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Research Article

ENVIRONMENTAL IMPLICATIONS OF ANTHROPOGENIC ACTIVITY ON GOMTI RIVER MORPHOLOGY AT LUCKNOW, THE GANGA PLAIN, INDIA

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ABSTRACT
The study of human-environment interaction helps us to understand the environmental implications of anthropogenic activities on the natural system. Present condition of the river is becoming perilous day by day due to various human activities. This is due to an exponential increasing of the human population in its urban area that catalysis these adverse effects. The human impact on the river morphology is displayed by the building of barrage and bridges, bank stabilizations, artificial levee and human settlements on the floodplains. It can be concluded that natural characteristics of the Gomti River is ruined by the several human activities in the name of development. This study acts as a key to enrich our understanding of how humans alter rivers and to protect these rivers for future generations.

Key Words: *Gomti River, Anthropogenic activity, Lucknow, Ganga Plain*

INTRODUCTION

The Human environment interaction explains how people adapt to the prevailing environment and also the modifications in the environment to suit their demands. People change the river environment by making artificial levee, Bridges and Barrage. Although, these activities are important for the development but they have adverse affect on natural characteristic of river. They have intervened in the natural course and behavior of river. Since before recorded history- to manage the water resources, to protect against flooding or to make passage along or across river easier. From the late 20th Century, River Engineering has environmental concerns broader than immediate human benefit and some river engineering projects have been concerned exclusively with the restoration or protection of natural characteristics and habitats. Gomti River is encroached for Human settlement as is evident from the establishment of Gomti Nagar and Gomti Nagar extension which have restricted the normal flood plain area of Gomti River. This apart, river Gomti collects large amounts of human and industrial pollutants (Srivastava and Srivastava 2011) as it flows through the highly populous areas (18 million approx) of Uttar Pradesh.

Since independence a large number of developmental and protective works have been taken up in different river basins all over the country. The developmental works include construction of irrigation, hydro-power, multipurpose water resources projects and navigation works. The protective works include flood embankments, marginal embankments, channel improvements and anti-erosion works like spurs, revetments, bank pitching etc. Most of the protective works have been taken up on Gomti river system where the problem of river instability and consequent bank erosion are particularly severe.

It is being increasingly realized that the morphological study of river needs to be properly documented and analyzed and the unique characteristics of each river should be understood so that the responses of the river due to any encroachment in the flood plain and more in the case of future man-made structures may be anticipated and preventive measures as considered necessary may be planned before hand.

Human activities are creating the interferences between nature and human beings. The importance of these activities is reflected in the Geomorphology Symposium on the *Human Role in Changing Fluvial System* held recently. The main objective of this study is to present an overview of the human impact on the Gomti River. The study is significant in the sense that this river plays a vital role for millions of people living in Lucknow.

Study Area

Gomti River and Its Geomorphology

The Gomti River flows in the northern part of the India and is a major tributary of the Ganga River system. It originates from a swampy area in the Piedmont Zone in District Pilibhit near Puranpur, located about 50 km south of the Himalayan foothills at an elevation of about 186 m above sea level (latitude 28^0 34´ and longitude 80^0 07´) and ultimately meets the Ganga River. Total length of the river is about 900 km and it drains a catchment area of about 30,437 25 km^2 located in an interfluve region of the Ganga and Ghaghara Rivers. The basic information about the Lucknow urban centre is given in Table1.

Geomorphology of Lucknow

Lucknow is located on both banks of the Gomti River flowing through the central part of the Ganga Plain in the region of Ghaghara-Ganga interfluve. The Gomti River is an alluvial plain river, which is fed by ground water and sheet runoff. In the Lucknow area, the Gomti River exhibits meandering characteristics, which are highly distorted indicating neotectonics activity in this region. This area exhibits three different geomorphic surfaces with their characteristics features, namely. The Upland Terrace Surface (T_2) or Upland Interfluve, River Valley Terrace Surface (T_1) and Active Flood Plain Surface (T_0) (Shukla and Bora 2003). The upland surface is described as Older Alluvium or Bangar. The ponds and lakes are usually associated with rained natural leeves and alluvial ridges which are often ancient sites of human settlements. Deposits of T_2 surface are seen in cliff sections, exposed (Kanker) horizons. T_1 surfaces are located within the Gomti River Valley, above the level of annual floods of the river. The T_1 surface is 5-10m above the T_0 surface; T_2 surface is about 15- 20 m above the T_1-surface. The geomorphology of Gomti River with in Lucknow area is displayed in Figure1. Incision of the Gomti river and its valley has been studied using characteristics of longitudinal profile, escarpment heights and valley morphology and channel sediment characteristics by (Thakur *et al.* 2009; Dutta *et al.*, 2011).

