REMOTE SENSING BASED ANALYSIS OF CRITICAL BENDS OF KUSHIYARA RIVER IN BANGLADESH

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ABSTRACT:
Streams are continually changing position as a consequence of hydraulic forces acting on their beds and banks. This stress is mainly a result of climatic changes from year to year in the amount of water flow variation that occurs in the stream (*Matsuda, 2004*). The present study has been conducted to scrutinize the meandering parameters at critical bends of Kushiyara River using Remote sensing technology and Geographic information system. The name Kushiyara River used here to represent the river reach from India border, Zokigonj to the confluence with Kalni River. The width of the Kushiyara River changes over time. Eight critical bends have been selected over different places which are changing with the time. The Sinuosity of the river also varies from 1.11 to 2.24. The minimum width as found was 96.12m near Fertilizer industry; Fenchugonj (chainage 90.1 km) in 1997, the maximum width was 272.9m at Ranigonj union, Sunamgonj (chainage 156.5 km) in 2006. The study shows that the meandering ratio varies from 0.32 to 1.23.Wavelength of the Kushiyara River vary from 1062.85m to 2240.57m. The river shows its characteristics relation between the radius of curvature and width.

Key-words: *River morphology, Bend migration, GIS, Remote Sensing, GPS, ArcGIS 9.2.*

1. INTRODUCTION

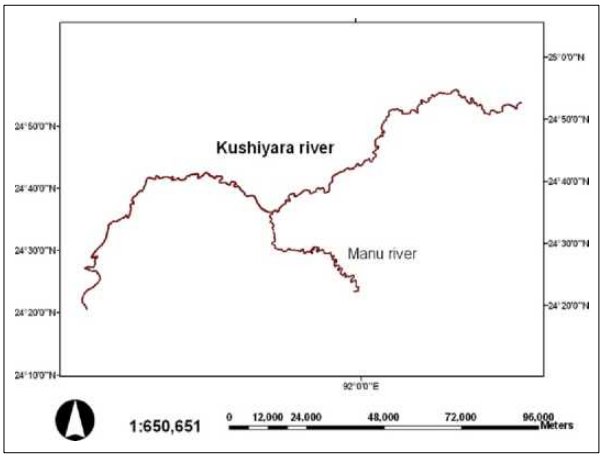

Fig. 1 Study area (Kushiyara River).

Start point	End point
24°52'39.178" N	24°20'31.249" N
92°30'23.841" E	91°9'53.712" E

The Kushiyara is one of the major rivers in North-Eastern Bangladesh and the study area consist a length of 236.4 km. Highest and lowest discharges have been measured at Sheola Point of the Kushiyara River are 2731 cumec and 47.1 cumec respectively (*Tajmunnahar, 2003*). It is an alluvial meandering river. Our study area in Kushiyara River represents the river reach from India border, Zokigonj to the confluence with Kalni River. For study, eight major meander points have been selected in this reach.

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2. MEANDER PARAMETERS

A meander in general is a bend in a sinuous watercourse (*Garg, 1991*). A meander is formed when the moving water in a stream erodes the outer banks and widens its valley. A stream of any volume may assume a meandering course, alternatively eroding sediments from the outside of a bend and depositing them on the inside. The result is a snaking pattern as the stream meanders back and forth across its down-valley axis. When a meander gets cut off from the main stream, an oxbow lake is formed. Over time meanders migrate downstream, sometimes in such a short time as to create civil engineering problems for local municipalities attempting to maintain stable roads and bridges.

The technical description of a meandering watercourse is termed meander geometry. It is characterized as an irregular waveform. Ideal waveforms, such as a sine wave, are one line thick, but in the case of a stream the width must be taken into consideration. The bankfull width is the distance across the bed at an average cross-section at the full-stream level, typically estimated by the line of lowest vegetation.

Meander Length (M_L): It is the axial length of one meander, i.e. the tangential distance between the corresponding points of a meander.

Meander Width (M_B): It is the distance between the outer edges of clockwise and anti-clockwise loops of a meander.

Meander Ratio: It is the ratio of meander width to meander length, i.e. M_B/M_L.

Sinuosity: It is the ratio of the length along the channel (i.e. actual length) to the direct axial length of the river.

Crossing or Cross-over: The short straight reaches of the river, connecting two consecutive clockwise and anti-clockwise loops are called crossing or cross-over.

Wavelength: At any cross-section the River/stream is following the sinuous axis, the centerline of the bed. Two consecutive crossing points of sinuous and down-valley axis define a meander loop. The meander is two consecutive loops pointing in opposite transverse directions. The distance of one meander along the down-valley axis is the meander length or wavelength.

