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Channel Migration and Its Impact on Habitable Area of Lower Reach of River Manas in Assam, India

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Abstract

This study examines the implications of channel migration on the habitable area of the lower reach of the Manas River in Assam, India. The research aims to address the erosion and deposition processes associ-ated with the movement of the river channel. A sample size of 359 geographical areas near ten villages located along the riverbank was selected for the study. The research utilizes a literature review to under-stand the socio-economic impacts of the

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geomorphological system of the Manas River. The Brahmaputra River, of which the Manas River is a major tributary, also plays a significant role in the geomorphologi-cal processes of channel migration in the region. Climate change and human activities are identified as factors influencing channel migration and the habitable and cropped areas along the river. Regression analysis reveals a significant relationship between channel migration and the habitable and cropped are-as. The study concludes that channel migration in the Manas River has substantial implications for the region's geographical and socio-economic aspects. It underscores the need for comprehensive research utilizing GIS and remote sensing techniques to understand and effectively manage channel migration. The findings emphasize the importance of adopting sustainable development practices and preserving the ecological and socio-cultural significance of the Manas River.

Keywords

Manas River, Channel Migration, Cropped Area, Habitable Area, Climate Change.

1 Introduction

Channel migration is the important geomorphological process of channel morphology because river erosion leads to the process of lateral migration of river channels across its floodplain. Channel migration does not occur suddenly because it is the result of gradual erosion. After all, river erosion is one bank of the river and deposits its sediments along with opposite of the river. In the process of channel migration, channel geometry gives a broader explanation of channel migration because it includes channel geometry, channel fluid dynamics, hydraulic geometry, channel types, and channel pattern. These consequences of the geomorphological process determine the process of channel migration of rivers in a specific geographical region.

It is well known that channel migration develops the geomorphological process of the river in the context of grading the river channel through the stage of degradation where the process of river erosion works more than the process of a deposition while the river deposits erosion materials in the stage of aggradations. Both stages of degradation and aggradations determine the geomorphological structure of the river as well as channel migration. It also determines the pattern of the channel comprising to straight channel pattern; meandering channel pattern; braided channel pattern; anastomosing channel pattern, and a branching channel pattern. This mentioned pattern of the channel is the result of channel migration. Based on the above short introduction to channel geomorphology, it can be emphasized that both erosion and deposition

determine the pattern of channel migration, but the geomorphological structure is associated with channel fluid dynamics because both are the important factors of channel migration as well as affect each other.

In North-East India, the Brahmaputra River is the major river of India and the Northeast region because the Brahmaputra River is the lifeline for the fertile plain of Northeast as well as well known for its flood. Brahmaputra river gives an important role in both erosion and deposition in its catchment areas as well as its fluid dynamics are the result of the geological structure of rocks in the cross-sectional and longitudinal profile of Brahmaputra River in the Northeast (Bristow, 1987). It has been found that the application of remote sensing (RS) and geographical information system (GIS) is an important tool for observing the pattern of channel migration in historical sequences of geomorphological processes. It is observed that the Khowai river is the important river of Tripura in the Northeast, and this river follows the geomorphological structure of its catchment areas in Tripura. It is also found that the Khowai river affects the pattern of land use in the context of cultivation and human habitation in Tripura in the Northeast (Debnath et al.2017, pp.197-210). Based on the study of the channel migration in Subanshiri river in Assam through mapping with Remote Sensing (RS) and Geographical Information System (GIS) show that there are historical sequences in the mechanism of channel migration in Subanshiri river in Assam. As well as it largely affects the land utilization pattern and habitable area in the Northeast (Gogoi and Goswami,2014, pp.1113-1120). In North India, Ganga is an important river of India and there is large importance of Ganga River in the context of its geographical and socio-economic impact in India. It is observed that the Ganga River gives an important role in the geomorphological process of channel migration with its branches from origin to fall in the Bay of Bengal. It is observed that there are geomorphological diversities in the catchment of the Ganga River because channel migration of the Ganga River influences the land utilization pattern in North and East India (Mukharjee & Pal, 2018, pp.2281-2203). Yamuna river is the important branch Ganga River and is confluent with the Ganga River in Prayagraj in Uttar Pradesh. There are differences in the structure of channel morphology between the Ganga and its main branch Yamuna River developed river valley due to the process of erosion and deposition on its way (Ali et al. 2019, pp.367-375).

