GIS-BASED ASSESSMENT OFBANKLINE SHIFTING AND MIGRATION OF DHARLA RIVER IN INDIA

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Abstract - *The Dharla River, locally knownasthe Singimari in parts of West Bengal, is a transboundary river flowing through India, Bhutan, and Bangladesh before joining the Jamuna, a majordistributary of the Brahmaputra. The river is highly dynamic, showing seasonal variation in channel pattern, flow behavior, and bank stability. During the monsoon, increased discharge often causes channel shifting and severebankerosion, threatening nearbysettlementsand agricultural land. This study focuses on the Dharla River stretch between Jaridharala, Daribosh, and Dhamaligachh areas, located near the India -Bangladesh international border, where strategic importance and limited land availability restrict development. Bank-line changes from 2016 to 2025 were analyzed using Google Earth and Landsat 8 satellite images in ArcGIS 10.4.1 . Spatial analysis of fourteen equally spaced points were used to evaluate bankline shifting at country and river side as well as erosion and deposition at both riverbanks.*

Key Words: Dharla River, Singimari River, Bank Erosion, ArcGIS, Remote Sensing, Spatial Analysis, Transboundary River.

1. INTRODUCTION

Both banks of the Dharla River have been facing severe instability for many years due to seasonal flooding, high sediment load, and continuous channel meandering (Das & Saha 2021). During the monsoon season, the river carries a large volume of water and sediment, which accelerates erosion along the riverbank and causes frequent changes in channel alignment (Sarma et al. 2018, Alam et al. 2007). These changes pose serious threats to nearby settlements, agricultural fields, roads, and other local infrastructure. Continuous bank erosion also results in land loss and creates difficulties for communities that depend on agricultureand river-relatedactivitiesfortheirlivelihood(Roy et al. 2023).

Previous studies based on remote sensing and multi-temporal satellite image analysis have highlighted the dynamic nature of the Dharla River and its associated floodplain changes (Ophra et al. 2018). Such studies have shown significant bankline migration, formation of sand bars, and shifting of river channels over time, which are important indicators of river instability (Khan et al. 2021). These observations provide valuable information for understanding river behavior. In this context, the present study focuses on analyzing the bank line shifting status of the Dharla River and examining the pattern of erosion and deposition along both the riverbanks during the study period from 2016 to 2025.

2. STUDY AREA

In this study, the focus is limited only to the Dharla river portion between JariDharala, Daribosh, and Dhamaligachh Areas, because Dhamaligachh area is located just a few meters upstream from Bangladesh border along with Madnakura Border Outpost (BOP). So, thisareaand the river reachhavestrategicalimportance fromsecuritypoint of view too. The site location is shown in Fig. 1.

Geographically, the study area lies between from Latitude=26.0241176 N, Longitude=89.433455 E to Latitude= 26.007267 N , Longitude=89.451601 E.

Fig-1: Area between Daribosh & Jaridharala and Dhamaligachhalong the international boundary

3. METHODOLOGY

This study used high-resolution satellite imagery from Google Earth and Landsat-8 data to delineate the bank lines of the Dharla Riveraccurately. Satelliteimages from 2016 to 2025 were collected at annual intervals through Earth Explorer, with all images selected from non-monsoon periods to avoid the influence of seasonal flooding. Initial image processing, including band combination and mosaicking, was carried out in ArcGIS 10.4.1 to prepare clear composite images of the study area. Riverbank lines for each year were digitized using GIS polyline tools, and polygon shapefiles were generated for spatial analysis. A datum line is drawn and this line is divided into equally spaced fourteen points to examine bank line movement in detail for both the right and left banks of the Dharla River. Points 1 to 3 are considered to be in upstream reach; Points 4 to 9 are considered to be in middle reach and Points 10 to 14 are considered to be in Downstream reach. Measurements of bank line shifting along with the erosion and deposition trends are carried out within the GIS environment. In the shifting analys is; negative values represent shifting of banklines toward the country side and positive values represent shifting of banklines toward river side. In the migration analysis; erosion is considered as negative, while deposition is represented as positive.

