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RIVER HEALTH ASSESSMENT OF GANGA BASIN IN INDIA: A COMPARATIVE PERSPECTIVE

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ABSTRACT

The Ganga basin has modest geographical and hydrographic attributes; it has a demographic distinction of being the largest populated river basin in the world. The Ganga as the Himalayan River has a total area of only 1.01 million km² and supports a much higher population than the Yangtze Basin of China with an extent of 1.8 million km². The ecology and spirituality of Ganga need a River health assessment (RHA). I t also requires River Health Indexing (RHI) for the catchment and command area, floodplain and channel preservation. The honing out of the RHA and RHI methodology and manual for the ecological and morphological rejuvenation and land use and riparian sustainability is only thematic nut timely in the context of Ganga River. Still, the bio-physical entity Ganga sustains the variable fortunes of over 600 million persons in northern India and Bangladesh. The restoration strategy demands that prevention and control of the pollution and contamination from the industrial, municipal and domestic sources. The Amazon of Brazil, Congo in Africa, Mississippi-Missouri of the USA and Nile in Egypt drainage basins are more prominent but not so polluted on comparative basin study.

KEY WORDS : River Health Assessment, River Health Indexing, Ganga Basin, Hydrographic Attributes, Morphological Rejuvenation.

INTRODUCTION

The Ganga River is has a unique distinction of small Basin but sustains 600 million persons in northern India and Bangladesh. Ganga is the longest river of India with a length of 2,525 km yet; it merits only 34th longest river in the world. Ganga basin is the largest drainage basin in India. It has a total geographical area of 1, 087,300 sq.km. Despite this large size, Ganga drainage basin geographically ranks only 16th largest river basin in the world. Hydrographically, there are at least five significant rivers which carry more water in their bowls than the Ganga River (Bhargava, 1983). Ganga Plain is an outstanding geomorphic feature in the Indian sub-continent. It is remarkable for its levelled topography, high agricultural productivity and high population density (Nomani, 2020)a. The Ganga Basin as such located between the Himalayas and the Indian Peninsular Craton.

It stretches to over 1000 km in an east-west direction. The north-south width varies from 450 km in the west to about 200 km in its eastern part (Rao, 2001). The Ganga Plains have a great variety of surface features including incised river valleys, entrenched valleys, abandoned channels, palaeo-channels, alluvial ridges, ponds and lakes (Nomani, 1998). The paper dwells on the River health assessment (RHA) and River Health Indexing (RHI) of Ganga River in contemporary perspective. The study helps to analyze the operation of geomorphic processes over a range of spatial and temporal scales to predict future landscape trajectories" (Jain *et al*., 2012).