2 Review of Literature

Based on the above prescribed concise introduction about channel migration, it can be realized that channel migration is led by channel fluid dynamics where bedrocks of rivers keep an

important role in the determining geomorphological structure of the river. In the context of India, it is observed that there are geographical diversities in the pattern of the geography of rivers in India, as well as there is socio-economic and geographical importance of every river in India. Therefore, this section emphasizes the review of literature in the following sections:

- Geography of Manas River
- Channel Migration of Manas River
- Importance of Manas River

"The river Manas, which forms one of the most important snows fed originated river of Assam has a total length of 376 kilometers (flows about 272 kilometers in Bhutan and then 104 kilometers through Assam) before it joins the mighty Brahmaputra River at Jogighopa (90°34'18" E and 26°11'57.4" N). In Assam, the river is bifurcated at Mothanguri (90°57'41.9" E and 26°46'90.2" N) to give rise to a tributary named Beki which passes through the Manas National Park (26°35' to 26°50'N and 90°45' to 91°15'E. Boulders, cobbles, pebbles, gravels, and sands are the major characteristic feature of the river Manas at its upstream, providing suitable habitat for spawning and rearing of coldwater fishes. On the contrary, the downstream is bedded with mud and sand providing habitat for plain dwellers fishes" (Sharma & Sharma, 2017). The Manas River basin has covered an area of 31,400 sq. km and it is an important river of Assam due to its geographical importance. The mean bifurcation ratio of the Manas River is 3.8, which indicates that there is a cordial impact of geological structure on the basin of Manas River. Additionally, drainage density is around 0.8 per km^2 and is elongated in shape. The length of the Manas river's overland flow value of the basin is 0.6 which indicates high relief (Nongkynrih &Husain, 2011, pp.647-654). Geography of Manas River keep an important role in the socio-economic and geographical development of Assam but is measured water quality index (WQI) of Manas River with two indicators – extremely poor and poor and it is found that water quality index is poor, and it created a problem for the health of human in its habitable area of Assam (Singh et al.2018, pp.1-10). It is observed that the geography of the Manas River is affected by climate change because the biodiversity of the Manas River is so critical due to climate change in the geographical region of Manas River which is influencing the Manas wildlife sanctuaries and hydrology of the upper part of Manas River. The changing pattern of the hydrology of Manas River is affecting the channel migration in geographical areas of Manas River because it is affecting the cycle of erosion and deposition in Manas River (Bora, 2018, pp.157-168). The pattern of channel migration of Manas River is being affected

by climate change on both living and non-living organisms of Manas River. Additionally, it is also observed that the geography of channel fluid dynamics of Manas rive is largely affected by fluid dynamics of Manas River because the impact of climate change created a transformation in the pattern of erosion and deposition of the river valley of Manas River (Bora &Kar 2014, pp. 166-177). Based on the above-prescribed review of literature, it can be realized that the Manas River is the important river of Assam in the Northeast. There is geographical and socio-economic importance of Manas River in Assam, but the consequences of climate change produced a geographical problem for the hydrology of Manas River with its channel migration. The mentioned review of the literature shows that consequences of climate change produced a transformation in the cyclic process of erosion and denudation of Manas River because both changing patterns of hydrology are affecting the fluid dynamics of Manas River as well its channel migration. In these consequences, it is also observed that changing pattern of the geography of Manas River is cordially associated with biodiversity and human habited area in the catchment area of Manas River in Assam. Therefore, the present Study tries to examine the trends of channel migration and its impact on the habitable area of the lower reach of river Manas in Assam.

3 Methodology: Objectives, Study Areas, and Analysis

Based on the above-prescribed review of literature, it can be realized that there is a geographical and socio-economic impact of the geomorphological system of the Manas River in Assam. Additionally, it is also observed that the pattern of channel migration is associated with the geomorphological structure of the geographical area of Manas River in Assam. It is also found that the geomorphological feature and hydrology of Manas River are affected by climate change and the consequences of climate change affect the biodiversity of geographical areas of Manas River as well as its cropped and habitable region. The phenomena of climate change are the result of human activity in the geographical area of the Manas River because the pattern of development is influencing the geography of the Manas River in Assam.