The Cis- Gomti area exhibits mostly higher surface. The main residential areas are located on Upland Terrace Surface T_2 free from annual river floods. The Upper part of T_1 surface was developed into parks and gardens with few monuments on rained grounds. The Bara Imambara is a fine example of using T_2 and T_1 surfaces to create split-levels. The T_2 surfaces extend in Chowk, Aminabad, Charbagh and Cantonment areas with general altitudes of about 124 m above mean sea level. Husainabad, Kaiserbagh and Hazratganj are located on degraded T_2 and T_1 surfaces. Many new settlements in Lucknow, namely Nirala nagar, Maha nagar, Gomti Nagar Extension and parts of Gomti Nagar (Trans-Gomti area) are located on the T_1 surfaces. During planning of these new residential areas, no consideration was given to geomorphic features and water outlets. Often natural drainages have been blocked and depressed areas with small ponds were converted to residential complexes without giving consideration to the water movement during monsoon rains (Singh *et al.*, 2005).

Geomorphology of a river basin describes the status of topographic features of the surfaces and streams, and its relationship with hydrology provides the geomorphological control on basin hydrology (Jain and Sinha, 2003; Rai *et al.*, 2009).

MATERIALS AND METHODS

In present study the methodology has been divided into two parts. The first part deals with the collection of basic information of the study area. The second part deals with the extensive field survey in and around the Gomti River in Lucknow to document the present day human activities.

Data Collection

For present study, data were collected throughout the channel. This study provides the data of bridges and barrage, bank stabilization and river valley settlement at several stations within the Lucknow urban centre. All these data provide basic information to understand and to present the overview of the present day human impact on the Gomti River at Lucknow.

Field Survey

Two field surveys were conducted to collect the onsite data and relevant photographs of the Gomti River sites where the anthropogenic activities are more pronounced. Field surveys have been carried out from 9th April, 2013 to 11th April, 2013 to observe the human impact on river Gomti in Lucknow. Through out the channel, construction of the artificial levee and bank stabilization were observed during the field work. During these field trips, several bridges and the Gomti Nagar barrage sites were observed. The conditions of river morphology covering the whole stretch of the Gomti River in Lucknow were observed and recorded the present study.

RESULTS AND DISCUSSION

Barrage and Bridges

The Barrage and Bridge play a significant role in the Gomti River morphology. Table 2 shows the complete list of all bridges and Barrage in Lucknow. The Gomti Nagar Barrage is made to harvest the river water for the paper industry located nearby area and to manage the river water level in Lucknow during the summer season **(**Maurya, 2008). Barrage is made on Gomti River to check the flow of water and is also responsible for to reduce the flow of water. Figure 2 (A) showing downstream view of the Gomti River barrage near Gomti Nagar. This Barrage is also used to check upside and downside level of Gomati River in Lucknow. The closest view of Gomti barrage is shown in Figure 2(B).

On the other hand the construction of bridges to facilitate the transportation between the urban settlements of right and left banks of the Gomti River. There are 11 bridges in all built on the Gomti River in Lucknow. These bridges affect the fluvial transportation processes of the river during monsoon. Figure 2(C) shows that upstream view of Gomti River to show the Daliganj Railway Bridge and Lalpul near Hussainabad.

Bank Stabilization

The Gomti River bank is also used for establishment of multi-storied buildings. In the Lucknow area, the Gomti River develops a river meander. In a meandering stream, erosion takes place on one bank and deposition on the other bank. This fluvial process is governed by running water velocity during monsoon season (Herget *et al.,* 2007). When this aspect is not taken into account, lot of problems stand in future as river behaves in its own way during monsoon season. The problem becomes more serious when the human settlements are on erosional-bank side. Some engineers suggest the use of artificial levee on the both banks to tackle this problem during peak flood discharges. This is not the permanent solution of the problem. Proper urban planning can avoid this problem related to the Gomti River in future.