4. RESULTS & DISCUSSIONS

In ArcGIS10.4.1; a datum line is drawn from JariDharala, Daribosh to Dhamaligachh area and it is divided into equally spaced fourteen points to find the shifting status at the country and river side along with the erosion and deposition at the both river banks. Polylines areusedtodraw bank lines at both theleft and right bank fortenconsecutive yearsfrom 2016 to 2025 as shown in Fig-2.

To study shifting status at the country and river side of both the banks; consecutive years from 2016 to 2025 is used with a interval of 1 year. In which the distance of bank line between two consecutive years at all fourteen points are used for evaluating shifting status at all fourteen points for each year up to 2025. For the study of migration at the both left and right bank; 2016 is considered as a base year. At both theriverbanks; withrespect tothe base year 2016; the distance of bank line for each consecutive year up to 2025 from the datum line is measured to evaluate migration pattern.

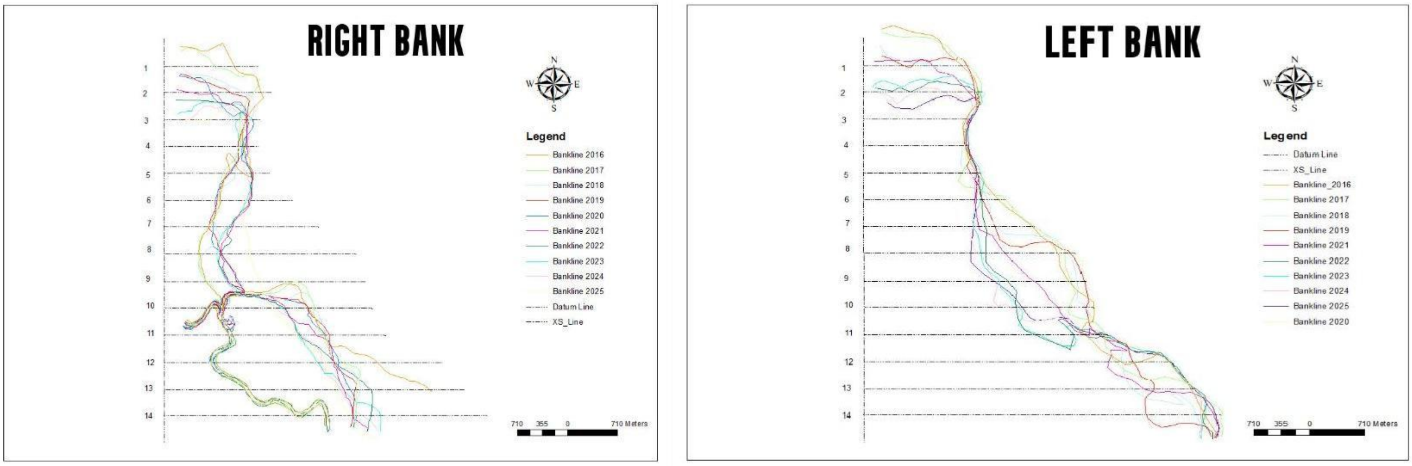

Fig-2: Bankline of Dharla River from 2016- 2025 at both the right and left banks with respect to datum line

4.1 Study of Bank line Shifting of Dharla River From 2016-2025

Table-1 and Table-2 representscombined shifting of banklines at all equally spacedfourteen pointsfrom 2016 with one year interval up to 2025 with each successiveyearfor both country and river sides at right bank and left bank respectively. Inthe above table, negative values represents shifting of bank lines toward country side and positive values represent shifting of bank lines toward river side.