3.1 Research Questions, Objectives, and Study Area

3.1.1 Research Question

. . Based on the review of the literature and the nature of the study, there are the following research questions:

1. What are the geographical characteristics of the Manas River in Assam?

2. What are the historical sequences of channel migration of the Manas River in Assam?
3. How does the nexus of geomorphological structure and hydrology system affect the channel migration on the Manas River?
4. What is the impact of climate change on the pattern of channel migration on the Manas River?
5. What is the extent of the impact of channel migration of the river Manas on habitable and cropped area of the study region ?

3.1.2 Objectives

. . The main objectives of the study are-

1. To study the changing geomorphological characteristics of the lower reach of the river Manas through the channel migration.
2. To study the extent of the impact of channel migration of the river Manas on the habitable and cropped area of the study region.
3. To give suggested prescribed policies for the use of applied geomorphology in the study area of the region.

Based on the above-mentioned objectives of the research paper, the first objective of the study is justified by related literature about geomorphological characteristics of the Manas river through channel migration under the approach of retrospective to prospective study design because it can be emphasized that the present pattern of geomorphological sequences of Manas river is the result of its past geographical incidents which determine to present phenomena of the geomorphological process of channel migration because the present is key to the past according to James Hutton. In these consequences, the pattern of channel migration can be better explained by a review of literature in historical contexts about the geomorphological cycle of the Manas River.

Additionally, the second objective is justified by the review of related literature about the impact of channel migration of Manas River on the habitable and cropped area of the study region in the context of the present scenario with a focus on phenomena of climate change. Finally, it also gives prescribed policy for the use of applied geomorphology because the impact of channel migration may be better explained by the use of applied geomorphology on the ground level as well as the method and approach of applied geomorphology is suitable for understanding the geographical and socio-cultural impact of channel migration on human life. It is observed that human activity influences the geographical feature under the approach of

possibilism of nexus of human and environment where the role of the human is subject of discussion in the context of applied geomorphology.

3.1.3 Geography of Study Area

. The study area extends from the confluence zone of 3 different tributaries of River Manas near Hagrama Bridge (Lat.- 26º33′42″N, Log. 90º34′08″ E), BTAD Assam, India to the confluence zone with the river Brahmaputra at Chatla (Lat- 26º14′27″ N, Log.-90º40′ 50″ E), Barpeta Assam, India

Fig. 1 : Map of Manas River

Source:https://encrypted tbn0.gstatic.com/images?q=tbn:ANd9GcQBL5E8HCHSlkS7ITSVdaWFEtLAURFjPNfq7g&usqp=CAU

4 Result and Analysis

4.1 Geomorphological Feature of Channel Migration of Manas River

Based on the above-mentioned objectives of the study, it can be realized that there is needed to give depth analysis of channel migration and fluvial system of Manas River in Assam because Manas River is the important tributary of the Brahmaputra River in Assam. Manas River constituted a total of 5.5 percent of total flows of Brahmaputra River as well as recorded a maximum discharge of 7600 cubic meters. In these consequences, a fluvial system of Brahmaputra River affects the fluvial system and channel migration of in Northeast because

Manas River is an important river system on the North bank of Brahmaputra River. According to Sarma (2005), channel migration is an important part of the Brahmaputra and Manas River because the channel is expanding and segregated in its geographical area with the Manas River. The pattern of meandering is being changed by channel migration because of neck cut off as well as progressive shifting at the meander bends. The braiding index of the Brahmaputra and Manas River has been increasing from 6.1 in 1912- 1928 to 8.3 in 1996. During the twentieth century, the total amount of bank area lost from erosion was 868 km^2.

In this study, it is found that there are sequential dynamics of rivers of Brahmaputra including to Manas River. Based on the survey of Geographical Information System (GIS) for the years 1976 and 1987 to 2016 showed that channel migration is shaping and reshaping the morphology of the rivers of the Brahmaputra River. The image of rivers of Brahmaputra rivers gives a picture of morphological changes in the geomorphological system of rivers. It is observed that process of erosion, meandering activities, breaches, segregation, and confluences of the river are shaping the pattern of migration and morphological changes in Manas River in Assam (Sah & Das 2018, pp. 441-448). Manas River is confluent with the Brahmaputra River, but it created a long-term erosion in its catchment area. Based on the data about channel migration from 1976 to 2018, it is found that the confluence of the Manas River surrounded several villages like Mainbari and Chenglidiya with Baghbor hills. The aggressive nature of the river along the section has eroded 181 sq. km of land from 1976 to 2018. The rate of land loss along the section is nearly 4.3 sq. km/year, which is significant as the floodplain dwellers largely depend on the meager assets (Sah et al. 2022).

