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# Morphometric Analysis of Damodar River Course and Its Impact on Land & Land Cover

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**Abstract** The present study attempts to undertakes the analysis of morphometric characteristics of Damodar river tiles of DEM were downloaded from Isro's BHUVAN web portal, which were mosaic to form a single image. Subset image was created from the mosaic image from which drainage network within the river was generated. Further, utilizing the drainage network image, morphometric parameters such as stream length, bifurcation ratio, stream order, watershed length, area, drainage density and shape were calculated. The land use/ land cover maps of the study area were prepared for 5th different time periods viz., 1951, 1973, 1989, 2001, and 2009. The land use/ land cover map for 1951 was generated from Survey of India toposheets at 1:250000 scale while as the land use/ land cover map for 1973LANDLAT-MSS, TM1989, ETM2001 and L-4-5 TM was generated from LANDSAT-MSS TM, ETM through the method of digitization in ArcGIS3.2a GIS software. The generated land use/ land cover maps of the five different time periods were validated after ground truthing.

***Keywords:*** *DEM, BHUVAN, LANDSAT-MSS TM, Morphometric*

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## 1. Introduction

Changing course of rivers is a natural phenomenon. Interestingly, the rivers have a tendency to shift their courses in the piedmont zone where they debouch on to the plains and that can lead to change of the course downstream. In fact, shifting of course by arriver is an integral part of the alleviation process in a river valley that is responsible for the formation of vast plains on the earth surface. When a river leaves its existing course and takes a new course to maintain its follow it is termed as shifting or change of course. Changes in the course of a river can be attributed to geologic, geomorphic, climatic, and hydrographic factors or to human interference or combination of the two or more factors together as well. Significantly, course of river is almost liable to change during the extreme floods and tectonic movements in the river basin.

Rivers and streams are dynamic landforms subject to rapid change in channel shape and flow pattern. The river width, depth and meander wavelength are determined by the water and sediment discharges. In addition, physical characteristics such as width/ depth ratio, sinuosity, and the pattern of the river/ stream (meandering, braided or straight) are also significantly affected by changes in flow rate and sediment discharge, and the ratio of suspended to bed load. In a study conducted in the Missouri River downstream from Fort Peck Dam in Montana has identified that the dam construction has made a significant impact on river migration. The mean rate of channel centerline migration has fallen from 6.6 m per year to 1.8 m per year after the reservoir impoundment [1]. This implies that natural and man-made factors both attributed to changes in morphological characteristics and the migration of river courses. In some regions in the world, migration of rivers are very prominent and frequent (e.g. in North India and Bangladesh). However, river course change (river migration) can have many negative influences such as loss of land, changes in the riparian zone, effects on aquatic habitats and riparian ecology, and even changes of property boundaries [2]. In addition, the assessment of river course change will facilitate identifying the exploitation of river reservations for various activities with time. Damodar River is one of important monsoon dominated and severe flood prone Indian Rivers which carries out almost all the geomorphic work of erosion, transportation and deposition during summer monsoon season, mainly June to September [3]. Generally after a spell of heavy rains (due to depression) which may last for a period of several hours to several days, that large volume of runoff is generated in the upper catchment and river experiences floods [3].

The Damodar River has drawn attention for its shifting course and frequent and often disastrous floods, as is the case of many river in under Ganga-Brahmaputra plains have shown a tendency to shift their courses, and the triggering point of shift is invariably located in the piedmont zone. Both changing courses and floods of rivers pose threat to man and his civilization, thus considered as geohazards. Many a times, the development

is affected thus necessitating incorporation of studies of geohazards in the planning process. In this context the Damodar river basin, particularly its lower reaches, present an interesting case for study To support the specific land use planning, developed spreadsheet programs that run parallel to the GIS to help the municipal agricultural extension service assess agricultural restrictions for different types of land units [4].

# 2. Data Base & Methodology

## 2.1. Survey of India Topo Sheets

The following survey of India topographic sheets of 1951 on 1:250000 and 1:50000 scales were used to generate the base maps and various layers such as drainage, slope, land use/ land cover, and village location map for the base year.

**NF 45-7, NF 45-03, 73m/16, 73m/15, 73m/11, 73m/11, 73m/7**

## 2.2. Satellite Image

For changing dictation analysis land use/ land cover map of the study area was generated from the given satellite data:

**Table 1. Use of Database in the Study**

| Satellite image | date | Raw/path |
|---|---|---|
| **L-1-5 MSS** | 22-feb-1973 | - |
| **TM** | 3-jan 1889 | Path-139, raw-44 |
| **ETM+** | 26-oct-2001 | Path-139, raw-44 |
| **L-4-5TM** | 14-march-2009 | Path-139. Raw-44 |
| **L-4-5-TM** | 2-june-2009 | Path-139, raw-44 |
| **Google earth** | 10-june2013 | - |

Methodology involves comprehensive studies using a historical perspective and the application of geographical framework for better representation and understanding both in time and space.

## 2.3. Generation of Digital Elevation Model

A digital elevation model is a regular array of terrain elevations (x, y, z) normally obtained in grid or generated using; (a) cartographic digitization of contour data, and /or (c) photogrammetric measurements. Existing topographic maps contain a wealth of terrain data that may be used for digital terrain modeling. For the generation of Digital Elevation Model, contour lines were digitized from the survey of India topo sheets (1:50000). These contours were labeled with their respective elevation values. The contour map was then processed in the ERDAS Imagine software to create a continuous raster surface by interpolating the elevation values. In the data preparation module of ERDAS imagine software, the surfacing was done and 20 meter spatial resolution Digital Elevation Model was obtained. The Digital Elevation Model was used for the topographic analysis of the study area.