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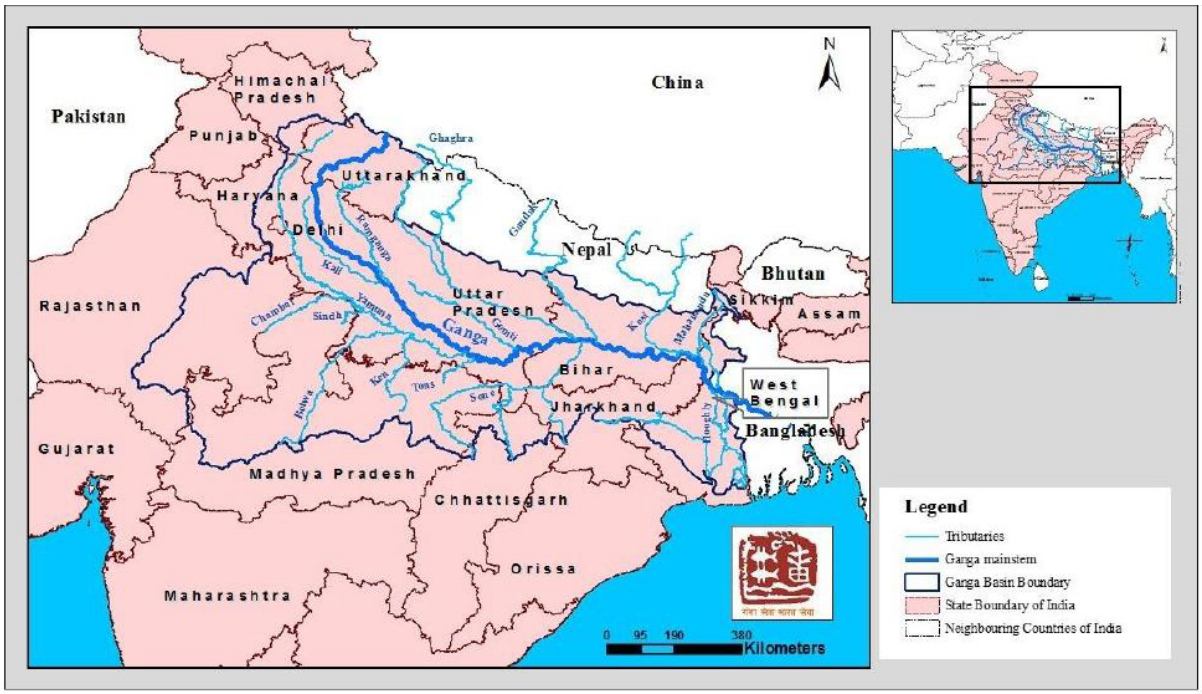


MATERIALS AND METHODS

River health assessment (RHA) studies renewed the interest of the scientists in the world, including Australia, China, European Union, USA and South Africa. The RHA indicators and protocol for the assessment of river health under sustainable development canopy has assumed currency. However, a comprehensive RHA study of the health river Ganga drainage basin, command and catchment, floodplain and aquatic ecosystems (Nandi *et al*., 2016) is essential. The River Health Index (RHI) methodology undertakes the land use and riparian habitat of the Ganga Rivers. It encompasses the environmental impact on the forest, natural resources and agriculture management (Nomani, 2009). The comparative study of river basin management carried out in the methodological perspective of Merritt and Cooper's River Basin Riparian vegetation. It embodies three stages of transformation of the deep, meandering and shallow, braided channel change (Merritt *et al.*, 2000). The floodplain, stream, morphological channels and aquatic diversity of the river require participatory action, multi stake holding approach, and holistic planning.

RESULTS

The River health assessment (RHA) protocols and tools applied universally for the ecological fitness of the river such as catchment health, floodplain health, channel health, flow health, quality health and biotic health indicators (Meyer, 1997). It also dwells on the Human intervention by constructions of dams, excess water abstraction, channel diversion, and several other factors contribute to the depletion of diverse flora and fauna of a river. We need to harness these methodologies for the restoration of ecology and spirituality of Ganga River through public participation (Nomani, 2010).

Command Area Ratio of Ganga Basin: The Ganga River sustains the variable fortunes of over 600

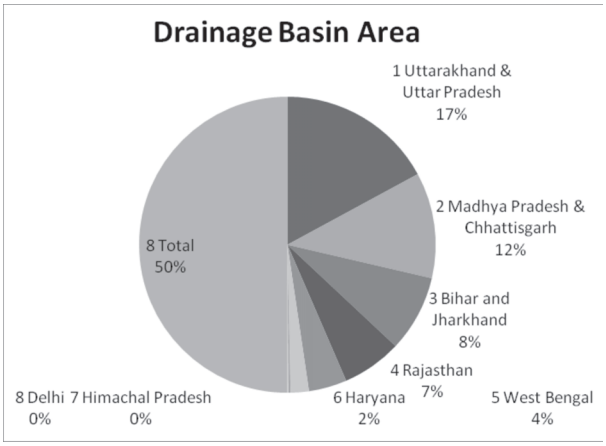


Fig. 1. State-Wise Ganga Basin & Drainage Area
Source: National Mission for Clean Ganga (NMCG), 2019.https://nmcg.nic.in

million persons in northern India and Bangladesh. Ganga Basin socio-economically supports a much higher population than the Yangtze Basin of China with an extent of 1.8 million km^2. The Ganga Basin, within the Indian territory, extends over 11 states of Himachal Pradesh, Uttarakhand, Uttar Pradesh, Haryana, Delhi, Rajasthan, Madhya Pradesh, Chattisgarh, Bihar, Jharkhand and West Bengal (Kumar *et al.*, 2002). Table 2 depicts the major state-wise distribution of Ganga drainage basin.