Based on the analysis of the above-related literature about changing geomorphological characteristics of river Manas through channel migration, it can be following remarks:

i. The geomorphological characteristic of the Manas River is the result of a geomorphological cycle of erosion and deposition in the lower region of Assam because Manas is the important branch of the Brahmaputra River. As well as geomorphological characteristics of Manas River are associated with the geomorphological feature of Manas River because the result shows that the fluvial system of Manas River is largely affected by a pattern of vertical erosion or downcutting, valley widening, and valley lengthening. These three are the important phenomena of the geomorphological cycle of erosion of channel migration.

ii. Secondly, the concept of the gradient is an important part of the way of channel migration of Manas River because it is found that channel migration of Manas River is the result of stage of degradation and stage of aggradations according to the cycle of erosion and deposition. It is found that the Manas River contributes to minimizing erosion in the upper course followed by maximum erosion in the middle course and minimizing erosion in the lower course. In these consequences, Manas River developed its geomorphological features with antecedent valley and superimposed valley in their geographical way in Assam.

iii. The channel migration of the Manas River largely affects the hydraulic geometry of the Manas River because it produced changes in the cross-sectional area of the Manas River. In these consequences, stream discharge is the result of the following equation:

$$Q=w*d*v$$

Where, Q is stream discharge, w =width of the channel, d= depth of the channel, and v =average velocity of the channel.

This equation determines the geomorphological pattern of channel migration of Manas River in Assam because channel migration affects the geomorphological feature of fluid dynamics, channel configuration, sediment load, and bedrock and structure of the channel.

Based on the above-prescribed analysis, it can be realized that channel migration of Manas River is the result of channel types included to bedrock channel and alluvial channel is the mainstream of Manas River because both types of channels are an important geomorphological feature of channel fluid dynamics of Manas River.

4.2 Impact of Channel Migration of the river Manas on Habitable and Cropped area of the study region

Based on the review of literature, it is observed that there is geographical and socio-economic importance of Manas River in Assam because the geographical area of Manas River is associated with the biodiversity of Manas River in cropped and habitable areas of Manas River. Additionally, the biodiversity of the Manas River is the lifeline of Manas sanctuaries in Assam, but phenomena of climate change affect the geographical and socio-economic importance of Manas River in Assam (Saikia et al.2015, pp.180-196). In Manas River, people of lower Assam are cordially associated with their livelihood in biodiversity because people of surrounding

Manas River use the resources of Manas River for cropping and fisheries because both fisheries and cropping work as a pull factor for migration of people from the rest of Assam to the catchment area of Manas River. As well as it is also observed that the occupation of fisheries determines the settlement pattern in the lower reach area of Manas River because fisheries are the major occupation of people in the surrounding geographical area of Manas River in Assam. Additionally, it is also observed that phenomena and climate change and global warming affected the habitable and cropped area of Manas River in Assam (Jabeen et a. 2016). The geographical area of the Manas River is habitable for golden langur in Manas's sanctuaries because Manas's sanctuaries give the platform of bio-diversity due to its geographical features and socio-economic importance. Manas River is being largely affected by phenomena of climate change and global warming due to human activity in the geographical area of Manas River which is affecting cropped and habitable areas of Manas River in Assam (Wayre 1968, pp.337-339).

4.3 Regression Model

In these consequences, the impact of channel migration of the river Manas on the habitable and cropped area of the study region through a regression model. In this study, channel migration is a dependent variable while cropped and habitable areas are predictors (constant) in the context of the nexus of channel migration and cropped and habitable areas of the study region of Manas River Assam.

The table shows that PASW indicates assigning numerous models in one regression command. Here, the R-value is 0.752, as well as R, is the square root of R-Squared. The value of R-Square is .565 which means about 56.5 percent variation in the dependent variables. The value of adjusted R Square is 0 .562. It tries to give a more realistic picture of the fit of regression value to estimate the R-squared for the population. Here, channel migration is the dependent variable and habitable and cropped areas are the predictors(Constant) variables (Table 1).

