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Evaluation of course change detection of Ramganga river using remote sensing and GIS, India

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ABSTRACT

Visibility of Ramganga river course change detection was made using Remote Sensing and GIS in study area among period of forty-one years from 1972 to 2013. Landsat MSS, TM, ETM+, LISS-III satellite images from 1972, 1989, 2000, 2006, and 2013 respectively were used to delineate the historical changes of the river course. This study shows that for a long time this area has been suffering due to erosion problem and shifting characteristics of the Ramganga River. The Ramganga river course has been shifting and the overall shifting is towards the south-west direction in different places which leads to the village erosion. The area has remained undeveloped due to infrastructure damaged by flood, changing course. This study may be helpful for the overall river management and planning for future prevention of food, changing coursing, loss of properties.

1. Introduction

A river is a natural water course, usually freshwater, flowing towards an ocean, a lake, a sea and another river (Hooke, 1984). In a few cases, a river simply flows into the ground or dries up completely at the end of its course, and does not reach another body of water. River bank erosion is a common geomorphological process of alluvial flood plain rivers (Nath et al., 2013). River is an essential component of the human existence which is continuously changing from its evolution. The cycle of river is starting after the uplifting of the land mass (Panda and Bandyopadhyay, 2011).

River course change is a natural phenomenon which takes place majorly due to flood occurrence (Mahmood et al., 2015). Rivers flowing downhill, from river source to river mouth, do not necessarily take the shortest path (Pan, 2013). In this study, we have focused on the river course change detection of Ramganga River.

2. Study area

The study area of Ramganga river lies between latitude 23°9′45″N to 27°57′0″N and longitude 79°57′45″E to 79°15′44″E (Fig. 1) and drainage area is 1193 km^2. The duration of study is considered from 1972 to 2013. Ramganga River joins to the Ganga at 120 m elevation in an Ismilpur village in Kannuaj District. The average slope of the study area is 0.070.

River Ramganga is a spring fed river and important tributary of holy river Ganga, originated in the southern slopes at Dudhatoli (3110 MSL) of the middle Himalaya of Uttrakhand state. The total catchment area of the basin is 32,493 km^2 and river is divided into four segments A, B, C and D for the better understanding of the river course change detection during the study period.

3. Methods and methodology

Geographical Information System (GIS) software was used to visualize the change of channel pattern of Ramganga River (Nath et al., 2013; Pan, 2013). ArcGIS 10.1 (Esri, Redlands, California, United States) and ERDAS IMAGINE 2010 (Hexagon Geospatial, GA USA) were used to analyze the collected image. First of all, images are mosaic through ERDAS IMAGINE 2010 and AOI (Ramganga) is extracted from the images and Normalized Difference Water Index (NDWI) is calculated for the study area and from study area using

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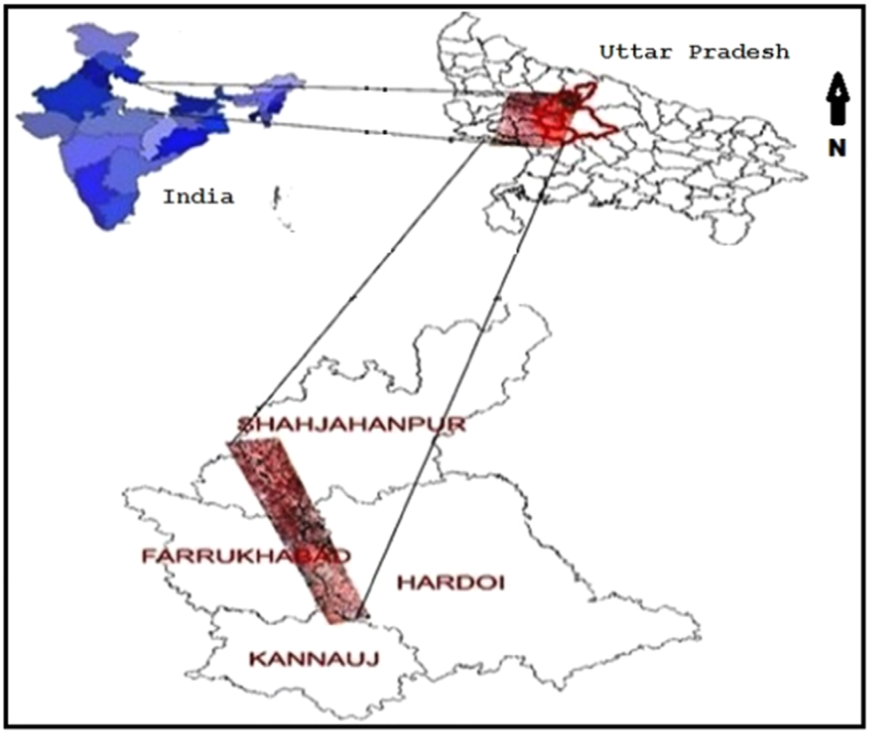

