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Channel Deranging and its Impact: A Study on Mayurakshi-Kuya Interfluve, Santal Pargana and Birbhum Districts, Jharkhand and West Bengal

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Abstract: *The causative factors of channel deranging, its impact on hydro-morphological characteristics, flood and land use modification have been analysed in this study. Two major bifurcated channels on the right bank of the Mayurakshi river are the major focus of the paper. Widening of the Kuya river after receiving the waters of the bifurcated channels, thinning of the master stream of Mayurakshi after bifurcation and formation of misfit channels are some of the hydro-morphological impacts of deranging. Formation of new channels or decaying of old channels also has direct link with changing nature of flood as well as cropping pattern over the Mayurakshi-Kuya interfluve area.*

Introduction

Channel deranging means unsystematic creation of new channels or loss of existing channels and the resultant modification of the expected drainage pattern. Deranging of channels is very common over the lower reach of the basins when the stream attains minimum velocity and the interfluve is not very prominent (Bloom, 1979; Morisawa, 1985; Richards, 1987). Stream bifurcation and subsequent meeting have significant impact not only on channel morphology but also on riverine land use. Less attention has been paid to investigate the nature of channel spilling and its influence on the water flow and sediment transport. Micro level study on the process of channel bifurcation is vital for the preparation of flood management models (Richard, 2001). Bifurcations and re-linking of channels are the two major components of the channel deranging process. The paper aims to analyse the phases of river deranging over the study area. On the basis of this analysis, the future trend of channel derangement can be predicted.

Study area

Mayurakshi flows over the Jharkhand plateau and Bengal Basin and is one of the well known rivers of India. It emerges from Trikut Hill of Jharkhand (10 km south of Deoghar in Santhal Pargana district) at an elevation of 400 m and flows down along a 380 km long course, covering a large part of eastern India. Massanjore dam and Tilpara barrage were constructed on this river in 1956 and 1971 respectively. The presence of these structures has complicated the channel morphological character (Mukhopadhyay and Pal, 2009).

