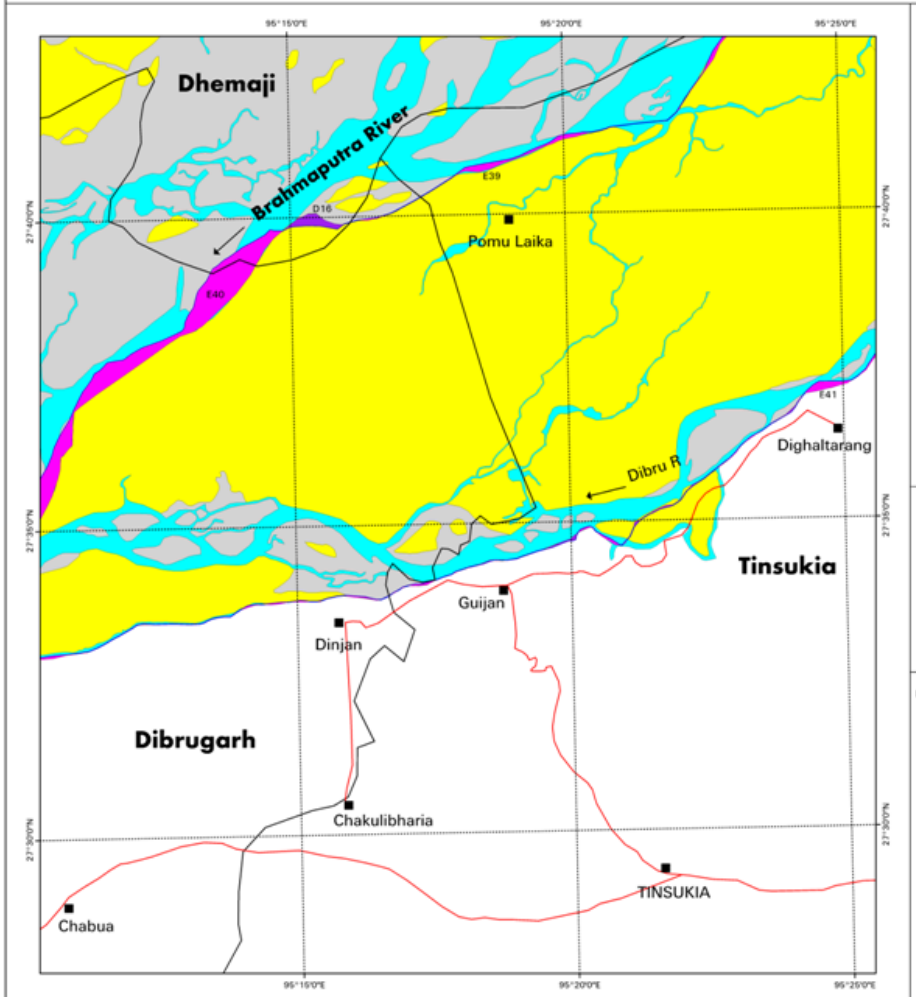
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dibrugarh, Tinsukia and Dhemaji districts

Map showing Erosion and Deposition during 1996-2002

Plate 5



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E39	40
2	E40	570
3	E41	51
4	D16	35

Prepared for

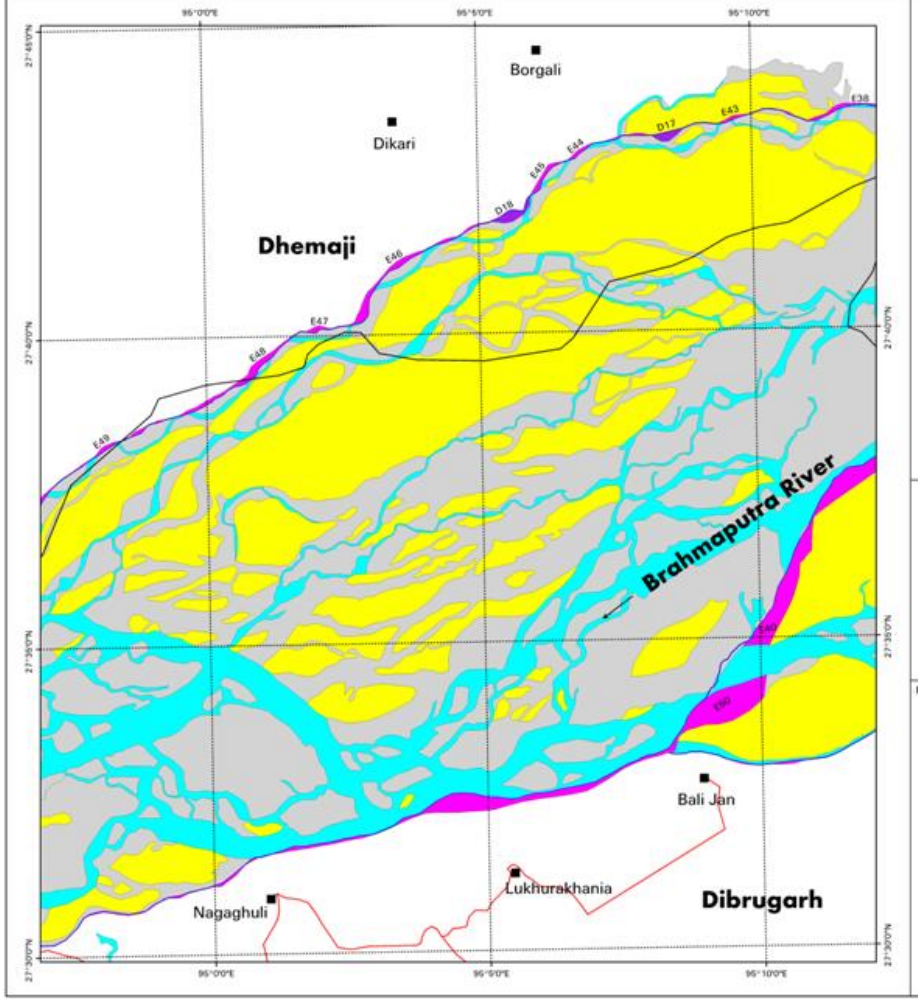
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space, Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dibrugarh and Dhemaji districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 6**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale
1 0 1 2 3 4 Kilometers
1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics
(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E40	170
2	E42	6
3	E44	6
4	E45	13
5	E46	41
6	E47	7
7	E48	44
8	E49	7
9	E50	386
10	D17	16
11	D18	55

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

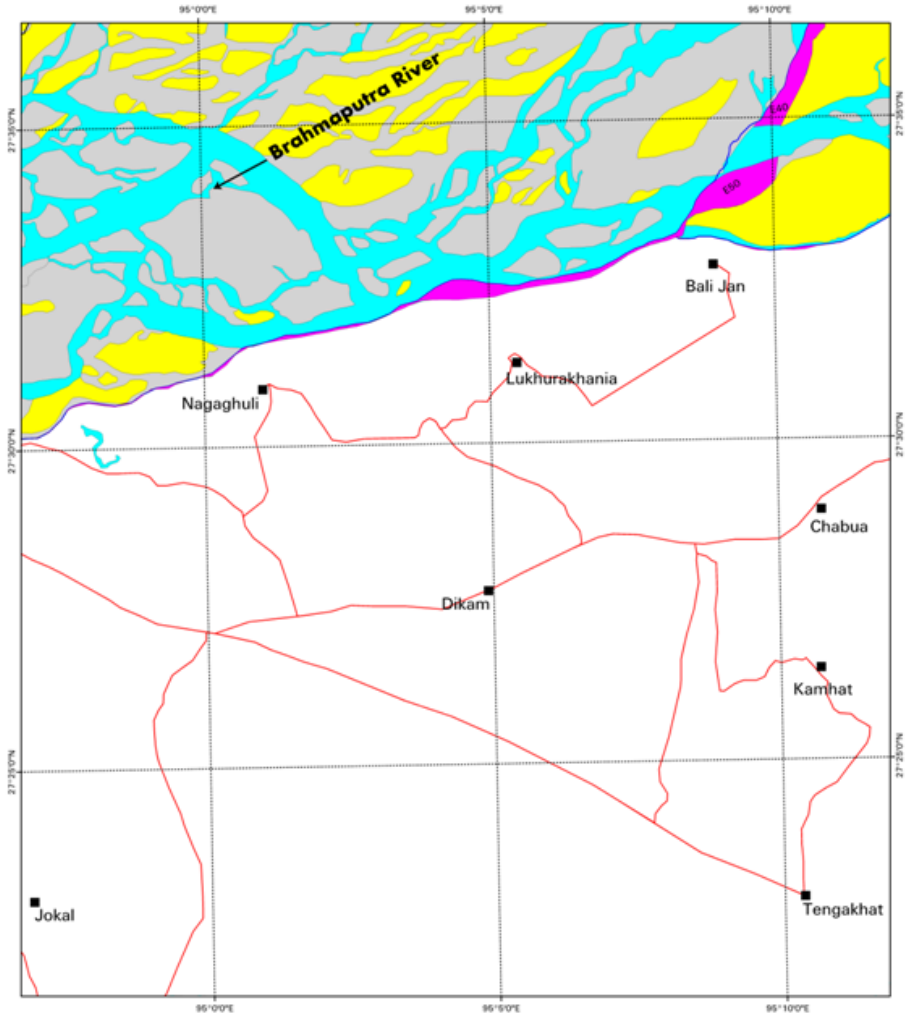
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dibrugarh district

Map showing Erosion and Deposition during 1996-2002

Plate 7



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

S.No	Location	Area (ha.)
1	E50	386

Prepared for

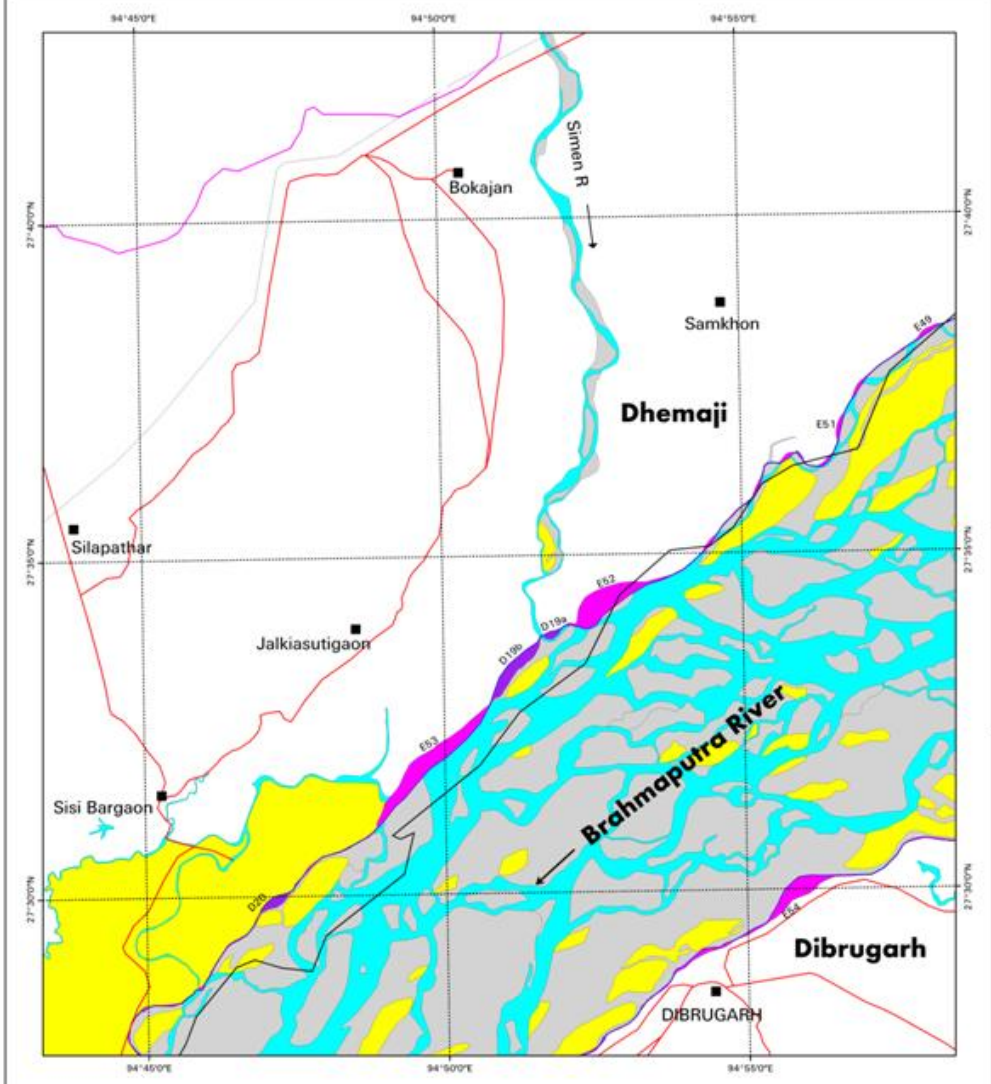
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dhemaji and Dibrugarh districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 8**

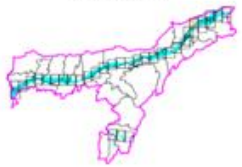


LEGEND

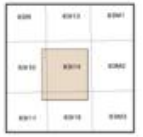
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale
1 0 1 2 3 4 Kilometers
1 : 50,000

Plate Reference



SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E49	7
2	E51	6.7
3	E52	113
4	E53	141
5	E54	80
6	D19a	7
7	D19b	49
8	D20	16

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

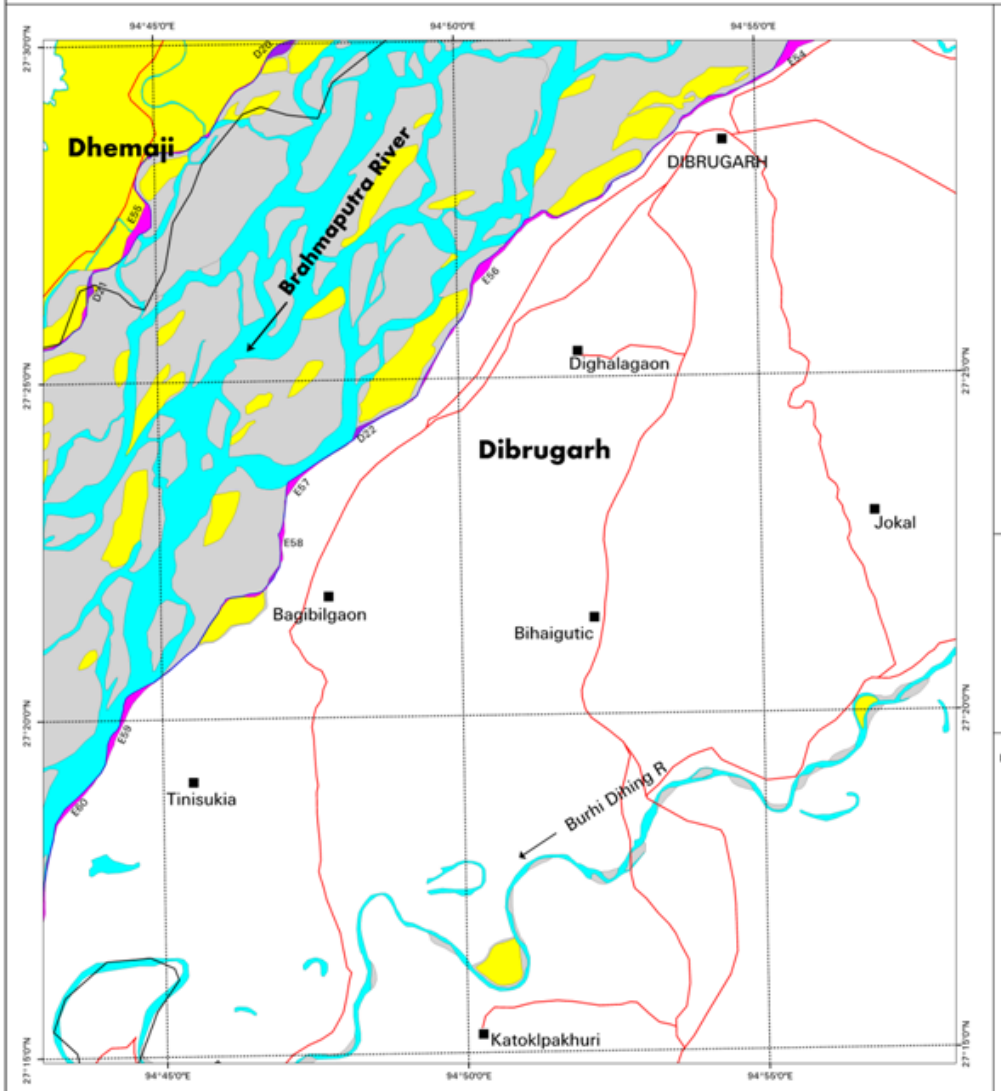
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dhemaji and Dibrugarh districts