Table-1: Bank-lineshifting from 2016 to 2025 at right bank of Dharla river

Point	Shifting at right bank in 2016-2017 (In m)	Shifting at right bank in 2017-2018 (In m)	Shifting at right bank in 2018-2019 (In m)	Shifting at right bank in 2019-2020 (In m)	Shifting at right bank in 2020-2021 (In m)	Shifting at right bank in 2021-2022 (In m)	Shifting at right bank in 2022-2023 (In m)	Shifting at right bank in 2023-2024 (In m)	Shifting at right bank in 2024-2025 (In m)
1	-280.03	-448.73	-478.79	-43.18	-214.29	-105.91	-381.19	-217.66	-218.01
2	-98.74	-152.4	-153.67	-285.75	-250.61	-293.79	-227.55	-89.17	-76.2
3	-101.6	140.54	-46.35	86.36	-59.26	3.22	-124.35	44.02	5.72
4	-43.18	-15.08	-10.5	60.85	57.15	-23.5	-40.23	88.9	11.71
5	-55.88	167.64	-65.4	-27.94	349.25	-31.75	15.25	-66.05	80.46
6	-13.54	-8.3	-8.57	-20.21	476.25	24.34	-58.42	30.5	-44.03
7	25.08	67.31	-89.74	51.3	276.86	-19.49	-32.8	-14.82	252.31
8	-11.3	73.55	242.14	4.49	-7.4	-12.18	-45.72	-5.92	481.51
9	20.32	-31.32	452.12	23.81	-151.34	4.19	-15.87	-15.24	465.67
10	-3.22	7.95	-6.56	4.74	14.18	-0.82	6.6	-10.83	-5.92
11	2.25	27.95	42.75	-49.91	-136.52	-225.42	-19.68	-48.15	-70.48
12	-471.81	-105.83	-19.5	67.94	-76.2	25.93	-254	-47.62	65.61
13	-1037.2	47.62	-65.61	-70.8	-91.44	376.76	-374.22	-53.97	-50.8
14	-1367	-18.11	-28.57	45.72	-41.49	260.35	122.78	-242.99	-166.68

Table-2: Bank-lineshifting from 2016 to 2025 at left bank of Dharla river

Point	Shifting at left bank in 2016-2017 (In m)	Shifting at left bank in 2017-2018 (In m)	Shifting at left bank in 2018-2019 (In m)	Shifting at left bank in 2019-2020 (In m)	Shifting at left bank in 2020-2021 (In m)	Shifting at left bank in 2021-2022 (In m)	Shifting at left bank in 2022-2023 (In m)	Shifting at left bank in 2023-2024 (In m)	Shifting at left bank in 2024-2025 (In m)
1	-84.67	472.44	-431.8	-55.03	-312.21	783.17	-44.56	164.06	53.46
2	-46.57	-25.4	101.6	531.28	-447.67	-87.64	-43.91	454.02	160.87
3	12.70	-33.04	-8.89	-13.97	-26.03	8	1.9	51.86	-38.1
4	-7.79	35.58	25.4	-2.32	-27.94	-23.28	33.34	-15.24	1.31
5	202.56	-96.54	-14.81	110.07	-197.48	2.01	-42.86	78.75	-23.76
6	-96.84	238.12	61.38	68.79	31.75	-87.21	8.2	86.78	-20.35
7	-21.70	470.96	35.58	82.13	125.09	-83.83	157.48	4.87	1.35
8	-93.13	-44.45	-33.02	-51.22	897.47	250.14	66.06	33.6	100.01
9	-24.76	-77.26	-81.28	-20.32	666.75	349.25	114.3	53.76	6.98
10	311.15	-206.59	-7.14	-97.79	457.2	560.94	-44.02	107.95	-149.25

11	-262.46	-21.63	103.71	-9.32	8.38	165.95	-202.56	-103.72	29.84
12	69.85	-74.11	149.01	-459.31	778.93	-788.64	1.69	-18.1	3.42
13	-48.26	781.05	-249.76	-520.70	636.69	-653.53	6.03	22.86	-2.62
14	-206.40	320.69	641.35	-755.65	-107.96	148.19	-27.94	59.69	-193.04

4.2 Study of Migration of Dharla River from 2016-2025

In the table-3 and table-4; erosion is considered as negative, while deposition is represented as positive.