## 2.4. Generating Land use/ Land Cover Maps

The land use/ land cover maps of the study area were prepared for 5th different time periods viz., 1951, 1973, 1989, 2001, and 2009. The land use/ land cover map for 1951 was generated from Survey of India toposheets at 1:250000 scale while as the land use/ land cover map for 1973LANDLAT-MSS, TM1989, ETM2001 and L-4-5 TM was generated from LANDSAT-MSS TM, ETM through the method of *digitization* in ArcGIS3.2a GIS software. The generated land use/ land cover maps of the five different time periods were validated after *ground truthing.* A portable Global Positioning System (GPS) was used to collect the accurate locations of the reference points, which were used in the validation..The necessary changes resulting from ground truthing were incorporated into the data layers. Finally, land use/ land cover change detection analysis was done by comparing the same land use/ land cover area of five given time periods.

## 2.5. Morphometric Analysis

The Damodar River Basin is a sub-basin of the Bhagirathi-Hooghly River system of West Bengal and geologically the floodplain of this region is belonged to the western part of Bengal Basin and geomorphologically it is a mature fan-delta of Damodar River sloping toward east-south east, though its western part is associated with Ajoy – Damodar interfluve 'Rarh Plain'. Its funnel shape basin area is about 23,370.98 km2, spreading in the states of Jharkhand (73.7 per cent) and West Bengal (26.3 per cent). Damodar River is one of important monsoon dominated and flood-prone Indian Rivers which carries out almost all the geomorphic works of erosion, transportation and deposition during summer monsoon season, mainly June to September. In between Rhondia and Paikpara the total length of Damodar River is approximately 82 km, having numerous glimpses of spill channels and palaeochannels, viz. *Khari*, *Banka*, *Gangur*, *Behula*, *Sapjala*, *Deb Khal* and *Kana Damodar*. There is a sharp physiographic contrast in Damodar River Basin – (1) Upper and Middle Basin is covered by Archean to Gondowana formation, having high relief and (2) Lower Basin below Asansol exhibits newer to older alluvium tract of lower relief (Chandra, 2003). Basically below confluence point of Damodar – Barakar (at Dishergarh, near Asansol City) due to regional tilt and neo-tectonic activity the Damodar River enters into its lower portion of the ancient deltaic basin and after crossing Durgapur the River enters into the Quaternary Old and Recent alluvium plain, filling the Bengal Basin with coarse sediments of Chotangapur Plateau .

## 2.6. Channel Shifting

The river morphology has been changing with expansion of its course due to heavy sediments and lateral cutting and high deposition in downstream. Damodar has been intense bank cutting and frequent channel shifting and affecting thousand of families and destroying hectares of agriculture land in low land. The site 5 has top width in both respective years. And in near jujuti has highly changed its breadth. The 1625 meter breath expended during 36 years period and reach to 5375 meters in 1994. The sites 8, 9 and 10 has no expended in both respective years.

