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Role and Pattern of Drainage System of Bagmati River Basin in North Bihar: A Geographical Analysis

Sanoj Kumar

UGC NET
Research Scholar,
Department of Geography,
B.R.A.Bihar University, Muzaffarpur, Bihar (India)

Abstract: Nepal is the birth place of Bagmati river. The river flows from north to south direction in Nepal and to east direction in Bihar. Drainage patterns also display in the structural and litho logical control on the evolution of landforms. Drainage Pattern refers to the particular design which the stream course collectively form channel patterns such as meadering braided, straight etc. The study of drainage pattern assets in the interpretation of the nature of the terrain. "The pattern of drainage is one of the most refilling features of a landscape that cast light on the rocktype Geological structure stage in drainage evolution etc." The pattern of developed over an extensive area in Bihar region mostly in the specific areas of granite, mica, shale and phyllite offering relatively uniform resistance. The pattern of drainage that then ensures in dendritic, having stem, branches, limbs and twings, it is like an oak tree in the organization of its part. The drainage pattern generally discards structural control. But the trunk like courses of the lower Bagmati for more than 25 Km. The lower courses of the tributaries and many independent tributaries run parallel to the other before their conflux with the master stream and tributaries are so small as to make the major and subsidiary stream nearly parallel.

Index Terms **- Bagmati river basin, Drainage system, climate, Dendritic pattern, floods, Embankments.**

I. INTRODUCTION

Bagmati river flows from its upper Nepal (Kathmandu) catchment through an almost entirely embanked river channel towards its confluence with the Koshi River (Figure-1). The river is thus characterised by slope changes and high sediment load ('silt') causing meardering and instability but generally do not appear to posses flash flood characteristics. The flood plain is cultivated between the flood embankments. There is a ribbon of settlements all along the outside of embankments on both sides of the river. The river originates from Baghawar falls (Nepal) where the water flows out through a gargoyle shaped like tiger's mouth, situated in shivpuri nagarjun national park near sundarijal in Nepal.

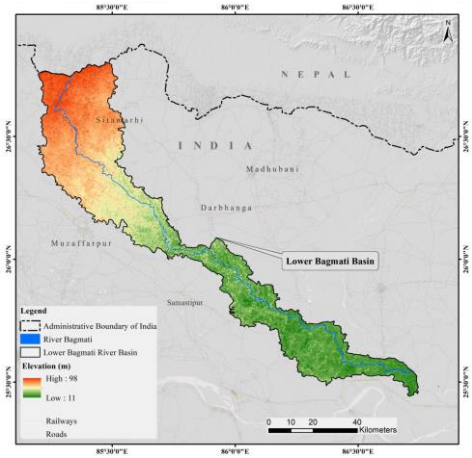

Figure 1 : Maps of Bagmati river basin (Indian Part) : Source : Deltaves & RMSI

II. CHARACTEISTICS OF BAGMATI RIVER

Sl.No.	*Particular*	*Quantity (FMIS, Bihar)*
1.	Total Drainage Area	1264.3 KM
2.	Drainage Area in Bihar	586.3 KM
3.	Population in Bihar	83.01 Lakh
4.	Water Resources	4035 MCM
5.	Average Annual Rainfall	1285 MM
6.	Town = Kathmandu & Patan (Nepal)	
7.	Total length of embankment in Bihar	3759.94 KM
8.	Total Length of Main River	389 KM
9.	Cropped area in Bihar	7600 Sq.KM

Source : FMIS, Bihar

The Bagmati river is a so called "Plainfed" river, which has different morphological, hydrological and sediment transport characteristics compared to other rivers in Northern Bihar, such as Burhi Gandak and Gandak ("Mountainfed") and Lakhandei ("Foothillsfed"). It implies that the ratio between upland and plains in almost zero, i.e. hardly any catchment area above the so called mountain front. The Bagmati river is a typical single channel river with a high sinuosity (meandering) (Sinha and Jain, 1998). The meandering pattern is more pronounced in the lower reaches. Gradual building of paint bar on the inner side of a bend and consequent lateral erosion of concave embankments is a common features of the river. There is several erosion points spread over the reach down stream in Sheohar district. Figure of elevation map of the Bagmatic river basin seeing the terrain and the hydraulic characteristics the river may be divided into three reaches from originated (i) Gosaisthan ranges to Rashulpur village, (ii) Rasulpur to Muzaffarpur, (iii) Muzaffarpur to Khagaria. The evelation of the countryside through which the river flows drops to about 80 metres over a distance of about 571 KM from the elevation of 310 M. at the elevation.