Table-3: Bank-line Migration at right bank from 2016 to 2025

Points	Dist. from point in 2016 (m)	Dist. from point in 2017 (m)	Migration from 2016 to 2017 (m)	Dist. from point in 2018 (m)	Migration from 2016 to 2018 (m)	Dist. from point in 2019 (m)	Migration from 2016 to 2019 (m)	Dist. from point in 2020 (m)	Migration from 2016 to 2020 (m)	Dist. from point in 2021 (m)	Migration from 2016 to 2021 (m)	Dist. from point in 2022 (m)	Migration from 2016 to 2022 (m)	Dist. from point in 2023 (m)	Migration from 2016 to 2023 (m)	Dist. from point in 2024 (m)	Migration from 2016 to 2024 (m)	Dist. from point in 2025 (m)	Migration from 2016 to 2025 (m)
1	989.50	719.70	-270.00	273.10	-716.00	155.60	-833.94	93.14	-896.40	74.27	-915.27	35.56	-954.00	30.02	-959.52	27.02	-962.53	21.86	-967.70
2	1386.00	1323.00	-63.50	1124.00	-262.00	939.80	-446.62	663.80	-722.60	312.21	-1074.20	76.20	-1310.00	71.30	-1315.10	56.01	-1330.40	42.98	-1343.00
3	1180.00	1069.00	-111.00	1207.00	26.46	1168.00	-11.64	1253.00	73.07	1169.50	-10.53	1179.00	-1.48	1057.00	-123.39	161.90	-1018.10	120.30	-1060.00
4	1122.00	1101.00	-21.10	1086.00	-36.00	1057.00	-64.56	1122.00	0.04	1174.80	52.95	1153.00	31.33	1113.00	-9.30	1197.00	75.14	1219.00	97.37
5	899.60	836.10	-63.50	1016.00	116.40	955.70	56.10	931.30	31.75	1270.00	370.41	1234.00	334.90	1219.00	319.63	1181.00	281.52	1270.00	370.42
6	799.10	793.80	-5.24	787.40	-11.70	752.50	-46.58	730.30	-68.80	1206.50	407.44	1219.00	420.10	1168.00	369.36	1200.00	401.10	1164.00	365.12
7	656.20	656.20	-0.02	717.60	61.39	638.20	-18.01	690.60	34.38	973.67	317.48	939.80	283.60	914.40	258.21	901.70	245.51	1139.00	482.58
8	497.50	476.40	-21.10	517.50	20.09	803.30	305.84	800.10	302.68	802.66	305.21	797.60	300.10	751.50	254.01	753.50	256.10	1223.00	725.99
9	587.40	645.70	58.27	590.60	3.19	1041.00	453.71	1054.00	466.72	904.26	316.86	919.50	332.10	890.70	303.32	889.00	301.60	1355.00	767.28
10	604.50	590.60	-14.00	606.60	2.10	594.40	-10.18	596.90	-7.64	629.94	25.40	608.50	4.00	619.80	15.22	605.40	0.83	596.90	-7.63
11	2271.00	2273.00	2.54	2292.00	21.60	2347.00	76.20	2280.00	8.86	2169.20	-101.61	1937.00	-334.00	1905.00	-365.75	1960.00	-310.73	1888.00	-382.70
12	3023.00	2546.00	-476.00	2445.00	-578.00	2408.00	-614.68	2470.00	-552.40	2397.80	-624.84	2413.00	-610.00	2179.00	-843.29	2235.00	-787.40	2299.00	-723.90
13	3723.00	2731.00	-992.00	2781.00	-942.00	2708.00	-1015.30	2629.00	-1094.00	2545.10	-1177.90	2916.00	-807.00	2545.00	-1177.90	2499.00	-1223.60	2460.00	-1263.00
14	3942.00	2724.00	-1218.00	2711.00	-1231.00	2682.00	-1260.10	2724.00	-1218.00	2682.30	-1260.10	2942.00	-1000.00	3078.00	-863.82	2814.00	-1128.00	2646.00	-1296.00