Radius of curvature (R): In contrast to sine waves, the loops of a meandering stream are more nearly circular. The radius of the loop is considered to be the straight line perpendicular to the down-valley axis intersecting the sinuous axis at the apex.

3. DATA COLLECTION AND METHODOLOGY

3.1. Satellite image data

A sequence of satellite images for the Kushiyara Rivers has been collected. The original source of the images is Bangladesh Space Research and Remote Sensing Organization (SPARRSO). For this study, satellite images of 1997, 2006 & 2010 were collected directly from SPARRSO.The software ArcGIS 9.2 was used to investigate the images. First, the river area was demarcated from the images using ArcGIS 9.2. Location of the bend apex, actual length, axial or straight length, sinuosity, radius of curvature, meander ratio and river widths were calculated to analyze the bends (*Deb, 2012*). Types of migration (extention, expansion, rotation, translation and combination) were determined.

Fig. 2 Landsat image of Kushiyara River (1997).

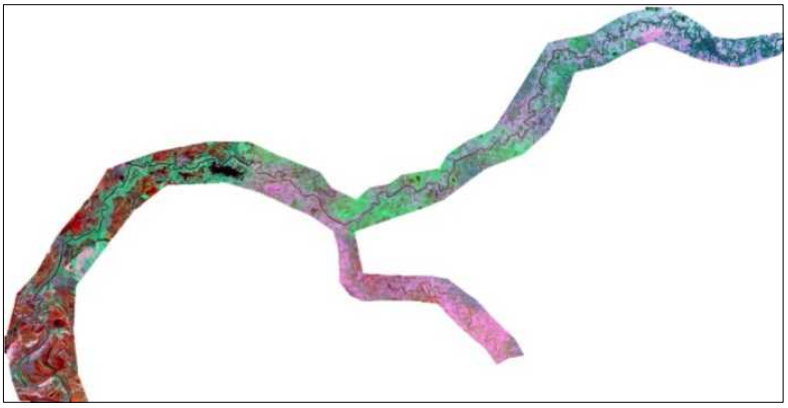

Fig. 3 Landsat image of Kushiyara River (2006).

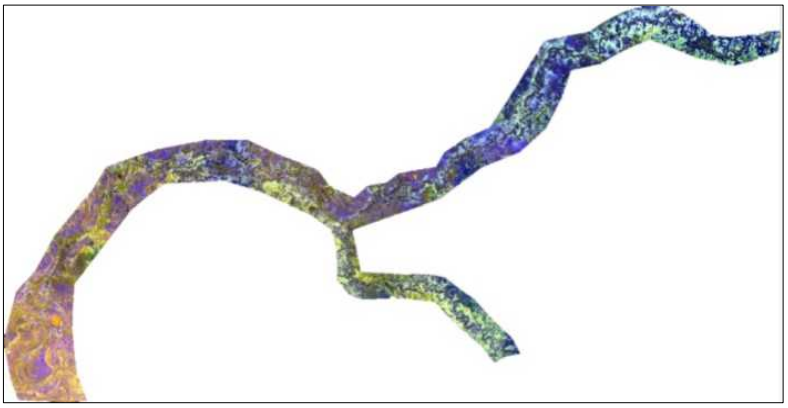

Fig. 4 Landsat image of Kushiyara River (2010).

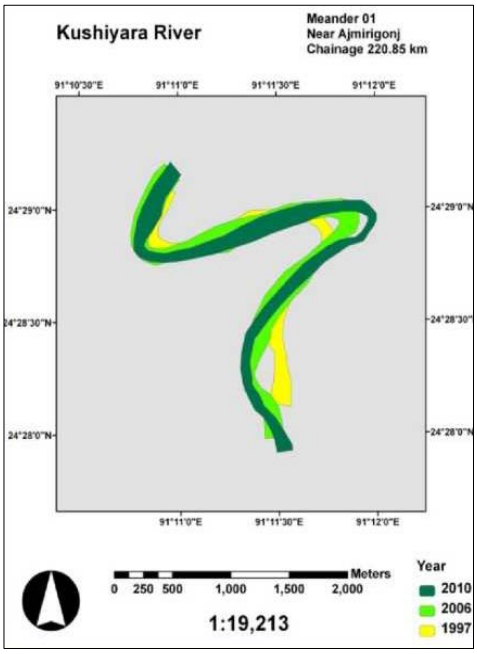

Fig. 5 Bend 01 at Ajmiriganj.