Fig. 1. Location map of the study area.

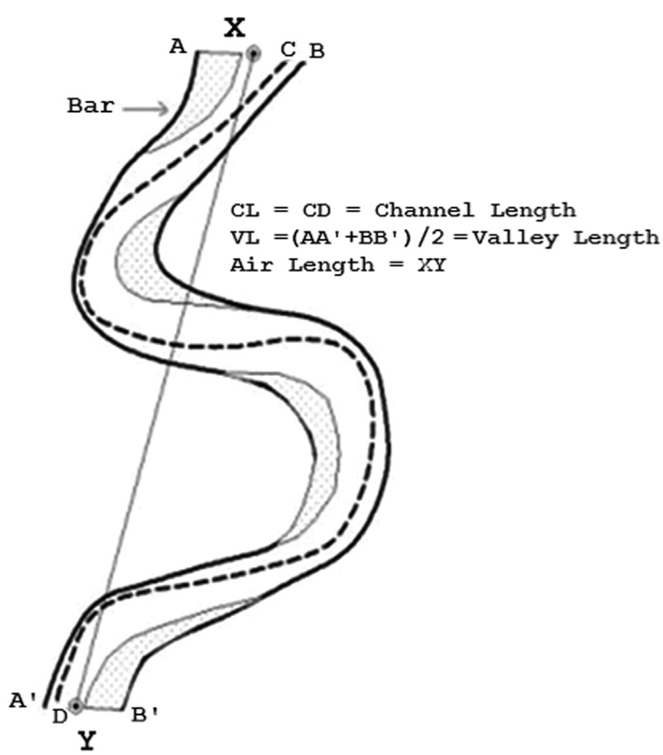

Fig. 2. Sinuosity index evaluation system.

ArcGIS software the Ramganga river is extracted and some area is edited through editing tools in ArcGIS and also overlapped bank line of different periods of Ramganga river image. Stream length and Valley length are also measured for calculating Sinuosity ratio. Total sinuosity ratio of 1.5 was selected by Leopold and Wolman to differentiate sinuous from meandering. Rivers having a sinuosity of 1.5 or greater refers meandering, and below 1.5 straight.

For calculating Sinuosity Index, the following formula was used based on Fig. 2 (Morisawa, 1985).

$$\text{Sinuosity Index} = (\text{Stream Length}).(\text{Valley Length})^{-1}$$

$$\text{Sinuosity (P)} = (\text{Lcmax}).(\text{LP})^{-1} = (\text{CD}).(\text{XY})^{-1}$$

Where, Lcmax is the length of the midline of the channel (in single-channel rivers), or the widest channel (Multiple channel rivers). And LP is the overall length of the reach.

For calculation of river sinuosity Index river is divided into four segment as A, B, C and D (Fig. 3) and polygons convert into the polylines and the field geometry is calculated to know the river length and Measure Tool is used to measure the shortest length and Field Calculator are used to calculate the sinuosity index in ArcGIS environment in Table 1 (Morisawa, 1985).

Some GCP (Ground Control Point) has selected on the left bank of 1972 river course and based on the measured direction distance between GCP and river course is measured during study and it has been estimated that how much river in which direction is shifted during study duration.

