

# Assessment of Gomti River Basin with Special Reference to Environmental Flows Requirements

## SUMMARY of THESIS

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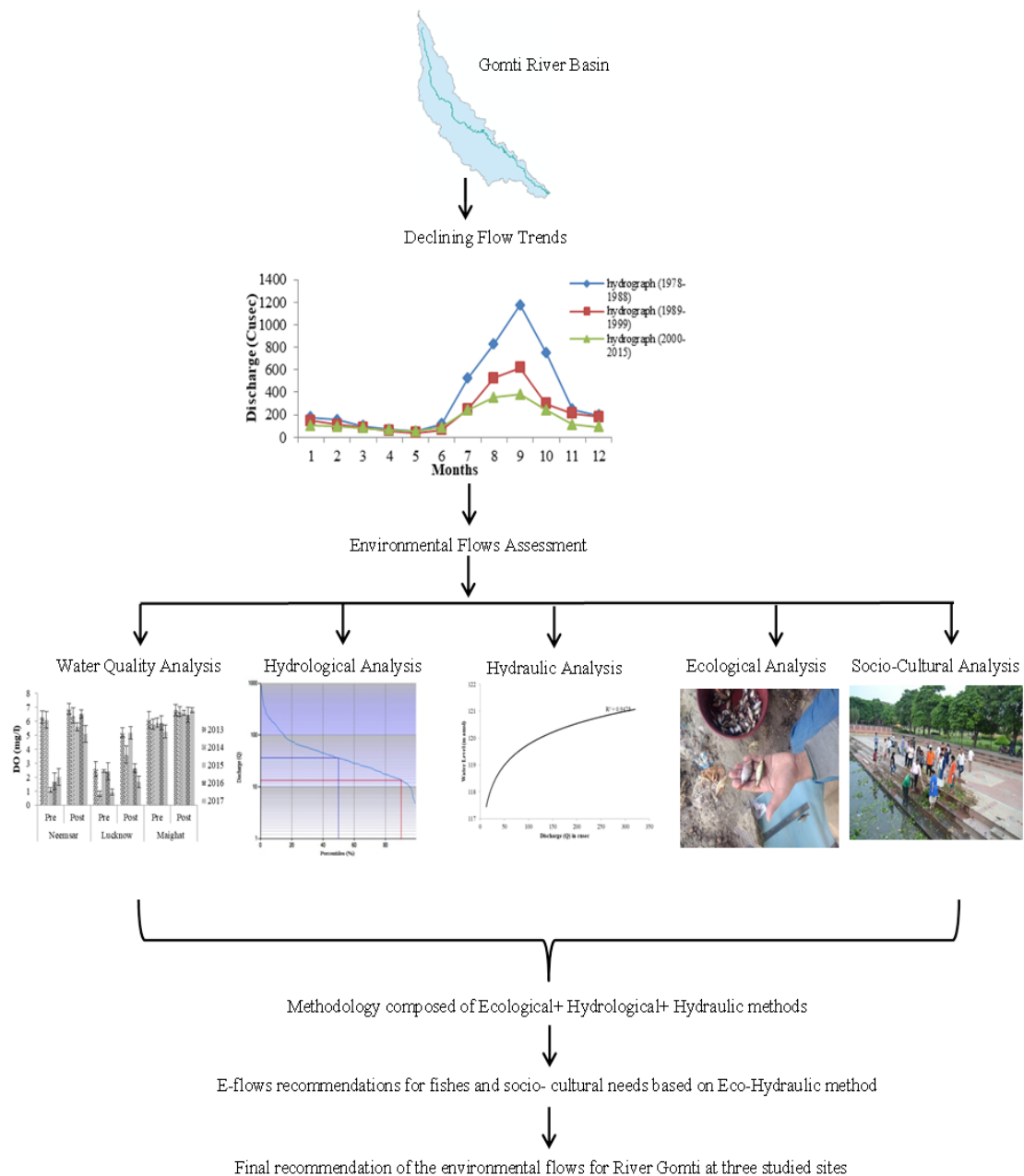
**Title: Assessment of Gomti River Basin with Special Reference to Environmental Flows Requirements**

**Executive Summary**

Various structural controls and ever-increasing freshwater demands are resulting in altered river functions compromising the resilience of the riverine ecosystems. Assessment of the Gomti River Basin was done to recommend e-flows requirements to sustain the riverine ecosystems and associated ecological services at its best. Gomti River was selected for assessing the e-flows requirements as it is a sub-basin of the larger Ganga River Basin. Gomti River, being a groundwater-fed river can become nurturing ground for various aquatic organisms during the lean flow seasons if requisite flow is maintained. Thus this river can play a crucial part in the conservation and management of aquatic fauna of Ganges.