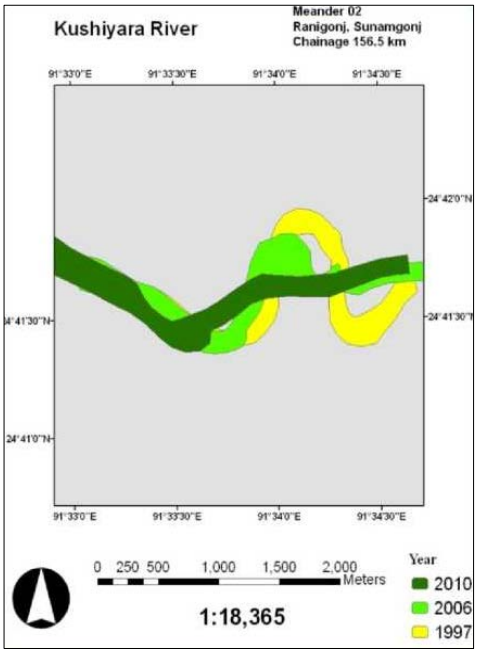

Fig. 6 Bend 02 at Sunamganj.

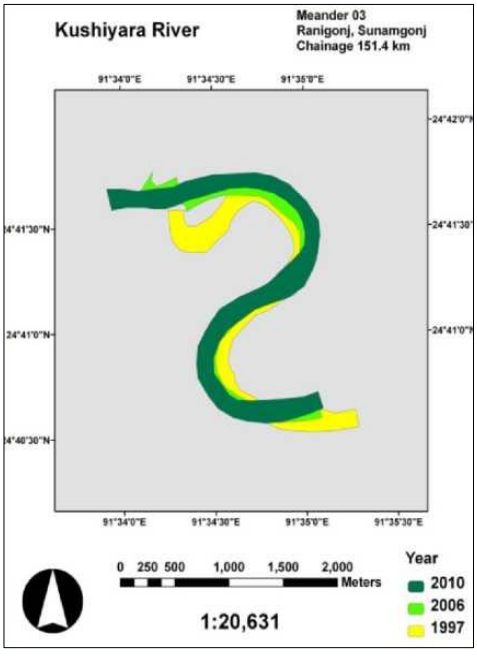

Fig. 7 Bend 03 at Sunamganj.

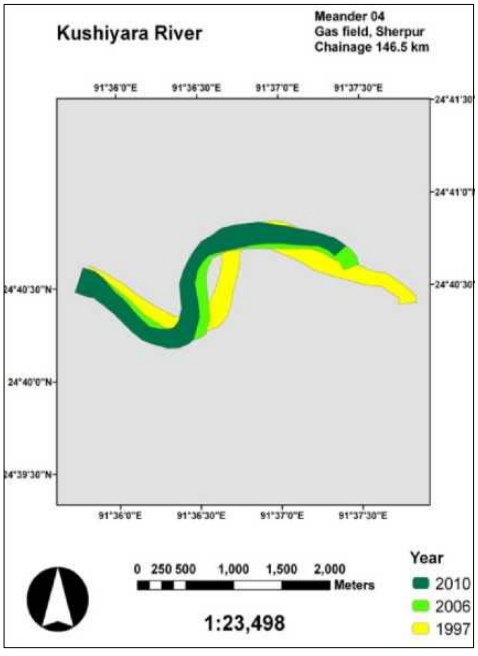

Fig. 8 Bend 04 at Sherpur.

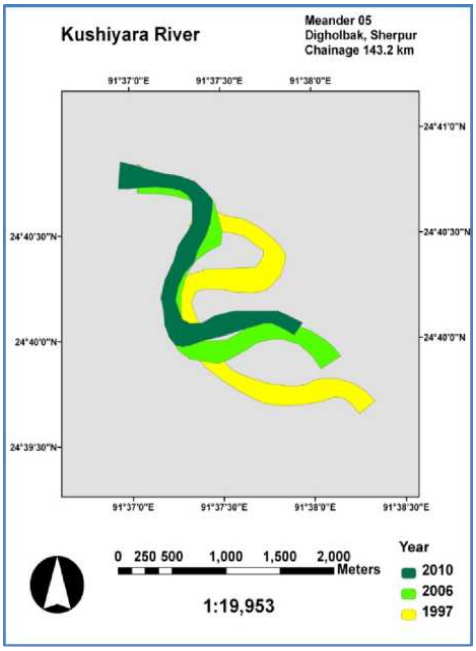

Fig. 9 Bend 05 at Sherpur.