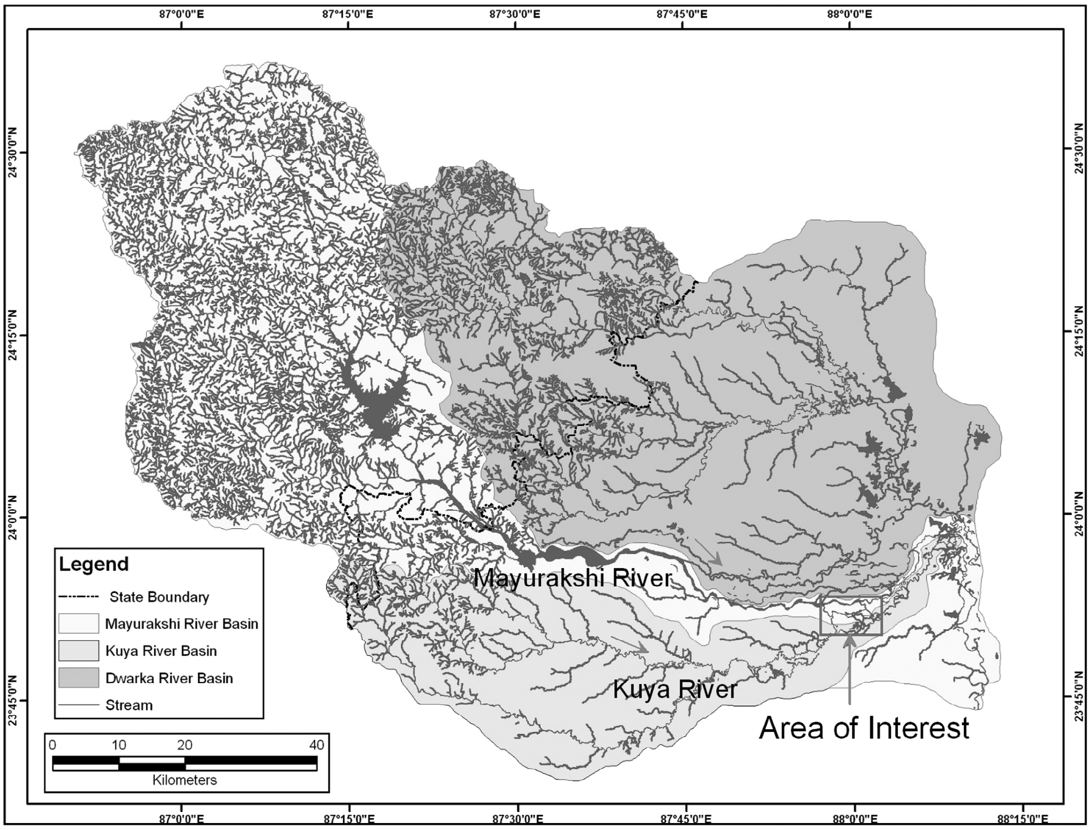

Figure 1. The Study Area — a part of the Mayurakshi river basin

Total area of this river basin is 6,400 km^2 including three main sub-basins viz. Mayurakshi, Dwarka and Kuya. The Kultore barrage on Kuya river also controls the up– and downstream morphological conditions of this river. The study area is located on Mayurakshi-Kuya interfluve between 23°40' N to 24°34' N and 86°58' E to 88°10' E.

In the downstream reach of the Mayurakshi-Kuya interfluve, inter-channel space is extremely small and the relief is so subdued that the tributaries of one basin merge with that of the other without considering the individual sub basins. So, channel diversion and shifting, human induced channel piracy and massive sand deposition on river bed become major geomorphic features of this area. Field observation has revealed that, at present the changing of courses over the present interfluve region are occurring at an accelerated rate.

Materials and methods

Survey of India topographical sheet of 1916-17, 1968-69, satellite image of 2009 (IRS 1C LISS 3), and field survey have been used to analyse the temporal changes in channel morphology and planform. The perception of the people dwelling near the river bank was used wherever necessary. ArcGIS and Surfer software have been used to present data in required form.

Channel width, velocity and sedimentation related data have been collected from field measurement along the channels at different reaches of the basin. Location of the sites has been recorded with the help of GPS and the cross sectional measurements have been done by Dumpy Level. Lithological data have been

Table 1. Lithological character at Sundarpur and Guddapara (source: tubewell log data)

	Litho-log at Sundarpur (near 1st bifurcation point: Fig. 2)			Lithological Character at Guddapara (near 2nd bifurcation point: Fig. 2)	
Depth in m	Characteristics	Moisture content	Depth in m	Characteristics	Moisture content
0–1.3	Sandy clay	Low moisture	0–1.15	Sandy clay	Low
1.3 – 3.5	Fine sand mixed with silt	Seasonally medium	1.15 – 3.1	Fine sand mixed with silt and clay	High
3.5 – 7	Fine to medium sand	Seasonally high	3.1 – 6.2	Fine to medium sand with blackish hue, high content of mica	Medium
7 – 11.5 m	Medium sand with some thin clay layers	Mostly saturated (major aquifer layer)	6.2 – 12.3	Medium sand with some thin clay layers	Mostly saturated (major aquifer layer)
11.5 – 16.5	Coarse sand with hard, thin rock layer	Saturated (major aquifer layer)	12.3 – 17.4	Coarse sand with hard, thin rock layer; whitish hue	Saturated (major aquifer layer)
16.5 – 20	Hard clay	Insignificant	17.4 – 20.7	Blackish sticky soil	Insignificant

collected by shallow drilling method and the collected sediment samples were analysed to determine the textural variation with respect to depth and moisture content. Information regarding agricultural pattern and flood character was collected from the official records of the panchayat, village level land use survey and community discussions.

Results and discussion

Causes of bifurcation

Massive sand deposition within channel decreases the carrying capacity of an overloaded river. The ratio between sand deposited area and active channel area of the lower stretch of Mayurakshi is 2:3, as detected from the field measurement of 30 sites along the channel. It means 40% of the channel area is occupied by thick sand deposition. In this situation high discharge may be one of the causes to enforce the main channel to bifurcate.

