Understanding the Complexity and Dynamics of Anastomosing River Planform: A Case Study of Brahmaputra River in Bangladesh

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Abstract

The Brahmaputra is one of the world's largest rivers, ranking fifth in terms of average discharge. Therefore, to dissipate it's enormous energy, it is severely braided with multiple complex pathways. Although, this river is typically classified as a braided river, however due to its multi-channel properties over alluvial plains, it has recently been classified as an anastomosing river. Additionally, the morphology of the Brahmaputra River is random in nature due to its high flow variability and bank erodibility. It's anastomosing planform varies in response to seasonal water and sediment waves, resulting in an extremely complex morphology. The goal of this study is to investigate the anastomosing planform entropy of the Brahmaputra river as a measure of disorder and how it relates to the energy expenditure by the river systems on alluvial landscape.

Brahmaputra River employs the anastomosing river principle

On alluvial plains, anastomosing rivers are a type of multi-channel river. They are most frequently identified at the local level in low-energy circumstances. Rather than emphasizing channel vegetation, anastomosing rivers should be classified according to their floodplain geomorphology and channel structure. This means that anastomosing rivers' channels may be straight, meandering, or braided. Avulsions, or structures that redirect flow and create new channels in the floodplain, are frequently used to create anastomosing rivers. Anastomosing rivers form in one of two ways as a result of avulsion: either bypasses are constructed and older channel belt segments remain active for a period of time after bypassing; or the redirected avulsive flow is disconnected, resulting in simultaneous erosion of numerous floodplain channels. Rapid base level rise could facilitate anastomosis by encasing a significant amount of overbank deposits and laterally related channel sand masses. It may contain fine-grained avulsion deposits that extend laterally and completely surround the channel sandstones. Ribbon-like geometries are typical of anastomosing channel sand bodies, whereas overbank deposits are defined by an abundance of crevasse splay deposits and thick natural levee deposits. According to the criteria outlined above, the Brahmaputra River is an anastomosing river that provides an ideal environment for using complex network theory and gaining a better understanding of physical processes occurring in alluvial landscapes.

Anastomosing function

Anastomosing function was developed employing a similar notion to that of a river basin's width function (see details in reference 1 and 2). Rather of computing the number of crossed channels as a function of the distance from the outlet, we examine the distance from the mouth of the Brahmaputra River (see details in figure 1).

Methodology (Entropy)

Entropy was used to determine the complexity of the anastomosing function. Entropy was used to determine the complexity of the anastomosing function. In particular, we investigated the usefulness of entropy as a measure of planform complexity using Approximate entropy (ApEn) and Sample entropy (SampEn) (see details in reference 1 and 4). .

