



A study on channel morphology of Bashistha and Bahini-Bharalu river systems, Assam and Meghalaya, India

Tarali Devi¹ and Pradip Sharma²

1. Department of Geography, Gauhati University, Guwahati, India

2. Department of Geography, Cotton College, Guwahati, India

Abstract

The morphological analysis of Bashistha and Bahini-Bharalu river channels has been carried out through the measurements of channel geometry (channel width, channel depth, bed width, wetted perimeter, hydraulic radius), channel fluid dynamics (water discharge, velocity) and downstream hydraulic geometry (relationships among independent and dependent channel variables). The study has been carried out in seven cross sections along the Bashistha river and in eight cross sections along the Bahini-Bharalu river. The cross sectional shapes and sizes of both the rivers are analyzed from the cross sectional profiles. The fluvio-geomorphic behaviour of the rivers are analyzed by the study of their hydraulic geometry.

Keywords: channel morphology, hydraulic geometry, fluvio- geomorphic behaviour.

1. Introduction

Bashistha and Bahini-Bharalu are two significant peninsular types of rivers flowing in the southern bank of the Brahmaputra River. The plain portion of the southern part of the Guwahati city topographically is the valley of the river Bharalu which has been expanding upstream and sideways since remote past (Bhattacharya, 1981). But in present days both the rivers create water logging and flood hazards within the Guwahati city. On the other hand the fluvial characteristics of the river channels are also affected by the urban morphology of the city. For solution of problems created by a river channel, a proper study regarding the channel is a must, as the study helps in tracing the causes of the problems. As the present work deals with the channel shapes/valley shapes (through cross sectional profiles) and the fluvio-geomorphic behaviour (through hydraulic geometry) of both the rivers, it is therefore expected to help in solving the fluvio- geomorphic problems connected with Bashistha and Bahini-Bharlu rivers. Channel

morphology encompasses the analysis of channel fluid dynamics, channel shapes, bed and bank materials etc. within its scope.

2. Study Area

The study area includes both the river channels from their source to mouth. Originating in the northern slope of Meghalaya plateau, both the rivers flow northward. Bashistha river has its origin in Jatabar peak of 639 meters height from msl (mean sea level) at Garbhanga reserved forest (Kamrup district, Assam) and merges with the Deepar Beel (Kamrup Metro district, Assam). Bahini-Bharalu river has its source at 460 meters height from msl at Myllem reserved forest (Ri Bhoi district, Meghalaya) and merges with the river Brahmaputra at Bharalumukh, Guwahati (Kamrup Metro district, Assam). The source of Bashistha river lies in the intersection of 26°02' 35" N lat. and 91°42' 47" E long. while its mouth lies in the intersection of 26° 07'03" N lat. and 91°40'24" E long. The source of Bahini –Bharalu river lies in the intersection of 25° 59' 54" N lat. and 91°44'56" E long. while its mouth lies in

the intersection of $26^{\circ}10'24''$ N lat. and $91^{\circ}43'56''$ E long. The length of Bashistha river is 33.12 km, while the length of Bahini-Bharalu river is 30.02 km.

The Ri-Bhoi district is located on the middle Meghalaya plateau. The Meghalaya plateau is a part of Chotanagpur plateau of Deccan foreland/Gondwana landmass (Sharma, 2003). The Kamrup and Kamrup Metro districts are located on the Meghalaya plateau

and the Brahmaputra plain. The Brahmaputra plain has been built up on a trough which was created at the time of upliftment of the Himalayas and filled by the sedimentary deposits (Taher *et al.*, 2001).

Physiographically the study area can be divided in to three categories—1. Lower hills and hillocks of Meghalaya plateau, 2. The Brahmaputra plain, and 3. Rivers and Wetlands.