The two major bifurcations, from the main channel of Mayurakshi can also be interpreted in the light of regional geological and topographical factors. Litholog information of sediment composition of the two major off-take points (Sundarpur and Guddapara) reveals that at both locations the sediment character is very fragile. Litholog data have been collected up to the depth of 20 m and 20.7 m at Sundarpur and Guddapara respectively (Table 1). In both the cases, except for the topmost layers, sandy soils are predominant. In order to accommodate the massive discharge during the monsoons, new courses are formed over this sandy region, following the slope of the land. Moreover the regional slope is toward the right in Mayurakshi river basin in general and in the study area in particular (Pal, 2012a). The lengths of the three bifurcated channels on the left bank of Mayurakshi are therefore short. According to the lithologs, the layers of clay or silt, with less proportion of sand is predominant up to 5 m depth in most part of the left bank (Table 1). It offers greater resistance against channel bifurcations. Moreover, relatively elevated left bank of the main river also hinders the formation of new courses along the northern sector of the basin.

Phases of drainage derangement

Prior to 1916

In this phase, two major bifurcated channels can be observed along the right bank of

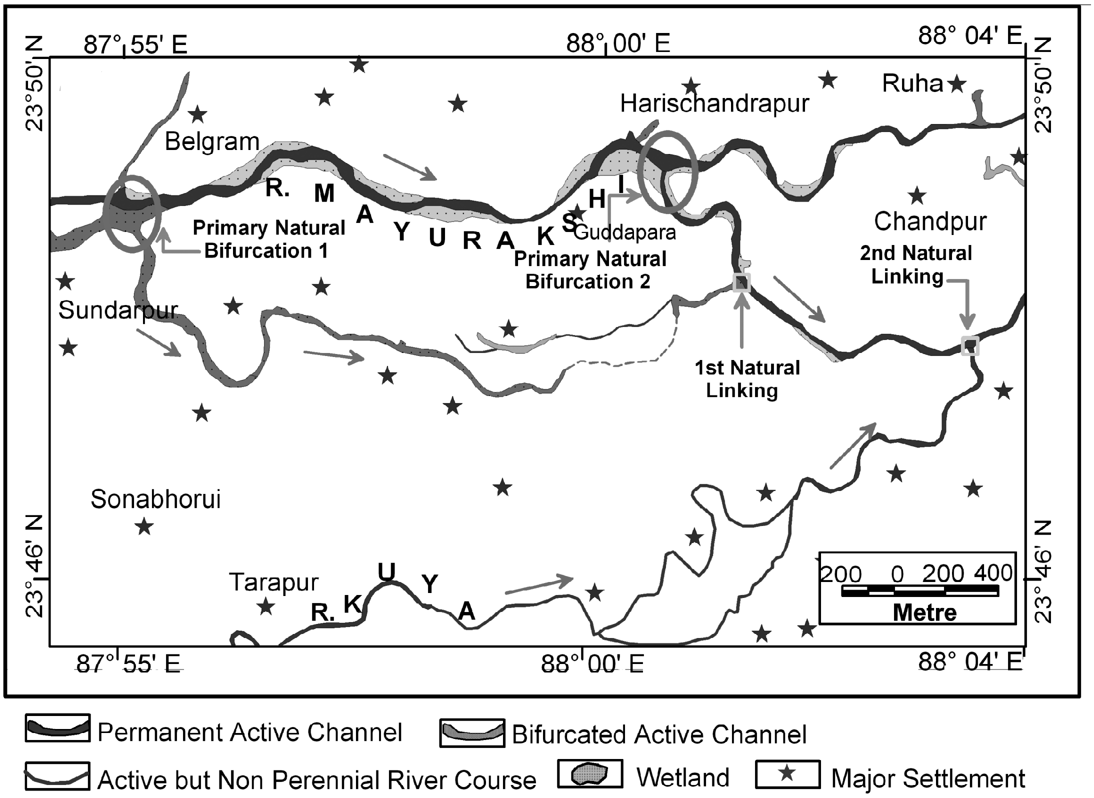

Figure 2. Channel deranging in parts of Mayurakshi-Kuya interfluve: 1916-17

Mayurakshi river — bifurcation 1 at Sundarpur (opposite to Belgram) and bifurcation 2 at Harischandrapur which is about 3.5 km downstream of Belgram (Fig. 2). Previously the first bifurcated channel had a link with the second bifurcated channel which is referred in the map as '1st natural linking'. Presence of linear wetlands between the main course of Mayurakshi and the first bifurcated channel are the evidences of old channel course. The first bifurcated channel is seasonal and is formed only with the spilled water of Mayurakshi during monsoon. The second bifurcated channel has joined Kuya river which is one of the major right bank tributaries of Mayurakshi river and subsequently this channel has widened its valley.