Table 1. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.752[a]	.565	.562	3.93919

a. Predictors: (Constant), Cropped area , Habitable

There are sums of squares associated with three sources of variance –Total, Model, and Residual. R-Square is obtained by dividing the regression Sum of Squares by Total Sum of Squares. Here, the values of the Sum of Squares are 7168.376 for regression and 5524.120 for residual while the value of the mean square is 3584.188 and 15.517 for regression and residual, respectively. The F-value is 230.982 and the significant value is 0.00, which is less than 0.05 which indicates that there is a significant impact of channel migration on cropped and habitable areas of Manas River in Assam (Table 2).

Table 2. ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7168.376	2	3584.188	230.982	.000[b]
	Residual	5524.120	356	15.517		
	Total	12692.496	358			

a. Dependent Variable: Channel migration

b. Predictors: (Constant), Cropped area, Habitable

The table of coefficients shows the value t and significance, it indicates that there are significant coefficients of channel migration on the habitable and cropped area in the study region of Manas River in Assam (Table 3)

Table 3. Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.364	1.120		.325	.745
	Habitable	1.277	.073	.886	17.550	.000

	Cropped area	-.334	.082	-.205	-4.055	.000
a. Dependent Variable: Channel migration						

In this study, it is randomly selected a total of 359 geographical areas of, near ten villages surrounding located on the bank of the Manas River. There is a geographical and socio-economic impact of the Manas River in the lower reach of Assam. Additionally, it is also observed that channel migration largely affects human activity because human is changing the geographical feature and biodiversity of the Manas River in Assam. It is the result of the wishes and abilities of humans regarding to access the resources of the Manan River for creating the socio-economic and cultural landscape in the geographical region of Manas River in its lower reach. Therefore, it concluded that there is a significant impact of channel migration on cropped and habitable areas of the study region of Manas River in Assam.

4.4 Conclusion and Recommended Policies

Based on the above-prescribed result and analysis of the present study, it can be realized that the study area of this paper is the subject of discussion of both physical and human geography where physical geography explains the geomorphological characteristics of the Manas River while human geography focuses the socio-economic and geographical impact of Manas River in the study area. It is observed that geomorphological characteristics are the result of the geomorphological cycle of Manas River along with Brahmaputra River because Manas River is the main branch of Brahmaputra River as well as gives an important geographical role in the geomorphological features of Brahmaputra River in Assam.

Apart, the pattern of channel migration of Manas River is the result of hydrology and fluvial system of Manas River because it is observed that topography of a geographical area determines the geomorphology of Manas River because Manas River developed river valley due to changing pattern of channel migration in their geographical areas of Assam. It is also found that the geomorphological feature of the Manas River is associated with the geographical importance of the Brahmaputra River because both rivers determine the channel migration through the pattern of erosion and deposition in the geographical areas of Assam. Manas River developed the river valleys due to its long historical sequences of channel migration in its geographical areas of Manas River in Assam.

Additionally, it can be concluded that there is geographical importance of Manas River with its socio and cultural importance in Assam because Manas River is the lifeline of Manas

sanctuaries due to its geographical diversity. The geographical area of the Manas River gives a broad geographical wetland to human and species for surviving in the geographical areas of the Manas River in Assam, but it is observed that phenomena of climate change and global warming is the major causes of reducing the importance of biodiversity in the geographical areas of Manas River due to human activity. Therefore, geomorphological features of the Manas River are being affected by the activity of humans because cropped and habitable areas are affecting the geomorphological feature of Manas River as well as changing pattern of channel migration is also affecting the cropped and habitable areas of Manas River due to largely erosion and denudation in the geographical area of Manas River in Assam.

Based on the above concluding remarks, it may be recommended that there is needed to depth study and research about the channel migration of Manas River through GIS and remote sensing because both GIS and remote sensing-based data can give a better picture for the use of applied geomorphology for ensuring the geographical and socio-cultural importance of Manas River in the context of the sustainable development approach. The sustainable development approach gives responsibility and duties to human for work with the eco-friendly approach to establish a balance between the concept of environmentalism and possibilism because human is responsible for both destruction and construction of the environment. Therefore, both government and non-government organizations should encourage to people for sustaining the geographical and socio-economic importance of the Manas River in Assam.

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