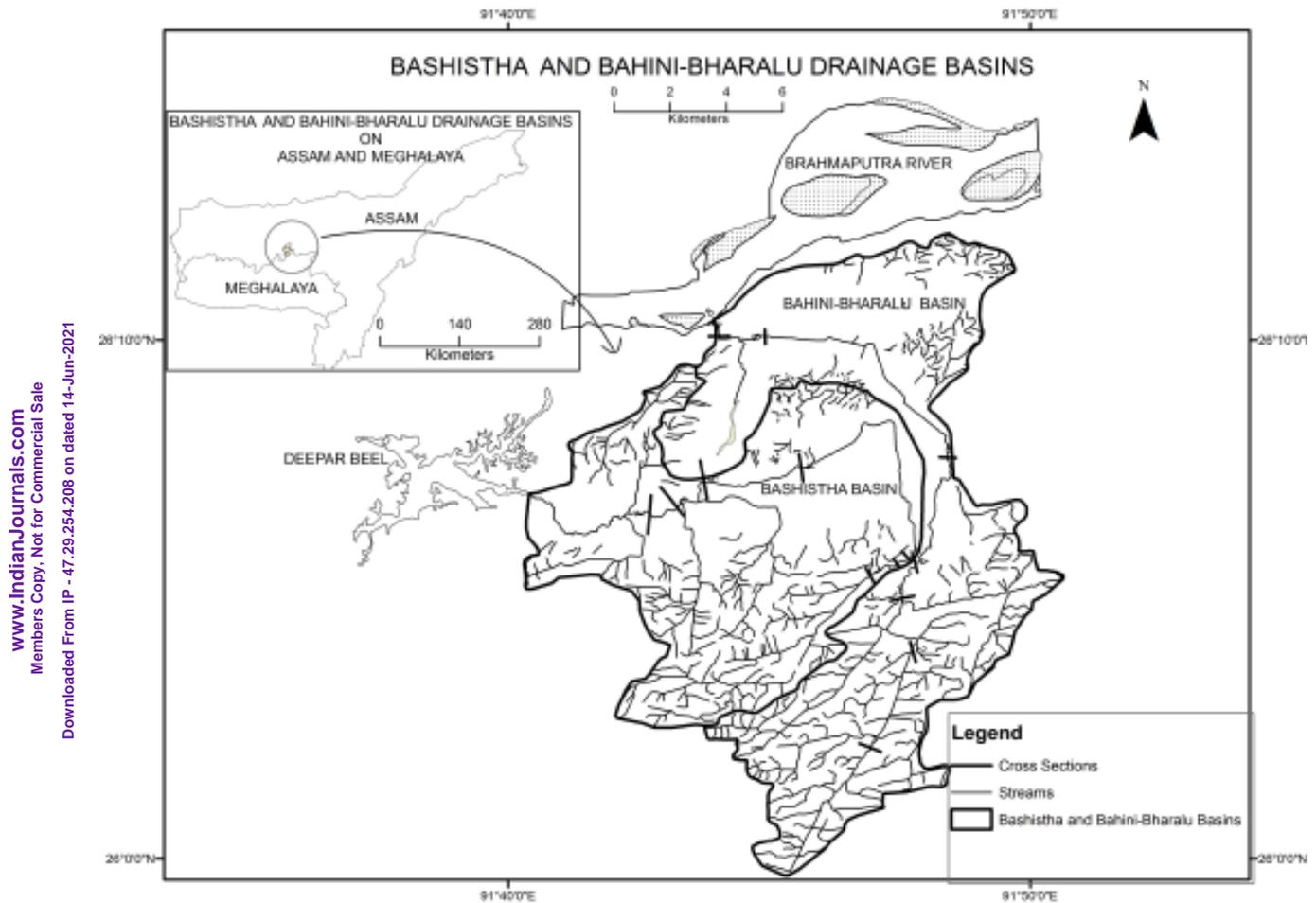


Fig 1: Location Map of the study area

3. Objectives

The objectives of the study are (1) to study the channel cross sectional shape patterns for better understanding of channel morphology and (2) to study the downstream hydraulic geometry of Bashistha and Bahini-Bharalu rivers as well as to analyze the fluvio geomorphic behaviour of both the rivers.

4. Database and methodology

The field survey (fluvio geomorphic survey) for the present research work has been carried out during

pre-monsoon (April, 2014) season. The study has been carried out in seven cross sections along the Bashistha river and in eight cross sections along the Bahini-Bharalu river in both upstream and downstream areas of both the rivers. In case of Bashistha river, Cross section 1 and Cross section 2 are located in upstream (in Garbhanga reserved forest, Assam) while the rests are located in downstream (within the Guwahati city, Assam). In case of Bahini-Bharalu river, Cross section 1, Cross section 2 and Cross section 3 are located in

upstream (in Myllem reserved forest, Meghalaya), while Cross section 4, Cross section 5, Cross section 6, Cross section 7 are located in downstream (within the Guwahati city, Assam) and Cross section 8 is located just before it merges with the Brahmaputra (in Guwahati, Assam).

The channel variables have been measured at all the cross sections of both the rivers at the time of surveying. For the surveying GPS, water current meter, theodolite and prismatic compass are used. Bed and bank materials are collected from all the gauging sites at the time of surveying and later on passed through laboratory analysis. To study the channel morphology the cross sectional profiles of both the rivers have been drawn based on surveyed data and analyzed.

The field data for all the cross sections have been tabulated, computed and processed to find out the channel fluid dynamics (velocity, discharge). The relationships of discharge to width, depth and velocity in downstream are shown with the help of the line of best fit for both the rivers. Correlation coefficient (r)s are calculated to examine the degree of relationship between the channel variables.

5. Analysis and Findings

5.1 Cross Valley Profiles and shapes

To study the channel morphology of Bashistha and Bahini-Bharalu rivers cross valley profiles have been drawn and analyzed. The profiles show the shapes and sizes of the river channels. 'The shape of the cross section of a river channel at any location is a function of the flow, the quantity and character of the sediment in movement through the section, and the character or composition of the materials making up the bed and banks of the channel.' (Leopold et al, 1964).