On the left bank of Mayurakshi river, three small bifurcations are noticed near the villages of Belgram, Harischandrapur and Ruha (Fig. 2). These bifurcations are formed during the monsoonal peak discharge of Mayurakshi river.

Between 1917-1968

SoI topographical sheet of 1917 and 1968 have been used for detecting the channel courses and the derangement pattern for the period 1917 to 1968.

Over time, the first and second bifurcated channels have increased their discharges, erosive powers and carrying capacities. Another bifurcation has occurred from the apex of a large bend of the first primary bifurcated channel, which is referred to as 'secondary natural bifurcation 1' (Fig. 3). Regional slope character of this region is one of the decisive factors for such secondary bifurcations. Moreover, within 1 km southwards from the former off take point, another bifurcation —'secondary natural bifurcation 2' has formed. Among these two channels, one flows towards south and another flows towards southeast.

The channel flowing southeast again forms a minor bifurcation, with one component flowing southward to get linked with the Kuya river as '3rd natural linking' and at the end of the eastward flow the Maldah *beel* (wetland) has formed as a result of accumulation of water over the depressed land. The expansion and depth of this wetland is controlled by the volume of discharge carried by this channel. Initially this region was a depressed land and monsoon water accumulated here, but after the formation of the 3rd natural linking it became a prominent wetland. Figure 5 indicates the seasonal flow character of these channels.

The south flowing channel from the 'secondary natural bifurcation 2' merged with the Kuya river during this period, as the '4th natural linking' near Tarapur just 300 m upstream of the '3rd natural linking' point (Fig. 3).

Gradual drying up of the 3rd natural link channel and the wetland link-channel may be the cause of the formation for the new 4th natural link. The flow of Kuya river downwards of this new link point becomes perennial with the direct flow from Mayurakshi (Fig 3). Towards the east, the remnant of the 1st natural linking has remained as an elongated palaeochannel.

Between 1968 and 2009

After the construction of Massanjore dam (1956) and Tilpara barrage (1971) over the Mayurakshi river, frequent flooding has become a familiar character of this river (Mukhopadhyay and Pal, 2009; Pal, 2012b).