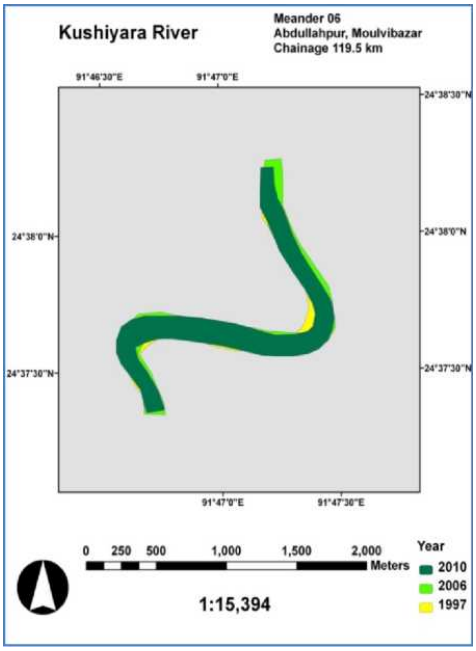

Fig. 10 Bend 06 at Moulvibazar.

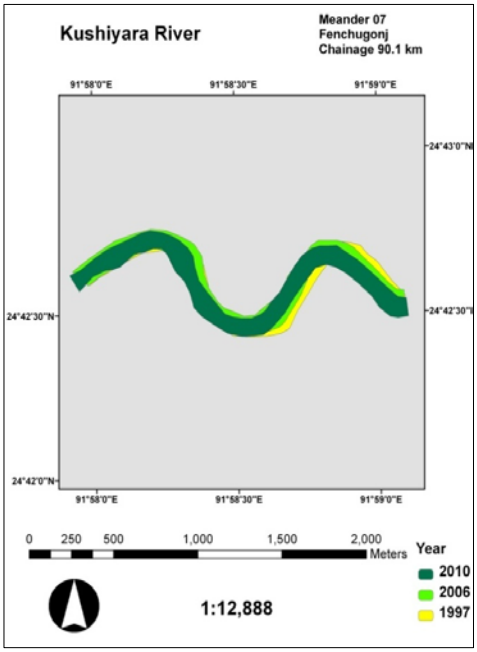

Fig. 11 Bend 07 at Fenchuganj.

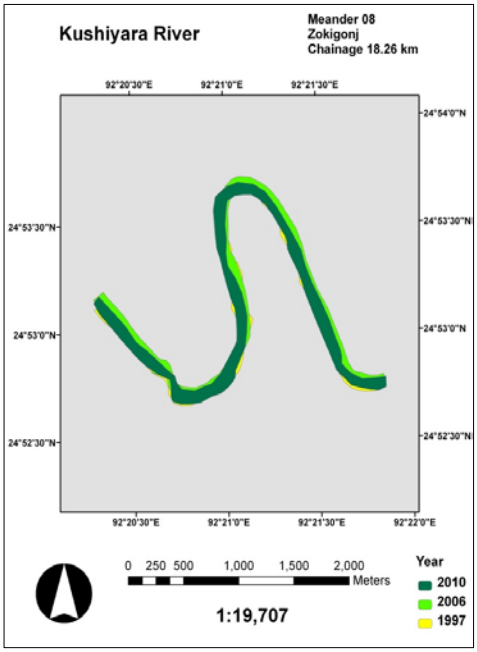

Fig. 12 Bend 08 at Zokiganj.

3.2. GPS data (field survey)

Field values were composed from two places (Sherpur and Fenchuganj) using GPS machine. The positions have been established to compare the field data with the satellite image. The width of the river in Sherpur and Fenchuganj found from the image of 2010 was 215m and 187m respectively. While, from ground survey on the same locations we have found the river width are 225m and 198m simultaneously.

Table 1. ***Kushiyara River in Sherpur.***

Point	Latitude	Longitude
1	24°37’37.5”	91°40’49.8”
2	24°37’42.8”	91°40’47.4”
3	24°37’46.1”	91°40’46.3”
4	24°37’52.1”	91°40’39.3”
5	24°37’01.9”	91°40’33.5”
6	24°37’08.2”	91°40’27.7”
7	24°37’59.7”	91°40’48.1”
8	24°37’56.8”	91°40’49.7”
9	24°37’49.7”	91°40’53.2”
10	24°37’54.3”	91°40’54.3”
11	24°37’44.1”	91°40’55.9”
12	24°37’38.2”	91°40’58.5”

Table 2. ***Kushiyara River in Fenchuganj.***

Point	Latitude	Longitude
1	24°41’53.4”	91°55’51.1”
2	24°41’55.7”	91°55’56.5”
3	24°41’59.6”	91°56’03.2”
4	24°42’02.8”	91°56’09.6”
5	24°42’05.8”	91°56’15.9”
6	24°42’09.1”	91°56’26.8”
7	24°42’10.4”	91°56’30.7”
8	24°42’11.2”	91°56’32.9”
9	24°41’51.5”	91°56’02.1”
10	24°41’53.1”	91°56’05..9”
11	24°41’55.1”	91°56’09.5”
12	24°41’57.8”	91°56’14.3”
13	24°42’00.0”	91°56’19.9”
14	24°42’01.6”	91°56’25.2”
15	24°42’03.0”	91°56’30.8”
16	24°42’03.5”	91°56’35.1”