Table 1 and table 2 show the cross sectional parameters of each cross section of Bashistha and Bahini-Bharalu rivers. Width (w) is the horizontal straight distance of a cross section from water edge to water edge of both the banks. Depth is the vertical straight distance from the water level to the river bed. The cross sectional depth from one bank to the other of a channel is not uniform. Maximum Depth (d_{max}) is the vertical straight distance from the water level to the lowest point of the river bed. Mean Depth (d) is the average depth of all the points, measured at the cross section. Wetted perimeter (P) is the horizontal distance of the wetted portion of the

channel bed at a cross section, measured through rotameter. Bed width (w_b) is the horizontal straight distance of the cross section from bank to bank. Hydraulic radius ($R = A/P$) is the area of cross section divided by the length of the wetted perimeter.

Shapes of Bashistha river course

The cross section 1 has been measured in the Sandhyachal (Kshobhak) hill at $26^{\circ}05'36''$ N latitude and $91^{\circ}46'55''$ E longitude. Though the depth of water found to be very less here the cross valley profile indicates high amount of water flow during the monsoon season. In the left bank of the cross section there lays the Sandhyachal hill. The channel is wide V shaped and channel bed is composed of gravels, sand, silt and red clay.

The cross section 2 has been measured near Bashistha temple at Sandhyachal hill at $26^{\circ}05'41''$ N lat. and $91^{\circ}47'04''$ E long., just after the river taking a U turn through the hill range. The river bed is composed of big boulders. Channel depth and water volume are increased compared to the earlier one but valley width decreases. The bank and bed materials are united and firm in this cross section for which changes for valley deepening and widening is less here. Channel velocity is found highest (1.3 m/sec) in this cross section in response to water discharge and channel gradient.

The cross section 3 has been measured near forest beat office at $26^{\circ}05'48''$ N lat and $91^{\circ}47'29''$ E long. The shape of the cross valley profile is symmetrical. The channel width decreases and valley takes V shape. Channel depth and water volume found to be still less. The bed materials are composed of silt and clay.

The cross section 4 has been measured at $26^{\circ}07'36''$ N lat and $91^{\circ}45'35''$ E long, at Dakshingaon. In this section, the channel depth is more towards left bank. It is due to dumping of solid wastes in the right bank which has been observed at the time of field survey. Cross valley profile is asymmetrical. Broad or flat valley which is a characteristic of a river's old stage has not been observed here.

The cross section 5 has been measured at Jyotikuchhi, Dhapalia at $26^{\circ}07'20''$ N lat and $91^{\circ}43'41''$ E long. The valley floor flattens but does not widen. Valley sides are of concave slope. The channel depth and water volume has been increased. The bed materials are composed of silt and clay.

The cross section 6 is taken at Ahomgaon, near

the N.H.37 at 26°06'54" N lat and 91°43'07" E long. The valley floor flattens and widens with uniform depth. But valley sides are not concave. Apparently the section is looked like a U valley. The volume of water is also high in this section. The cross valley profile is almost symmetrical. The bed materials are composed of silt and clay.

The cross section 7 has been measured near SBOA School, at 26°06'39" N lat and 91°42'44" E

long, almost 5 kms ahead from the river mouth. The channel becomes narrower here. The channel depth is more towards left bank. It shows that there is a tendency of shifting course towards left as in the right bank earth filling for building purpose is occurred, which has been observed at the time of field survey. Cross valley profile is asymmetrical. The bed materials are composed of clay.