4. Results

4.1. Analysis of river course change detection

River course change detection has been done from 1972 to 2013 with consideration of 1972 as base year shown in Figs. 4–8. It is clear that the maximum river course changed in B segment at

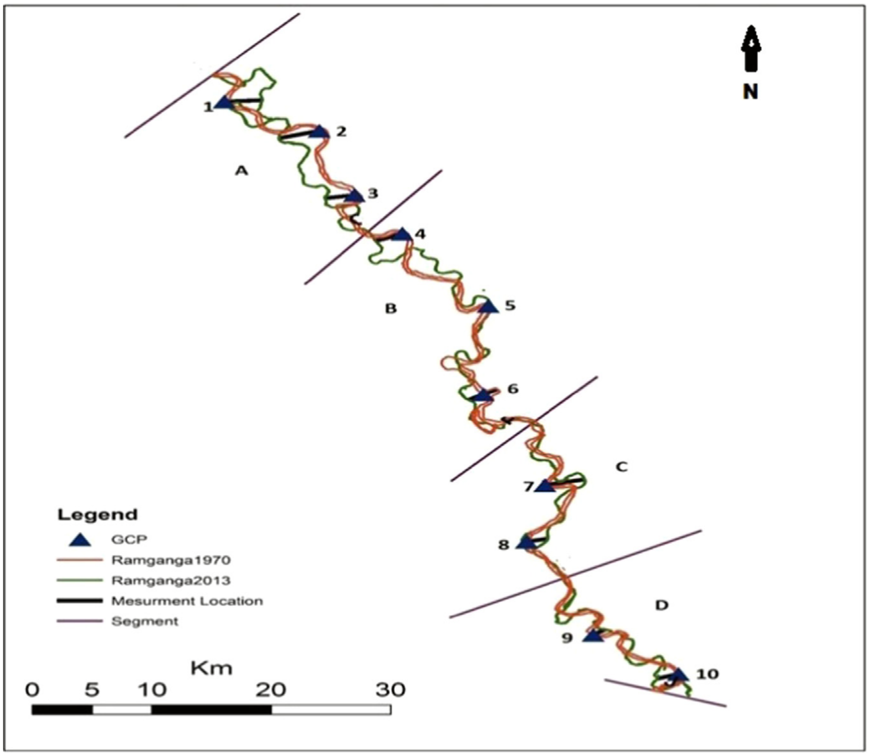

Fig. 3. Different Segments of A, B, C and D of the Ramganga River.

Table 1
Sinusity index values.

Type	Value
Straight	< 1.05
Sinuous	> 1.05
Meandering	> 1.5
Braided	> 2.0

fourth GCP is 3016 m and the minimum river course changed in the C segment at eight GCP of 147 m for year 1989. The maximum river course change was found in segment A at second GCP of 3512 m and minimum of 224 m in segment B at fifth GCP for year 2000. It is also observed that many branches has been emerged in the segment B and form the loop, so river course is more curved in the segment B. In the year 2006, river course has changed maximum 4048 m in the last 40 years and it changed in the segment A at second GCP and the minimum river is changed in the segment B at GCP five of 179 m.

It is observed that segment B has maximum river course change at second GCP of 3512 m of left bank and 3988 m of right bank shift and minimum river course changed is observed in B segment at fifth GCP of 215 m left bank and 135 m right bank of the river.

5. Discussion

The meander calculated for Ramganga river on different segments may have different reasons and the further soil based study is under process. According to Einstein (1926), a slight change in the velocity of flow between the banks of a river (due to a bend in the river) would give rise to secondary circular currents in the plane perpendicular to the direction of the flow. Even where there is no bend, Coriolis force caused by the earth's rotation can cause a small imbalance in velocity distribution such that velocity on one bank is higher than on the other. This can generate erosion on one bank and deposition of sediment on the opposite bank. The secondary currents cause the flow to proceed in the direction towards eroded portion until redistribution of velocity reverses the process.