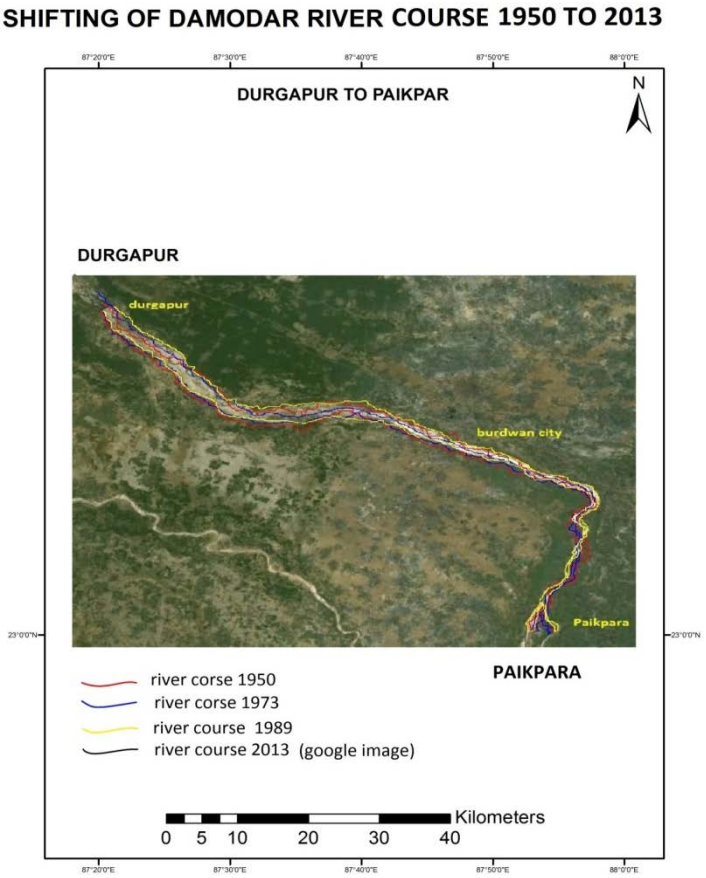


**Figure 1.** Shifting River Course Durgapur to Paikpara

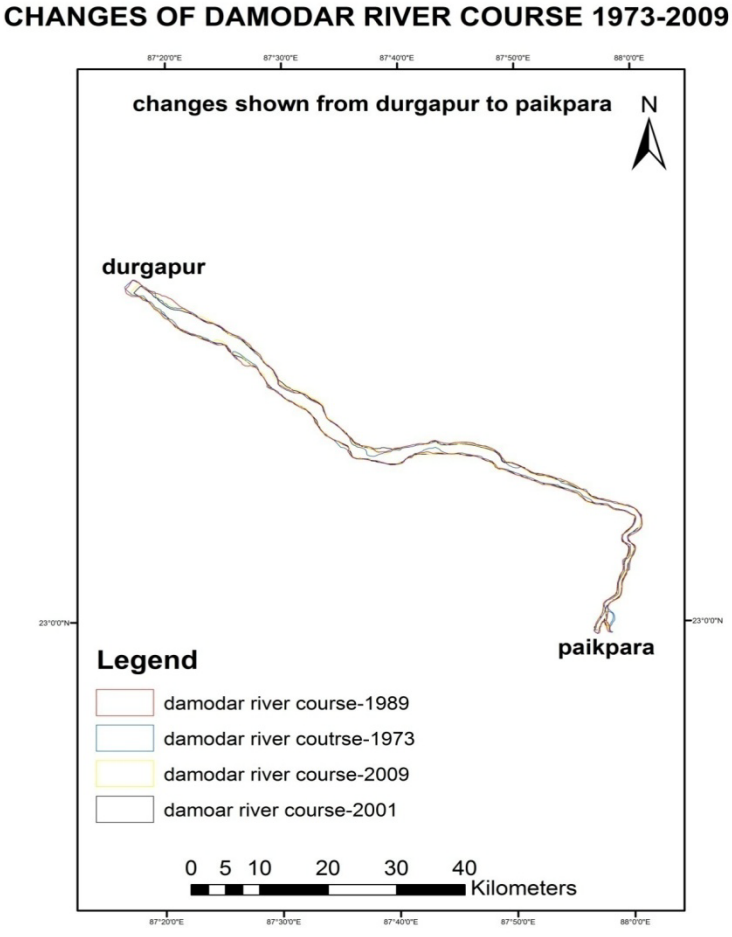


**Figure 2.** Changes of Damodar River Course 1973-2009

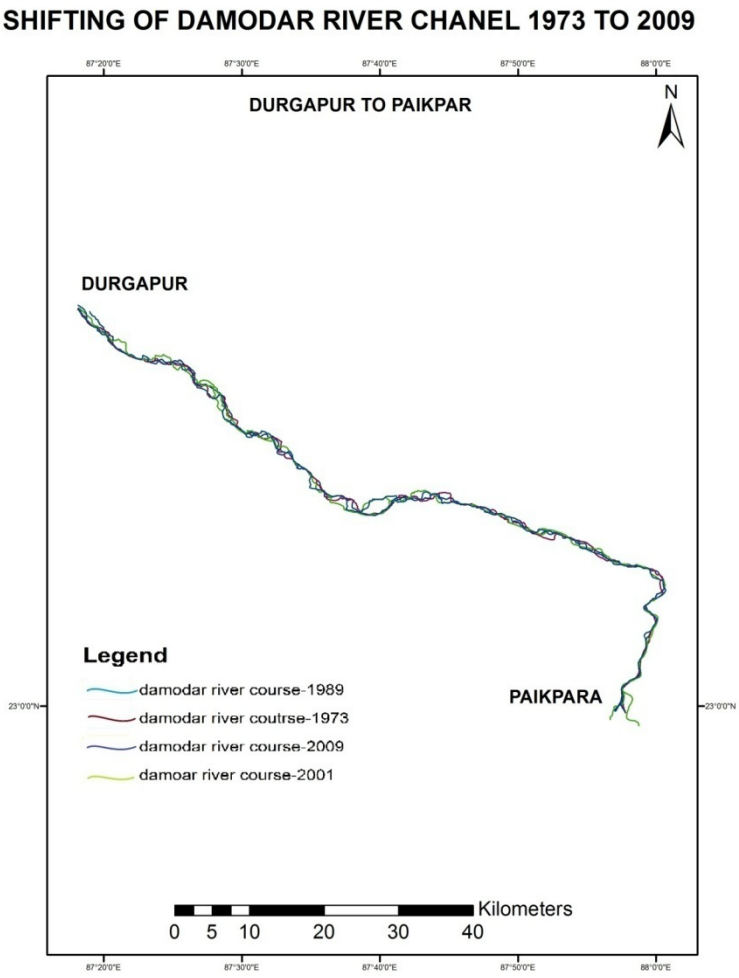


**Figure 3.** Shifting of Damodar River Channel

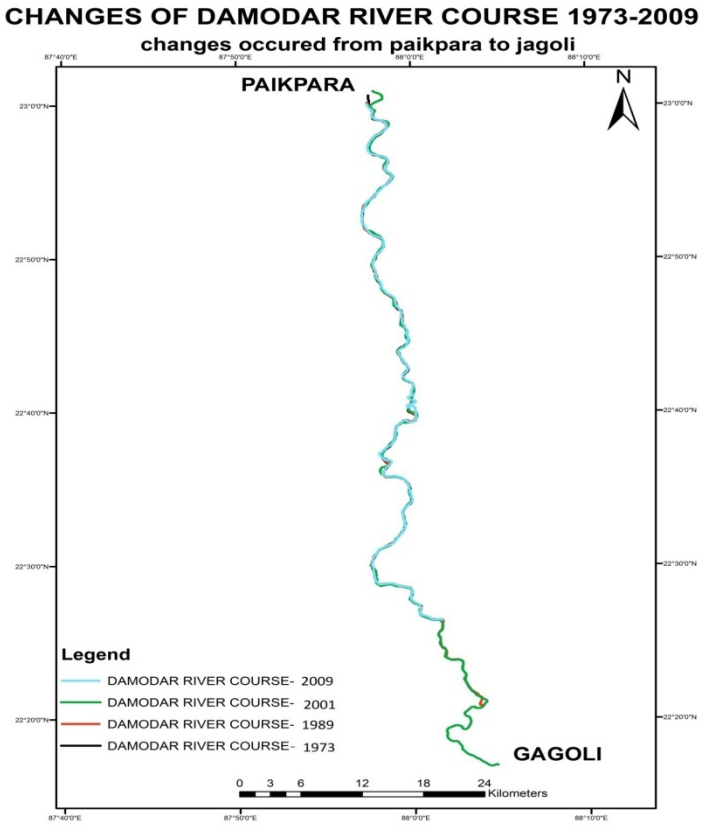


**Figure 4.** Changes of Damoadr River Course Paikpara to Gagoli

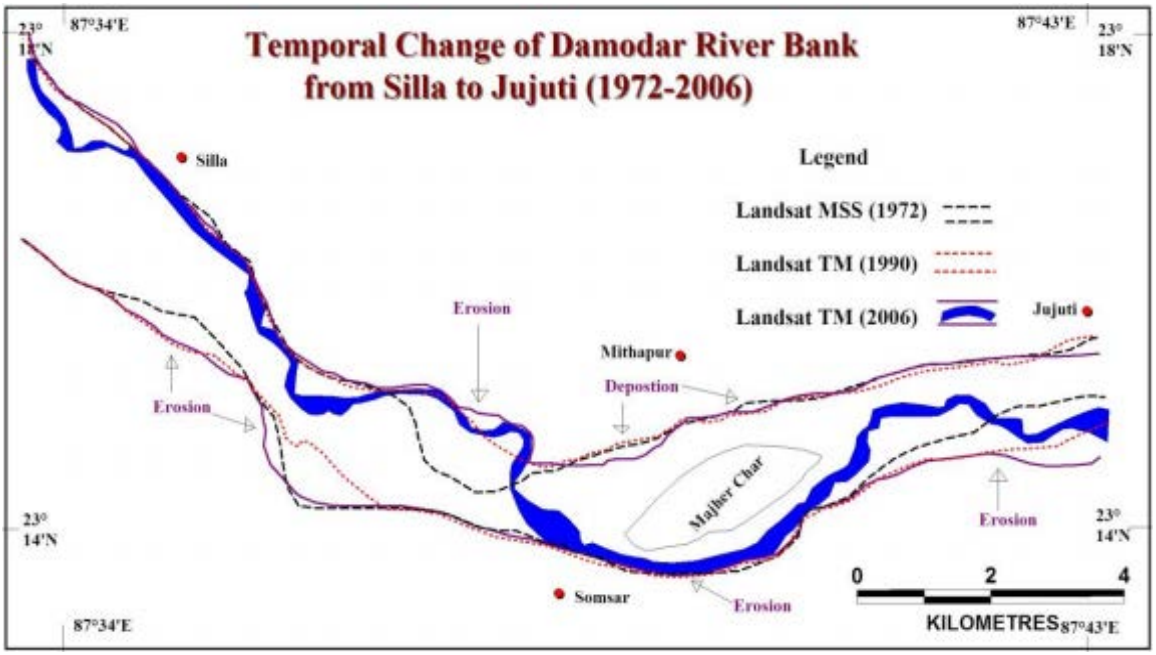


**Figure 5.** Temporal Changes of Damodar Bank from Silla To Jujuti 1972-2006

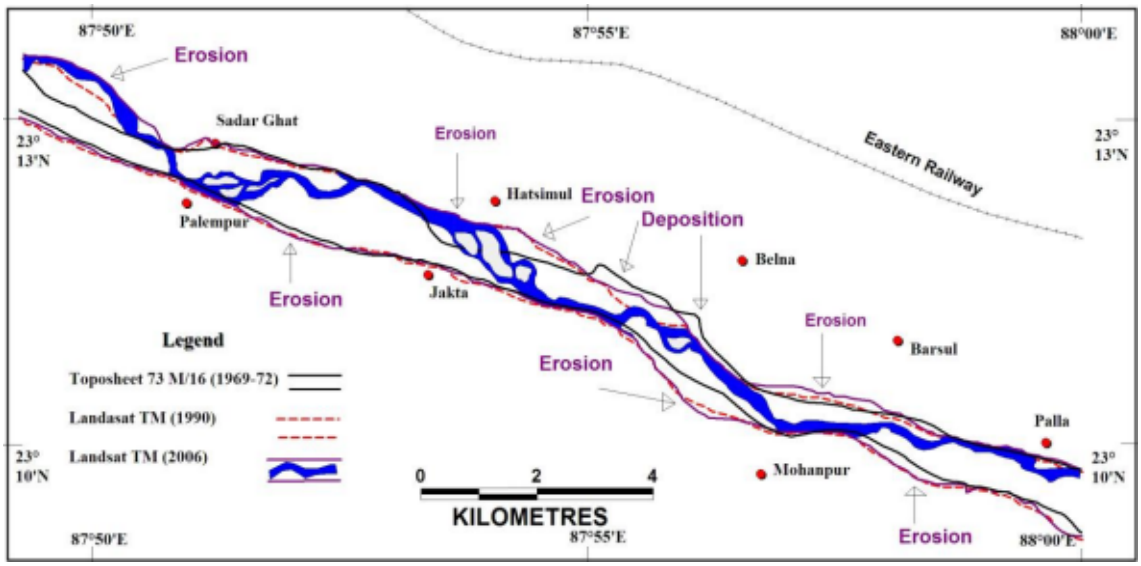


**Figure 6.** Temporal Changes of Damodar Bank from Sadar Ghat To Palla 1972-2006

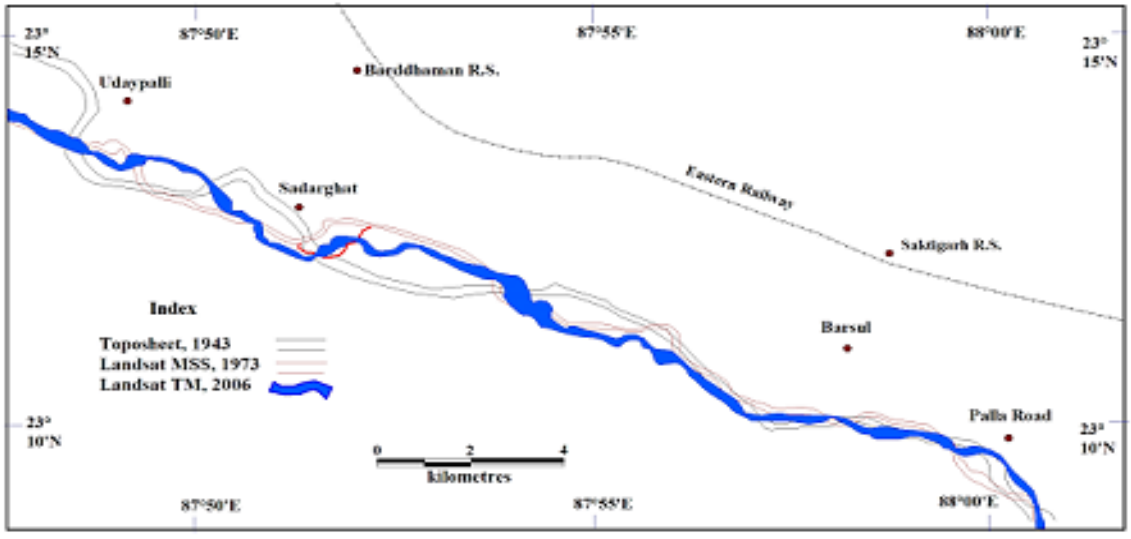


**Figure 7.** Temporal changes of Damodar bank from Chanchai to Paikpara 1972-2006

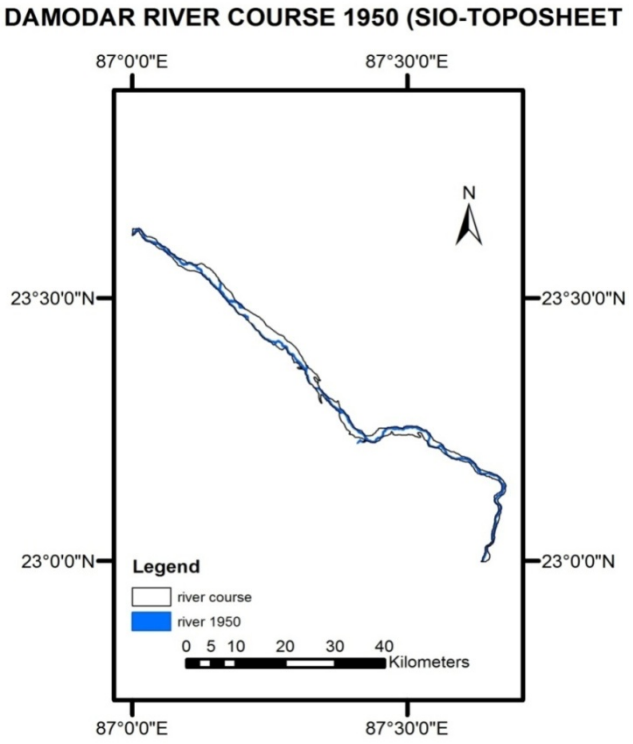


**Figure 8.** Damodar River Course 1950

Damodar is the sorrow of Burdwan, Hooghly and Howrah district. It works as the boundary line of the respective districts. The river has cutting to the bank, sediments filling in the course and making to an island in he ways and shifting its cannel is common. The huge agriculture land has converted into desert in both districts.

The river covered 121.346 Sq. Km. in 1958 and expended to 143.25 Sq. Km. in 1994. The river expended its coverage to 21.904 Sq. Km. within the 36 years of period. Thus the river has covered 0.5476 Sq. Km. farm land annually. Figure shown the shifting condation of Damodar River from Durgapur to paikpara. And it was shown that no hig-fi shifting are occur during this period but some short length shifting are occur in near Durgapur And burdwan city.

