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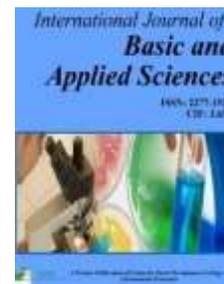
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Full Length Research Paper

Morphological Variation of the West Rapti River, Nepal

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ABSTRACT

Understanding the morphological variation is helpful to decipher reach scale character and behavior of a river. Further it also helps in conservation and sustainable management of a river system. Hence, the present study aims to understand the morphological variation of the West Rapti River in Nepal. To assess the morphological variation the river is divided into reaches with more or less similar geomorphic unit. The result shows that it has five distinct river class and ten river reaches. It is very important to preserve the river morphology for sustainable development.

Key words:

River style, reach,
confined, floodplain

Introduction

Rivers not only curve the landscape, but also play an important role in ecological and social system. (Wantzen et al., 2016; Singh et al., 2017; Anderson et al., 2019). It is important to identify the geomorphic processes of river channel and floodplain, which construct and sustain riverine ecosystem (Beechie & Sibley, 1997; Gilbert, Macfarlane, & Wheaton, 2016; Wheaton et al., 2010). Hence geomorphic mapping of variation in channel planform and floodplain morphology for the entire river determine the phase for reestablishment and management planning (Beechie & Imaki, 2014; Gore, 1985; Heede and Rinne, 1990; Milner, 1994; Brierley and Fryirs, 2005). Therefore, geomorphic diversity and underlain basic process is very important for river science and sustainable management.

Materials and methods

Study area

The study area lies in the mountainous part of the West Rapti River in the Nepal. The West Rapti River originates from Dregaurra range (3048 m) of Lesser Himalaya in Nepal. And after flowing through Siwalik Himalaya, Gangetic plain it meets with Ghaghra River, one of the major left bank tributary of the Ganga River. It has a total catchment area of 26043 km² out of which 56% (14642 km²) lies in India and 44 % (11401 km²) in Nepal. The length of the Rapti River is 782 km, out of which about 310 km lies in Nepal and rest in India. In Nepal it is joined by several tributaries such as Jhimruk, Mari, Arun, Lungri etc. and flows through Rolpa, Pyuthan, Arghakhanchi, Dang, Banke district. From the confluence of the Mari and Jhimruk, the river is named as West Rapti River in Nepal. The Geographical extension of the study area is from 28°27' 48"N to 27°49' 8"N and 81°47'14"E to 82°56'37"E (Fig. 1).

Data used and methods

To map the physical heterogeneity a high resolution geomorphic map of the study reach has been prepared using Sentinel satellite image of 2017 (spatial resolution 10m). The image is typically obtained in pre monsoon season with a cloud cover of less than 10%. A standard false color composite has been used to identify different geomorphic feature. To demarcate valley bottom margin or effective valley width a number of cross profile has been drawn across the river at short interval on ALOS WORLD 3D 30m (AW3D 30m) DSM data. On the basis of degree and break point in slope valley bottom margin has been identified and marked on the both side of the river.