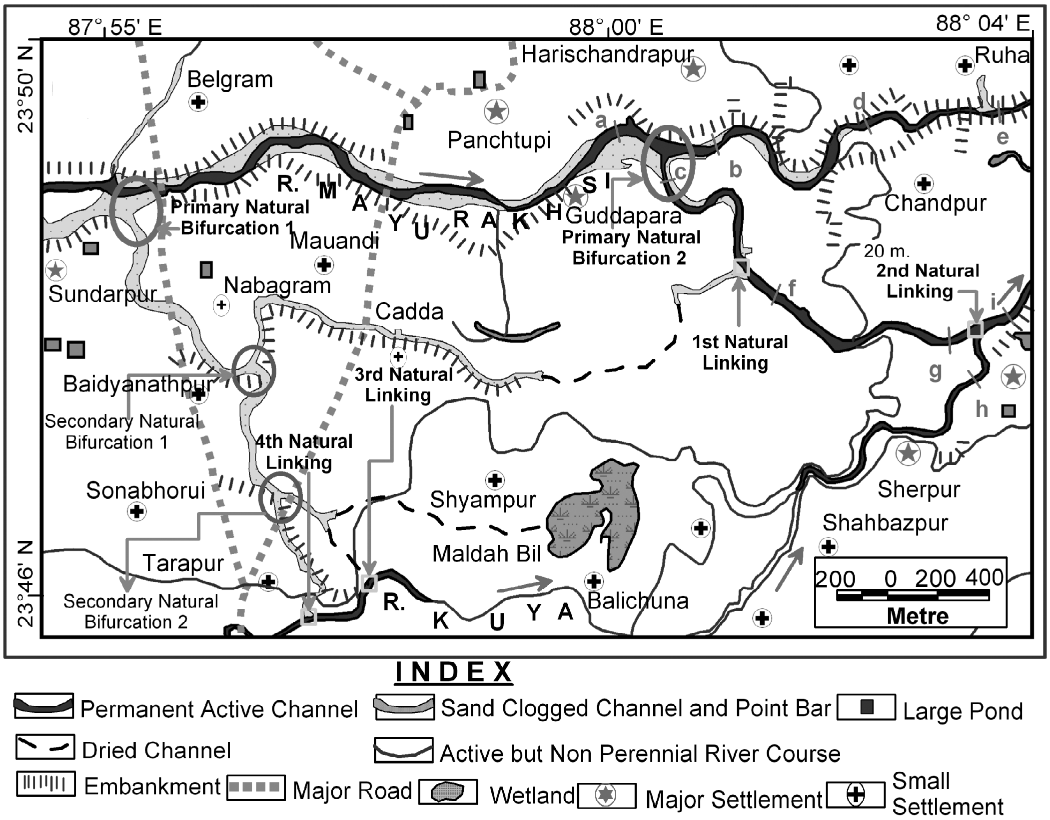

Figure 3. Channel deranging in parts of Mayurakshi-Kuya interfluve: 1968-69

The States Department of Irrigation and Waterways has constructed embankments along two sides of this river for protecting the adjoining land from flood (Fig. 3). Field measurements at 35 sites of lower Mayurakshi river have revealed the fact that average sand deposition rate in the channel is about 0.52 m during the last 25 years. Embanking of the river has hastened the sand deposition rate within the channel. During peak monsoon, huge volume of discharge from the 1st bifurcated channel inundated the surrounding area and it caused colossal failure in crop production.

An embankment was constructed in 1995, by blocking the source point of the 1st bifurcated channel, on the basis of local demand, without any proper investigation of the hydrological character of the concerned channels. As a result, this bifurcated channel started to dry up and thereafter the farmers started agricultural practices on this dried channel bed. At the initial phase the channel was used to store some water during monsoon period.

Due to drying up of the secondary natural bifurcation 2, Maldah wetland began to diminish in size. Simultaneously, people occupied the exposed land surrounding the wetland and used it as agricultural land. The 3rd natural link-channel and wetland link-channel almost lost their topographical expressions and its previous course is indicated by fragmented linear wetlands. Due to the drying up of the 1st bifurcated channel, the discharge has increased in the 2nd bifurcated channel.

2009 Scenario

As per IRS LISS 3 image of 2009, the 1st bifurcated channel has almost lost its existence (Fig. 4). During field survey in 2012, it was found that this river course was being used as agricultural land. Signatures of its previous existence can be detected by some linear wetlands and series of ponds along its palaeocourse. The soil profile analysis of the four sites along this old course has proved the existence of the channel. In all the cases, it is noticed that only up to 15 to 25 cm from ground surface, fertile silty soil is present and just below this layer sand layers of different characters with slight mixture of silt or clay are found. Moreover, during extreme summer, high soil moisture content at different depths indicates that this abandoned course used to store substantial amount of water. Soil moisture content at 12 cm depth is 18 to 23%, but it is less than 13% in the surrounding regions in the same period of time. Productivity level of paddy during monsoon in this abandoned course is not much, but it yields a good amount of potato. Due to loss of this channel, Maldah wetland has faced severe water crisis and it is almost at the verge of total degeneration.

The 2nd bifurcated channel over time has gained more strength because substantial amount of water is flowing through this channel. It should also be mentioned that gradual accumulation of sand deposition within this channel may again lead to generation of some new secondary bifurcation from the 2nd bifurcated channel or new primary bifurcation from the main channel to accommodate the increased discharge.

It is noticed that the off-take point of the 2nd bifurcated channel is advancing eastward and another new off-take has developed within 200 m downstream from the previous point. It is expected that the flow will eventually merge with the existing 2nd bifurcated channel in future, perhaps at a downstream location (Fig 4).

Hydromorphological modifications

The hydromorphological character of the Mayurakshi and Kuya rivers has been modified due to the derangement of channels. The width of the main Mayurakshi river is 424.9 m at site **a** (Fig. 3), upstream of the off-take point of the 2nd bifurcated channel, but it is only