Table-4: Bank-line Migration at left bank from 2016 to 2025

Points	Dist. from point in 2016 (m)	Dist. from point in 2017 (m)	Migration from 2016 to 2017 (m)	Dist. from point in 2018 (m)	Migration from 2016 to 2018 (m)	Dist. from point in 2019 (m)	Migration from 2016 to 2019 (m)	Dist. from point in 2020 (m)	Migration from 2016 to 2020 (m)	Dist. from point in 2021 (m)	Migration from 2016 to 2021 (m)	Dist. from point in 2022 (m)	Migration from 2016 to 2022 (m)	Dist. from point in 2023 (m)	Migration from 2016 to 2023 (m)	Dist. from point in 2024 (m)	Migration from 2016 to 2024 (m)	Dist. from point in 2025 (m)	Migration from 2016 to 2025 (m)
1	1238.13	1342.64	-104.51	892.44	345.69	1322.91	-84.78	565.19	672.94	914.44	323.69	59.86	1178.27	42.33	1195.80	31.68	1206.45	93.51	1144.62
2	1479.32	1503.43	-24.11	1519.49	-40.17	1439.34	39.98	908.05	571.27	1337.74	141.58	1456.27	23.05	1490.16	-10.84	118.54	1360.78	152.63	1326.69
3	1294.40	1318.50	-24.10	1350.68	-56.28	1354.68	-60.28	1346.21	-51.81	1371.60	-77.20	1371.60	-77.20	1380.07	-85.67	1329.26	-34.86	1380.09	-85.69
4	1310.48	1326.54	-16.06	1262.25	48.23	1307.05	3.43	1308.12	2.36	1329.27	-18.79	1354.69	-44.21	1337.74	-27.26	1320.83	-10.35	1337.74	-27.26
5	1455.20	1286.34	168.86	1358.22	96.98	1357.84	97.36	1270.00	185.20	1464.76	-9.56	1464.76	-9.56	1515.54	-60.34	1422.43	32.77	1464.74	-9.54
6	1736.58	1816.98	-80.40	1599.89	136.69	1534.60	201.98	1454.17	282.41	1430.89	305.69	1524.02	212.56	1532.47	204.11	1439.36	297.22	1447.83	288.75
7	2162.68	2178.75	-16.07	1712.44	450.24	1693.65	469.03	1606.56	556.12	1490.16	672.52	1549.23	613.45	1405.49	757.19	1405.47	757.21	1397.00	765.68
8	2484.28	2604.84	-120.56	2612.89	-128.61	2672.30	-188.02	2711.48	-227.20	1811.89	672.39	1574.82	909.46	1505.07	979.21	1456.27	1028.01	1380.07	1104.21
9	2628.96	2685.24	-56.28	2757.60	-128.64	2836.34	-207.38	2844.81	-215.85	2175.94	453.02	1837.27	791.69	1744.16	884.80	1693.36	935.60	1651.02	977.94
10	2958.60	2620.93	337.67	2846.04	112.56	2868.08	90.52	2946.41	12.19	2472.27	486.33	1930.42	1028.18	1998.16	960.44	1879.60	1079.00	2015.09	943.51
11	2829.96	3103.31	-273.35	3119.39	-289.43	3010.96	-181.00	3009.31	-179.35	3005.68	-175.72	2709.34	120.62	3031.07	-201.11	3175.00	-345.04	3132.67	-302.71
12	3296.26	3223.90	72.36	3328.41	-32.15	3454.41	-158.15	3917.96	-621.70	3149.60	146.66	3937.00	-640.74	3911.62	-615.36	3937.00	-640.74	3945.47	-649.21
13	4228.85	4261.01	-32.16	3473.12	755.73	3727.46	501.39	4260.86	-32.01	3581.42	647.43	4250.28	-21.43	4284.14	-55.29	4224.88	3.97	4233.45	-4.60
14	4037.57	4606.72	-569.15	4293.17	-255.60	3632.20	405.37	4381.53	-343.96	4504.28	-466.71	4360.34	-322.77	4377.28	-339.71	4334.95	-297.38	4512.74	-475.17

5. CONCLUSION

Between 2016 and 2025, the Dharla River showed noticeable bank line shifting along both country and river side. At right bank; points 1, 2, and 3 in the Jaridharala and Daribosh areas shifted towards the country side during 2016–2018, while points 4 to 9 later migrated toward the country side during 2019 to 2025. In the Dhamaligachh region, points 10 to 14 remained stable until 2018, shifted toward the river side during 2019 to 2021, partially returned to country side in 2022, and again moved away during 2023 to 2025. At the left bank; points 1 to 9 gradually shifted toward river side throughout 2016 to 2025, whereas points 10 to 14 first shifted towards the country side during 2016 to 2020 and later moved away after 2021.