***Homogeneous Zonation of River Basin for Identification of E-Flows Sites***

A constant flow in the river cannot sustain the riverine ecosystems. Thus, it is essential to maintain a variable flow regime in the river stream. To recommend variable flows for the river stream, initially, it is vital to find the homogenous stretches in the river stream based upon various parameters. In the homogenous zonation process, six distinct zones identified are Pilibhit to Shahajahanpur, Shahajahanpur to Dadhna-mau (Sitapur), Dadhna-mau (Sitapur) to Lucknow, Lucknow to Sultanpur, Sultanpur to Jaunpur, and Jaunpur to Ganga River, Varanasi. These six zones are distinct from one another and would require a distinct flow to maintain its channel morphology and associated ecosystems.



**Figure 1:** Graphical Abstract

The e-flows recommendation for each site was not possible during this study due to the unavailability of long term and real-time data for all the sites. Thus, three sites, namely Neemsar (located between Zone-I and II), Lucknow (located between Zone III and IV), and Maighat (located between Zone-IV and V) were selected to recommend e-flows for Gomti river. For these three sites, stream geomorphology, baseflow component, number of high and low flow months, type of fish diversity

supported and other studied parameters are different; thus, a variable, site-specific flow is desired.

### ***Environmental Flows for River Gomti***

This objective was aimed to recommend e-flows for River Gomti. Hydrological, desktop and hydraulic methods were used as well as the assessment of suitable water depth for the identified indicator species was done to recommend the e-flows requirements. The baseline data were collected on fish diversity, river cross-sections, water quality and habitat diversity. The baseline data and the secondary data collected was used to calculate the hydrological indicators, separating the baseflow, flow duration curves, calculation of stage-discharge relation curves, wetted perimeter-discharge relation curves, hydraulic analysis and water quality analysis. These analyses are fundamental preliminary analysis in the e-flows assessment. The five hydrological methods used for recommending e-flows are Tennant, Tessman, Q90-Q50, Smakhtin and Variable Monthly Flow. The instream flow recommendations made by Tennant method were modified according to the Indian monsoon cycle and termed as Habitat Health Classes (HHC). The Tennant, Q90-Q50 and Smakhtin methods are recommending flows for two periods only, i.e. for high flow and low flow seasons. Thus, these methods are not able to address the variability of flow in the Gomti river stream. The Tessman and Variable monthly flow methods are better hydrological methods in comparison to the above three methods used. The Tessman method is recommending the highest e-flow in comparison to other hydrological methods. The E-flows recommendations were made based upon the user-defined data in Global Environmental Flow Calculator (GEFC). The GEFC is recommending the flow following the natural reference flow. The flow recommended by GEFC is in the form of shifting FDCs based upon pre-defined EMCs. This method lacks the

establishing the relation between the ecological characteristics and the flow modifications in the river with changed hydrological regimes. The class 'A' and 'B' results are recommending unrealistically high flow in the river which needs further attention. This method provides low-confidence estimates of e-flows as the recommendation based on EMC is not very well justified in this method. The recommendation by the hydrological and desktop methods indicates a few percentages of MAF or MMF as e-flows. All the methods are recommending different values of flow. At this stage, it is hard to conclude which method is well suited for the Gomti River as the actual implementation of these estimates is not done yet. These methods individually will not be able to provide the flow in correspondence to maintain the critical riverine ecosystems and ecology. Thus a combination of eco-hydrological methods should be tried. As in this case, a combination of Tessman and ecological estimates can be used as a part of a holistic approach. This combination, when implemented in practice with a continuous monitoring and feedback system, would ensure suitable environmental protection for the aquatic ecosystem.