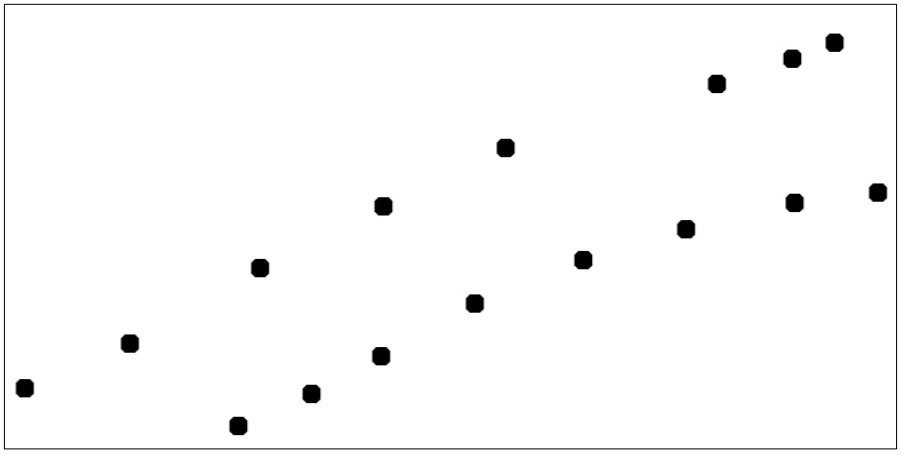

Fig. 13 *Kushiyara River in Fenchuganj by GPS observed value.*

4. RESULTS AND DISCUSSIONS

4.1. Width of the river

The width of the river measured from the images considering the point bars and active corridors, which go under water during monsoon. **Fig. 14**, illustrates the width of Kushiyara River of different periods. The minimum width as found from the time series was 96.12m at Fenchuganj in 1997, the maximum width was 272.9m on bend 2 at Sunamganj in 2006.

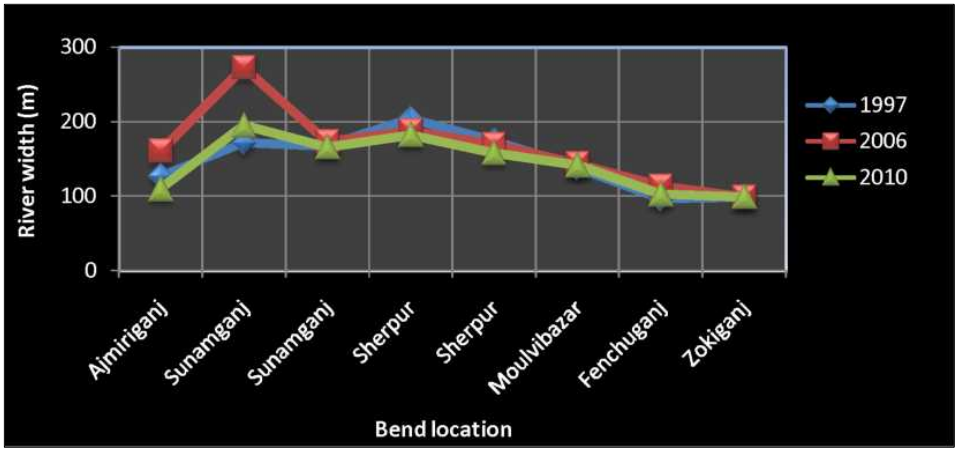

Fig. 14 Variation of width of the river.

4.2. Meander wavelength

Fig. 15 shows the dissimilarity of wavelength of the bends in different year. The wavelength varies from 1050m to 2250m. Bend-2 at Sunamganj has the minimum wavelength in 2006 and bend-4 at Sherpur has the maximum wavelength in 1997.