Stochastic theory ascribes random fluctuations in the flow velocity due to some debris or disturbance to affect velocity distribution across the segments, for the formation of meanders. Equilibrium theory states that meandering is the process by which a river adjusts its gradient (length along the course divided by the drop in elevation) so that there is an equilibrium between the erodibility of the terrain and the erosive power of the stream. Geomorphic theory attributes tectonic features acting as obstacles to deflect the stream to cause meanders.

It is believed that a necessary condition for the development of meander is erosion of the bed and its subsequent deposition further downstream. This is caused by the secondary currents, generated downstream of a bend, provided of course that the discharge and bed material are favorable for this process.

6. Conclusion

The present study was carried out to demarcate the changed areas in the study site for identifying possible river course change using GIS. The data integration, management and visualization in GIS environment were relatively efficient. GIS combines spatial data with other quantitative, qualitative and descriptive information databases. This technology offers an analytical framework for data capture, storage management, retrieval, analysis and display.

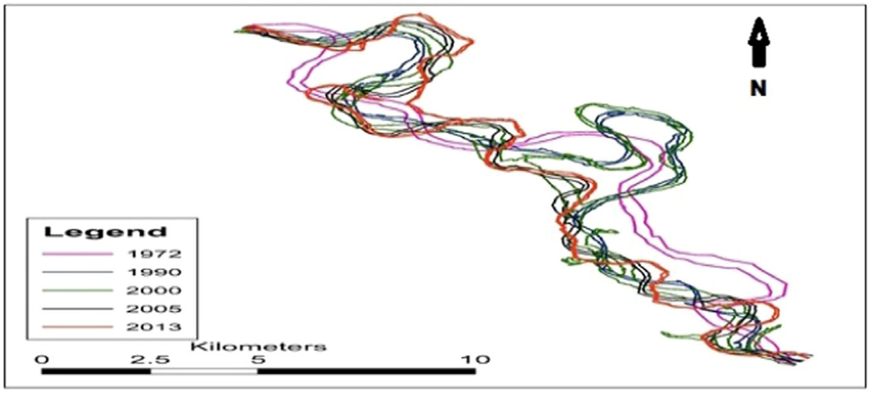

Fig. 4. Course change of Ramganga river in segment A during study.

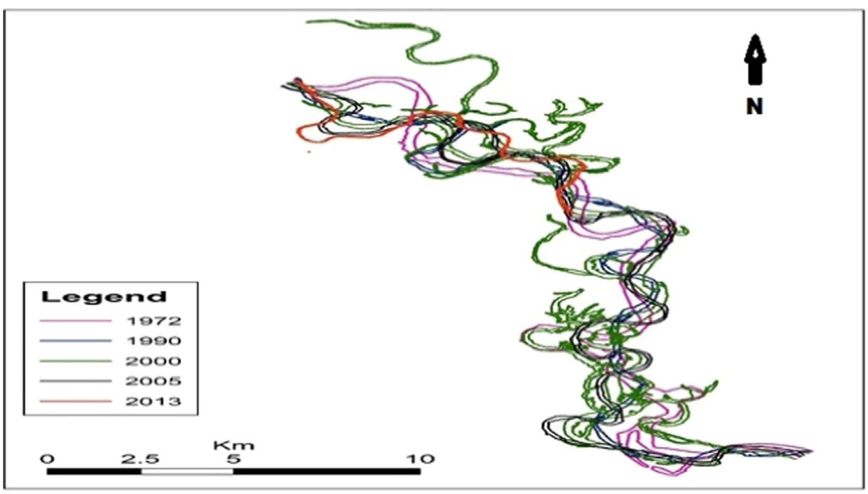

Fig. 5. Course change of Ramganga river in segment B during study.