Map showing Erosion and Deposition during 1996-2002

Plate 9



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E55	39
2	E56	39
3	E57	13
4	E58	7
5	E59	30
6	E60	13
7	D20	16
8	D21	7.6
9	D22	9

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

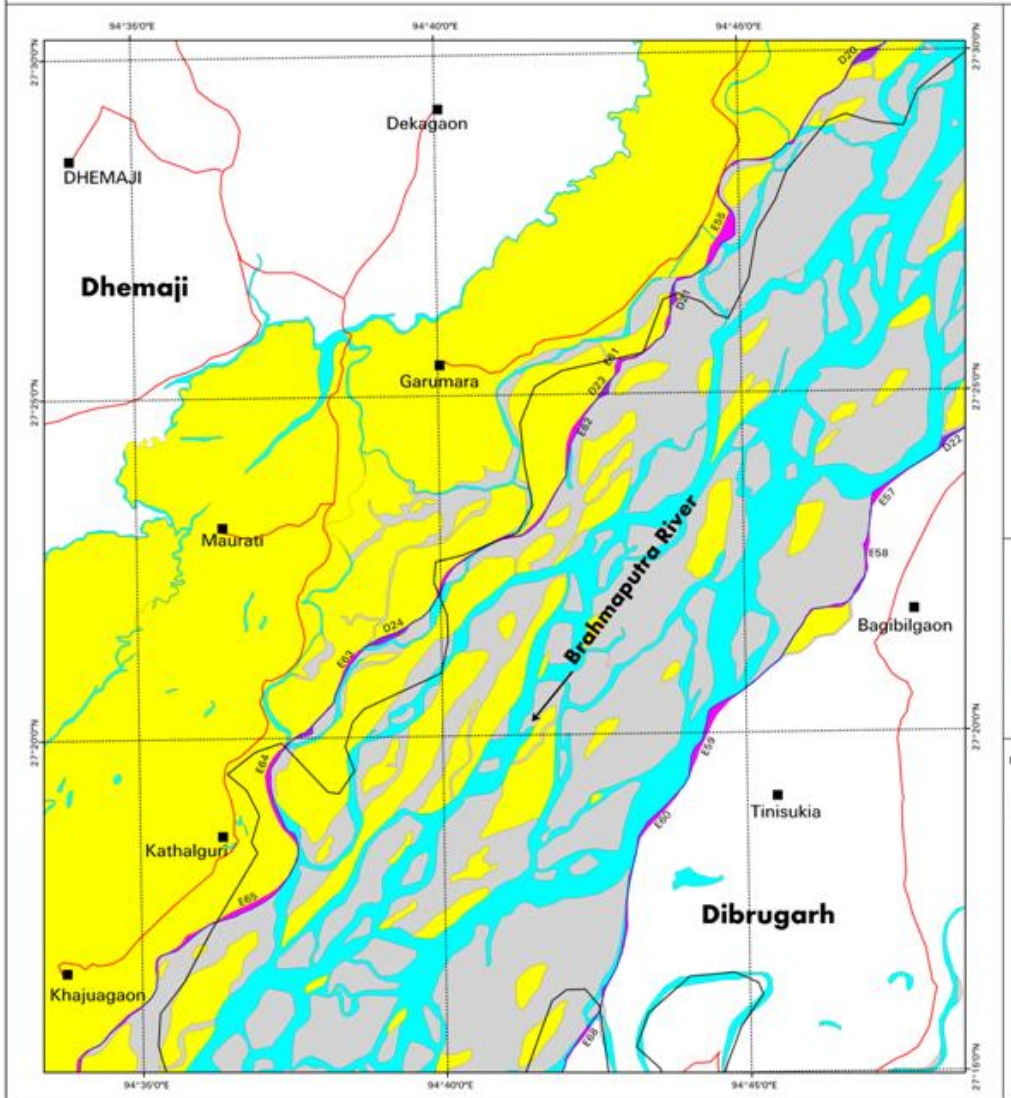
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dhemaji and Dibrugarh districts

Map showing Erosion and Deposition during 1996-2002

Plate 10



LEGEND

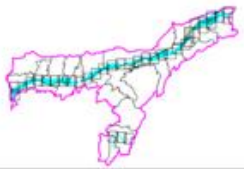
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Areas less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E55	39
2	E57	13
3	E58	7
4	E59	30
5	E60	13
6	E61	9
7	E63	40
8	E63	9.6
9	E64	30
10	E65	24
11	E66	6
12	D22	6.7
13	D24	13.6

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

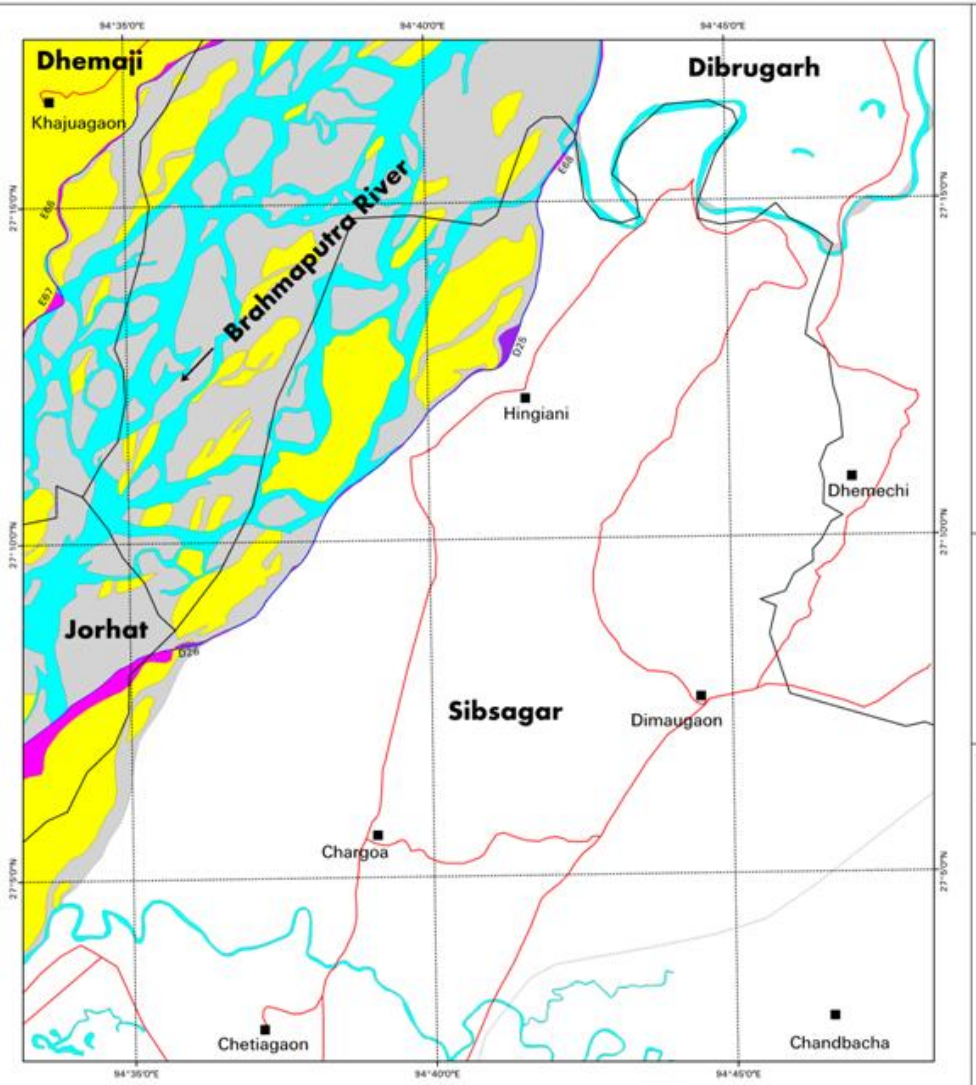
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Jorhat, Dhemaji, Sibsagar and Dibrugarh districts

Map showing Erosion and Deposition during 1996-2002

Plate 11



LEGEND

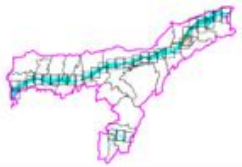
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E86	10
2	E87	13
3	E88	9
4	D25	31
5	D26	7.5

Prepared for

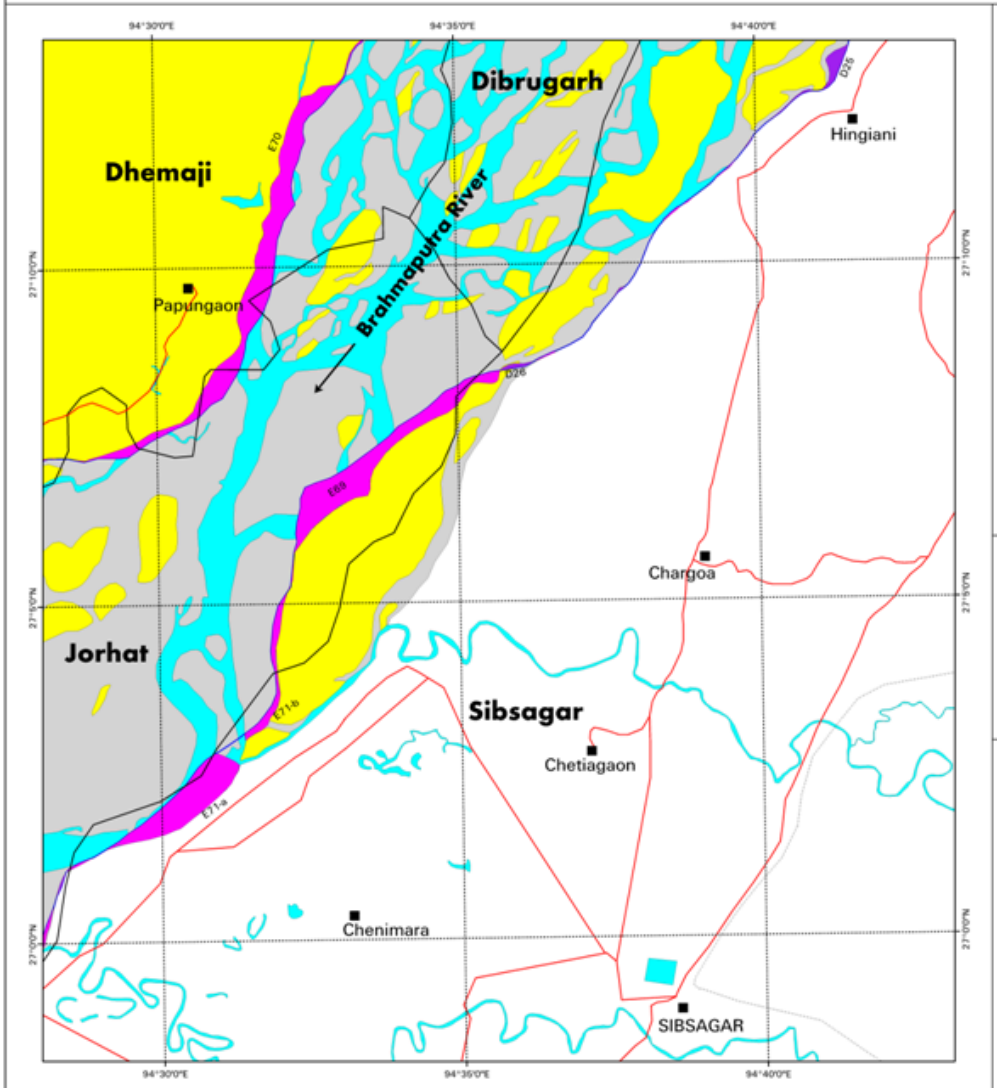
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Jorhat, Dhemaji, Sibsagar and Dibrugarh districts **Map showing Erosion and Deposition during 1996-2002** **Plate 12**



LEGEND

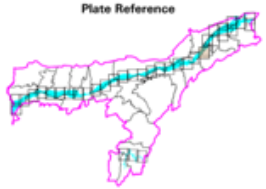
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Areas less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E69	357
2	E70	328
3	E71-a	266
4	E71-b	60
5	D25	31

Prepared for

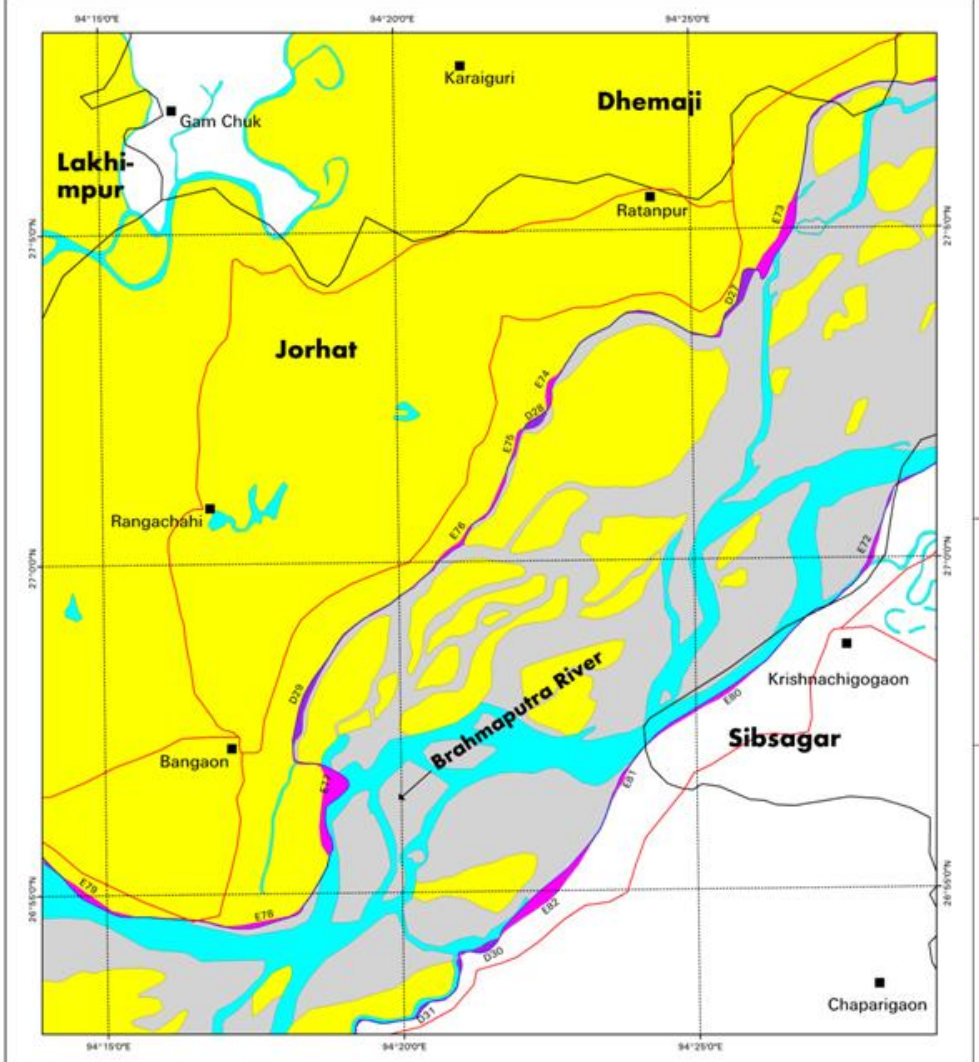
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Jorhat, Lakhimpur, Dhemaji and Sibsagar districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 13**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

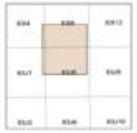
Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference



River Bank Erosion and Deposition Statistics

(Areas less than 5 hectares not tabulated)

S.No	Location	Area (Sq.Km)
1	E72	12
2	E73	64
3	E74	13
4	E75	7
5	E76	23
6	E77	78
7	E78	22
8	E79	26
9	E80	27
10	E81	6
11	E82	73
12	D27	27
13	D28	12
14	D29	35
15	D30	12
16	D31	8