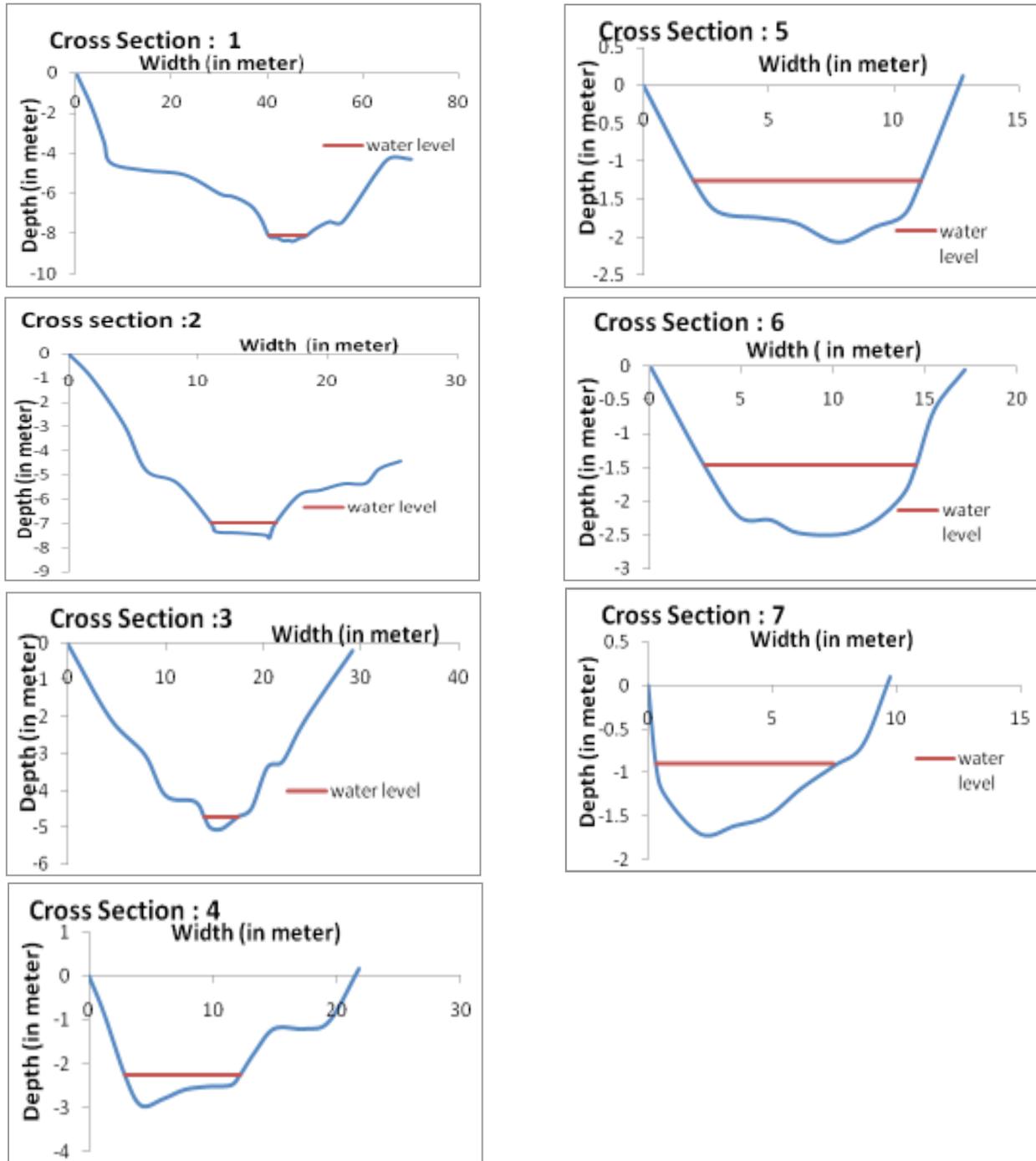


Fig 2: Cross profiles from upstream to downstream of Bashistha river.

Table 1: Cross sectional parameters of channel size, channel shape and channel fluid dynamics of Bashistha river.

| Cross Sections from upstream to downstream | Channel width (w) in meter | Mean Channel depth (d) in meter | Channel Cross sectional Area (A) in sq.m | Channel velocity (v) in m./sec. | Channel discharge (Q) in m ³ /sec. | Max. channel depth (dmax) in meter | Wetted perimeter (p) in meter | Hydraulic Radius (R) in meter | Bed width (wb) in meter |
|--|----------------------------|---------------------------------|--|---------------------------------|---|------------------------------------|-------------------------------|-------------------------------|-------------------------|
| Cross section 1 | 7.73 | 0.17 | 1.31 | 0.53 | 0.70 | 0.26 | 7.75 | 0.17 | 21 |
| Cross section 2 | 5 | 0.49 | 2.45 | 1.3 | 3.19 | 0.64 | 5.5 | 0.45 | 14.50 |
| Cross section 3 | 3.5 | 0.22 | 0.77 | 0.07 | 0.05 | 0.34 | 3.6 | 0.21 | 14 |
| Cross section 4 | 9.29 | 0.41 | 3.81 | 0.08 | 0.30 | 0.69 | 9.51 | 0.40 | 21.82 |
| Cross section 5 | 9.1 | 0.55 | 5.01 | 0.08 | 0.40 | 0.81 | 9.36 | 0.53 | 12.65 |
| Cross section 6 | 11.49 | 0.7 | 8.04 | 0.02 | 0.16 | 1.02 | 11.82 | 0.68 | 16 |
| Cross section 7 | 7.19 | 0.47 | 3.38 | 0.05 | 0.17 | 0.81 | 7.47 | 0.45 | 9.74 |

Shapes of Bahini-Bharalu river course :

The cross section 1 has been taken in the Merdu pahar, the upstream of Bahini –Bharalu river at 26°02'08" N lat and 91°46'43" E long. Channel is V shaped. The vertical side walls indicate active down cutting of the valley floor. The cross valley profile is symmetrical. Channel bed is composed of boulders, cobbles, gravels, sand and silt.