**Land Use and Land Cover**

**Water Bodies**

Main water bobies features are the mother river Damodar and others are surrounding ponds, lakes, reservoirs and man made tanks are included in this category. The area under this class has decreased from 14670 hec to 16780hec during the period of investigation.

**Forest**

**Land Use and Land Cover**

**Water Bodies**

Main water bobies features are the mother river Damodar and others are surrounding ponds, lakes, reservoirs and man made tanks are included in this category. The area under this class has decreased from 14670 hec to 16780hec during the period of investigation.

**Forest**

Forest is defined as all land bearing vegetative association dominated by trees of any size, capable of producing wood or other forest products and exerting an influence on climate or water regimes or providing shelter for wild life and live stock Forest is divided into different sub categories, viz., dense forest, open forest, scrub forest, forest blanks, forest plantations etc. ***Closed or Dense Forest:*** If the crown cover is more than 10% of the area then the area is divided into dense forest area. This class did not exist in 1950-2009 but due to the extensive efforts by the forest department for the regeneration of the forest, this category has increased from 0.12sq kms in 1996-97 to 25.59 sq kms in 2001-2002

**Agricultural Land**

The land primarily used for farming and for production of food, oil seed and other commercial and horticultural crops comes under this category. This area is further divided into different categories such as rabi crop, kharif crop, double crop and fallow. ***Kharif:*** Kharif season crops include all the agricultural crops, which are harvested between June to October. The major kharif crops grown in the area are jowar, bajra and paddy under food grain crops and bajra and jowar as fodder crops.