Prepared for

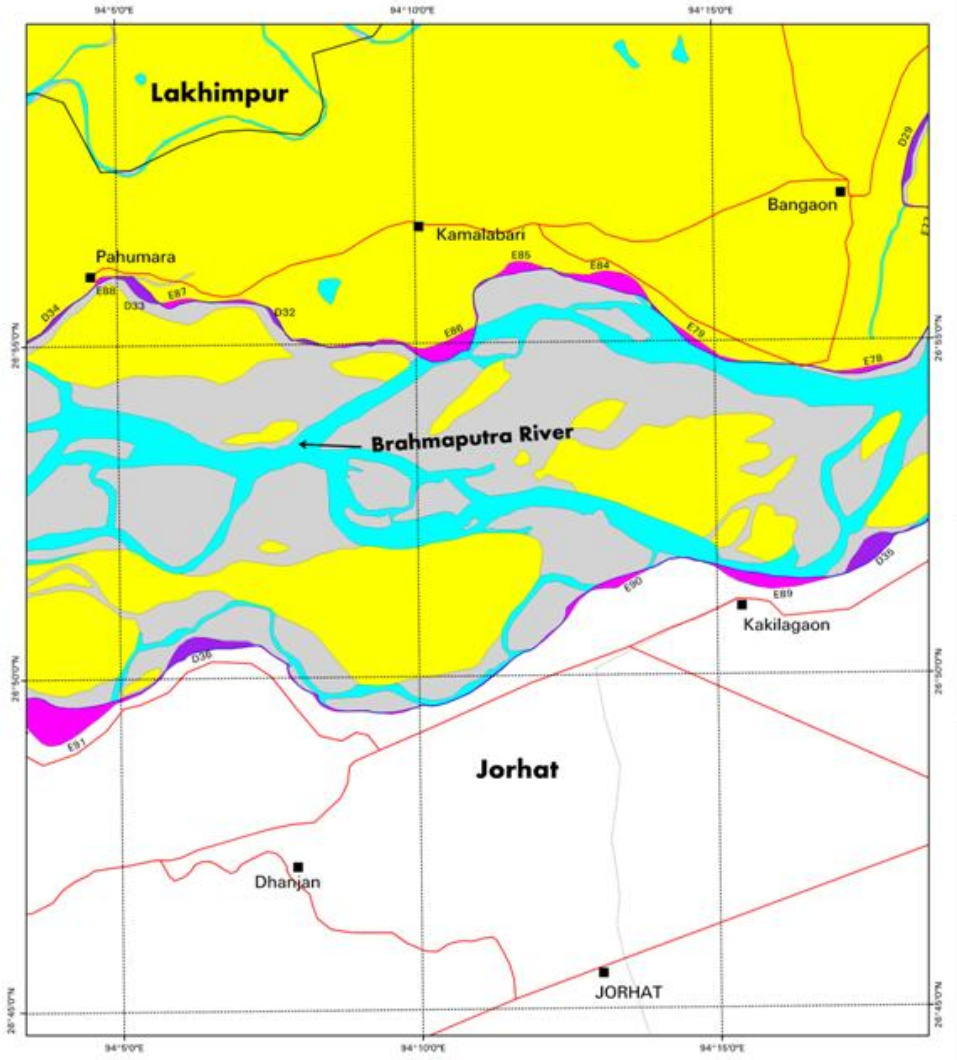
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space, Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Jorhat and Lakhimpur districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 14**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E78	33
2	E79	36
3	E84	74
4	E85	37
5	E86	88
6	E87	19
7	E88	6
8	E89	76
9	E90	35
10	E91	334
11	D32	7.8
12	D33	39
13	D34	13
14	D35	66
15	D36	69

Prepared for

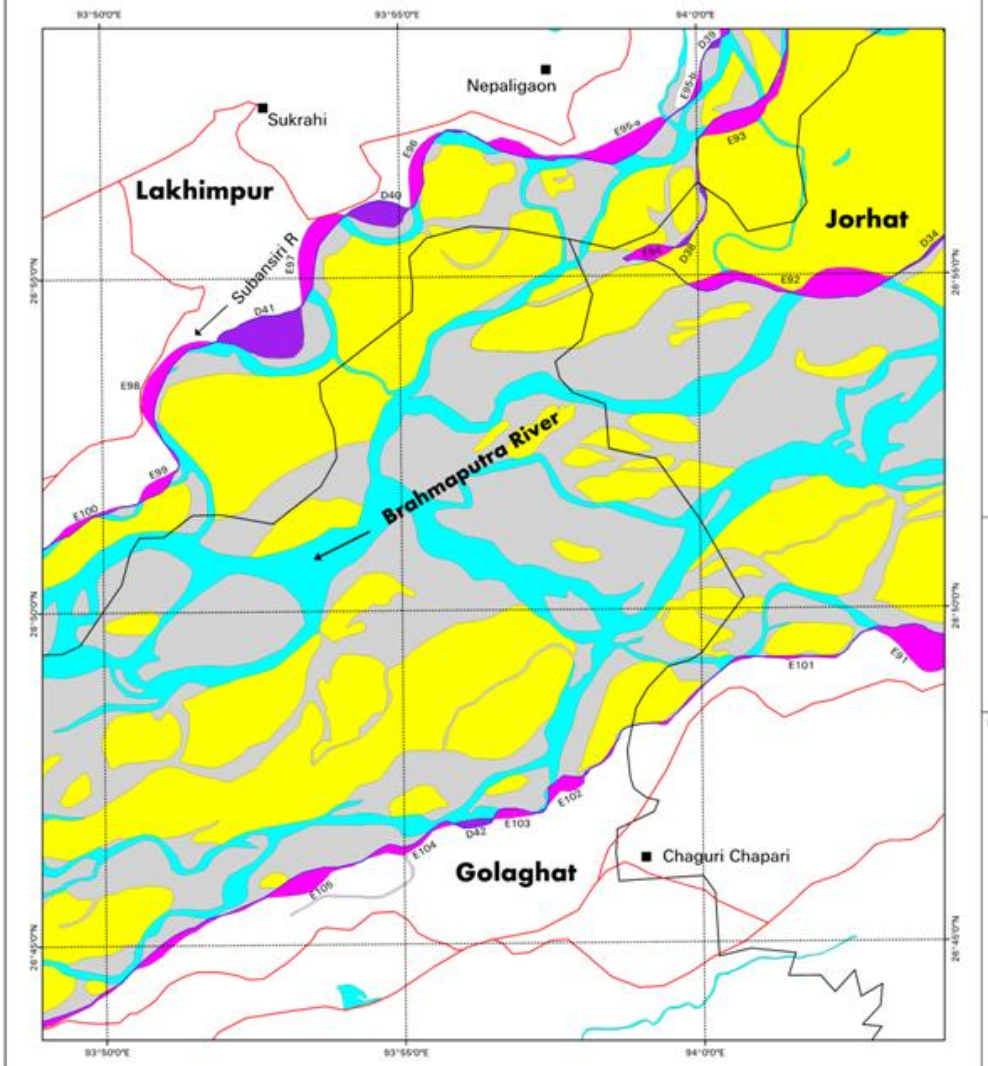
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Lakhimpur, Golaghat and Jorhat districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 15**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

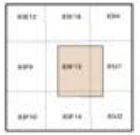
Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Prepared for

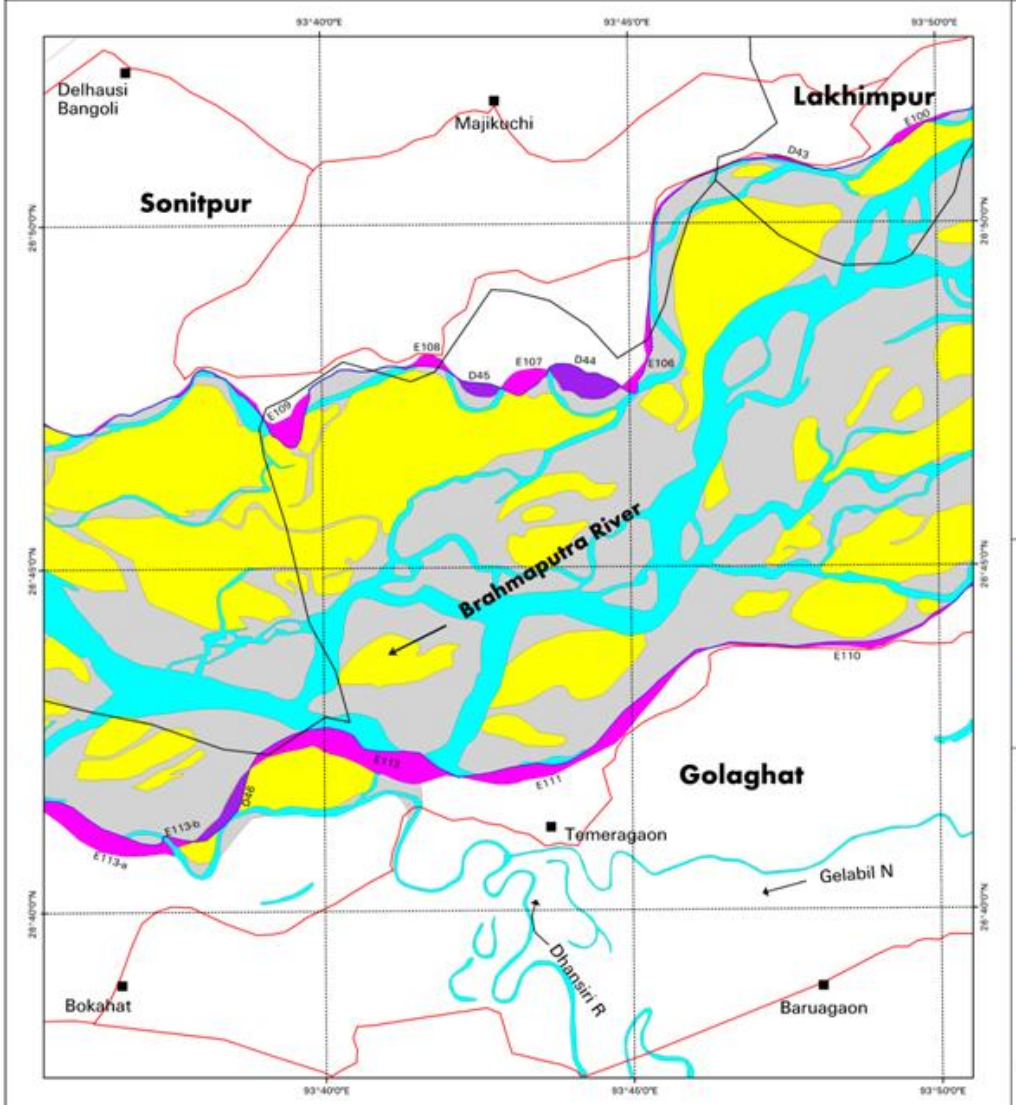
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RSbGIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Sonitpur, Lakhimpur and Golaghat districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 16**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E106	90
2	E107	53
3	E108	55
4	E109	83
5	E110	90
6	E111	192
7	E112	378
8	E113a	183
9	E113b	8
10	D43	10
11	D44	107
12	D45	31
13	D46	56

Prepared for

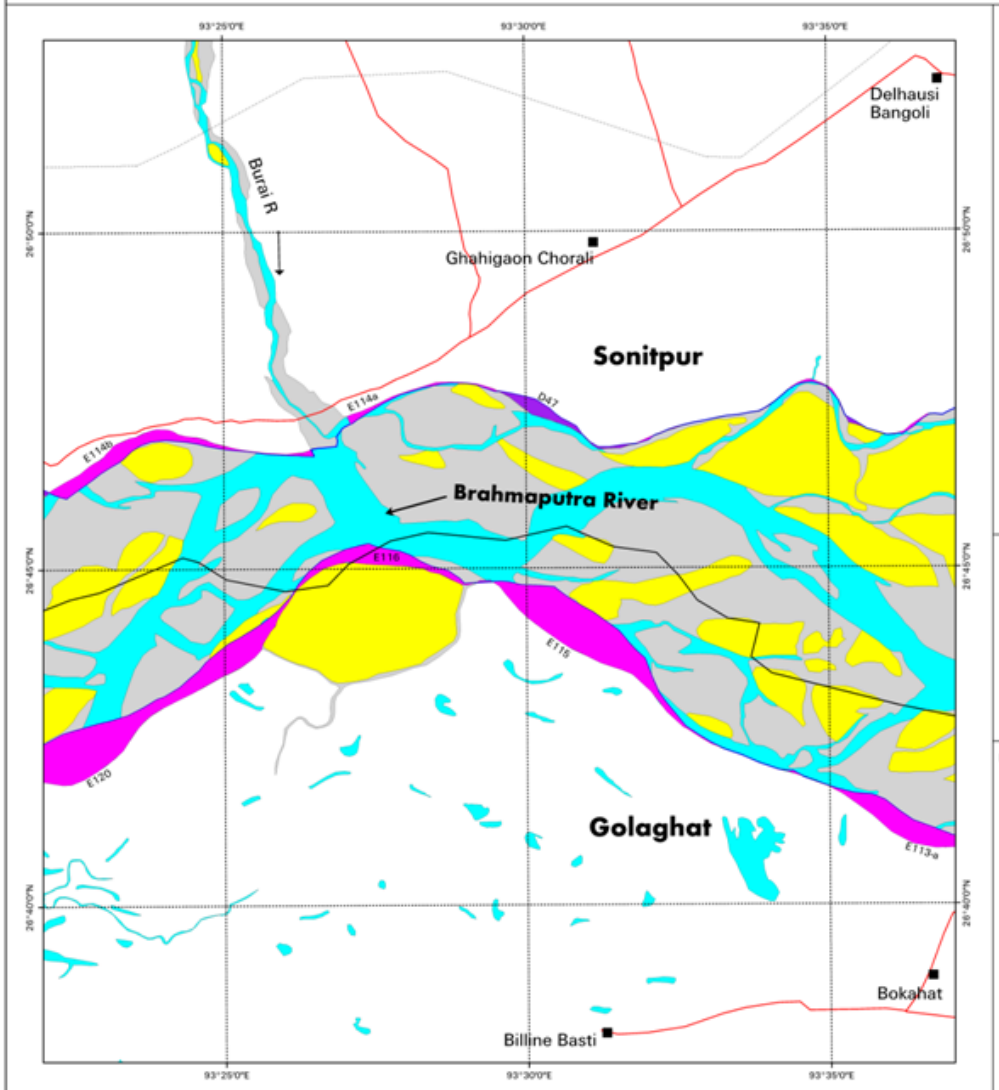
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Sonitpur and Golaghat districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 17**



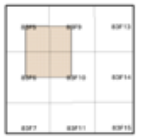
LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale
1 0 1 2 3 4 Kilometers
1 : 50,000

Plate Reference

SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E114a	34.6
2	E114b	156
3	E115	446
4	E116	763
5	E120	764
6	D47	58

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

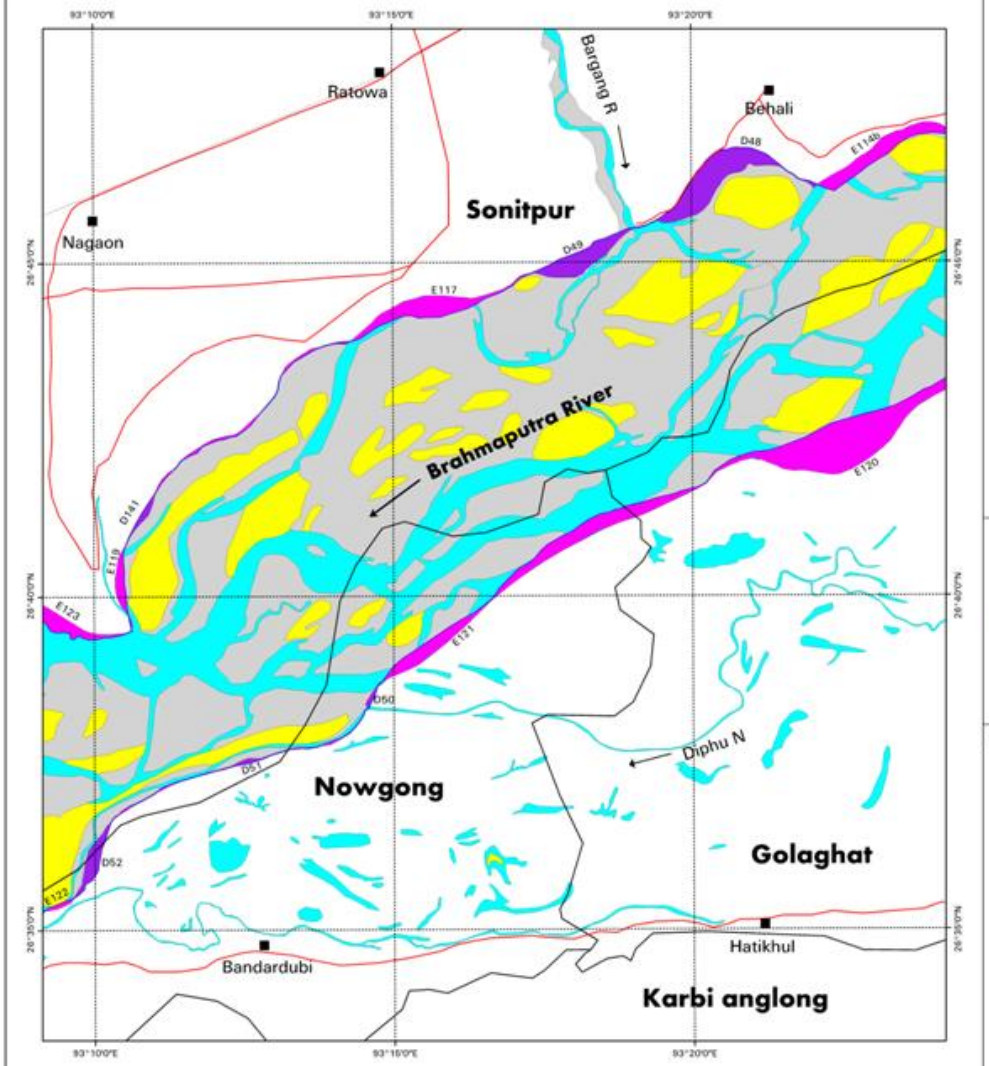
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Map showing Erosion and Deposition during 1996-2002