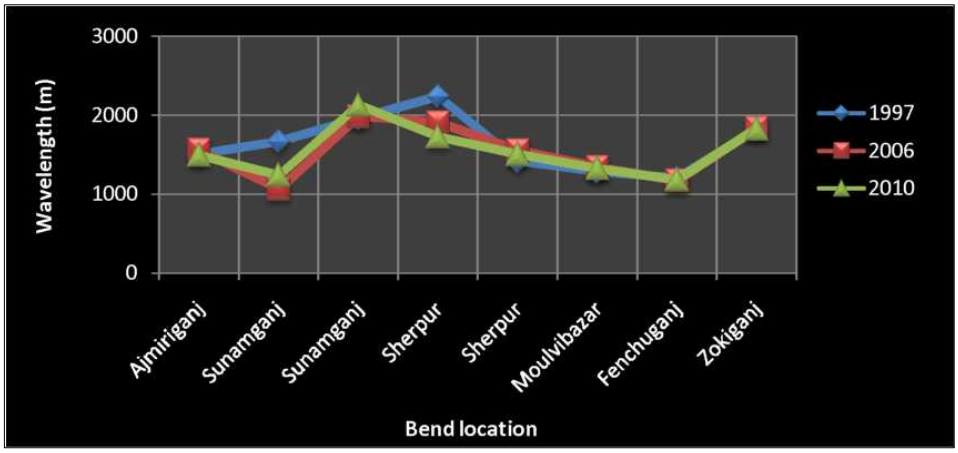

Fig. 15 Variation of Meander wavelength.

4.3. Radius of curvature

Fig. 16 demonstrates the variation of radius of curvature with time. In Sunamganj (bend 3), Sherpur (bend 4) and Zokiganj (bend 8) an increase in radius of curvature is viewed. A sharp variation of radius of curvature is observed in Ajmiriganj (bend-1), Sunamganj (bend-2), Moulvibazar (bend-6), Fenchuganj (bend-7). It was found that the maximum radius of curvature is 718m at Bend-3 on Sunamganj in 2010 and the minimum is 355.5m at Bend-7 on Fenchuganj in 2006.

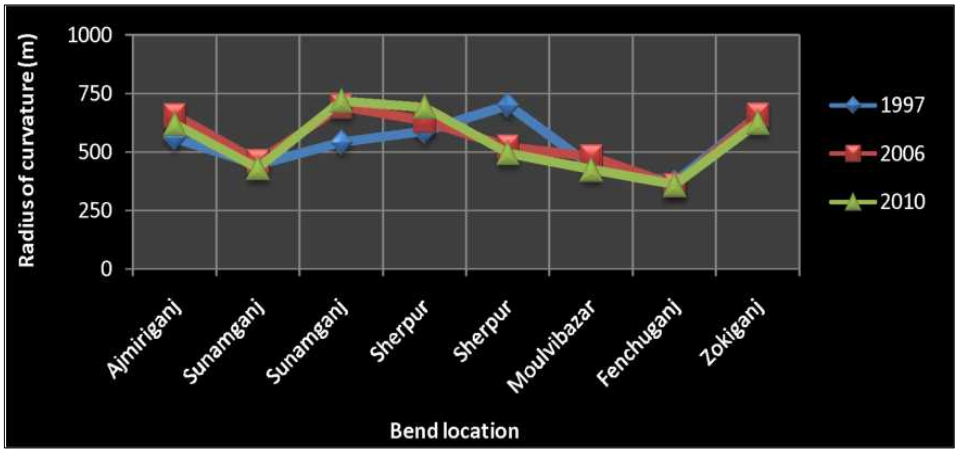

Fig. 16 Variation of Radius of curvature.

4.4. Sinuosity

The sinuosity of bends of the river Kushiyara varied from 1.11 to 2.24. Sinuosity of the bend-8, Zokiganj was higher from any other bends and varied from 2.15 to 2.24. On the other hand, sinuosity of bend-2, Sunamganj varied from 1.63 to 1.11. It was examined that, at Sunamganj (bend-3) and Sherpur (bend-5) it decreased slightly in 2006 while it has increased in the year of 2010.

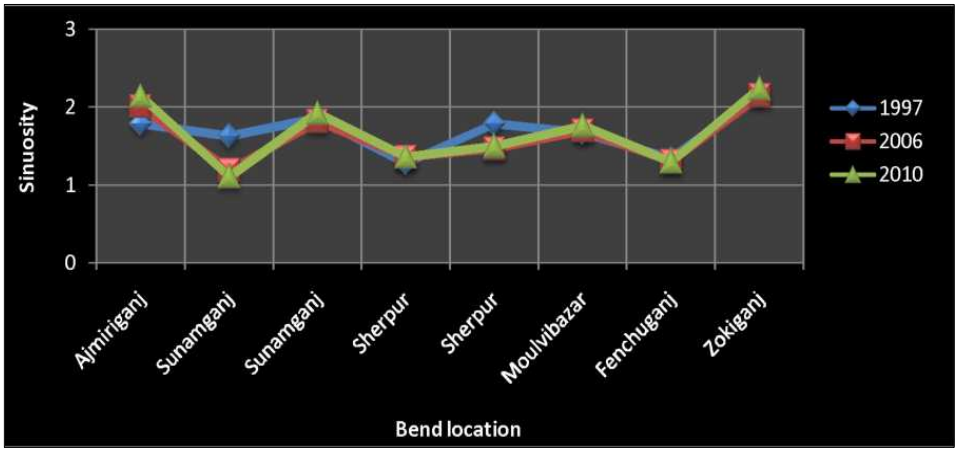

Fig. 17 Changes in Sinuosity.