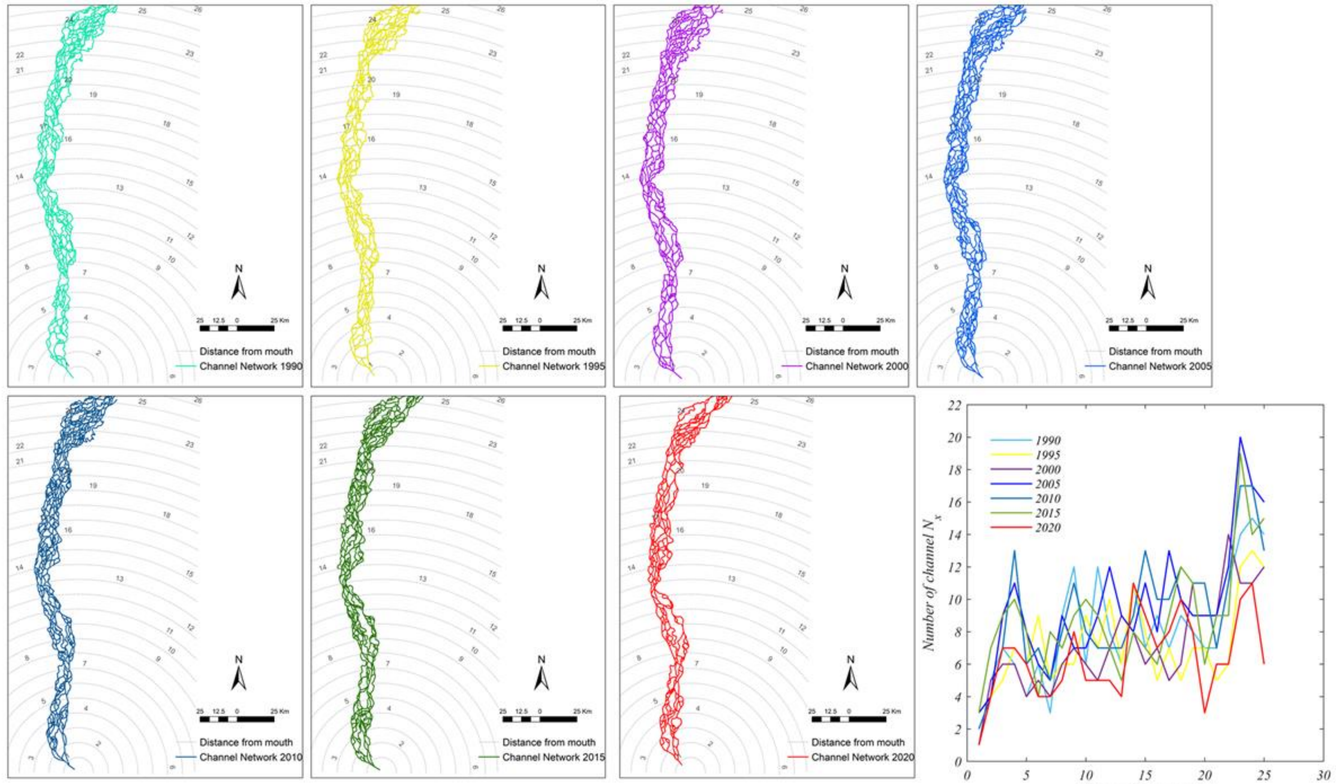

Figure 1. Calculation of the Brahmaputra River's anastomosing function from 1990 to 2020 (interval of five years).

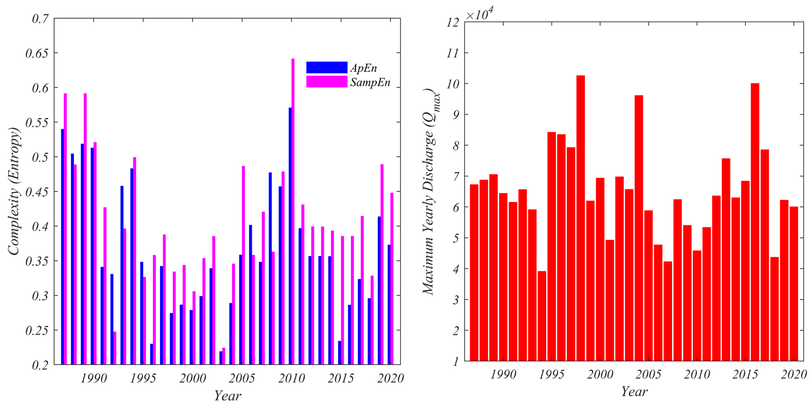

Figure 2. Entropy and annual maximum discharge of Brahmaputra River.

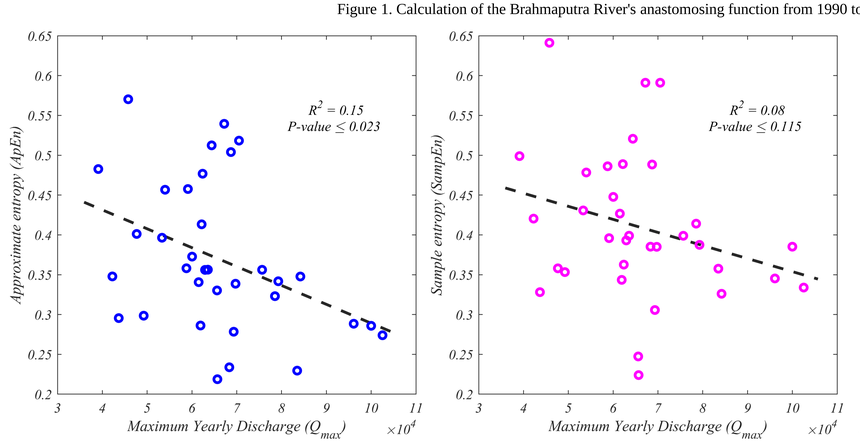

Figure 3. Correlation between entropy and annual maximum discharge.

ApEn vs Q_{max}	
Multiple R	0.390
R Square	0.152
Adjusted R Square	0.126
Standard Error	0.088
Observations	34

Regression Statistics

SampEn vs Q_{max}	
Multiple R	0.275
R Square	0.076
Adjusted R Square	0.047
Standard Error	0.090
Observations	34

ApEn vs Q_{max}	Coefficients	Standard Error	t Stat	P-value
Intercept	0.526	0.067	7.878	5E-09
Q_{max}	0.001	1E-06	-2.397	0.023

SampEn vs Q_{max}	Coefficients	Standard Error	t Stat	P-value
Intercept	0.518	0.068	7.581	1E-08
Q_{max}	-2E-06	1E-06	-1.620	0.115

Acknowledgement

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Study Area: Brahmaputra River

Conclusion and Future work

1. We introduced the anastomosing function in this study and investigated the planform complexity of the Brahmaputra River using the entropy of the anastomosing function.
2. The correlation between entropy and annual maximum discharge demonstrates promising results, implying that entropy can be used to understand the dynamics of anastomosing rivers such as the Brahmaputra.
3. We demonstrate that entropy may be a valuable metric for understanding and quantifying the complexity of anastomosing rivers such as the Brahmaputra River. Additionally, approximate entropy (ApEn) is a more accurate statistic than sample entropy (SampEn).

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