Part of Nowgong, Karbi anglong, Sonitpur and Golaghat districts

Plate 18



LEGEND

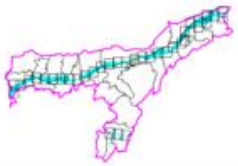
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Areas less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E117	139
2	E119	33
3	E120	764
4	E121	359
5	E123	7
6	D48	315
7	D49	109
8	D50	6
9	D51	7
10	D52	69
11	D141	12

Prepared for

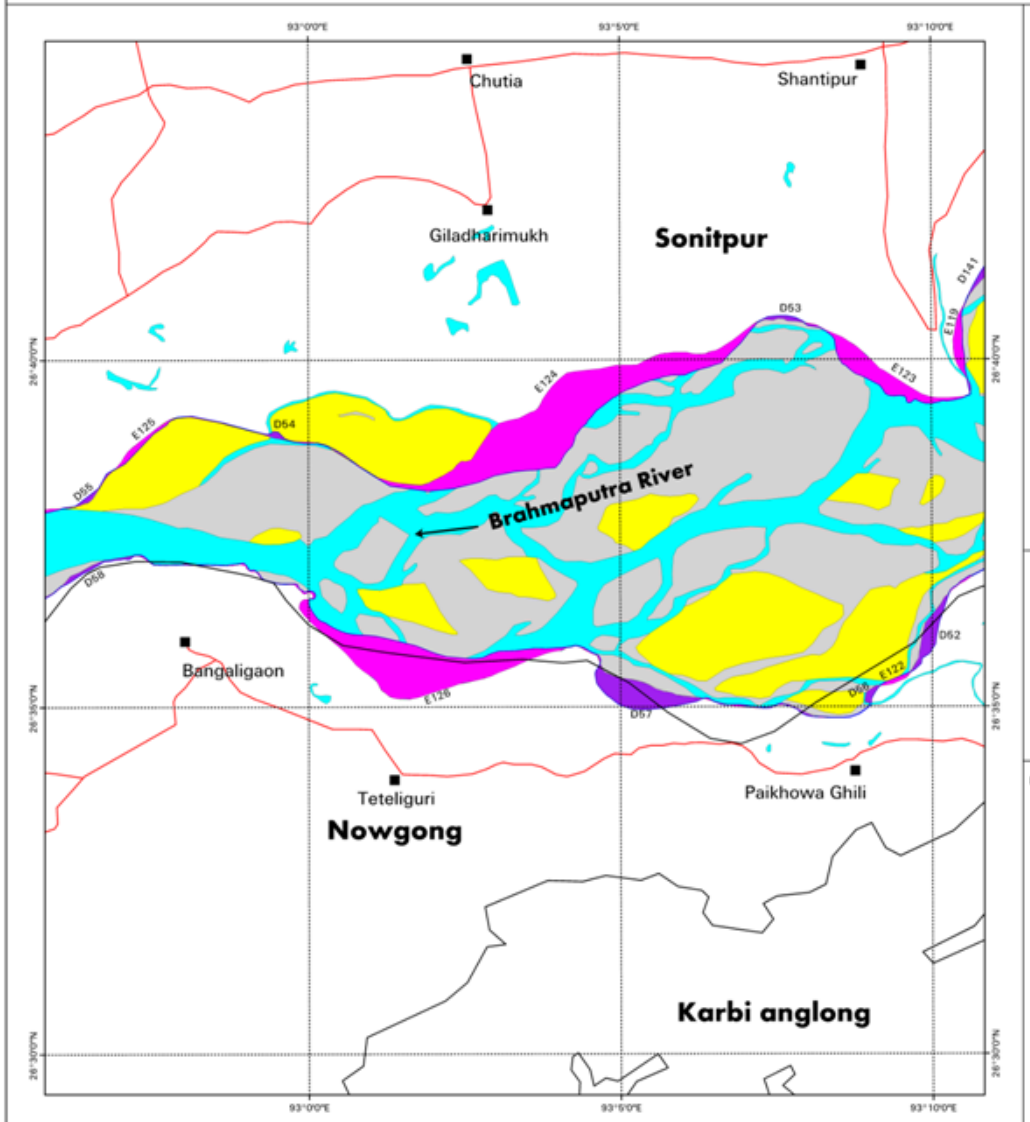
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Nowgong, Karbi anglong and Sonitpur districts **Map showing Erosion and Deposition during 1996-2002** **Plate 19**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E133	135
2	E134	800
3	E135	19
4	E136	494
5	D53	9
6	D54	9
7	D55	8
8	D56	8
9	D57	138
10	D58	13

Prepared for

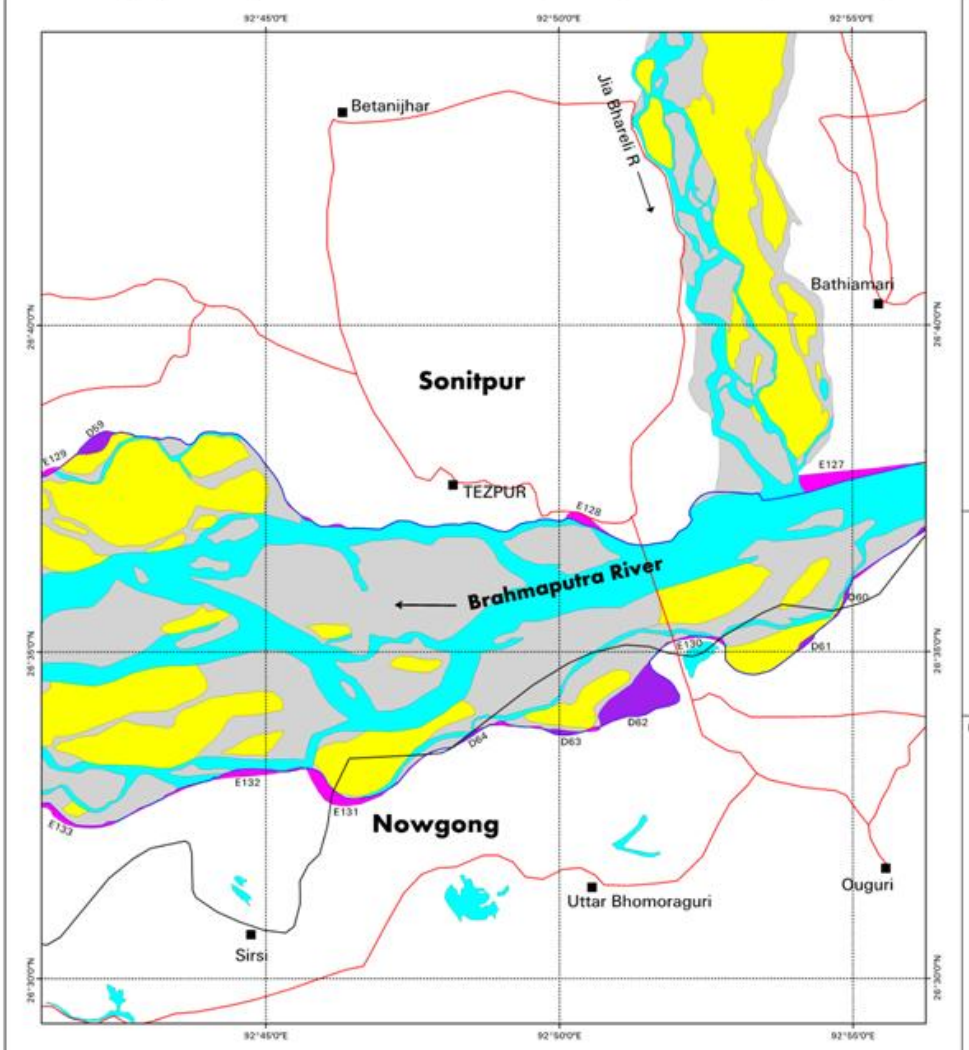
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Nowgong and Sonitpur districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 20**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale: 1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E127	80
2	E128	31
3	E129	9
4	E130	7.5
5	E131	30
6	E133	36
7	E132	33
8	D59	34
9	D60	6
10	D61	7
11	D62	192
12	D63	9.5
13	D64	5.8

Prepared for

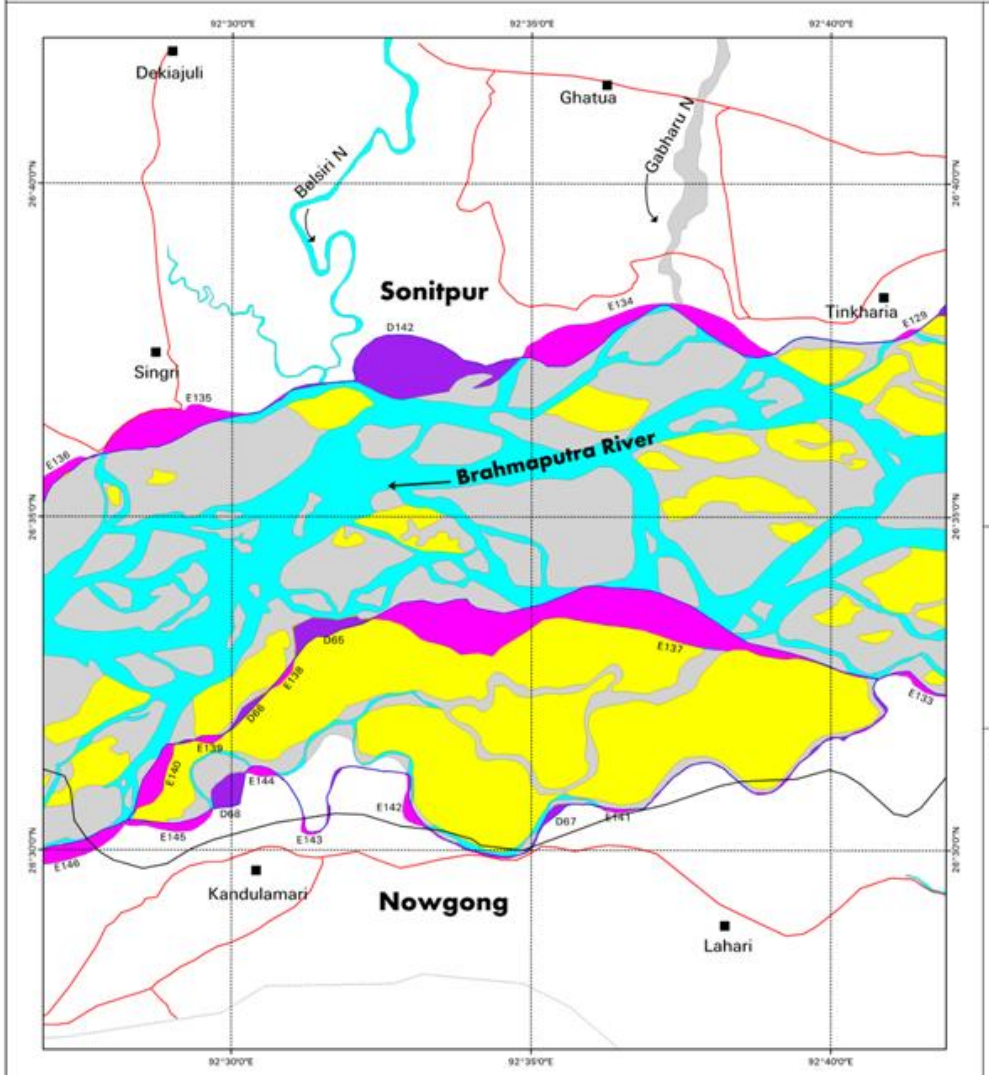
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Nowgong and Sonitpur districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 21**



LEGEND

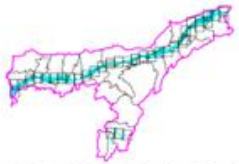
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E134	300
2	E135	339
3	E136	70
4	E137	933
5	E138	10
6	E139	13
7	E140	82
8	E141	7
9	E142	37
10	E143	7
11	E144	17
12	E145	48
13	E146	139
14	D65	83
15	D66	18
16	D67	19
17	D68	68
18	D142	469

Prepared for

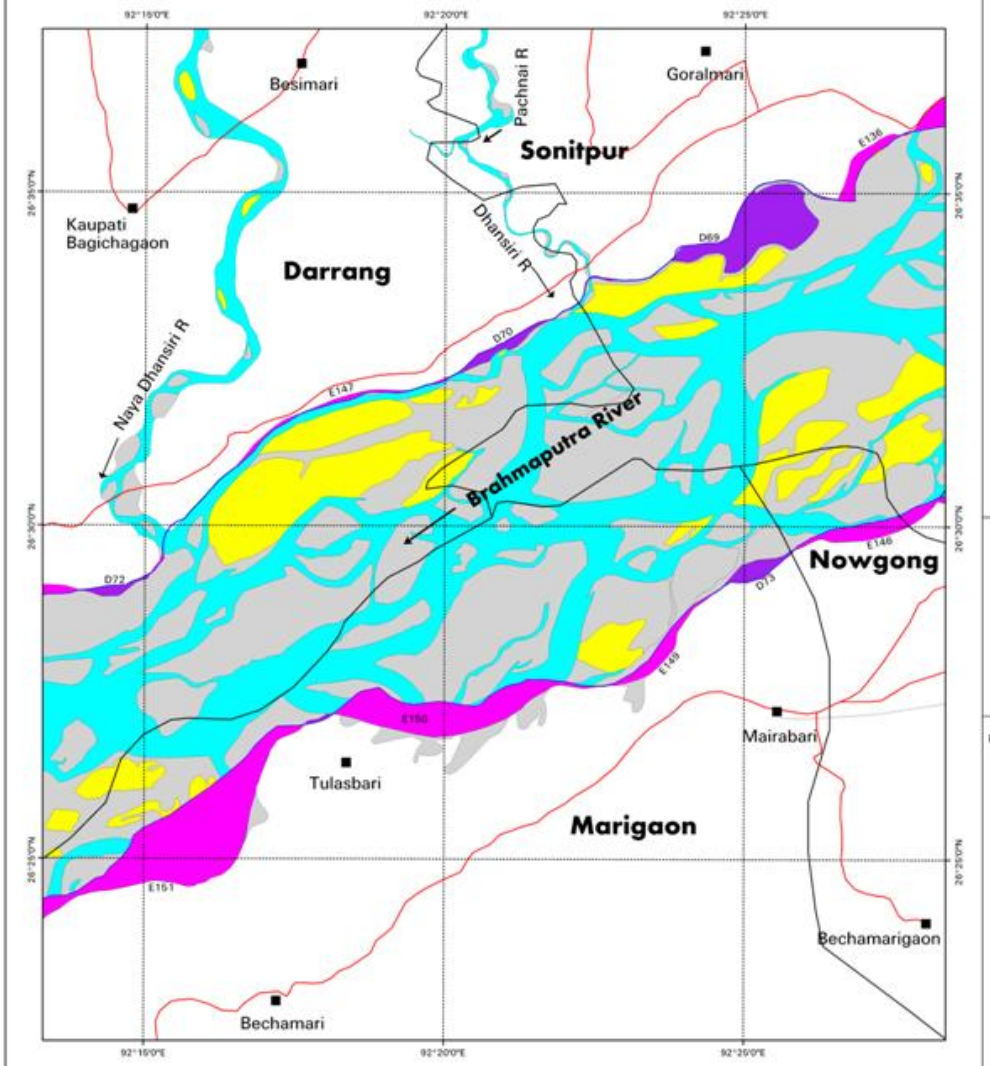
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Marigaon, Nowgong, Darrang and Sonitpur districts **Map showing Erosion and Deposition during 1996-2002** **Plate 22**