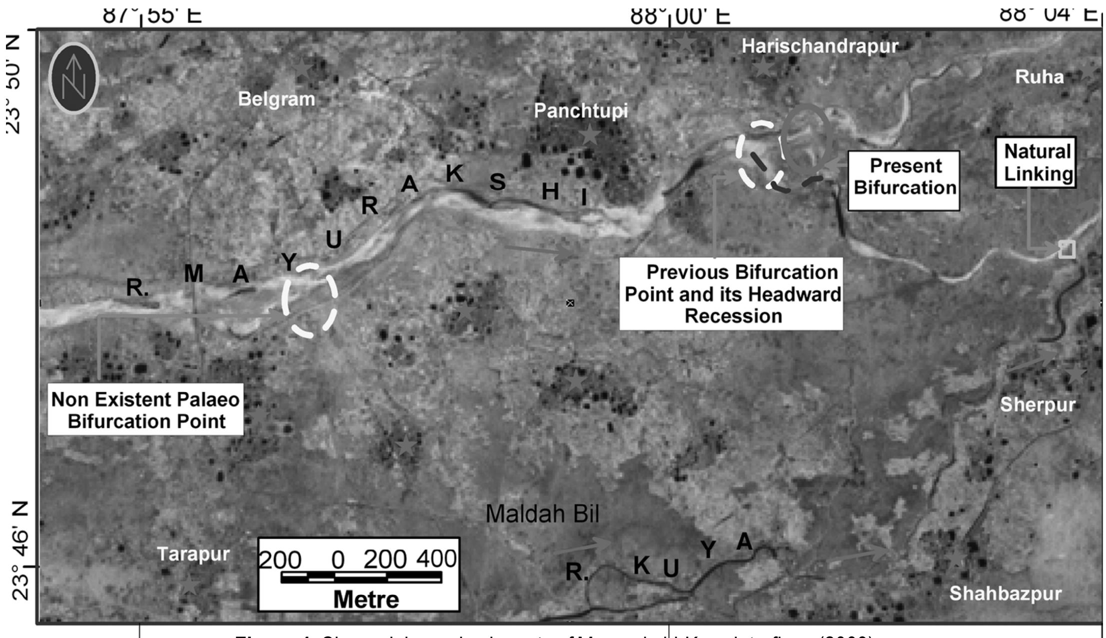

Figure 4. Channel deranging in parts of Mayurakshi-Kuya interfluve (2009)

162 m after bifurcation at site **b**. This drastic decline of width due to channel bifurcation and other associated causes may be termed as *channel leaning* or *channel weakening* or *channel thinning* (Leopold and Maddock, 1953; Richards, 2001). Fig 5a and Fig 5b show the channel cross sectional profiles of these two sites.

Such type of width-depth variation is also noticed over Kuya river at site **h**, before its

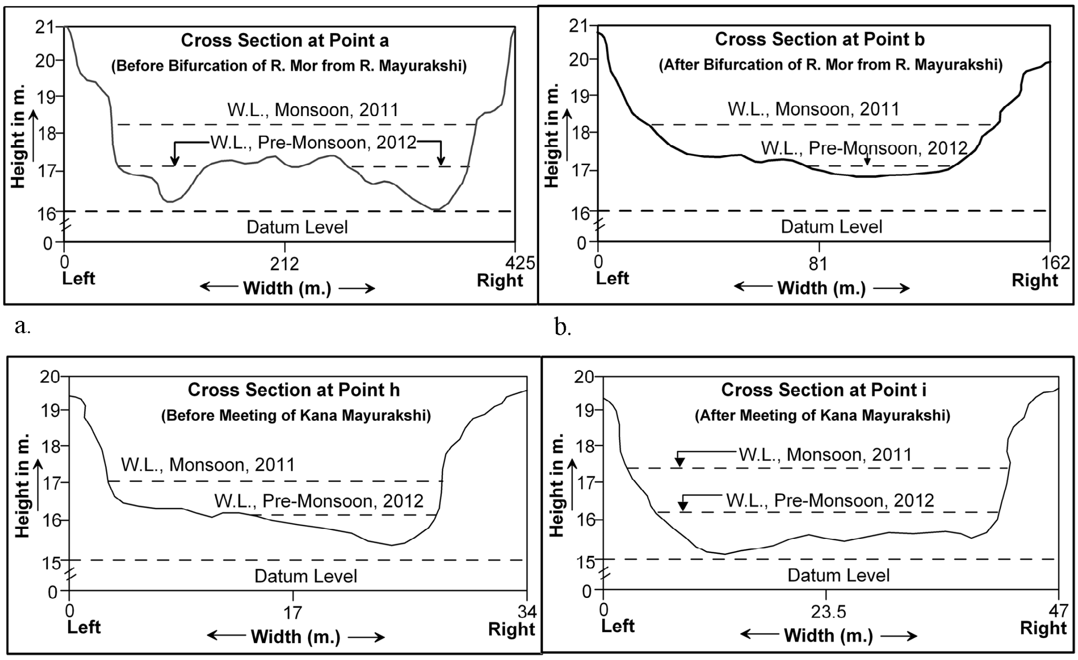

Figure 5. Cross sectional characteristics at locations a, b, h and i, as shown in Fig. 3