Bank stabilization is done to provide the stability by the construction (Gregory, 2006) and modification of floodplains. Particularly construction works is dealing with the both the bank of Gomti River. It is well shown in Figure 3. It indicates the construction work for bank stabilization on the right bank of Gomti River near Gaughat. Construction work along Gomti River indicates adverse effect for future prospect of the Gomti River.

Artificial Levee

Natural levee are formed by the river along the banks near the active channel of its own floodplain. Apart from natural levee deposited by the river itself, the artificial levees are constructed to modify the morphology of the Gomti River. They include the constructions of 5 to 10 m high thick mud and stone wall along the bank of the active channel, which run almost parallel to the river channel for 8 to 10 Km. In case of Gomti River; extensive artificial levee has been developed by to protect the dense human settlement along the both flood plains. It not only modifies the fluvial environment of the Gomti but also posses an alteration or disturbance active fluvial processes of the Gomti River. Artificial levee is the significant alteration of the Gomti River morphology, which is clearly shown in Figure 4.

River Valley Settlements

The Gomti River flows in its own valley. In a natural way, river do not occupies with its flood plain especially during floods. Ideally, there must not be any construction or human settlement in the flood

plains of river. In Lucknow, certain areas in the Gomti River valley like show a huge settlement such as Gomti Nagar. The Gomti Nagar is located in most of its settlement in the Gomti River flood plain. This creates an adverse impact on Gomti River morphology. The Gomti River cannot accommodate its flood water during the flood time and create a man-made problem. At the same time, the flood plain areas of the Gomti River must be used for the purpose of parks and play grounds that will minimum the flood hazards. The urban slums are also noticed in the floodplain of Gomti River upstream and downstream of Hanuman setu and downstream of Daliganj Bridge (Central Pollution Control Board, 2002). Figure 5 and 6 displays some of this human encroachment on the right bank of Gomti River in upstream and downstream of Nishatganj Bridge.

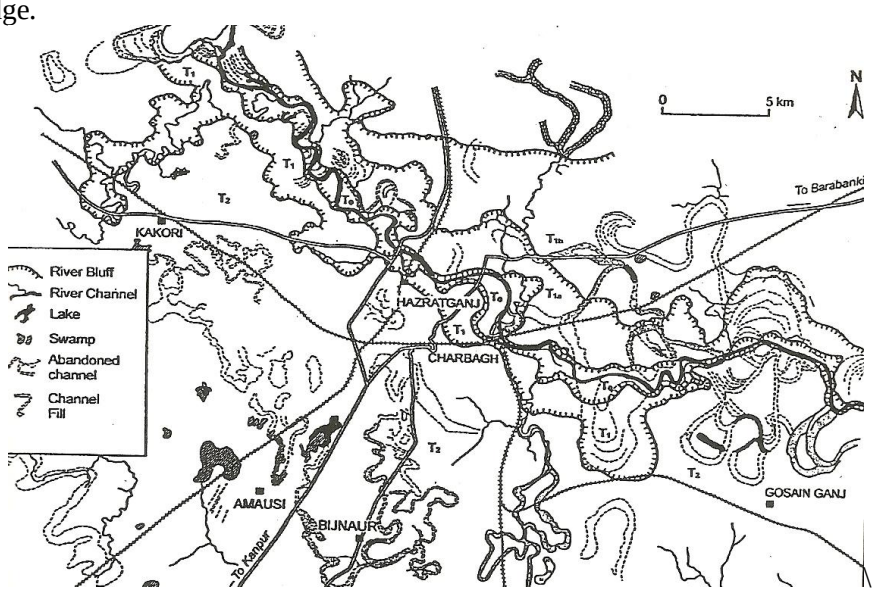

Figure 1: Geomorphology of the Gomti River at Lucknow. Based on Survey of India Toposheet (Dutta *et al.*, 2010)