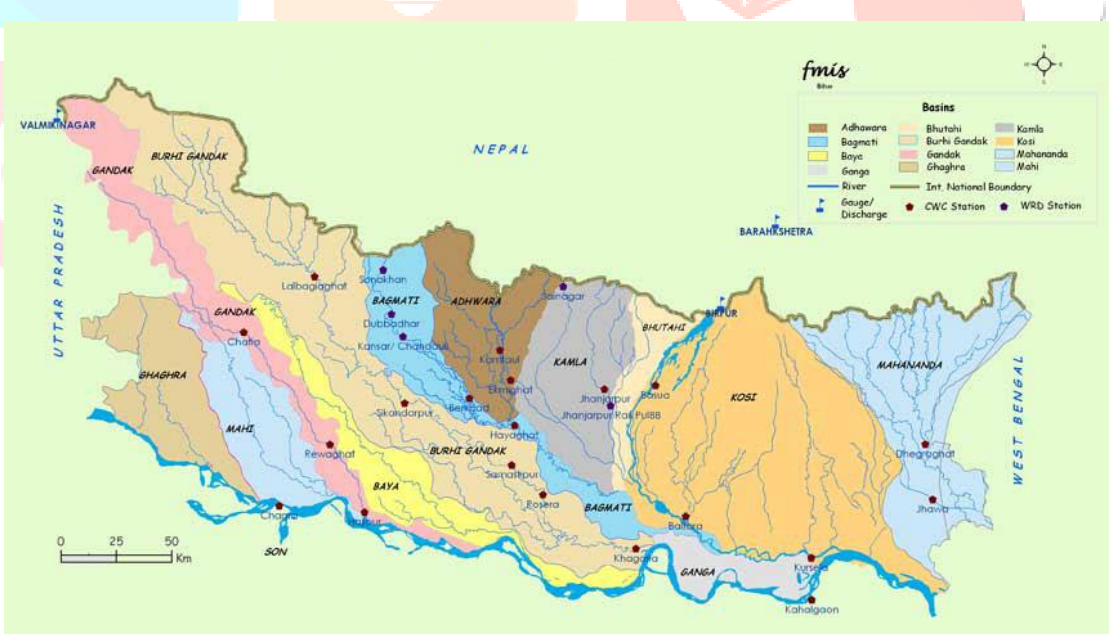

Fig.2 : Elevation Map of the Bagmati river

The rest of the catchment area is highly fertile alluvial plain. The agriculture area is 649 KM. thousand hectare (as per base year 1994 GFCC) and Predominantly being used for paddy, wheat and Maize. The area is well for connected by road and railways and also good communication network exist. There are no major industries in the sub basin. There is an international aerodrome in Darbhanga in sub-basin in Bihar.

III. FLOOD CHARACTERISTICS :

Before the embankments were constructed from Sheohar upto the confluence with Kosi, the river used to spill more or less throughout its length. But even now, when embankments have been constructed over most of the length, the area remains highly vulnerable to flood inundation not because of the floods of Bagmati River alone. The Bagmati River, which receives the floods of its tributaries in the upstream along with its own catchment generated floods, is a high stages in the monsoon in general and definitely during flood events. As such the backwaters push during flood events. As such the backwaters push the Bagmati River flood volume to its upstream channel. To add to the problem, the Burhi Gandak known for its flood funy and damage, running in the right side (south of Bagmati river, is also affected by high stages of Ganga and is not able to drain into Ganga.

As such, the Burhi Gandak pushes its flood into the Bagmati river channel. Thus the inundated waters spread upto even about 20 to 25 KM upstream of the Bagmati river. Both Bagmati and Burhi-Gandak look like a single channel in these plains. As such the boundary conditions for modelling and mapping are forseen to be a challenge, which we will have to address in an opt manner.

IV. FLOOD EXTENT IN NORTHERN BIHAR ON AUGUST 2019 (Source : Dartmouth Flood Observatory)

The flooding characteristics can be summarised as follows :

1. A cot of flooding is due to water logging and impeded drainage and not river flooding.
2. Flooding also occurs through breaching of embankments, which is said to be after man made.
3. Downstream inundation is partly also coming of room back water effect of Burhi Gandak and overflowing water from other rivers (Kamala, Kadone).
4. Bank erosion problems in the reach below Kara, Aurai and Gayghat block in Muzaffarpur district.
5. Inundation due to spilling of the river in the upstream reaches.
6. Drainage congestion due to in adequate water way provided in the rail/road bridge, especially in the Muzaffarpur district.