The cross section 2 has been taken in the Murilmi pahar at 26°04'02" N lat and 91°47'31" E long. The shape indicates structural control mainly the huge sized boulders. Channel is wide V shaped. The channel crosses a natural wide valley of the Meghalaya plateau, for which the channel width has been found wider than previous and preceding sections. The channel gradient is steep in both the banks. The cross valley profile is asymmetrical. Channel bed is composed of boulders, cobbles, gravels, sand and silt. The cross valley profile indicates high amount of water flow during the monsoon season and consequent erosion and transportation. "Channel size is not only influenced by the magnitude of discharge but also by the hydrologic regime. A river with a flashier regime and relatively high peak flows tends to develop wider channels". (Osterkamp, 1980, referred by Knighton 1984)

The cross section 3 has been taken at Umtringa at 26°04'59" N lat and 91°47'20" E long. Valley is wide V shaped. In this cross section, valley slope is steep in right bank as there exists a hill. The left bank is fully encroached and construction activities are going on for building houses by the encroached people,

which has been noticed at the time of field survey. The building materials (basically sand) are deposited in the river bank and bed and constitute a part of bank and bed materials. The other bed materials are silt and clay. Due to the deposition of sand in the left bank, the channel bed has been lifted there. The cross valley profile is asymmetrical.

The cross section 4 has been taken at Ganesh Nagar, Latakata at 26°05'42" N lat and 91°47'33" E long. In this cross section valley flattens but does not widen. Right bank is encroached by a gravel road. The channel depth and water volume has been increased. The bed materials are composed of silt and clay. The cross valley profile is symmetrical.

The cross section 5 has been measured at Rukminigaon at 26°07'43" N lat, and 91°48'12" E long where the river is mostly encroached. Channel width decreases and depth and discharge are the least among all the cross sections. The left bank is encroached by gravel road, while the right bank is encroached by multistoried buildings. Cross valley profile is almost symmetrical. The channel bed is composed of silt, clay, pieces of glasses, plastic and other solid wastes of Guwahati.

The cross section 6 has been measured at Ulubari, near G.S. Road at 26°10'04" N lat and 91°45'54" E long. Channel shape parameters and channel fluid dynamics have been increased. Cross valley profile is asymmetrical. Channel is characterized by broad valley with concave slope in the right bank. The channel bed is composed of silt, clay, plastic wastes etc. Channel depth is less in right bank due to dumping

of solid wastes in the right bank which has been observed at the time of field survey. The right bank becomes the PWD road.

The cross section 7 has been measured at Athgaon Kabarsthan at 26°10'04" N lat and 91°44'28" E long. The section is less encroached; however, solid wastes are present in both bed and banks. Cross valley profile is asymmetrical. Valley widening with concave slope of valley sides is not occurred which is a characteristic of the old stage of a river. Channel bed is composed of silt and clay. Channel depth is more in the middle.

The cross section 8 has been measured at

Bharalumukh, the river mouth, at 26°10'29" N lat and 91°43'48" E long. Channel width decreases remarkably and the valley takes V shape which is not a characteristic of the old stage. However, depth has been increased and velocity is almost same to the previous cross section. Profile is asymmetrical. Channel bed is composed of silt and clay. In the left bank of the cross section there exists the massive hard rock (monadnock) which is extended up to Nilachal hill. In the right bank of the cross section, earth filling has been done for protection of the Sankardev park boundary as well as the M. G. road.