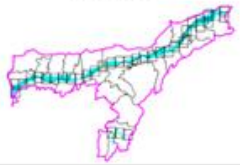


LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale
1 0 1 2 3 4 Kilometers
1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

S.No	Location	Area (ha.)
1	E136	70
2	E146	139
3	E147	38
4	E149	78
5	E150	455
6	E151	1055
7	D69	434
8	D70	50
9	D73	30
10	D72	60

Prepared for

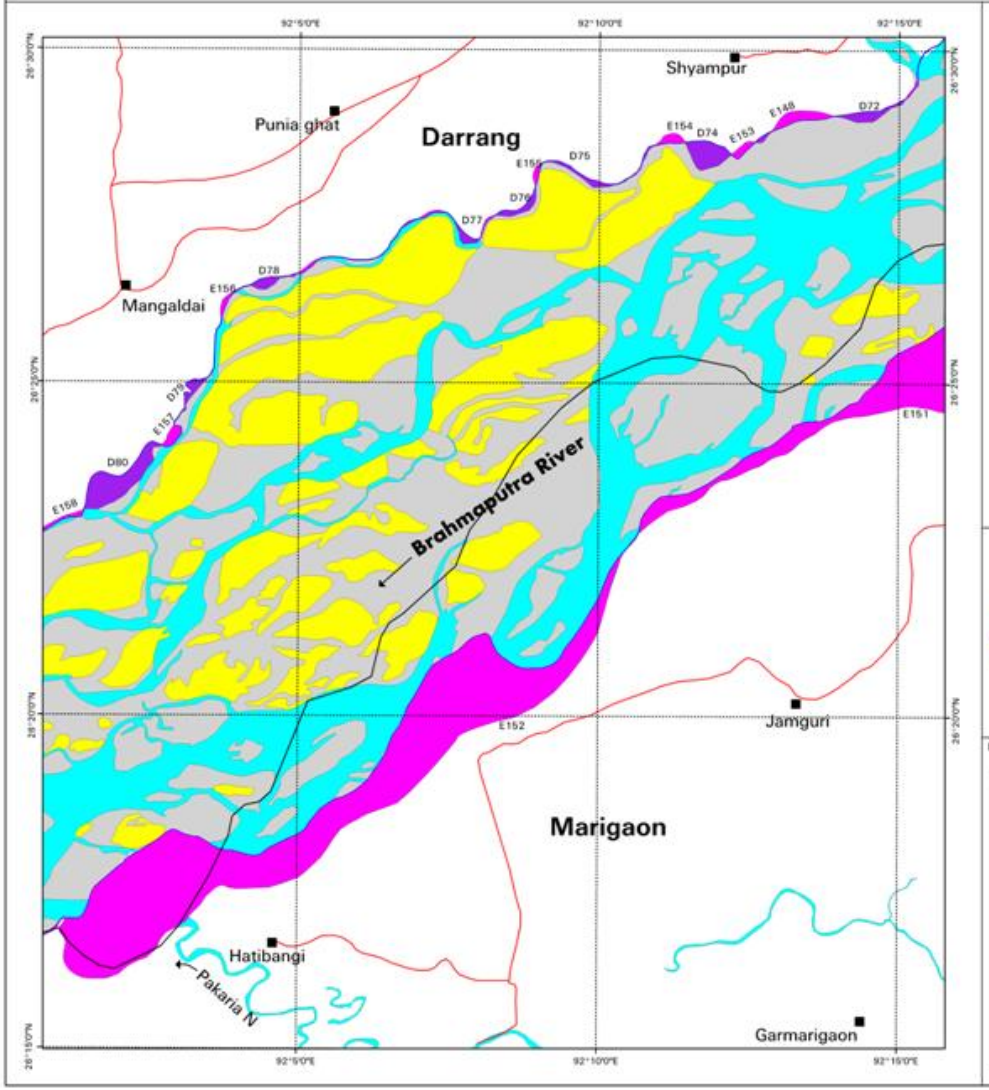
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: floodiinrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Marigaon and Darrang districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 23**



LEGEND

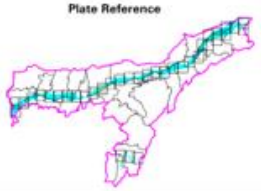
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E148	38
2	E153	3611
3	E153	13
4	E154	15
5	E155	7
6	E156	9
7	E157	17
8	E158	33
9	D72	30
10	D74	67
11	D75	17
12	D76	19
13	D77	13
14	D78	18
15	D79	16
16	D80	136

Prepared for

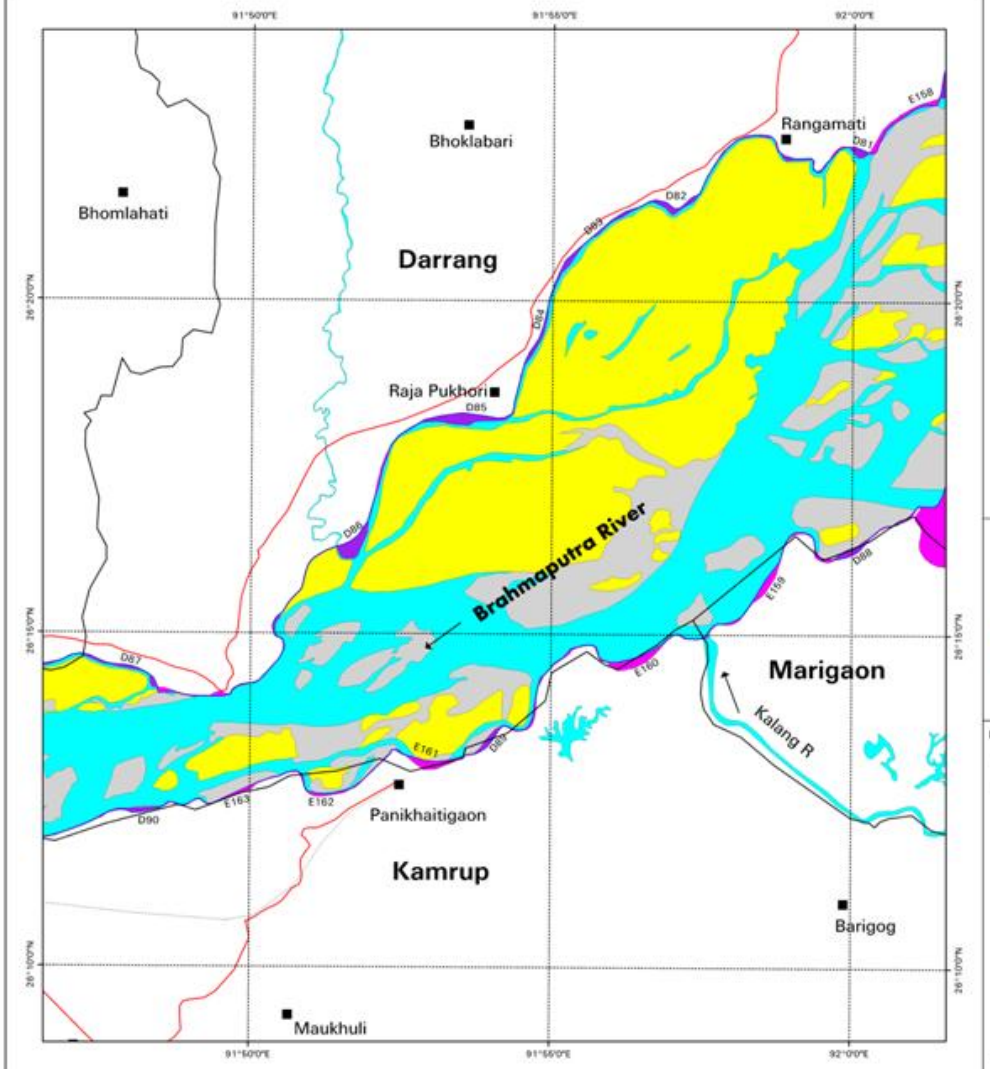
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Kamrup, Marigaon and Darrang districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 24**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 3 hectares not tabulated)

S.No	Location	Area (ha.)
1	E158	33
2	E159	36
3	E160	31
4	E161	33
5	E162	6.5
6	E163	7.5
7	D81	9
8	D82	15
9	D83	19
10	D84	11
11	D85	41
12	D86	35
13	D87	9
14	D88	13
15	D89	11
16	D90	10

Prepared for

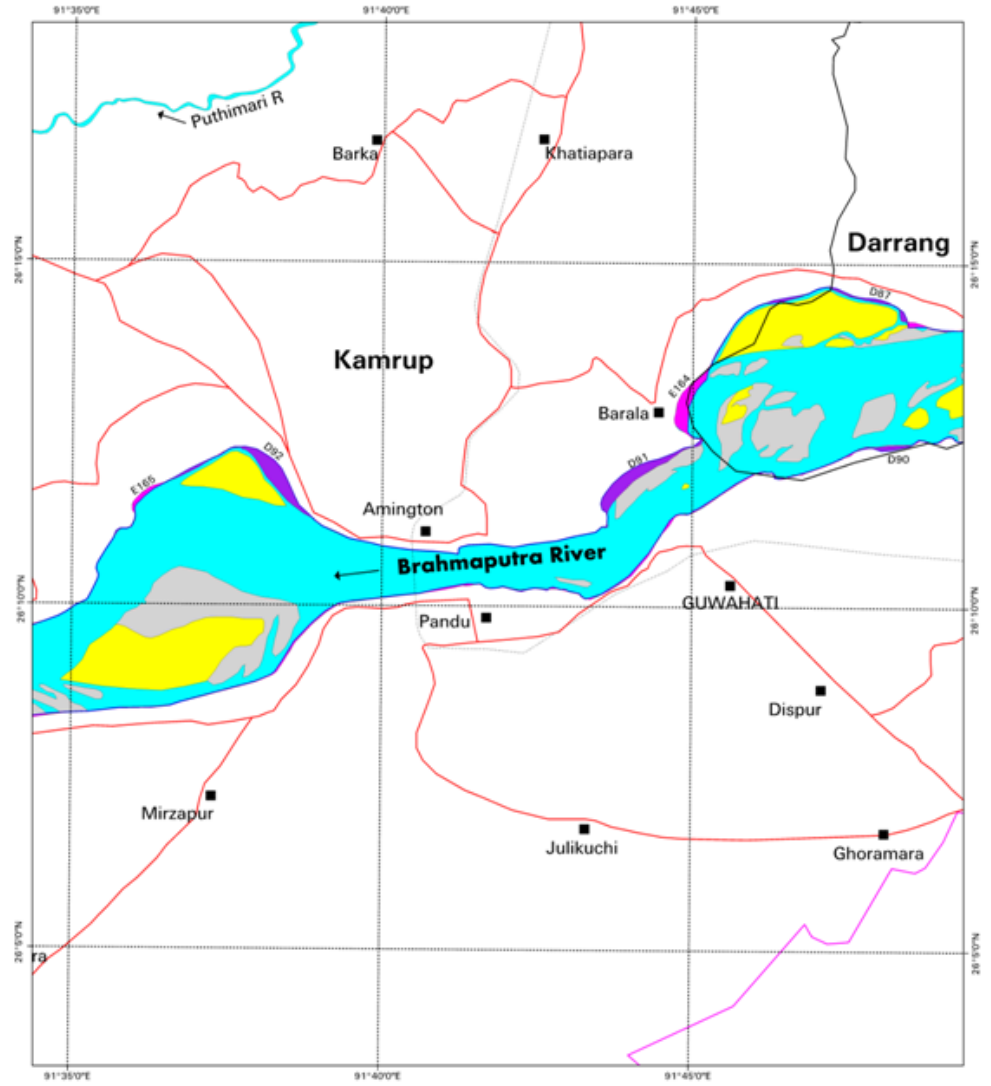
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Kamrup and Darrang districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 25**



LEGEND

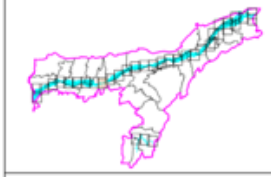
- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference



SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E164	50
2	E165	10
3	D87	9
4	D90	10
5	D91	69
6	D92	68

Prepared for

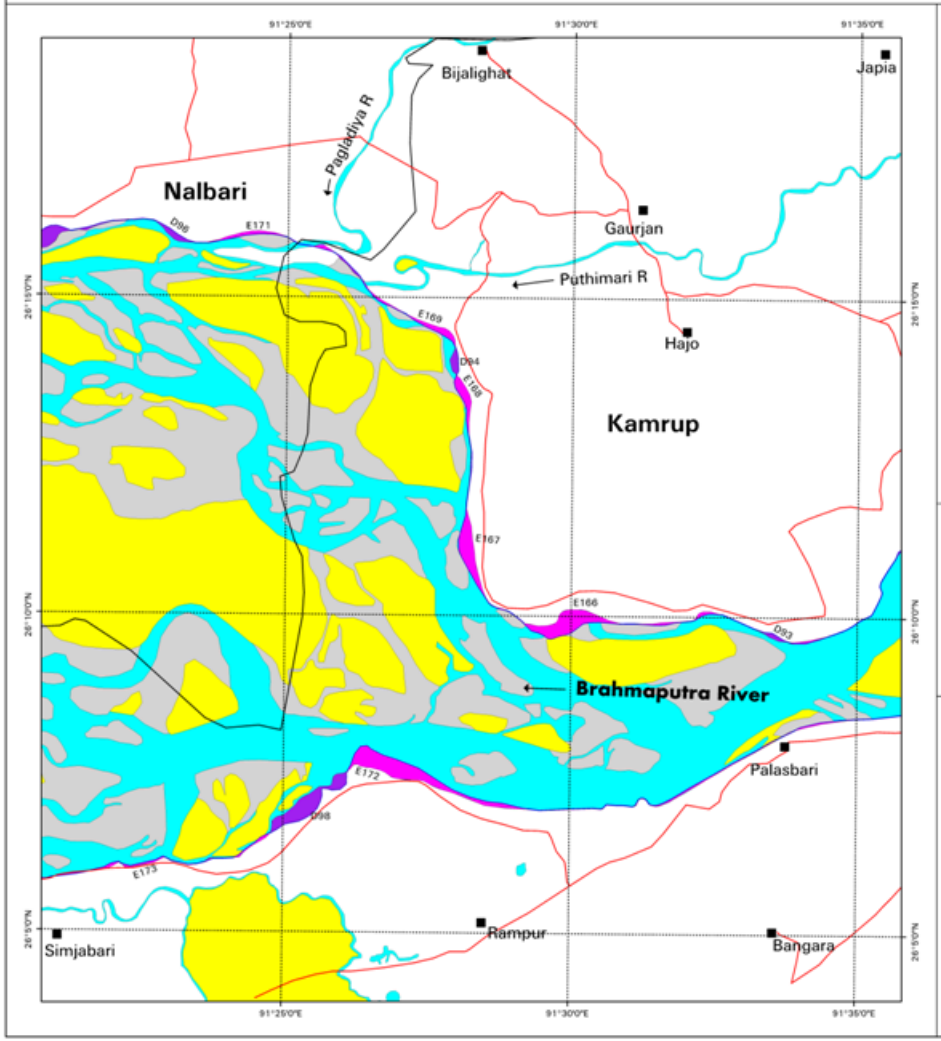
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Kamrup and Nalbari districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 26**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 3 hectares not tabulated)

S.No	Location	Area (ha.)
1	E166	88
2	E167	63
3	E168	36
4	E169	19
5	E171	15
6	E172	135
7	E173	6
8	D93	7
9	D94	13
10	D96	14
11	D98	89