This unit covered an area of 5.72 sq. kms and 14.73 sq. kms during 1996-97 and 2001-02 respectively. More area under kharif during 2001- 02 may be due to good rainfall during 2001-2002. ***Rabi:*** Rabi season crops include those agricultural crops, which are harvested between March and April. Rabi crops are mainly wheat and mustard and to some extent chickpea and vegetables

***Double Cropped Area:*** This is the intensive cultivated area which is used for raising both rabi and kharif crops. The double cropped area has decreased from 279.79 to 236.52 sq kms within a period of five years. ***Fallow:*** The land, which is temporarily lying vacant in both kharif and rabi seasons due to one or the other reason, is called fallow land. Fallow lands could be delineated by using two seasons' data, i.e., kharif and rabi. The area has increased from 0.52 to 7.49 sq kms.

**Settlement**

In lower damodar river course a settlement chain are seen in the left side of the river course from Durgapur to burdwan city. And others are dispread rural settlement.

**Sand dunes**

These are situated in the river valley and this are occupied most of the area under river course.

## 2.7. Changes in Land Use along the Riparian Areas

It is an interesting factor to identify that changes in the river riparian areas are mainly started from above Durgapur city. These changes are not much visible in upstream area of the river segment. This has resulted in many changes within the river reservation area of the downstream reach. Especially in the lower reach of the river segment, the transformation of home gardens into complete settlement areas can be seen. This is not at all a favorable development for the health of the river and the ecosystems of adjacent riparian areas.