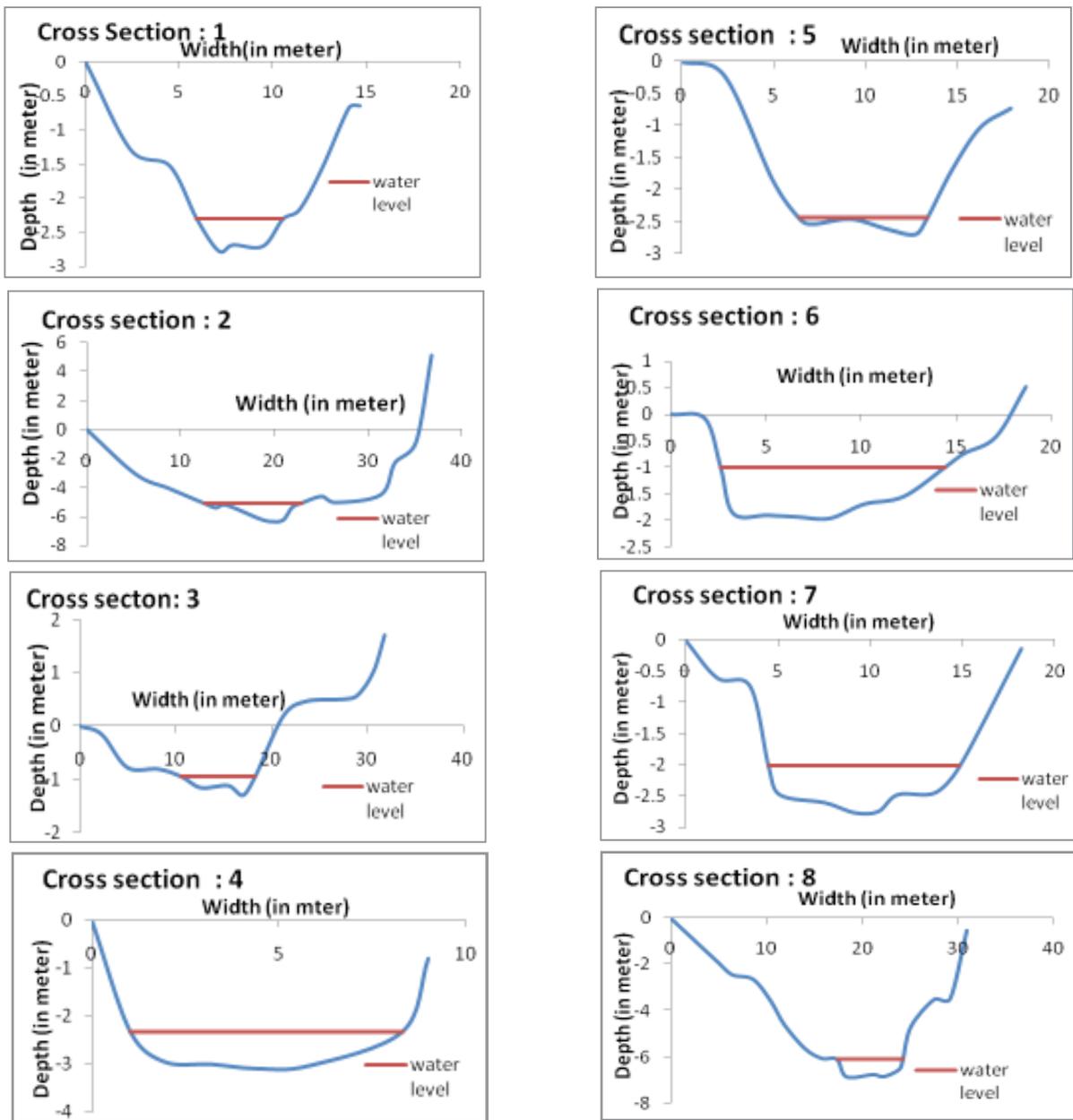


Fig 3 : Cross profiles from upstream to downstream of Bahini-Bharalu river.

Table 2 : Cross sectional parameters of channel size, channel shape and channel fluid dynamics of Bahini-Bharalu river

| Cross Sections from upstream to downstream | Channel width (w) in meter | Mean Channel depth (d) in meter | Channel Cross sectional Area (A) in sq.m | Channel velocity (v) in m./sec. | Channel discharge (Q) in m ³ /sec. | Max. channel depth (dmax) in meter | Wetted perimeter (p) in meter | Hydraulic Radius (R) in meter | Bed width (wb) in meter |
|--|----------------------------|---------------------------------|--|---------------------------------|---|------------------------------------|-------------------------------|-------------------------------|-------------------------|
| Cross section 1 | 4.6 | 0.42 | 1.93 | 0.34 | 0.66 | 0.47 | 4.76 | 0.41 | 11 |
| Cross section 2 | 10 | 0.63 | 6.30 | 0.35 | 2.21 | 1.29 | 11.04 | 0.57 | 27.50 |
| Cross section 3 | 7.69 | 0.24 | 1.85 | 0.14 | .26 | 0.35 | 7.76 | 0.24 | 29 |
| Cross section 4 | 7.28 | 0.68 | 4.95 | | 0.02 | .10 | 0.77 | 7.58 | 0.659 |
| Cross section 5 | 7 | 0.14 | 0.98 | 0.26 | .25 | 0.26 | 7.07 | 0.14 | 15.58 |
| Cross section 6 | 11.8 | 0.81 | 9.56 | 0.12 | 0.15 | 0.96 | 12.33 | 0.78 | 16.89 |
| Cross section 7 | 10.34 | 0.57 | 5.89 | 0.36 | 2.12 | 0.75 | 10.61 | 0.56 | 18.17 |
| Cross section 8 | 6.9 | 0.65 | 4.49 | 0.33 | 1.48 | 0.76 | 7.39 | 0.61 | 30.98 |

5.2 Hydraulic geometry

The analysis of relationships among water discharge (Q), velocity (v), channel depth (d), channel width (w), sediment load, channel slope, channel shape etc. is the hydraulic geometry of a channel (Sing ,S. 1999). The present research work aims to study the relationships of water discharge with channel width, channel depth and velocity in downstream case (i.e. along the courses of the rivers in downstream direction) of Bashistha and Bahini-Bharalu rivers. Downstream hydraulic geometry deals with spatial variation in channel properties at some reference discharge (Knighton, 1984). Discharge (Q) is the product of width (w), depth (d) and velocity (v). Discharge is calculated by the equation $Q = w.d.v$ where, w is the water surface width of a given cross section, d is the mean water depth of a given cross section and v is the flow velocity of water at a given cross section.

Downstream Hydraulic geometry of Bashistha river system

Downstream Discharge vs. Width relationship of Bashistha river : The fig 4(a) shows the downstream relationship between width and discharge by the regression equation $w = 0.864 + 0.022 Q$. The regression line of discharge vs. width shows the positive relationship i.e. width increases with

increasing discharge. However, the correlation coefficient (r) of discharge vs. width relationship is 0.071 which indicates that there is a very low relationship between the two variables in downstream.