Prepared for

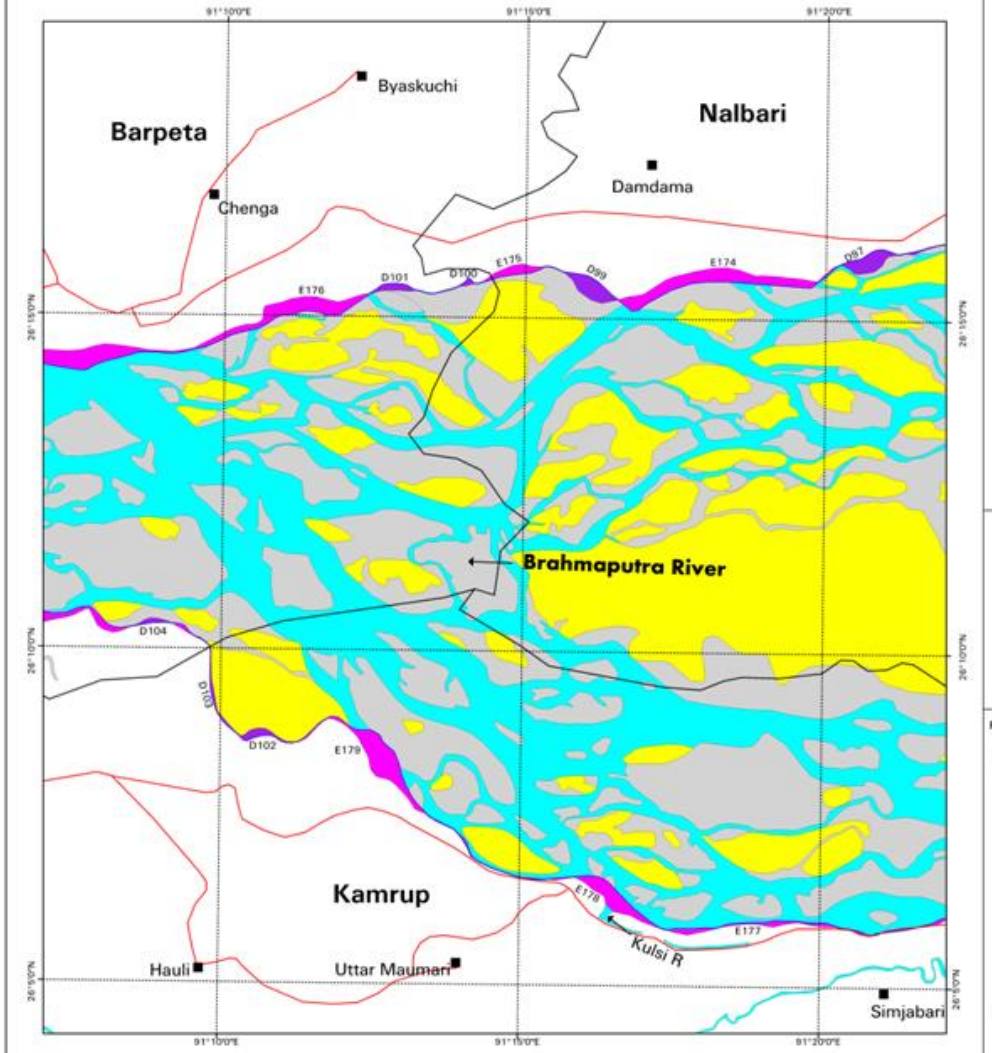
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Kamrup, Barpeta and Nalbari districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 27**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

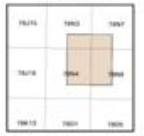
Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E174	164
2	E175	39
3	E176	441
4	E177	33
5	E178	89
6	E179	131
7	D97	54
8	D99	55
9	D100	5.3
10	D101	17
11	D103	19
12	D103	11
13	D104	8

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

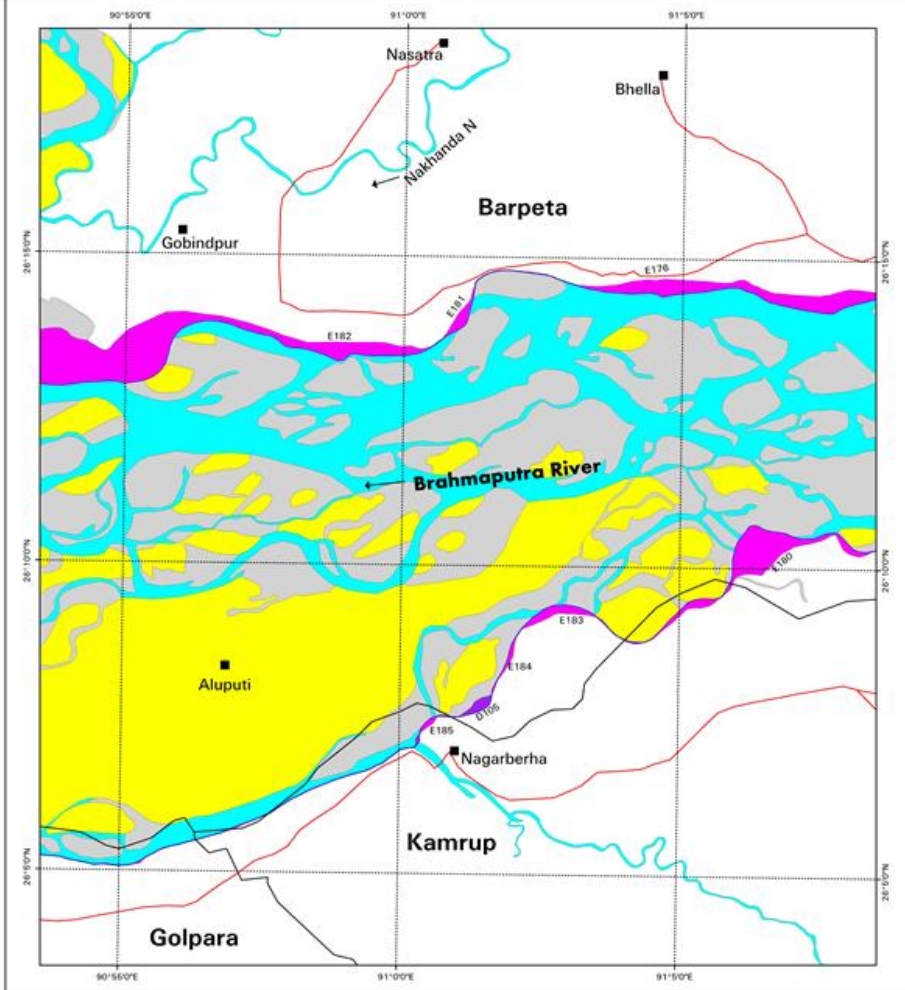
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Kamrup, Golpara and Barpeta districts

Map showing Erosion and Deposition during 1996-2002

Plate 28



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

N

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 3 hectares not tabulated)

S.No	Location	Area (ha.)
1	E180	357
2	E181	31
3	E182	963
4	E183	46
5	E184	12
6	E185	8
7	D105	33

Prepared for

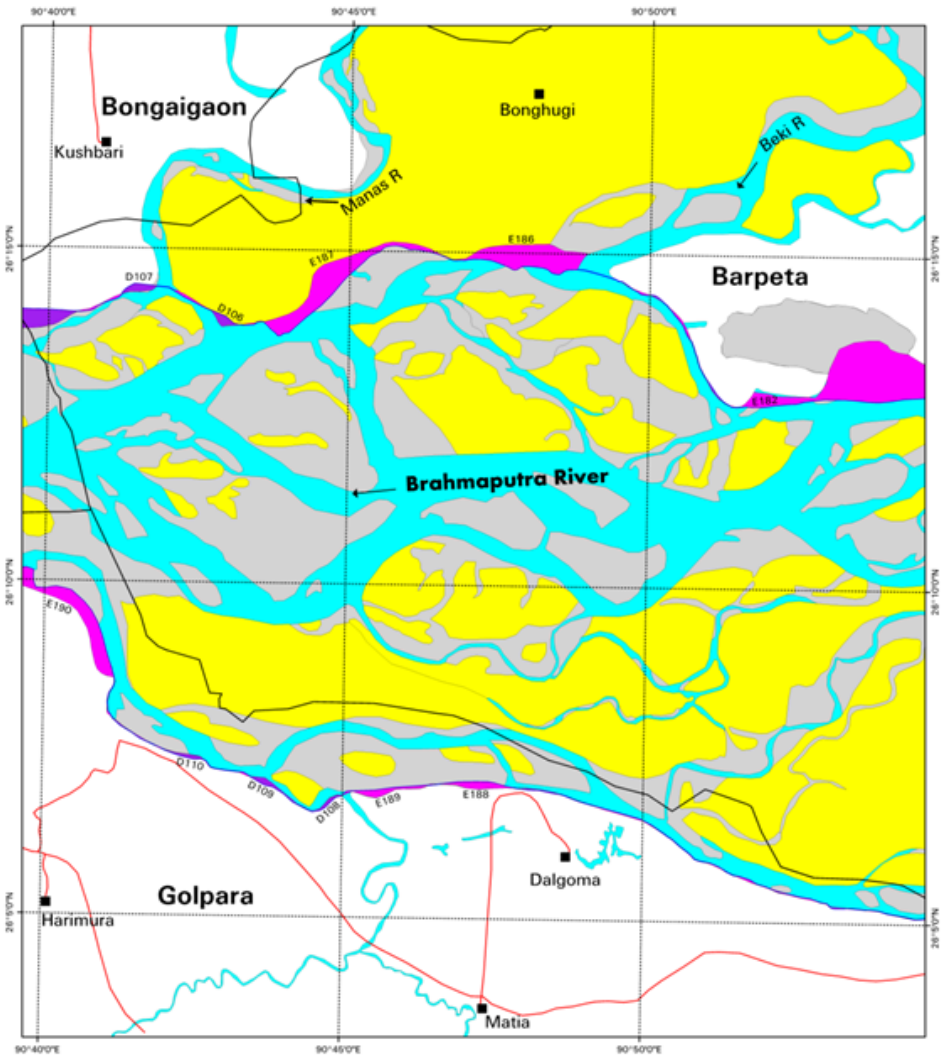
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Golpara, Bongaigaon and Barpeta districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 29**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale 1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E183	963
2	E186	198
3	E187	190
4	E188	33
5	E189	21
6	E190	165
7	D106	13
8	D107	18
9	D108	6
10	D109	11
11	D110	6.6

Prepared for

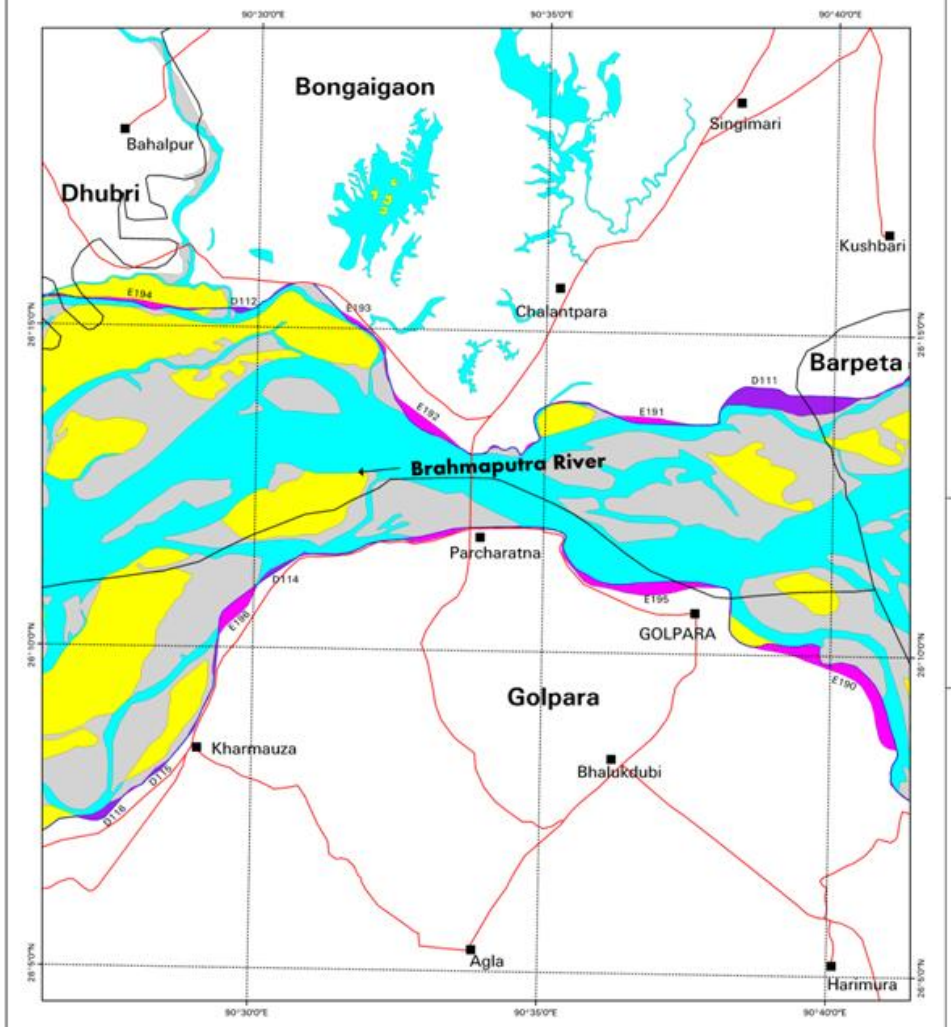
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Golpara, Bongaigaon, Barpeta and Dhubri districts **Map showing Erosion and Deposition during 1996-2002** **Plate 30**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

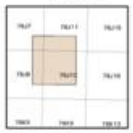
Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E196	165
2	E191	39
3	E192	48
4	E192	14
5	E194	36
6	E195	131
7	E196	45
8	D111	180
9	D112	6.7
10	D114	11
11	D113	6
12	D116	33

Prepared for

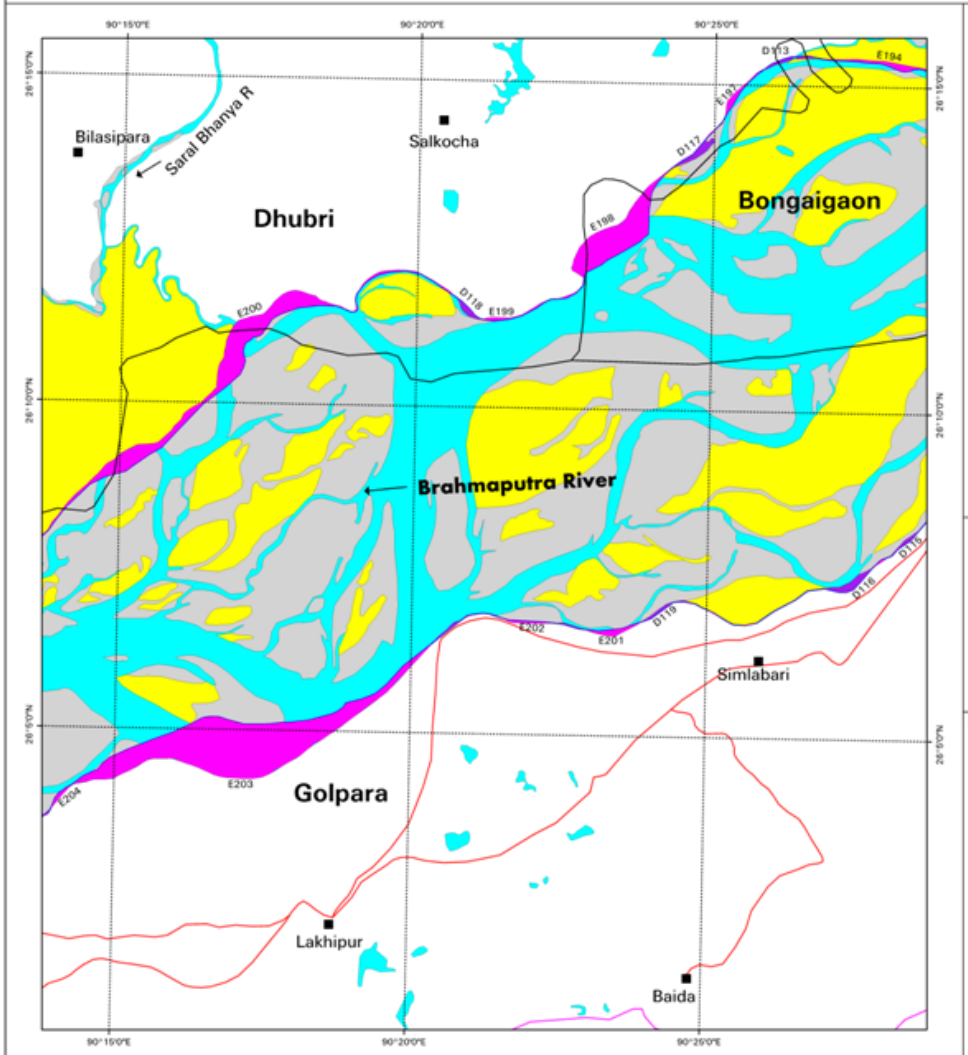
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space, Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Golpara, Bongaigaon and Dhubri districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 31**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale
1 0 1 2 3 4 Kilometers
1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha.)
1	E194	36
2	E197	13
3	E198	314
4	E199	9
5	E200	331
6	E201	16
7	E202	6.8
8	E203	769
9	E204	6
10	D113	6
11	D115	6
12	D116	22
13	D117	19
14	D118	10
15	D119	6