Water quality plays a vital role in maintaining the overall integrity of the riverine ecosystem. However, the e-flows assessment methods principally focused on the quantity of water required. The flow allocation for the dilution of pollution at highly polluted sites will not be a feasible situation as the allocated flow might surpass the total available natural flow in the river. The water quality analysis of the Gomti River indicated that the river is falling between 'D' and 'E' class, as per CPCB standards based on DO and BOD concentrations. The best practice to improve the water quality of the river is to prevent the discharge of untreated water into the river.

### *Flow Requirements for Indicator Species*

The variability in climatic conditions, high variability in flow regimes and high ecological diversity suggest that the hydrological methods alone are not adequate to recommend the adequate environmental flows to address the needs of GRB. Thus there is a need to add extra steps to make them suitable for tropical rivers. One of the steps is e-flows requirements for indicator fish species. Six indicator species were identified based on their international, national, genetic, ecological, economical and sport fishing values. The water depth requirements to sustain each life form of fishes, i.e., spawning, migration, food and resting were identified. Spawning and migration being the two most crucial life stages to sustain the fish population were considered to recommend the e-flows. The information gathered during surveys and taking the expert opinions, a 2m depth profile is considered suitable for the spawning, and 4m depth is considered suitable for migration purposes for juveniles and adults. The channel morphology does not remain the same throughout the stream. To access the corresponding flow for maintaining the desired depth in the stream, stage-discharge relation curves and wetted perimeter-discharge relationship curves were used. The stage-discharge relation curves were prepared using the logarithmic equations. The wetted perimeter-discharge relationship curves were prepared using the manning 'n' equation. The channel is shallow in its beginning and deepens as it flows down towards the confluence with Ganga. Thus a range of flow is recommended as e-flows for maintaining the fish diversity based upon the desired depth. An average depth of 1.98 m to 2.18 m is recommended in the upper stretch i.e. at the Neemsar site of the river stream, the corresponding discharge is between 14.99 cusecs to 35.58 cusecs, respectively. The upstream site being shallow with parabola shape stream morphology and a high baseflow component will be suitable for spawning of fishes. However,

over-abstraction of the groundwater and steadily decreasing groundwater level had resulted in the drying of the upper parts of the river and its associated tributaries. At the Lucknow (midstream) site depth of 0.85 m to 1.84 m is recommended with corresponding discharge between 26.98 cusecs to 143.83 cusecs. The midstream region should also facilitate the active movement in the stream from upstream to downstream. The change in the habitats and the hydraulic parameters of the river due to channelization could have resulted in an increased abundance of exotic species such as *C. carpio*, and *O. niloticus*. These non-native species are a threat to the native fish species. In the downstream region at Maighat the average depth range should be between 3.08 m to 6.04 m, with the corresponding discharge of 17.12 cusec to 56.23 cusecs, respectively. As the depth of the river channel increases, the downstream stretch will be highly suitable for maintaining the rich stock of fishes. There is also a need for small floods each year in the upstream and downstream region, an average depth of 3.09m and 7.57m is recommended as the flushing flow depth each year. In the midstream region, the small flushing flows were not recommended due to the channelization of the stream in the Lucknow city. At the Maighat site, a broad range of the flow level is recommended to sustain the fish diversity during low flow months identified as of March to June, a minimum of 3.08m average depth should be maintained. In the intermediate flow months identified as from December to January, a minimum of 4.72m average depth (Discharge (Q): 35.97 cusecs, Velocity: 0.51m/s, Cross Section Area (CSA): 70.80 m<sup>2</sup>, Wetted Perimeter: 24.44m) should be maintained and in the high flow months identified as of July to November, a minimum average depth of 6.04m should be maintained with small annual flushing flows depth of 7.57m. This study points out that the planning and implementation of any developmental project in the river corridors should be carried out in small phases.

After completion of each phase, the interlinking of the functional responses of fish communities to habitat disruption should be analyzed.