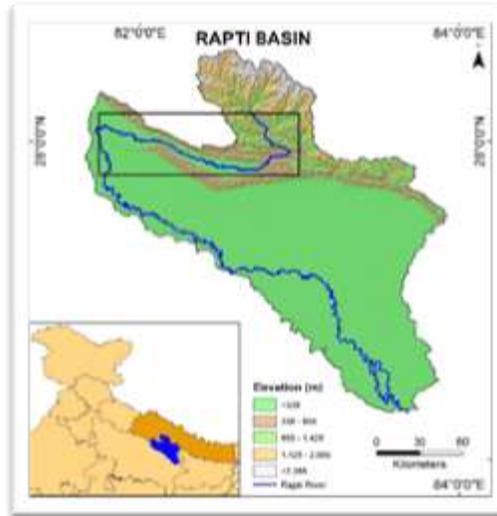


Fig. 1 Study area

Finally, on the basis of geomorphic assemblage the study reach divided into 10 reaches on the basis of nested hierarchical approach of the River Style Framework developed by K. Fyris and Barely, 2000. In this approach basin to reach scale parameters such as landscape setting, valley setting, Floodplain setting, and channel morphology has been considered to define a river reach within which operating bio- physical processes are more or less uniform. At first tier landscape setting has been used which refers to the geologic and geomorphic characteristics of the catchment. Valley setting is incorporated at second tier, which refers to the ability to lateral adjustment of the channel in terms of confinement. At third tier, floodplain setting was added, which refers to the presence or absence of the floodplain and its boundary condition to the valley wall (Bawa et al. 2014). Fourth tier, Channel morphology was integrated, which refers to the planform geometric characteristics of the river.

Computation of attribute of different channel units of the river

In this stage measurement of attribute of different geomorphic features of the channel is done. For examples, channel width was measured along the centerline for the entire Rapti River at an interval of 2 km. In addition, channel length, channel area, sand bar area are also computed. Lastly, statistical analysis is done to infer useful information and draw comparison between reaches. Average stream power and unit stream of each pixel of different reaches are also computed to infer process-form relationship.

Extraction of long profile from the DEM

For automated extraction of stream network in ArcGis 10.1, ALOS 30 DEM from JAXA is used. To extract stream network first DEM data is filled using hydrology tool of ArcGis 10.1. Then flow direction is generated using unidirectional D8 method followed by the generation of flow accumulation raster layer. Subsequently, stream network is produced in raster format and corrected accordingly. Then main stream raster data of the Rapti River following the thalweg line is converted into point layer. The flow accumulation and elevation value of each pixel along the entire river is then extracted. Subsequently, the distance of each pixel from source to downstream is computed using V.Distance tool in QGIS 3.16.10. Finally, this data was exported in excel format and sorted according to distance from the source of the river.

Results and discussion

Using hierarchical river style classification approach the West Rapti River is divided into 10 reaches and 5 distinct river classes to understand character and behavior of each reach in a holistic way and are given below (Fig. 2)

Reach 1: Mountainous, confined meandering and no floodplain

In this reach the river is flowing through the mountainous landscape of Lesser Himalaya. The channel is confined by steep valley wall. As a result no floodplain is developed. The river is bedrock in nature. The river pattern is meandering which is governed by the bed rock geometry of Himalaya. In channel deposits are Lateral, Mid channel, Point bar, Tributary delta. The mean width is 60 m. The length of the channel is 120 km with a total area of 7.99 km². The total sand bar area is 3.45 km².

Reach 2: Mountainous, partly confined braided and floodplain

In this reach the river is also flowing through the mountainous landscape. The channel is partly confined and floodplain is also partly confined in nature. The pattern of the channel is braided. In channel deposits are Chute channel, Concave bench, Lateral, Mid channel, Point bar, Island. The mean width of the river is 260 m with length of 12 km. The total channel area and sand bar area are 4.10 and 2.98 km² respectively.

Reach 3: Mountainous, confined meandering and no floodplain

This reach is similar to reach 1. Here the channel is confined with no floodplain. The meandering geometry is governed by the bedrock structure of the Himalaya. The average width of the channel is 130 m with a total channel area of 0.98 km². The length of the channel is 6.8 km with atotal sand bar area of 0.52 km².

Reach 4: Intermonate basin, confined braided and unconfined floodplain

In this reach the river is flowing through the intermonate basin landscape of Siwalik Himalaya. The channel is confined by valley margin in one side and embankment on another side. Whereas the floodplain is unconfined in nature, which indicates that the floodplain can grow laterally. The river pattern is braided. In channel deposits are Concave bench, Lateral, Mid channel, Point bar. The mean width of the river is 652 m with a total bar area of 6.8 km². The length of the channel is 12 km with area of 8.5 km².