4.5. Meander width

From **Fig. 18**, it has been evaluated that the maximum width was 1925.2m at bend-10 (Zokiganj) in 2010 and minimum width was 398.46m at bend-2 (Sunamganj) in 2010. It was observed at bend-2, Sunamganj that, the meander width decreased tremendously forming an oxbow lake.

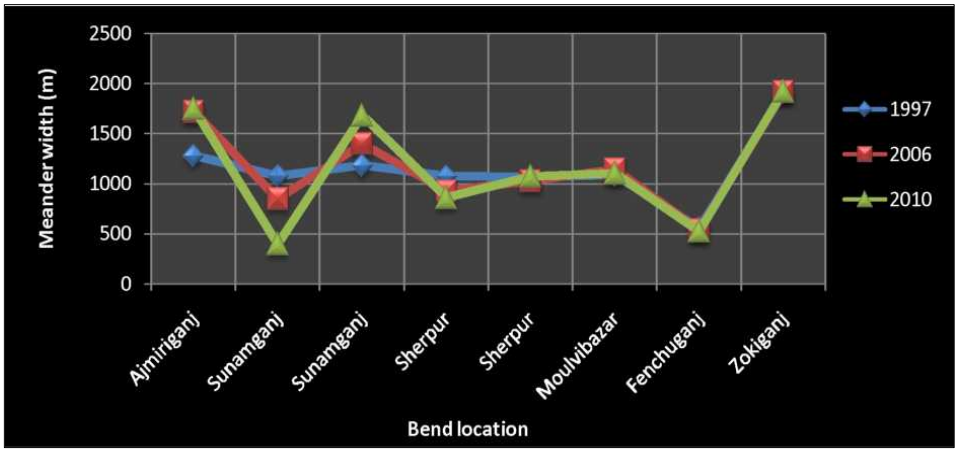

Fig. 18 Variation of Meander width with time.

4.6. Meander length

It is the axial length of one meander, i.e. the tangential distance between the corresponding points of a meander. It has shown in the **Fig. 19** that, the maximum length was 2315.5m at bend-4 (Sherpur) in 1997 and minimum length was 1010.98m at bend-7 (Fenchuganj) in 2006.

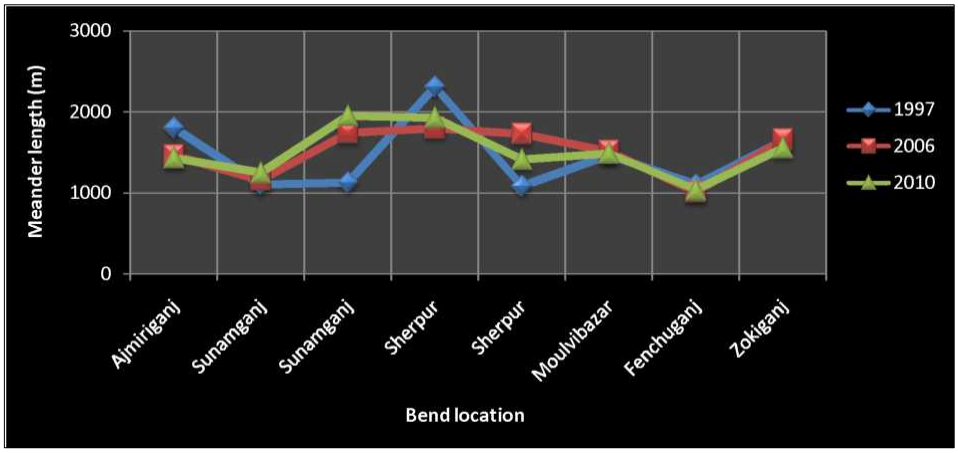

Fig. 19 Variation of Meander length with time.

4.7. Meander Ratio

Fig. 20 shows that in bend-4 (Sherpur), bend-6 (Moulvibazar), bend-7 (Fenchuganj) and bend-8 (Zokiganj) the meandering ratio remained nearly same. In bend-1 (Ajmiriganj), the ratio increased from 0.71 in 1997 to 1.18 in 2006. But in bend-2 (Sunamganj) it decreased massively from 0.73 in 2006 to 0.32 in 2010. It is remarkable that at bend-5 (Sherpur) it has decreased in 2006 to 0.6 and then increased again in 2010.