Since there were no considerable changes in terms of river migration identified in this study, an assessment was not conducted in terms of changes in the land extents or ownership. Ecosystem changes or resulting biodiversity alterations were also not studied.

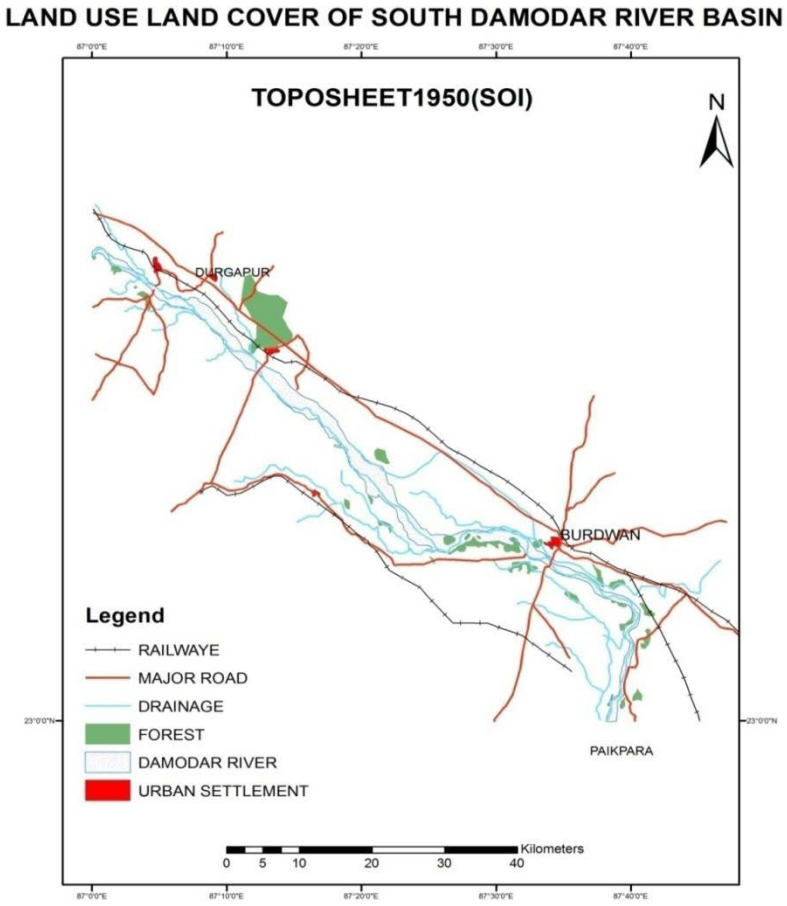


**Figure 9.** Land Use Land cover map of lower Damodar River & surrounding

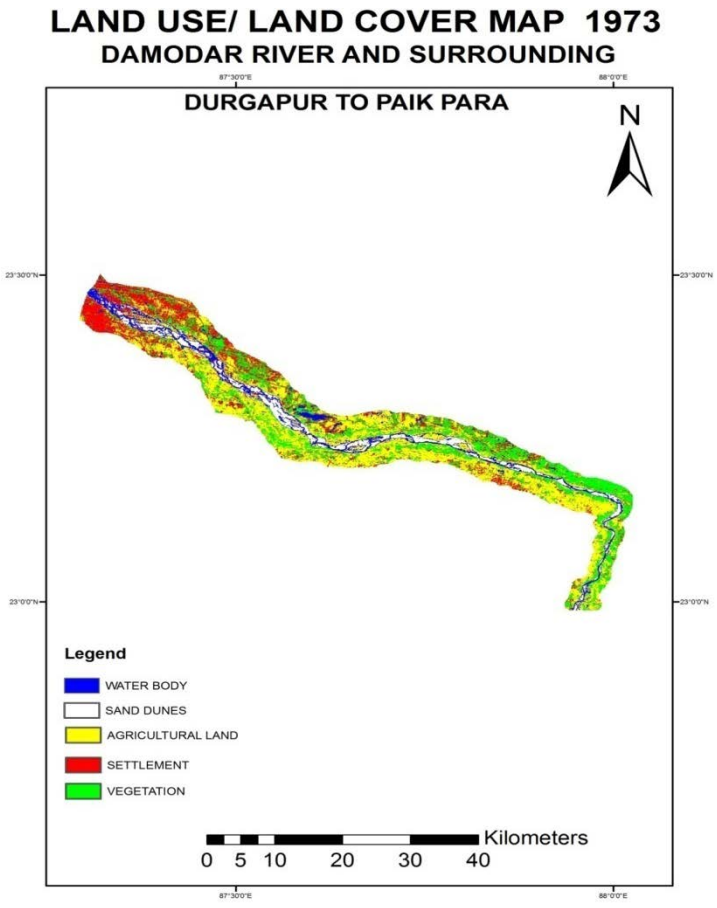


**Figure 10.** Land use land cover map 1973 (Durgapur to Paikpara)

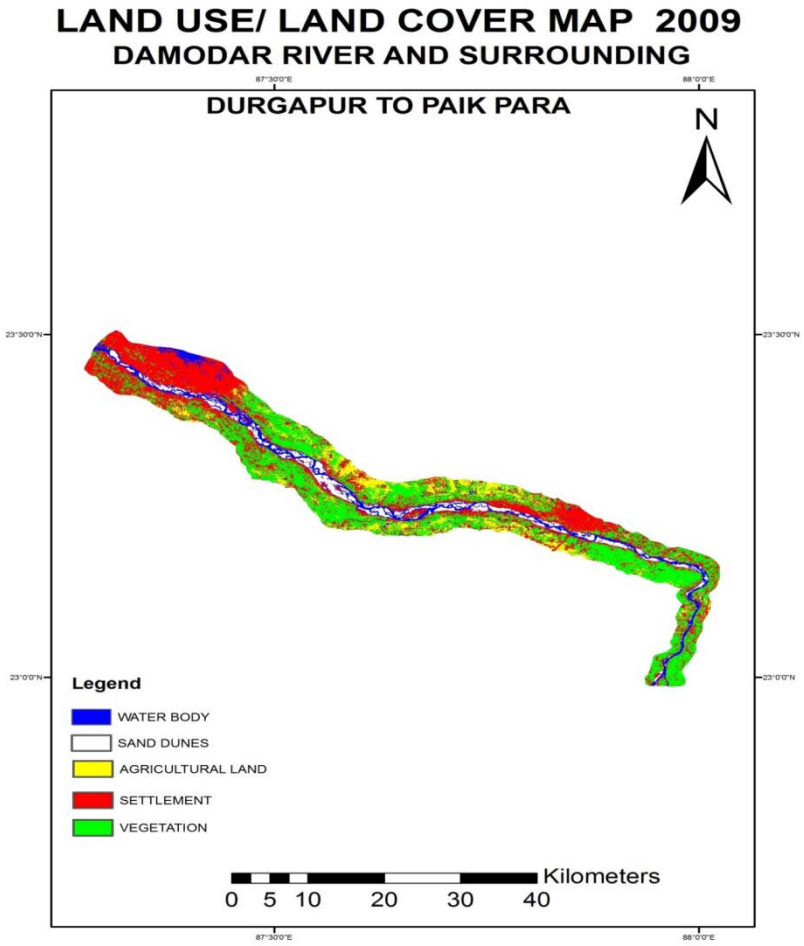


**Figure 11.** Land use land cover map 2009(Durgapur to Paikpara)

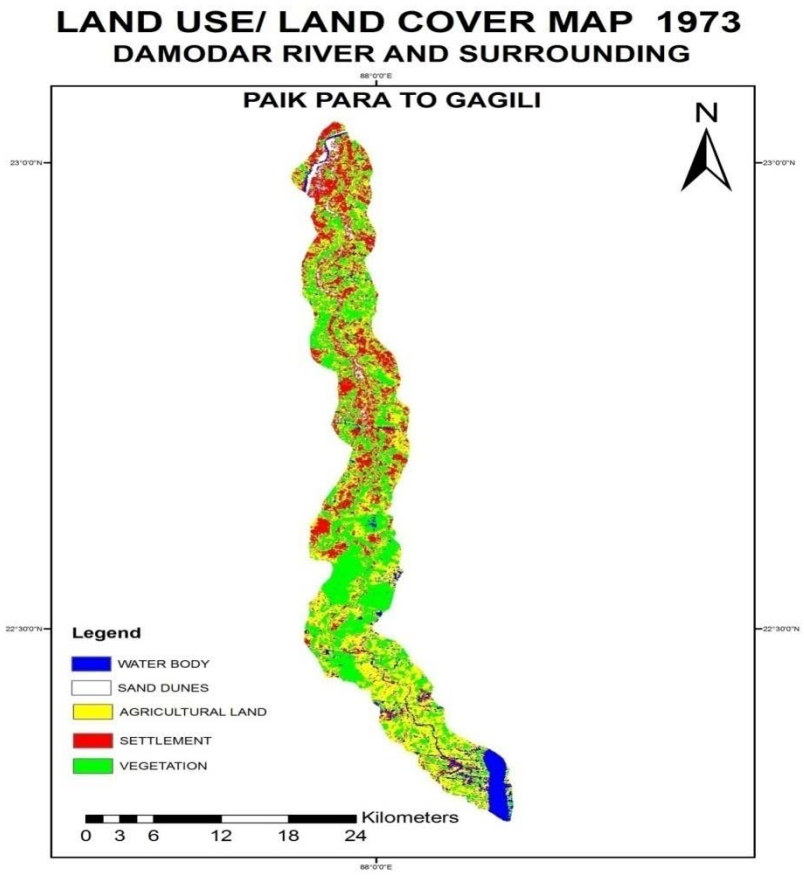


**Figure 12.** Land use Land Cover Map 1973 (Paikpara to Gagoli)

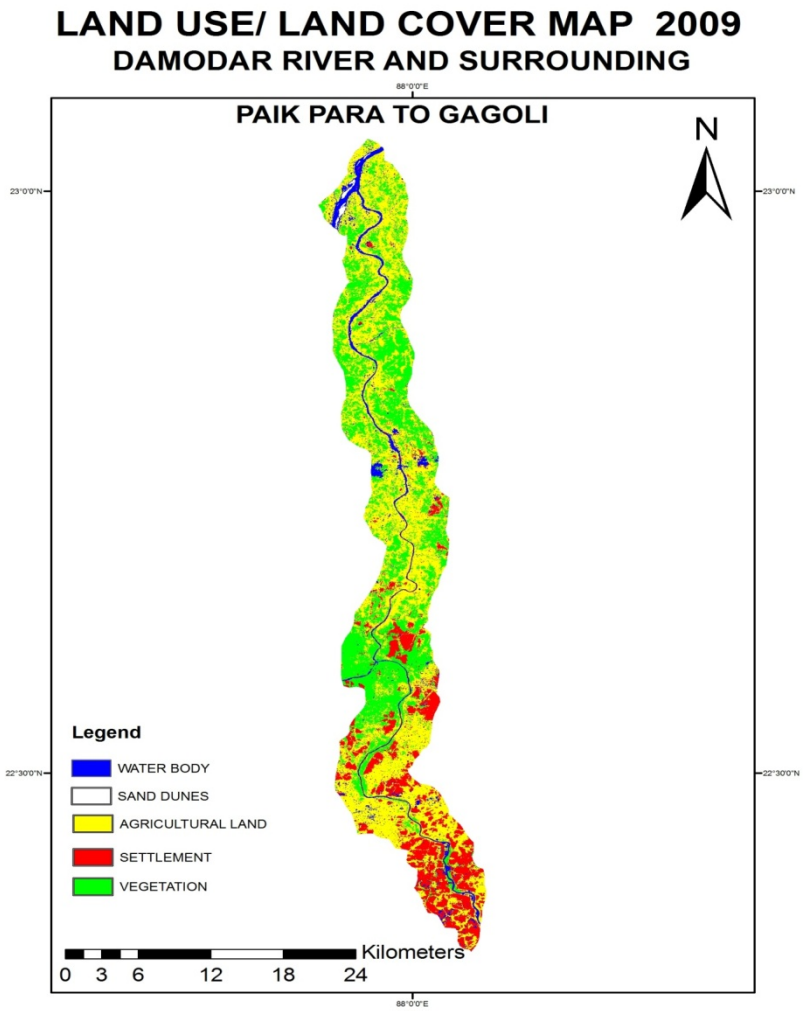


**Figure 13.** Land use land Cover Map 2009 (Paikpara to Gagoli)

## LAND USE CLASSIFICATION 1973
## DURGAPUR TO PAIKPARA

**Table 2. Land Use Classification 1973( Durgapur to Paikpara)**

| CLASSES | NO OF PIXEL | AREA IN HECTARES |
|---|---|---|
| SAND DUNES | 17505 | 5687.3745 |
| AGRICULTURAL LAND | 84215 | 27361.4535 |
| WATER BODY | 23263 | 7558.1487 |
| SETTLEMENT | 44483 | 14452.5267 |
| VEGETATION | 58033 | 18854.9217 |
| TOTAL | 227499 | 73914.4251 |

## LAND USE CLASSIFICATION 1973
## PAIKPARA TO GAGOLI

**Table 3. Land use classification 1973(paikpara to Gagoli)**

| CLASSES | NO OF PIXEL | AREA IN HECTARES |
|---|---|---|
| WATER BODY | 11214 | 3643.4286 |
| SAND DUNES | 3916 | 1272.3084 |
| AGRICULTURAL LAND | 54337 | 17654.0913 |
| SETTLEMENT | 27119 | 8810.9631 |
| VEGETATION | 44836 | 14567.2164 |
| TOTAL | 141422 | 45948.0078 |

**LAND USE CLASSIFICATION 2009**
**DURGAPUR TO PAIKPARA**

**Table 4. land use classification 2009(Durgapur to Paikpara)**

| CLASSES | NO OF PIXEL | AREA IN HECTARES |