Prepared for

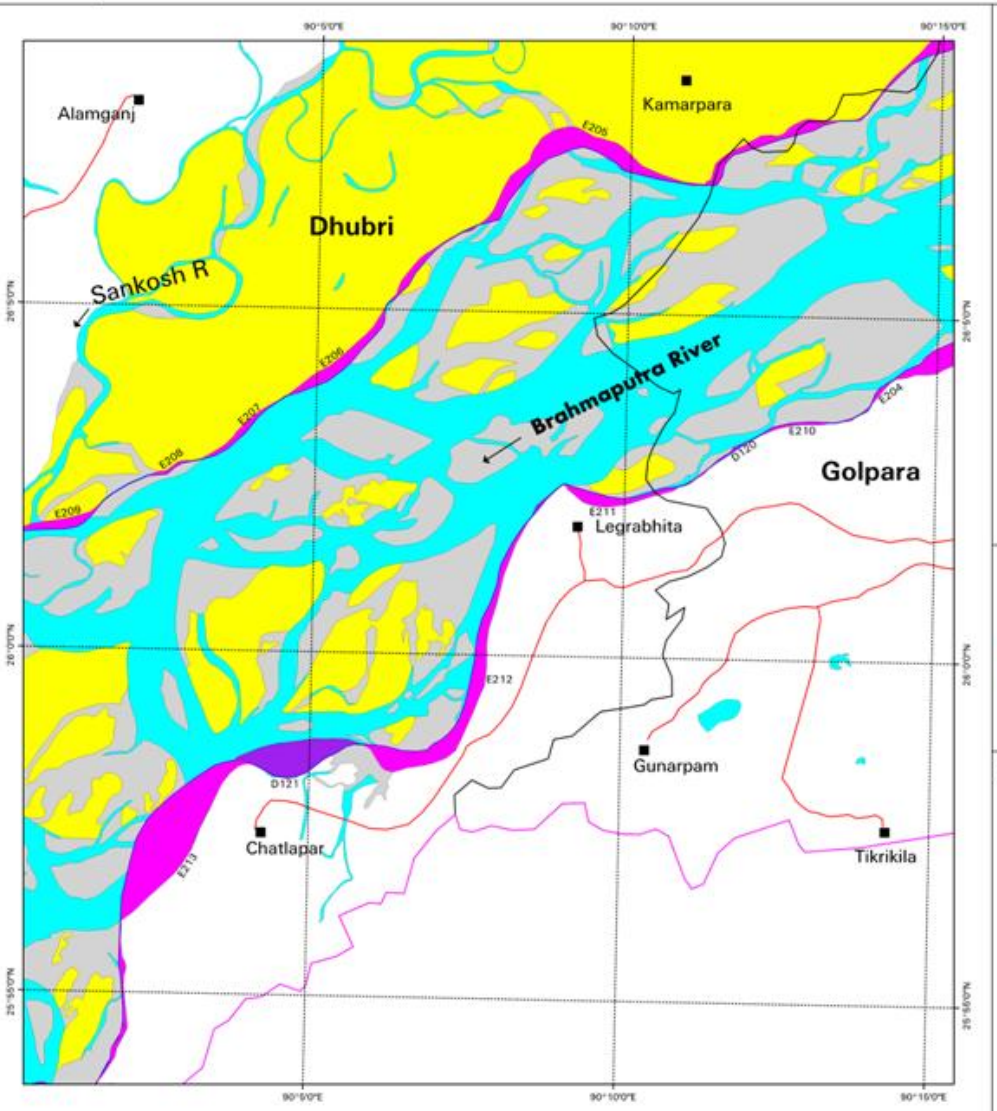
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Golpara and Dhubri districts | **Map showing Erosion and Deposition during 1996-2002** | **Plate 32**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale
1 0 1 2 3 4 Kilometers
1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha)
1	E204	6
2	E205	309
3	E206	105
4	E207	27
5	E208	7
6	E209	51
7	E210	11
8	E211	58
9	E212	252
10	E213	506
11	D120	55
12	D121	182

Prepared for

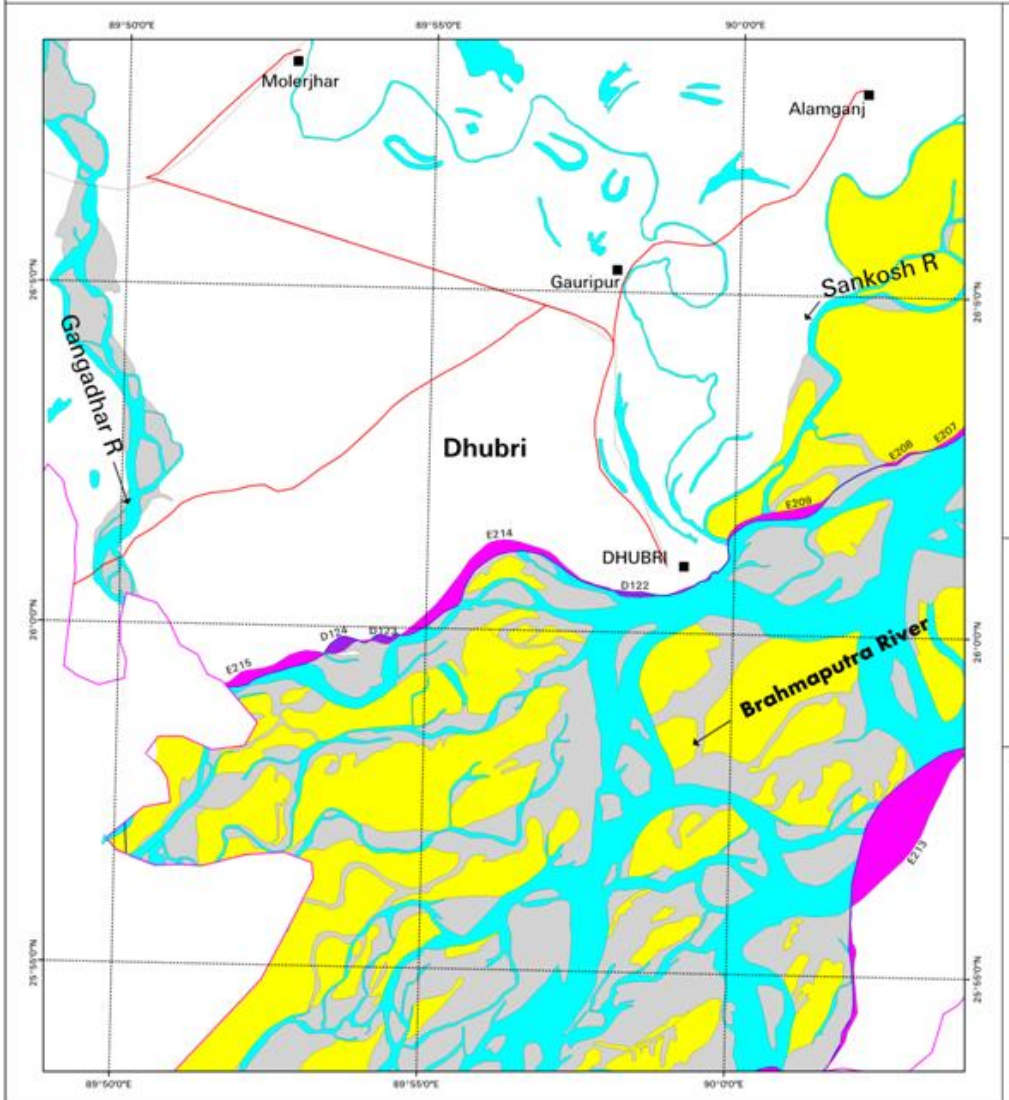
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dhubri district | **Map showing Erosion and Deposition during 1996-2002** | **Plate 33**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha)
1	E208	7
2	E209	51
3	E213	500
4	E214	158
5	E215	70
6	D122	12
7	D123	12
8	D124	23

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

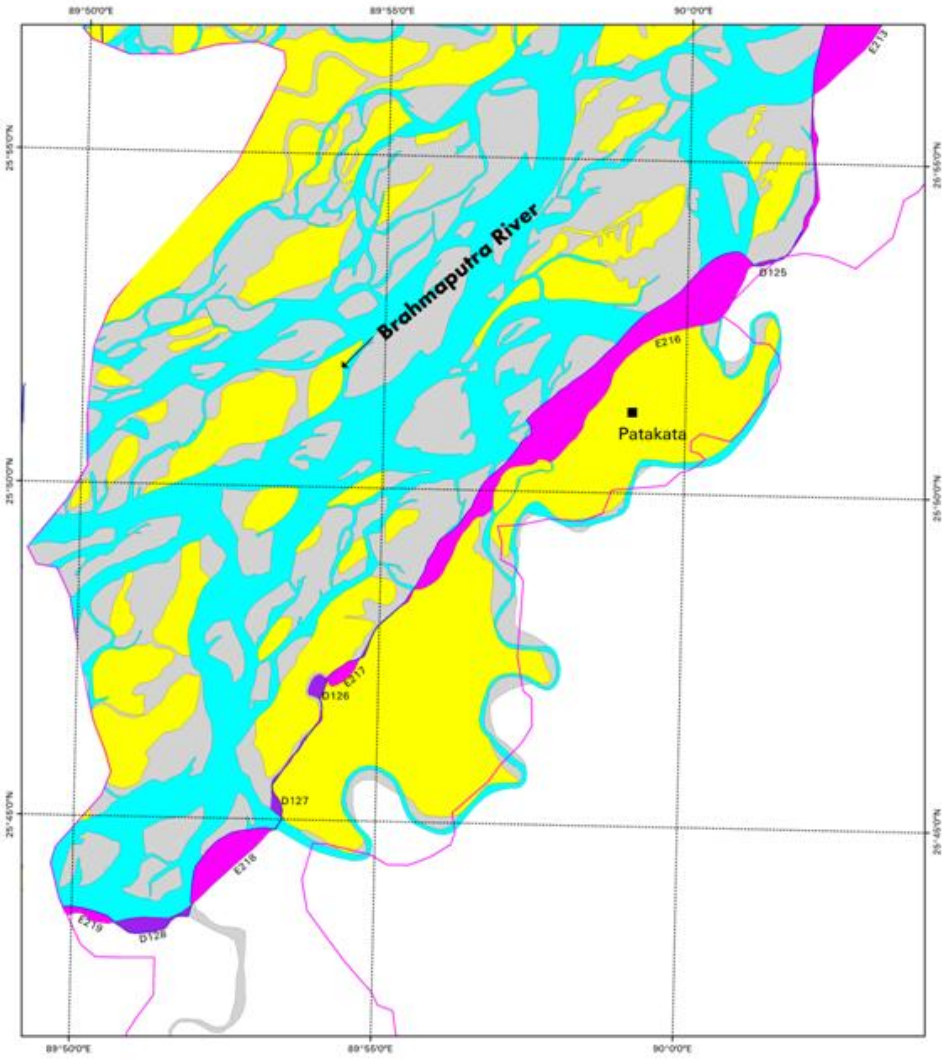
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Dhubri district

Map showing Erosion and Deposition during 1996-2002

Plate 34



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

(Area less than 5 hectares not tabulated)

S.No	Location	Area (ha)
1	E216	926
2	E217	29
3	E218	172
4	E219	26
5	D125	5.6
6	D126	23
7	D127	15
8	D128	65

Prepared for

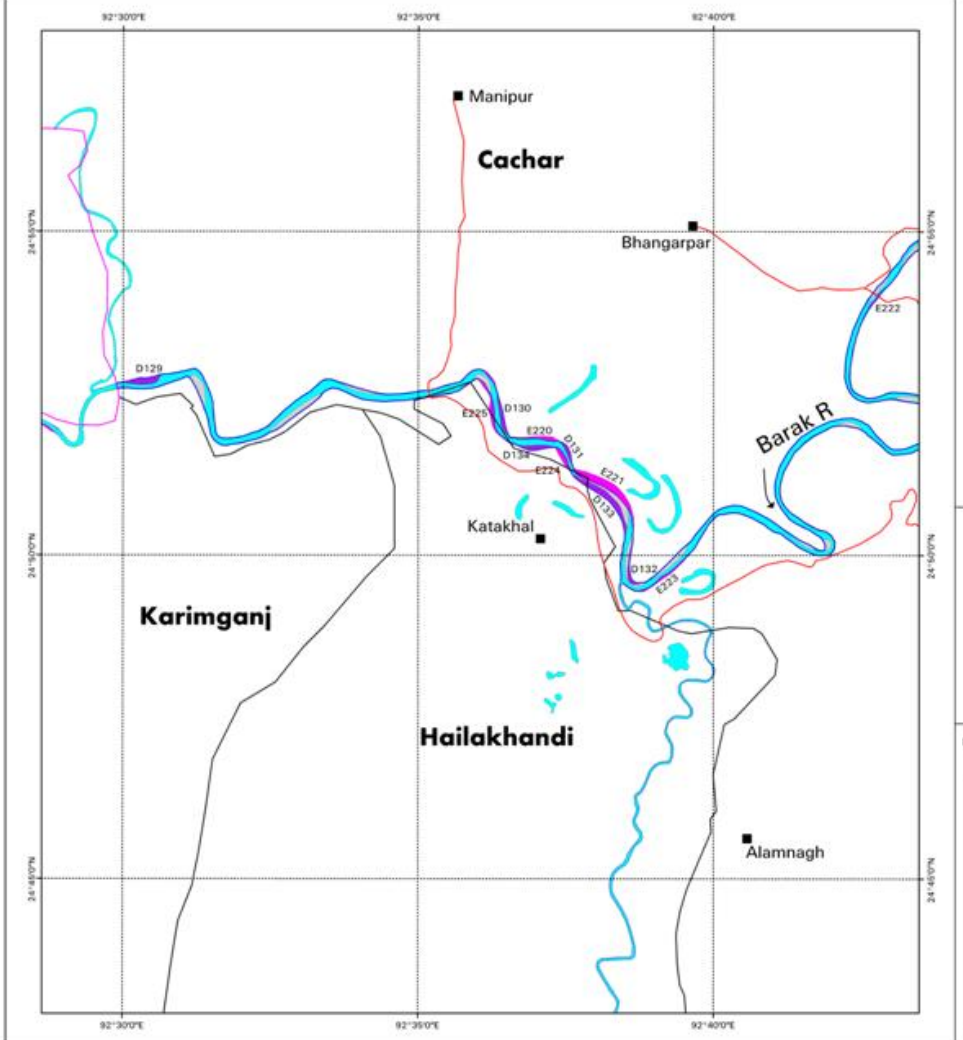
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Cachar, Hailakhandi and Karimganj districts — **Map showing Erosion and Deposition during 1996-2002** — **Plate 35**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

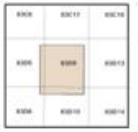
Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference



River Bank Erosion (E) and Deposition (D) Statistics

S.No	Location	Area (ha)
1	E220	9
2	E221	37
3	E222	5.8
4	E223	7.6
5	E224	7.6
6	E225	12
7	D129	15
8	D130	9
9	D131	5
10	D132	7
11	D133	29
12	D134	9

Prepared for

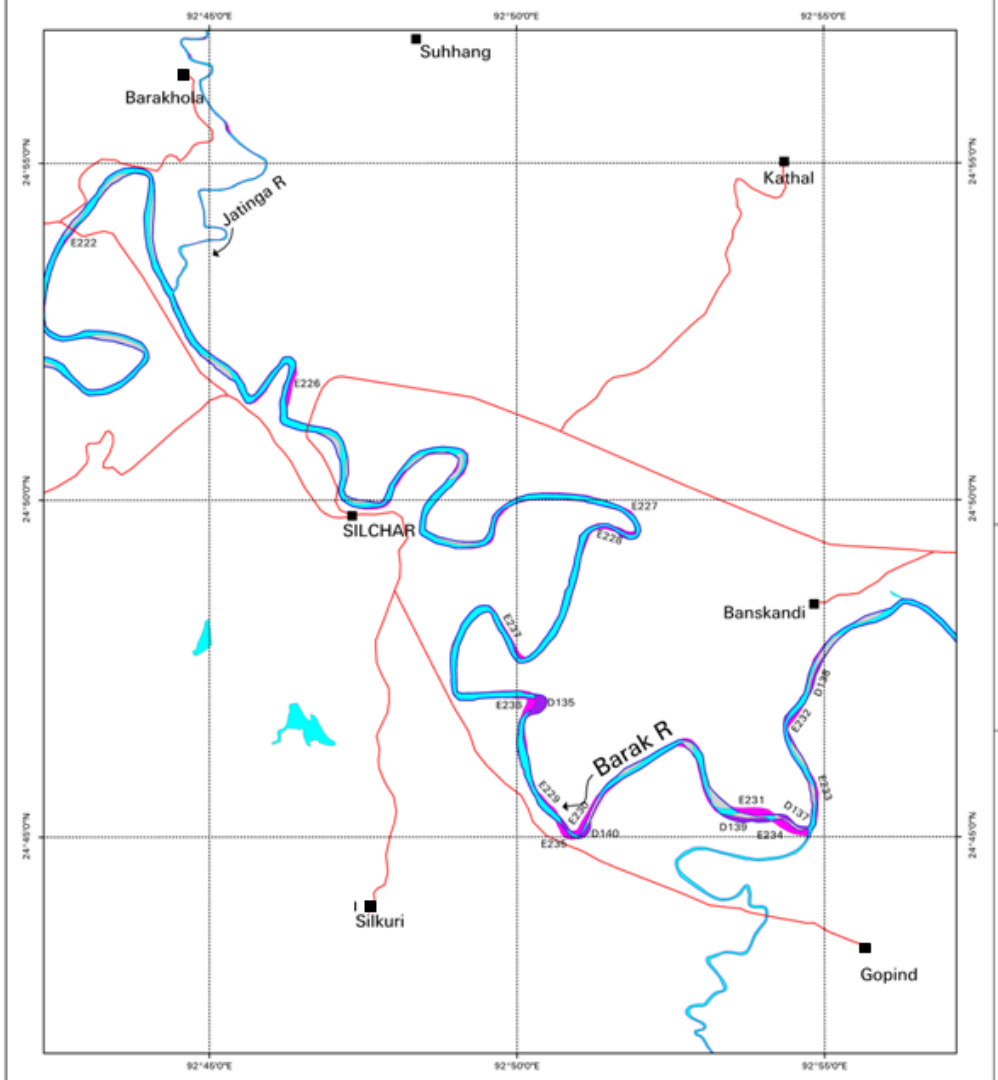
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Cachar district | **Map showing Erosion and Deposition during 1996-2002** | **Plate 36**