Downstream Discharge vs. Depth relationship of Bashistha river: The fig 4(b) shows the downstream relationship between depth and discharge by the regression equation $D = -0.387 + 0.044 Q$. The regression line of discharge shows the positive relationship i.e. depth increases with increasing discharge. The correlation coefficient (r) of discharge vs. depth relationship is 0.111 which indicates that there is a very low relationship between the two variables in downstream.

Downstream Discharge vs. Velocity relationship of Bashistha river: The fig 4(c) shows the downstream relationship between velocity and discharge by the regression equation $V = -0.387 + 0.044 Q$. The regression line of velocity vs. discharge shows the positive relationship i.e. velocity increases with increasing discharge. The coefficient of correlation (r) of discharge vs. velocity relationship is 0.834 which indicates that there is a high relationship between the two variables in downstream. The high relationship among both the variables indicates that there occurs erosion, transportation and deposition in the channel.

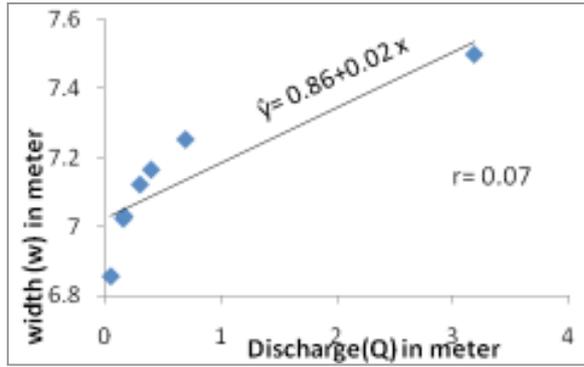


Fig : 4(a)

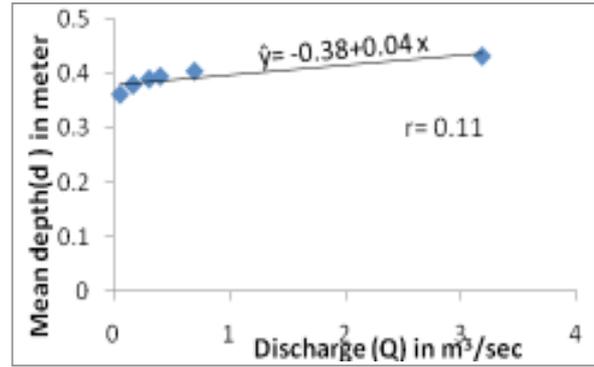


Fig : 4(b)

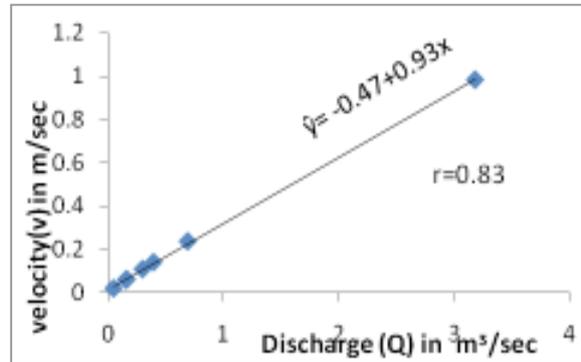


Fig : 4(c)

Fig 4 (a), (b), (c) : Downstream hydraulic relationships of discharge to width, depth and velocity along the Bashistha river.

Downstream Hydraulic geometry of Bahini-Bharalu river system :

Downstream Discharge vs. Width relationship of Bahini- Bharalu river: The fig 5 (a) shows the downstream relationship between width and discharge by the regression equation $w = .918 + .11Q$. The regression line of discharge vs. width shows the positive relationship i.e. width increases with

increasing discharge. The correlation coefficient (r) value of discharge vs. width relationship is 0.42 which indicates that there is a low medium relationship between the two variables in downstream. The low relationship reveals that towards downstream in most of the cross sections (cross section 3, cross section 4, cross section 5, and cross section 8) channel width is less.

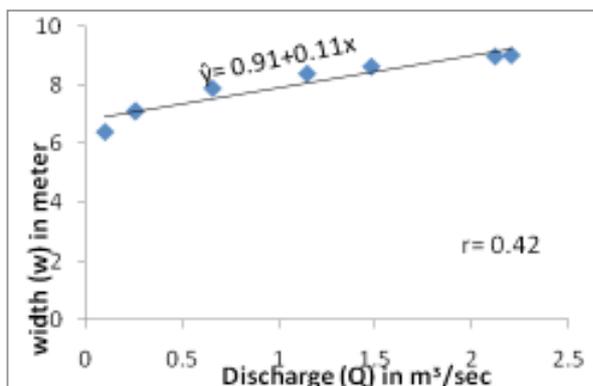


Fig: 5(a)