By observing migration in the right bank of Dharla River from 2016 to 2025; it can be concluded that the points 1, 2, 3, 12, 13, 14 are more prone to erosion and less stable. On the other hand; points 5, 6, 7, 8, 9 are more prone to deposition and are relatively more stable. Again, by observing migration in the left bank of Dharla River from 2016 to 2025; it can be concluded that the points 3, 4, 5, 11, 12, 13 and 14 are more prone to erosion and less stable. On the other hand; points 6, 7, 8, and 9 are more prone to deposition and more stable.

From the conclusion of Shifting and Migration; a erosion vulnerability map can be prepared to show the relative risk of erosion vulnerable river reaches at both the left and right banks of Dharla river as shown in Fig-3.

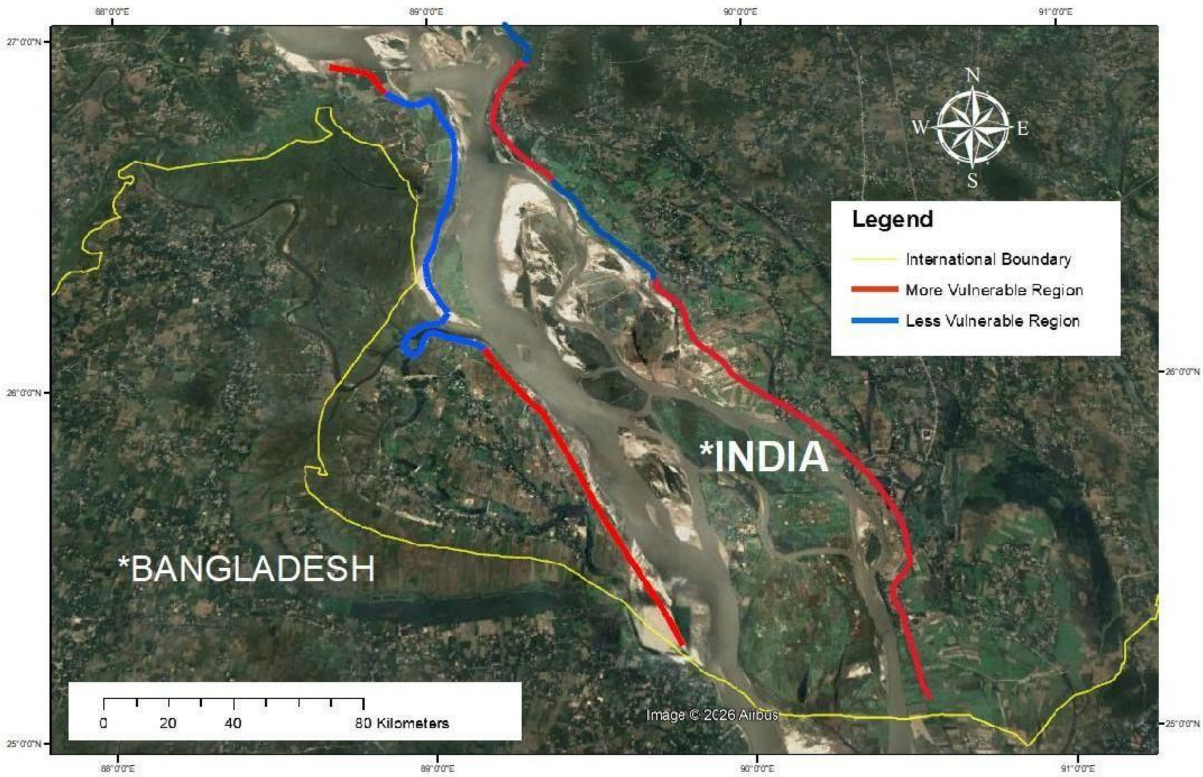

Fig-3: Map showing erosion vulnerable reaches of Dharla river

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