### ***Socio-Cultural Mapping and E-flows Need***

The e-flows requirements for fulfilling the socio-cultural needs indicate that, at Neemsar site an average depth of 0.87 m in lean flow season and 1.98 m in high flow season is suitable. To maintain the desired depth, a discharge of 3.74cusec and a velocity of 0.22 m/s in lean flow seasons and a discharge of 14.99 cusecs and a velocity of 0.35 m/s in high flow seasons are required. At Lucknow, to maintain an average depth of 0.85m in lean flow season, a discharge of 26.98cusec and velocity of 0.44 m/s is required. In high flow seasons at Lucknow, to maintain average depth of 1.41m, a discharge of 70.08 cusecs and velocity of 0.6 m/s is required. At Maighat site, the channel is deep and parabola shape, to maintain an average depth of 2.1m, a discharge of 2.31cusec and velocity of 0.25 m/s is required in lean flow seasons. In high flow seasons, an average depth of 3.08 m can be attained with a discharge of 17.11cusec, and velocity of 0.41m/s is required. One has to realize that practically it is difficult to maintain the required depth of water and flow velocity. Therefore as a thumb rule, efforts should be made to at least, maintain the depth-flow-velocity conditions significant enough to not fall below the recommended values with minimum deviations in the flow.

### ***Maintaining the Baseflow Contributions to E-Flows***

In this study, it was observed that the baseflow contribution is high in the Gomti River. The contribution observed at the three sites is about 78, 76 and 69% at Neemsar, Lucknow and Maighat respectively. This study highlights the importance of surface water and groundwater interactions for planning a holistic management approach for the river systems. Baseflow contributions are crucial for maintaining the variable flow regimes in perennial rivers. To maintain the 'aviral' (unfragmented)

flow in the groundwater-fed rivers, the groundwater resources should be adequately enough. The groundwater and surface water interactions continue to provide groundwater recharge in high flow periods and regain the riverine flow in lean flow periods through baseflow. This study further stresses on the need of restoring sufficient groundwater recharge possibilities in the form of natural inland water bodies such as ponds and lakes. In place of larger water storage systems, small check dams on lower order streams would be beneficial in controlling the quick flow of the water towards downstream regions.

### ***E-Flows Assessment Approach for Indian River Systems***

The results of the study indicate the e-flows requirements for the index species is exceeding the flows as per MAF calculated for each site. The e-flows recommendations made by hydrological methods and the desktop method are in a percentage of MAF and MMF. The ecological flow requirements are much higher than what hydrological methods are recommending. Every river has unique flow requirements. To maintain the healthy riverine ecosystems, only thumb rule can be applied to keep the flow near to the natural flow regime as much as possible. The over-abstraction of water is not only dehydrating the ecosystems but also dehydrating the national economy. Water resource management should not focus on short term economic goals. Instead, it should focus on the long term ecological sustainability of the freshwater ecosystems. The e-flows assessment used in this study has some limitations and has room for further modifications. Some of the limitations are as follows:

1. The hydrological methods do not address the variability and duration of flow required.

2. Tennant, Smakhtin and Q90-Q50 methods recommend flow for two periods only i.e., high and low flow periods.
3. The industrial, domestic and agricultural demand-side management was not considered in this study.
4. The assessment of the actual riparian corridor width was not done in this study.

This study also puts forward to take a bottom-up approach where tributaries can be managed first, and subsequently, the main channel will be approached. In any e-flows assessment studies, it is hard to predict whether the selected method will deliver results which will improve the overall ecology of the study area. Thus, this study suggests that initially, the assessment and implementations of the e-flows should be done on a smaller tributary of a larger river system. The River Gomti is a major tributary of river Ganga, and by restoring its flow, and many other tributaries of Ganga River a better River Basin Management outcome can be achieved.

#### ***Restoration of River-Corridors and Connected Water Bodies***

The strong connections of the riparian population with the river will ensure healthy riparian corridors and river water quality. Well informed and aware society will not pollute their water bodies and prevent them from further degradation. Any developmental plans on the bank of the river and in its corridors should incorporate a thorough environmental impact assessment (EIA) study. In these EIA studies, a public hearing should be mandated irrespective of the extent of the development project. Assessment of the riparian width for each river should be done and this area should be protected and left in the name of the river from the origin of the river to its mouth. Healthy riparian corridors will facilitate uninterrupted ecological services.