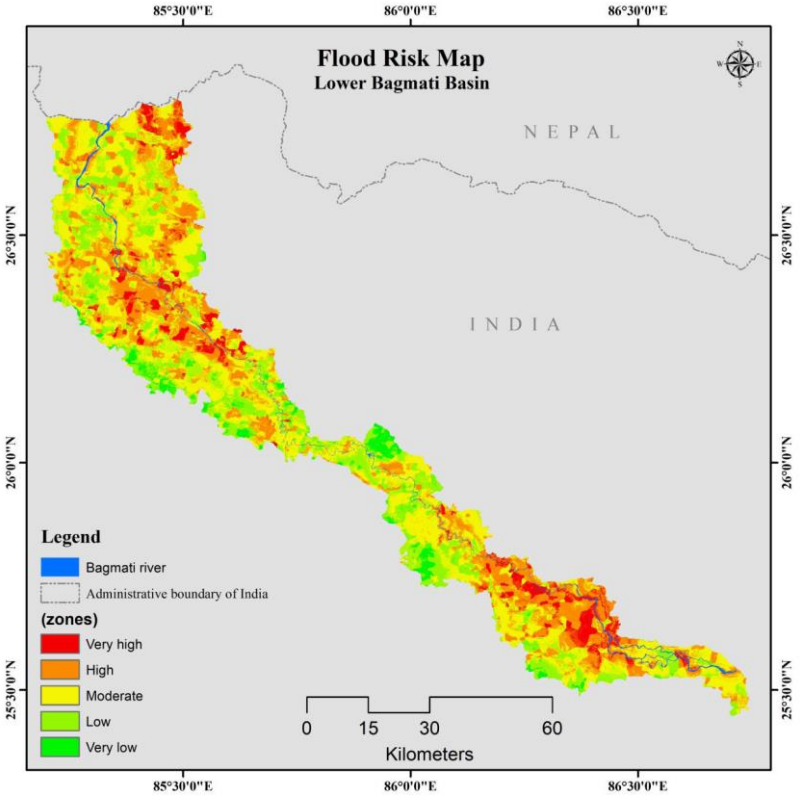

Fig.3 : Flood Risk Map of the Bagmati river

V. RECENT FLOODS AND THEIR IMPACT

The plains of north Bihar have experienced extensive and frequent loss of life and property over the last several decades. Based on the years 1968 to 1990 th eGFCC estimated the average annual flood damages to crops, houses and public utilities as Rs. 1141 lakhs. 168 lakhs and 233 lakhs respectively. The annual loss of human life was 11 and that of cattle was 62. The average annual area affected was 2.13 lakh hectares. From 1991 t0 2012 the damages and fatalities are given in Table for the districts of Sheohar, Muzaffarpur, Darbhanga, Begusarai, Khagari (based on the Disaster Management Department of Bihar). Although it is tricky to compare these figures because of possible differences in data collection, they suggest a significant increase in damages in the last two decades.

The applied hydrodynamic model for Burhi-Gandak consists of a ID channel flow combined with a lumped hydrological model. The ID model includes the rivers and larger channel system of the Burhi-Gandak basin. The implementation of the hydrodynamic ID model requires the insertion of the cross section profiles of these river branches at regular intervals. The cross sectional data has been drawn up by combining several data sources.. Firstly, a selected number of cross sections have been surveyed in the downstream part of the basin. Secondly, already available cross section information has been combined with assumed cross sections based on the width of the river and general width-depth relationships. A typical trapezoidal profile is used for the assumed cross sections. the use of these profiles is an expedient solution, but allows the application of the ID model in absence of the real cross-section profiles where no additional information is available. In the Burhi-Gandak basin a total number of 60 cross sections have been surveyed. The surveying activities have been carried out during the period March-May 2015 in 3 batches of 20 cross sections each. The location of the surveyed cross sections is shown in figure.

VI. CLIMATE CHANGE

As a transitional zone, Bihar with a humid subtropical climate experiences four distinct seasons (Cwa-Koeppen‘s climatic classification). The western part of Bihar is relatively dry, while the eastern experiences a humid climate and the north is colder than the south. The average precipitation in the region is 1200 mm (Fig) and the average temperature is 27°C. The monsoon plays a very crucial role in the region which has become more erratic and unpredictable in recent decades. In the last decade, Bihar experienced 6 drought years. The Begusarai district is one of the worst affected with 500 to 600 mm precipitation in 2018 which is less than the state average (1100 mm) (IMD).