Reach 5: Intermonate basin, unconfined meandering and floodplain

In this reach the river is also flowing through the intermonate basin. The channel and floodplain is unconfined by characteristics. So that the channel can migrate laterally. The river pattern is braided with a mean width of 698 m. In channel deposits are Concave bench, Lateral, Mid channel, Point bar and island with an area of 14.5 km². The length of the channel is 32 km with an area of 20.4 km².

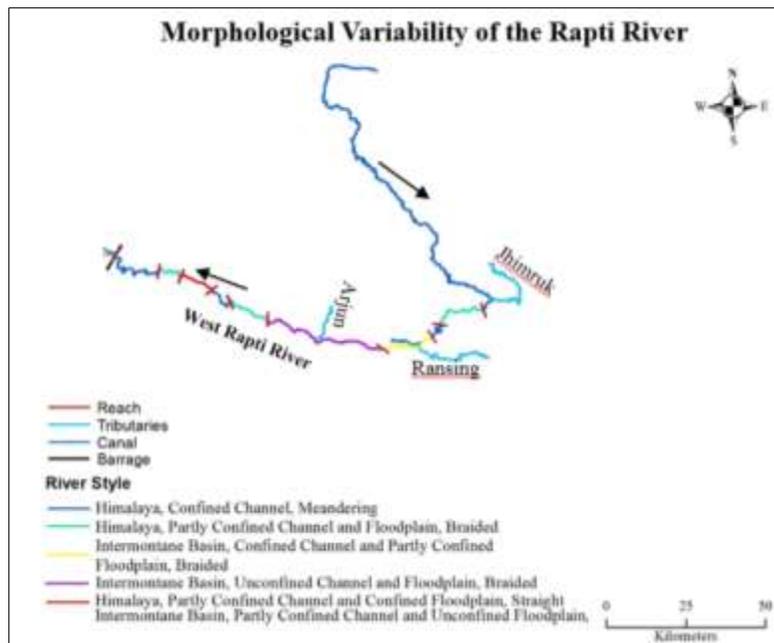


Fig. 2 Morphological variation of the West Rapti River

Reach 6: Mountainous, partly confined meandering and floodplain

The channel is again flowing through the mountainous landscape. The channel and floodplain is partly confined by characteristics. The river planform is meandering in nature with a mean width of 235 m with a total bar area of 1.14 km². The total channel area is 2.5 km² having a length of 11.2 km

Reach 7: Mountainous, confined meandering and no floodplain

In this reach the river is flowing through Himalaya with confined channel and resulting no floodplain. The planform is meandering controlled by Himalaya. The mean width is 146 m. The channel length is 7.5 km with an area of 1.2 km². The total bar area is 0.45 km².

Reach 8: Mountainous, partly confined meandering and confined floodplain

In this reach the river is flowing through the Siwalik Himalaya. The channel is partly confined by nature. Whereas, the floodplain of the river is confined. The river pattern is meandering with a mean width of 242 m with an area of 2.14 km². The total sand bar area is 1.3 km².

Reach 9: Mountainous, partly confined meandering and floodplain

The river is flowing through Himalayan landscape. Here the channel and flood plain is partly confined by valley margin. The planform of the river is meandering with an average width of 356 m. The side bar, point bar, midchannel bar, island dominant the in channel deposit with area of 1.24 km². The channel length is 7.5 km with an area of 2.57 km².

Reach 10: Mountainous, confined meandering and no floodplain

The river has a meandering planform with confined channel and no floodplain. The mean width is 142 m with a length of 20 km. The total channel and sand bar area are 2.98 and 0.95 km² respectively.

Conclusion

The result shows that it has five river classes with different combination of hierarchical nested framework. In confined channel setting the river can't migrate laterally. Hence, the channel can do either incise or aggradation. Further, in unconfined settings the floodplain can grow laterally. Whereas, in partly confined channel discontinuous flood plain is present on either of the channel. For management of the river the pattern must be preserved. In mountainous landscape the channel and floodplain is confined whereas in intermontane basin the channel is braided and unconfined with floodplain on both sides.

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