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

S.No	Location	Area (ha)
1	E222	5.8
2	E226	10
3	E227	6
4	E228	8
5	E229	5
6	E230	11
7	E231	17
8	E232	5
9	E233	6
10	E234	17
11	E235	8
12	E236	11
13	E237	6
14	D135	16
15	D137	5
16	D138	7
17	D139	13
18	D140	5

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

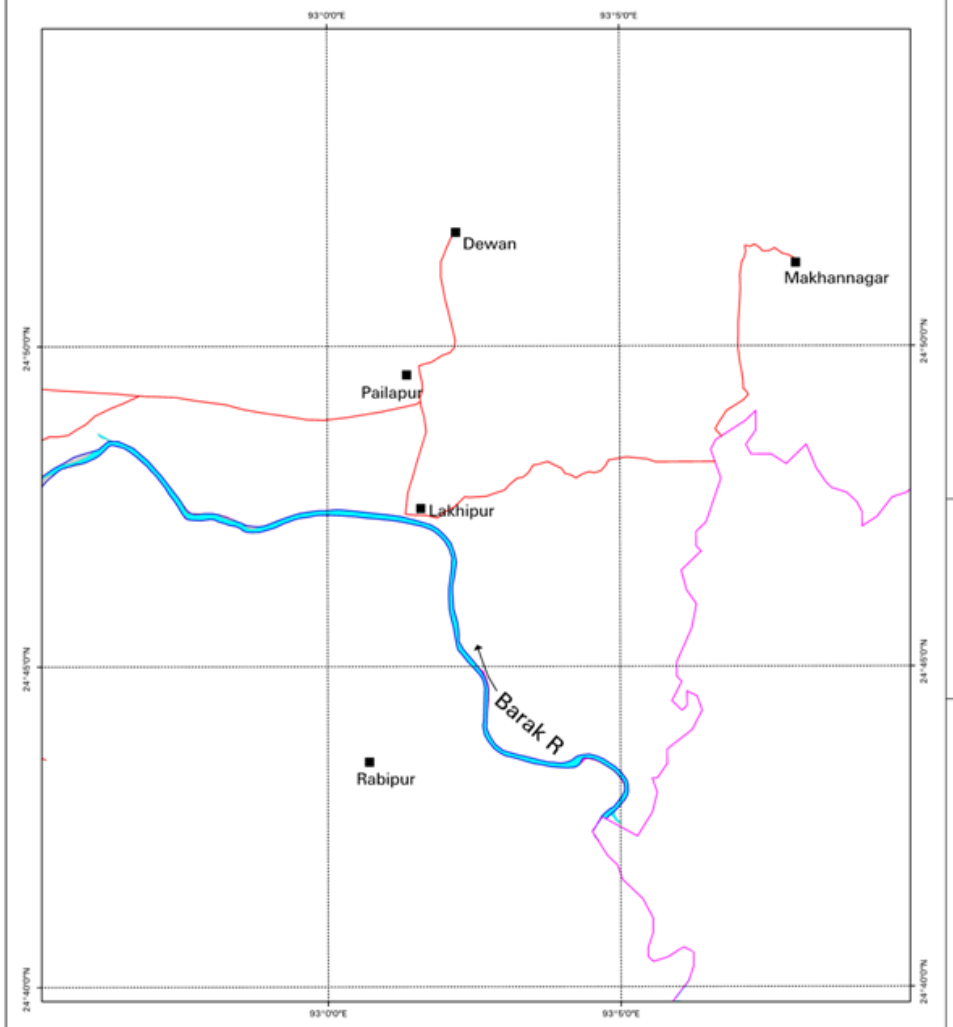
Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Part of Cachar district

Map showing Erosion and Deposition during 1996-2002

Plate 37



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Railway
- Road
- Settlement

Scale

1 0 1 2 3 4 Kilometers

1 : 50,000

Plate Reference

SOI Toposheet Reference

River Bank Erosion (E) and Deposition (D) Statistics

S.No	Location	Area (ha)

Prepared for

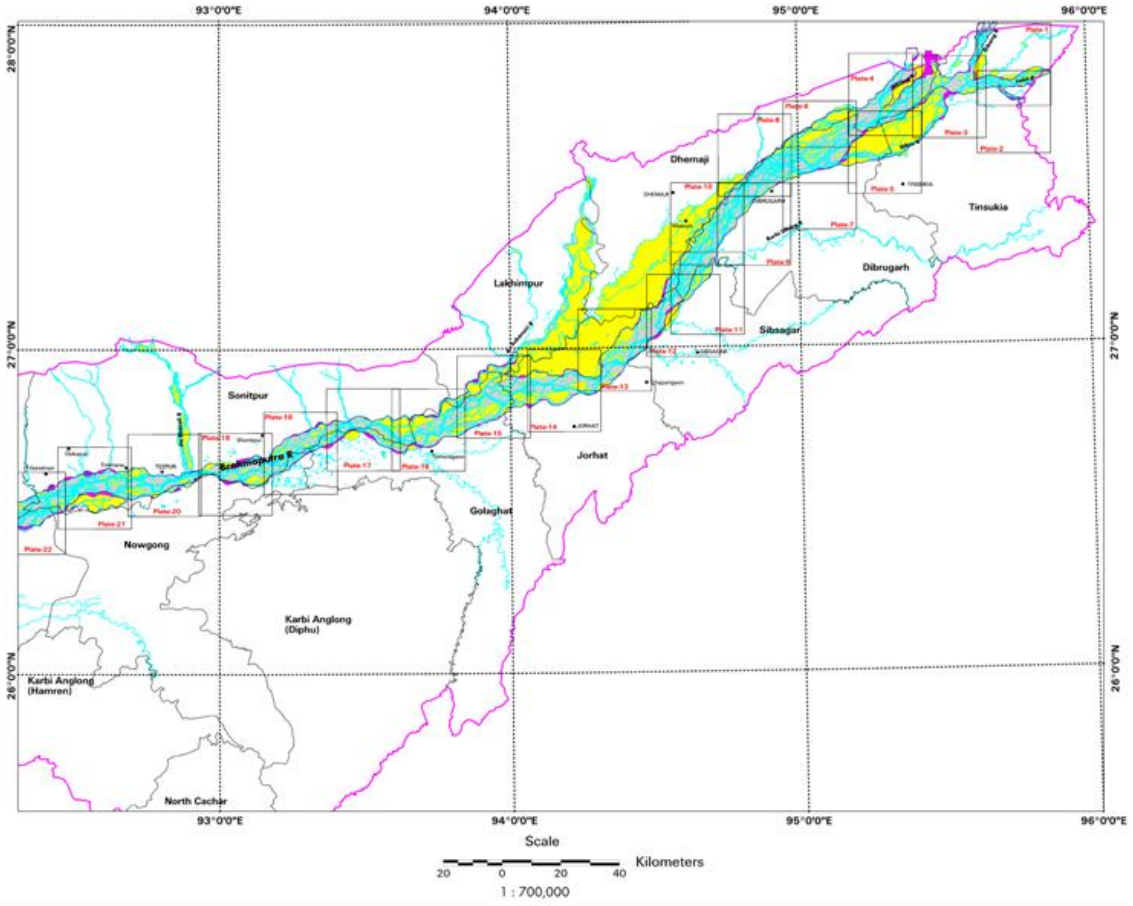
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Plate 38



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Settlement

Prepared for

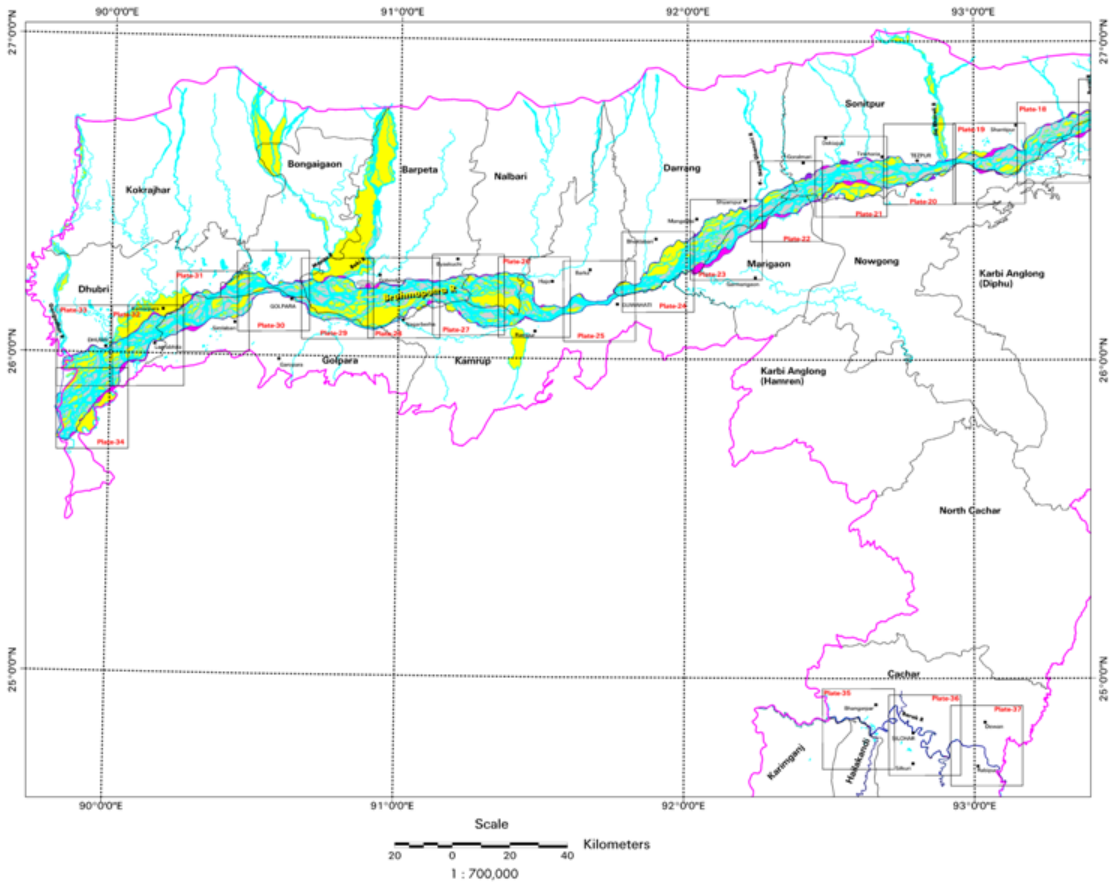
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

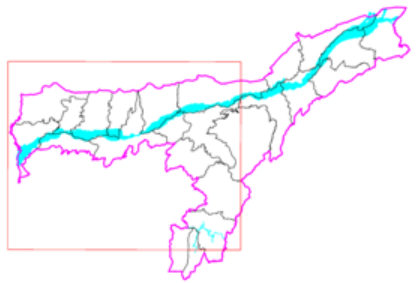
Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Plate 39



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (approx.)
- Settlement



Prepared for

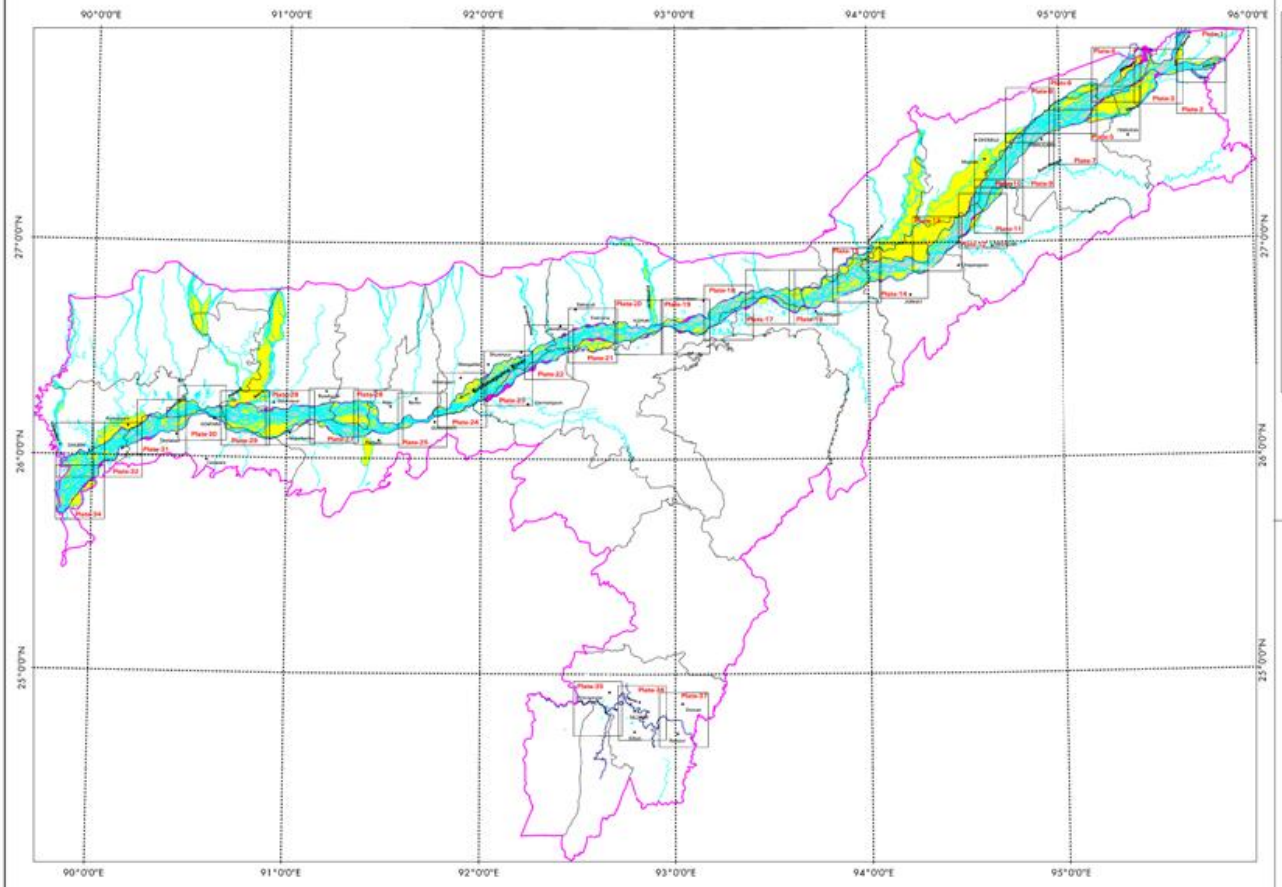
Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in

Bank Erosion Study of Brahmaputra and Barak Rivers in Assam using Satellite Remote Sensing

Plate 40



LEGEND

- Active river channel during 2002 and water bodies
- Sand
- Island
- River Bank Erosion
- River Bank Deposition
- River bankline of 1996
- State Boundary
- District Boundary (appox.)
- Settlement

Scale
20 0 20 Kilometers
1 : 1 Million

Prepared for

Central Water Commission
Guwahati, Assam

Prepared by

Decision Support Centre
RS&GIS Applications Area
National Remote Sensing Agency
Dept. of Space. Govt. of India
Balanagar, Hyderabad.
Email: flood@nrsa.gov.in