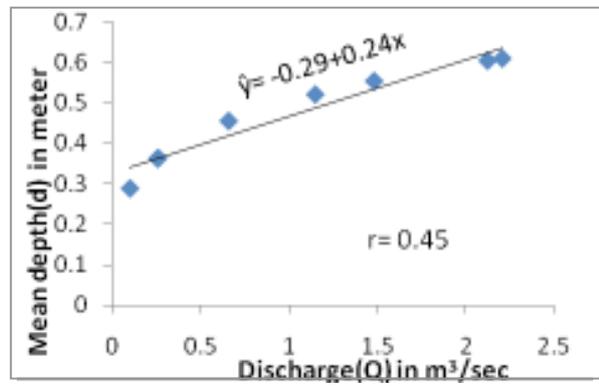


Fig: 5(b)

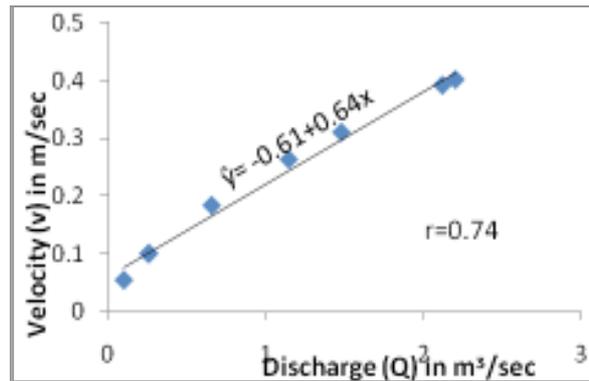


Fig: 5(c)

Fig 5 (a), (b), (c) : Downstream hydraulic relationships of discharge to width, depth and velocity along the Bahini-Bharalu river

Downstream Discharge vs. Depth relationship of Bahini-Bharalu river : The fig 5 (b) shows the downstream relationship between depth and discharge by the regression equation $D = -.298 + .243 Q$. The regression line of discharge shows the positive relationship i.e. depth increases with increasing discharge. The correlation coefficient (r) value of discharge vs. depth relationship is 0.457 which indicates that there is a low medium relationship between the two variables in downstream. The low medium relationship between Discharge and velocity reveals the probability of channel overflow in rainy season.

Downstream Discharge vs. Velocity relationship of Bahini- Bharalu river : The fig 5(c) shows the downstream relationship between velocity and discharge by the regression equation $V = -.619 + .647 Q$. The regression line of discharge vs. velocity shows the positive relationship i.e. velocity increases with increasing discharge. The correlation coefficient (r) value of velocity vs. discharge relationship is 0.747 which indicates that there is a medium to high relationship between the two variables in downstream; resulting in erosion, transportation and deposition in the channel.

6. Conclusion

The present study reveals that the consistency among the shapes of the cross sections has not been found as it normally seen in other rivers of the Brahmaputra valley. As the human interference is more along the courses of both the rivers for dumping of garbage and encroachment probably the expected shapes of the sections has not been found.

In case of Bashistha river, **discharge vs. width**

relationship shows very low positive relationship ($r=.071$) resulting in increasing velocity, hindrance in channel flow and consequent overflow. The **discharge vs. depth** relationship is also found to be very low ($r=.111$) resulting in the chances to backflow at the time of high rainfall. On the contrary, the **discharge vs. velocity** relationship shows high positive relationship ($r=.834$) indicating the existence of a turbulent channel. High velocity also results in erosion and transportation processes. In case of Bahini-Bharalu river, the **discharge vs. width** relationship shows low to medium positive relationship ($r=.423$) in response to narrowing the channel bed within the city. In respect of **discharge vs. depth** relationship also, the river shows low medium relationship ($r=.457$) resulting in the chances for over flow and back flow. However, the **discharge vs. velocity** relationship shows medium to high positive relationship ($r=.747$) indicating the existence of a turbulent channel during monsoon period.

The correlation coefficient (r) values of discharge vs. width and discharge vs. depth in both the rivers indicate improper fluvio geomorphic behaviour of Bashistha river reach and Bahini-Bharalu river reach in Guwahati city. This is probably due to the narrowing of channel width and rising of channel bed in downstream. Such fluvio geomorphic behaviour of the rivers indicates greater chances of channel over flow and consequent inundation of neighboring areas. As a whole the study provides scope for understanding the human interference on the behaviour of the two river systems in Guwahati and to find out the clues to maintain the overall environment of the city.

References

- Bhattacharya, N.N., 1981: Morphology of Towns of Assam, Mani Manik Prakash, Guwahati-781001, p25
- Knighton, D., 1984: Fluvial Forms and Processes, Edward Arnold, pp 101,105
- Leopold, Wolman, Miller, 1964: Fluvial Processes in Geomorphology, Dover Publications, INC, New York p 198
- Sing, Savindra, 1999: Geomorphology, Prayag Pustak Bhawan, Allahbad 211002, p 398
- Sarma, Siddheswar, 2003 : Meghlaya, The Land and Forest, A Remote Sensing Based Study, Geophil Publishing House, Guwahati-781018, p 6
- Taher and Ahmed, 2001: Geography of North East India, Mani Manik Prakash, Guwahati 781001, pp 26, 27