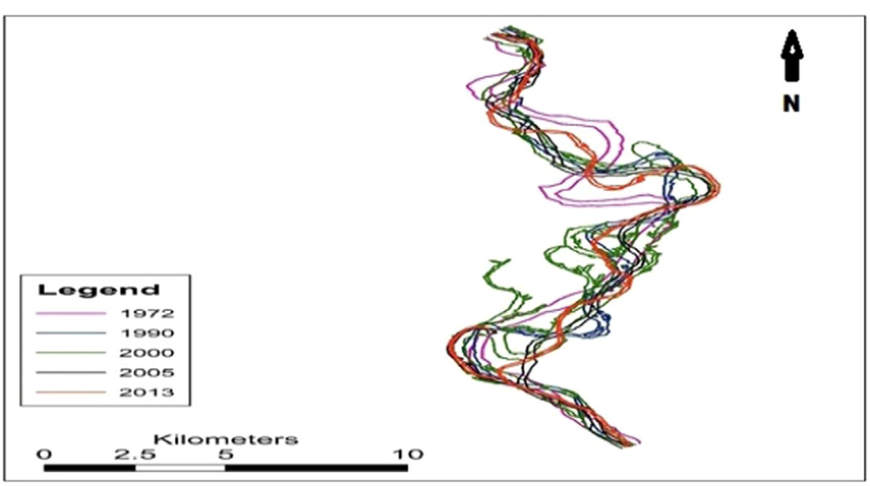

Fig. 6. Course change of Ramganga river in segment C during study.

So, the integrated approach of GIS and remote sensing was used to locate the course change in river. Remote Sensing is one of the excellent tools for inventory and analysis of environment and its resources, owing to its unique ability of providing the synoptic view of a large area of the earth surface and its capacity of repetitive coverage. When remotely sensed data are combined with

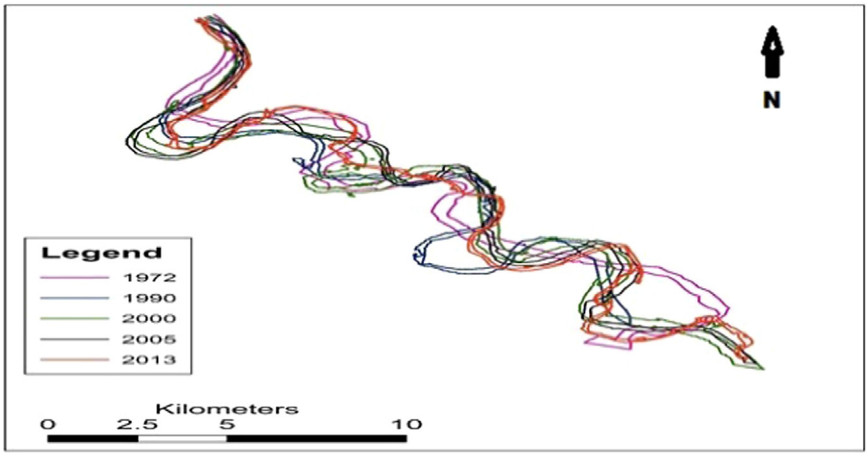

Fig. 7. Course change of Ramganga river in segment D during study.

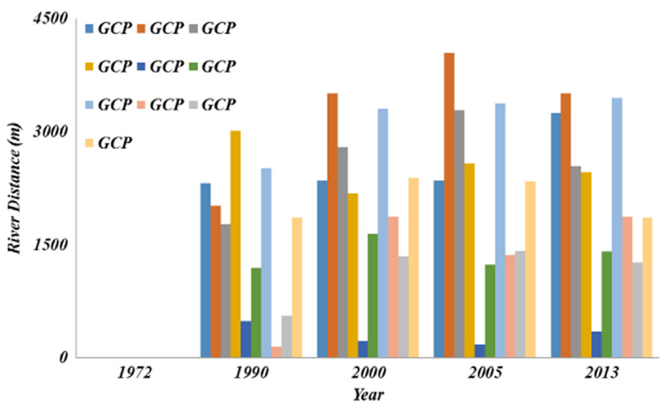

Fig. 8. Ten ground control points (GCP) taken for each satellite data during study.

other surface water variables organized with in a GIS. They result of the identified changes indicates that enormous changes in river course have occurred in the areas.

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