|---|---|---|
| **SAND DUNES** | 54154 | 4873.86 |
| **SETTLEMENT** | 297244 | 26751.96 |
| **AGRICULTURE** | 84443 | 7599.87 |
| **VEGETATION** | 308829 | 27794.61 |
| **WATER BODY** | 83545 | 7519.05 |
| **TOTAL** | 828215 | 74539.35 |

**LAND USE CLASSIFICATION 2009**
**PAIKPARA TO JAGOLI**

**Table 5. land use classification 2009 (Paikpara to Gagoli)**

| CLASSES | NO OF PIXEL | AREA IN HECTARES |
|---|---|---|
| **AGRICULTURE** | 229021 | 20611.89 |
| **SAND DUNES** | 1185 | 106.65 |
| **WATERBODY** | 28266 | 2543.94 |
| **SETTLEMENT** | 64657 | 5819.13 |
| **VEGETATIONM** | 139932 | 12593.88 |
| **TOTAL** | 463061 | 41675.49 |

**Changing dictation of area between 1973 to 2009**
**Changes are shown Paikpara to Gagoli**

**Table 6. Changes shown Paikpara to Gagoli**

| CLASSES | Area 1973 | Area 2009 | Changes | Change rates |
|---|---|---|---|---|
| **AGRICULTURE** | 3643.42 | 20611.89 | 4.26 | -.52 |
| **SAND DUNES** | 1272.30 | 106.65 | 3.52 | +.05 |
| **WATER BODY** | 17654.09 | 2543.94 | 4.02 | -2.2 |
| **SETTLEMENT** | 8810.96 | 9819.13 | 3.58 | 1.2 |
| **VEGETATION** | 14567.21 | 12593.88 | 4.68 | -1.5 |
| **TOTAL** | **45948.00** | **41675.49** | **3.88** | |

**Changing dictation of area between 1973 to 2009**
**Changes are shown Durgapur to Paikpara**

**Table 7. Changes shown Durgapur to Paikpara**

| Classes | Area 1973 | Area 2009 | Changes | Change rate |
|---|---|---|---|---|
| **AGRICULTURE** | 5687.3745 | 4873.86 | 3.7 | -.45 |
| **SAND DUNES** | 27361.4535 | 26751.96 | 4.8 | -.18 |
| **WATER BODY** | 7558.1487 | 7599.87 | 2.5 | +.04 |
| **SETTLEMENT** | 14452.5267 | 27794.61 | 2.8 | +3.5 |
| **VEGETATION** | 18854.9217 | 7519.05 | 4.1 | -.3.1 |
| **TOTAL** | 73914.4251 | 74539.35 | | |