confluence with the 2nd bifurcated channel and at site **i** after the confluence point (Fig. 3, 5c and 5d). In this case, the widening of the channel can be attributed to the changing hydro morphological parameters and this condition can also be termed as channel fattening or channel thickening (Dury, 1964; Richards, 2001). As huge amount of sediment and water is draining into the Kuya river from Mayurakshi, the overall character of both the 'donor' and 'receiver' rivers have changed in recognisable dimensions.

The concept of misfit river is basically applied to describe disproportional width-depth condition, valley width and channel width condition, width-depth and discharge ratio of the river (Leopold and Maddock, 1953; Dury, 1958; Keller, 1975). The width of the river may be modified disproportionately in comparison to the width of the existing upstream reaches, and then the river can be termed as quasi misfit river. In the present study area, due to channel bifurcation, width of the master stream (Mayurakshi) has drastically reduced downstream of channel bifurcation and width of the receiver stream (Kuya) has increased downstream after the linking with bifurcated stream (Mor) from Mayurakshi river. These altered forms of both Mayurakshi and Kuya may be referred to as quasi misfit stream.

Table 2. Width of channels and measurement of sand bars at selected sites (see Fig. 3 for site locations)

Site	Channel width (m)	Sand bar coverage (%)
Before 2nd bifurcation at Mayurakshi river (a)	425	46%
2nd bifurcated channel (c)	38	—
After bifurcation (b)	162	57%
2nd bifurcated channel before meeting with Kuya (g)	52	—
At Kuya before in fluxing of 2nd bifurcated channel (h)	34	43%
At Kuya river after mixing with 2nd bifurcated channel (i)	47	—

Flood modification

The main aim of the closing of the off-take point of bifurcated channel was to protect the interfluve from flood. But it should be mentioned that this deliberate closing is not an absolute step to abate flood conditions. The closing of one off-take source may force to form several other sources downstream for diverting its discharges. So here the flood situation is modified only by shifting the place of flood occurrence from one area to another. During monsoon period there is a tendency of water to stagnate in the detached courses of old channels, which has increased the flood water stagnation period over this interfluve. Moreover the embankment restricts the flow of water from the interfluve towards the main river channel, which has also increased the spatial extension of flooded area.

Impact on Agriculture

Some of the notable changes in agricultural pattern noticed due to the derangement of the channels are as follows: (1) Agricultural practices have flourished within and astride the decayed channels which has increased the extent of *aman* paddy command area, from 76% to 91% of the cultivable land. (2) Area of *boro* paddy cultivation has reduced due to inadequate supply of water from the old bifurcated channels. Though the dependency on river water irrigation has reduced but it is replaced by ground water irrigation for supporting *boro* cultivation. (3) Non availability of water supply from the decayed river has encouraged people to diversify their cropping practices and the cropping intensity has also increased from 133% to 144% by applying the modern agricultural methods.

Conclusion

Channel derangement, especially over the gently sloping land, is a natural process of extension of the drainage network. These new channels are mostly formed for carrying the spilled water from the main rivers during rainy season. The connecting route of the bifurcations and linkage points can act as the flood flow corridor. However, in many cases embankments are constructed as flood abatement measures which block the diversion channels from the main rivers. People lose faith on such structural attempts and agricultural extension is carried out depending on the excessive use of ground water. But the recharging of ground water is being retarded due to lack of seepage water from the nearby deranged channels.

It is suggested that micro level study on the process of channel derangement is necessary for delineating the future trend of channel bifurcation and linkage. This study may support decision making regarding agricultural planning, settlement relocation etc. Reclamation of the old channels with participation of local people may be useful for en-routing the flood water which will ultimately reduce the spatial extension of flood affected area.

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