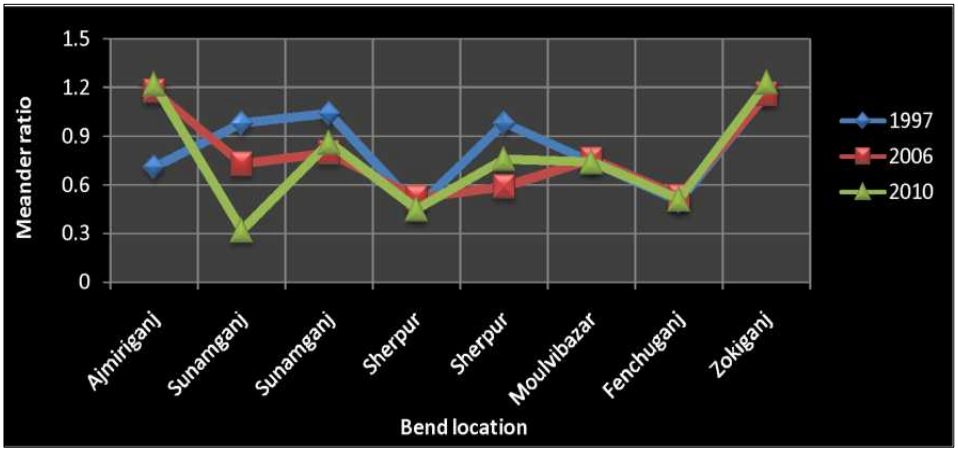

Fig. 20 Variation in Meander ratio.

4.8. Bend Migration

To demonstrate how the bends of Kushiyara River migrated through time, satellite images of 1997, 2006 and 2010 were examined. The bends migrated by following expansion, extension, rotation, translation and combination process (**Fig. 21**). The bend migrated or not were determined by comparing the images of different years. From the analysis it seemed that at bend-1 (Ajmiriganj) it has extended through the years.

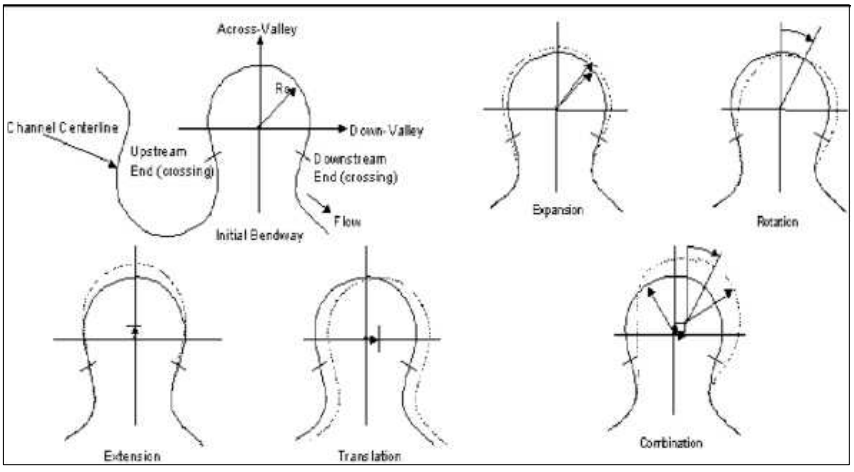

Fig. 21 Bend Migration types.
(*G.J Klaassen and G.Masselink, 1992*)

But in bend-2 (Sunamganj) from analysis we saw, the meander diminished forming an oxbow lake. A small rotation have found in bend-3 (Sunamganj). Translation with the time is recognized in bend-4 (Sherpur) but a combination of translation and rotation was observed in bend-5 (Sherpur). In the case of upstream side of the river, at bend-6 (Moulvibazar), bend-7 (Fenchuganj) and bend-8 (Zokiganj) it has remained almost unchanged.

5. CONCLUSIONS

- From the investigation it was detected that the Kushiyara River within the study reach is predominantly irregular meandering channel. The Kushiyara River was found sinuous in the upstream side and less sinuous in downstream side within the study period during 1997-2010.
- The bends of Kushiyara River was migrated inward or outward for the period during 1997-2010. All types of bend migration (extension, rotation and translation) were viewed to occur.
- Development of oxbow lake was also found on some bends during the study.
- Sinuosity of the Kushiyara River was greater than 1.5 at most of the time which indicates the river highly sinuous and the bends are critical (*Akhand, 2008*). The sinuosity of bends of the river Kushiyara varied from 1.11 to 2.24.

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