## 2.8. Changes of Land Use and Land Cover

To indicate the changes during the two periods we are used supervised classification of Damodar River and its surrounding. And it's shown that in between this two period the settlement are increased rapidly. And the vegetation cover area is destroying same speed. But in these changes there is no directly impact of changing river course.

But some small scale changes are seeing in the image in agricultural, and vegetation covered area which is directly affected by changing river course of Damodar River.

## 3. Conclusion

The studies identified that the studied Damodar river segment from upstream of Durgapur to Gagoli has not significantly migrated during 1950 and 2009. However, small changes can be observed in river bends in few locations. Islet formation is another change identified within the river. However, in Majer char, Natun Pally area, when the river channel is braided, one part of the river has been converted to a built up area through encroachments towards the immediate floodplain. This is a significant identification of this study. Land uses of adjacent riparian areas have changes considerably. Conversion from home gardens to residential/ built up area can pose a considerable impact to the river ecosystem due to discharge of waste, destruction of riparian areas, etc. It is recommended to improve the analysis by incorporating assessment of riverine ecosystems and also by including data long before construction of the Damodar reservoir to identify the situation before the impoundment of reservoir. Contemporary changes of the course after 1950 as derived from the maps, satellite data, have been confined to the recent flood plain, most of which occupied the channels of the prior courses.

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