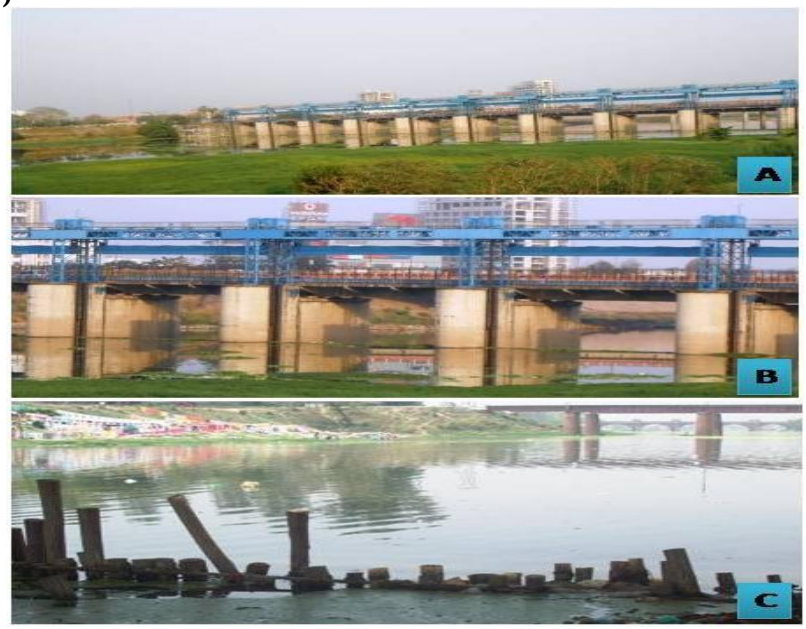

Figure 2: (A) Downstream view of the Gomti River Barrage near Gomti Nagar. (B) Closest view of Gomti Barrage showing upside and down side level of Gomti River Water. (C) Upstream view of Gomti River showing Railway Bridge at Daliganj and Lal-Pul near Hussainabad in background

Figure 3: Photograph shows the construction work for bank stabilization on the right bank of the Gomti River near Gaughat

Figure 4: Photograph shows the artificial levee (bank ground) on the left bank Gomti River at Gaughat pumping station

Figure 5: Photograph shows the urban slums situated in the Gomti River valley in both bank of Upstream of Hanuman setu

Figure 6: Photograph shows the urban slums situated in the Gomti River valley in both bank of downstream of Daliganj Bridge

Table 1: Basic characteristics of Lucknow urban center, the Ganga Plain, India

Geographical location	**Ganga Plain**
Latitude	27º 52'
Longitude	80º 56'
Climate	Uniformed Tropical climate
Temperature range	4-44 ºC
Rainfall	100 cm/annum
Urban Area	250 km^2
Total population	45,88,455 (2011)
Urban population	23,42,239 (2001)
Urban population below age of 6 year	2,76,747 (2001)
Hindus	70%
Muslims	26%
Jains	1.7%
Other Religions	2.3%
No. of house hold	3,02,613
Literates	10,28,077

Tables 2: Lists of Bridges and Barrage on Gomti River (arranged in downstream)

1. Road Bridge near Dubagga.
2. Lalpul near Hussainabad (Road Bridge).
3. Railway Bridge at Daliganj
4. Road Bridge at Daliganj-I
5. Road Bridge at Daliganj-II
6. Hanuman Setu Bridge (Road Bridge).
7. Nishatganj Bridge (Road Bridge).
8. Barrage near Gomti Nagar (with Road Bridge).
9. Road Bridge near Gomti Nagar-I
10. Road Bridge near Gomti Nagar-II
11. Railway Bridge near Dilkusha

Conclusion

The important findings of the present study on "Environmental Implications of Anthropogenic Activity on Gomti River Morphology at Lucknow" can be summarized as follows:

The human activities affect the river morphology especially on floodplain through engineering works including channelization, barrage & bridge construction, bank stabilization, construction of artificial levee, diversion and culverting were recognized.

It is ironic that over the past several years Supreme Court of India has provided much better example of comprehensive and integrated planning of rivers. The Supreme Court, on Nov 1, 1995, states that we are of the view that the only way to shape the Gomti River from Human Impact is to entrust the responsibility solely to the National River Conservation Directorate along with State Government, Ministry of Environment, Forest and Ministry of Urban Development. We the residents of Lucknow can also participation in whole process to make a difference for an integrated action plan to ensure timely implementation of the recommendations to preserve the Gomti River for future generations.

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