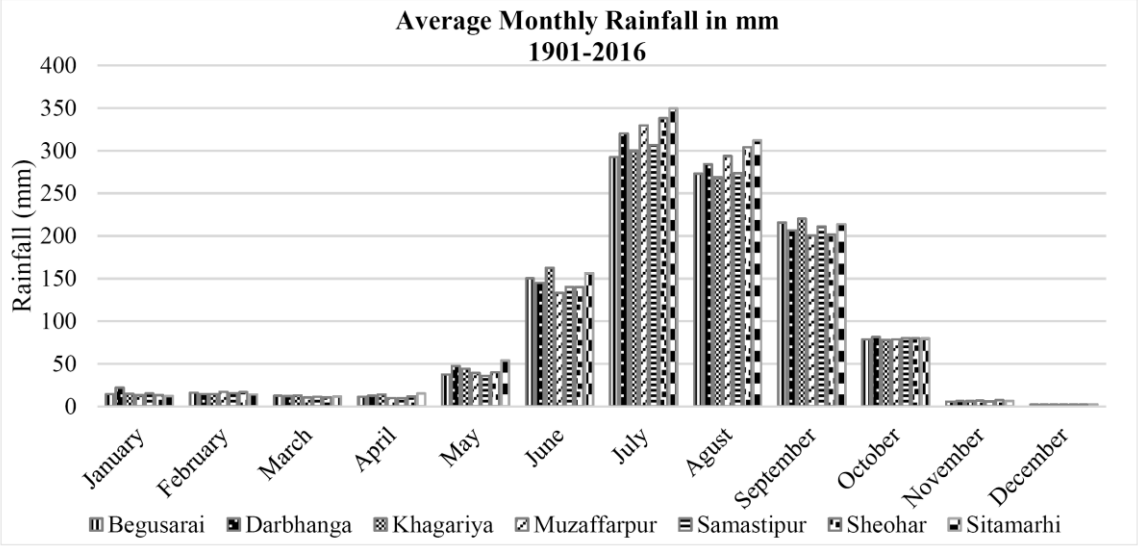

Fig. 4. Average precipitation
Source: WRD, India

The simple linear regression (SLR) is one of the most widely used models to identify the trend in time series data. This is a parametric model, which was implemented to analyze the historical rainfall pattern. The analysis was done for annual, and seasonal rainfall patterns from 1901 to 2016, and the districts included in this analysis were Begusarai, Darbhanga, Khagaria, Muzaffarpur, Samastipur, Sheohar, and Sitamarhi in order to explore temporal monotonic trends in the time series of rainfall. The data was collected from India Water Portal and, Indian Meteorological Department (IMD) for the selected districts.

VII. CONCLUSION

From the above discussion it become clear that river Bagmati originates in a very higher elevation, flows down through the Tarai region, and the plains of Bihar until it joins river Kosi. The study also showed that the basin is characterized by recently deposited alluvium transported from the upper course and gets deposited in the plain featuring various landforms (bars along the river channel, meandering, natural levees, palaeochannels and various ox-bow lakes).

The study of basin morphometry reveals that the basin is highly elongated indicating less discharge of water, active soil erosion, less structural control, and relief is characterized by flat land. The higher sinuosity index indicates the river is highly meandered, thereby causing avulsion due to simultaneous bank erosion and deposition. The stream length in the basin was found to be longer than usual, showing less steep and flow more slowly, consequent upon the suspended particles are being continuously deposited on the flood plain.

The bifurcation ratio values of the Bagmati basin are found to be inconsistent due to strong geophysical control in the basin. A high bifurcation ratio indicates a large amount of water received, showing a large amount of water discharge in the 2nd order streams. The low mean stream length value in the basin indicates young morphological development and high erosion potentiality. The value of basin relief indicates the difference between the highest and the lowest points, which was found to be 86 m indicating less variation as compared to the mountain region and plateaus.

Most of the streams found in the basin are relatively longer in length, and this indicates less slope gradient. The stream length ratio is showing abrupt changes indicating the basin is in the early stage of geomorphic development, and higher tendency of alteration in near future, also an indication of irregular hydrological response. Low average drainage density indicates low relief, low slope, high infiltration capacity and low water regimes in the basin. The relief ratio values are generally higher in mountainous compared to the plateaus and plains. It is 0.63 in the Bagmati basin indicating a lower relief plain, high overland flow area as well as the maximum denudational process.

The historical rainfall pattern showed gradual decrease of monsoonal rainfall in the selected districts except the district of Sitamarhi which is located in the upper course in the lower Bagmati basin. The increasing trend in Sitamarhi had tremendous effects in the middle and lower reach of the river.

The basin was characterized by very high density of population (over 1700 / sq. km), with large number of non-workers, seasonal and agricultural laborer, making them more vulnerable to flood disasters.

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