The states of Uttarakhand and Uttar Pradesh have the most substantial extent of the Ganga drainage basin extending over an area of 2,94,364 sq.km. Madhya Pradesh and Chattisgarh comprise the second most significant area of the Basin, encompassing, 1,98,962 sq.km. Bihar and Jharkhand consist of 1,43,961 sq.km of the Ganga Basin. Rajasthan, with Chambal sub-basin, comprise 1,12,490 sq.km area West Bengal also covers 71,485 sq.km of the Ganga basin. The Ganga is the national river of India and confers series of human rights to Indian populace (Nomani, 2000).

Geographical Status of Ganga Tributaries: This appears a universal truth in almost all the major drainage basins that the tributaries contribute at least two to three times water as compared to the main river. Table 1 shows a quantitative tribute of associate streams to make the Ganga look so formidable a river. The biggest water tribute to Ganga comes from the Ghaghra and its streams. The Ghaghra river system contributes an annual water supply of 94.4 billion cubic metres. Yamuna-Chambal System follows this. These rivers, along with their streams, supplement 79.3 billion cubic meters of water annually (Singh, 2010).

Table 1. Quantitative Tribute of Associate Streams to Make Ganga System Functional

Tributary Streams	Annual Water Supplement (in bm^3)
Ghagra	94.4
Yamuna-Chambal	79.3
Kosi	61.56
Gandak	52.5
Son	22.42
Ramganga	15.28
Gomti	7.39
Burhi Gandak	7.1
Tons	4.93
Total Tributaries	> 400

Source: Khullar, D.R. (2016). India: A Comprehensive Geography, New Delhi: Kalyani Publishers, pp 105.

Hydrographically, Yamuna is one-and-a-half times bigger than Ganga at its confluence. This higher water status of Yamuna at its confluence is the courtesy of an enormous water supplement of Chambal tributaries to the Yamuna. Kosi, further east, in the much higher rainfall region contributes an annual water supply of 61.6 billion cubic metres to river Ganga. Gandak is another major tributary of Ganga. Gandak supplements 52.5 billion cubic metres annually. Moreover, domestic waste also includes the urban wasteland of the burgeoning cities in the Ganga Basin (Trivedi, 2010). Ganga Basin bears a sizeable municipal population pressure of over 145 million persons and calls for a community-based approach to its ecological maintenance (Nomani, 2002).

Comparison of World River Basins: The average population density of Amazon basin is 25 persons per sq.km. On the other hand, the average population density of Ganga basin is 602 persons per sq.km. Amazon basin has the largest geographical area of 7.5 million^2 km. The river has annual maxima of water supply from a very high equatorial rainfall throughout the year (Blomquist *et al*., 2005). Amazon tributaries also receive the water supply from the glaciated peaks of the Andes Mountains. Amazon basin is 7.5 times larger than the Ganga basin. It carries ten times more water than the river Ganga. Most of the Amazon basin has per-humid, humid and sub-humid climate.

On the other hand, Ganga basin has sub-humid to semi-arid climate and resulting in to rise of chronic disease in India (Nomani, 2020)b. However, the population of the Amazon basin is 190 million persons against a population of 650 million persons in the Ganga valley. It is indicative of the population sustainability; population density and importance of a river basin are not merely a function of its real personality or the water availability in the drainage basin. Table 3 draws an area, population and density comparison of Ganga basin with the major drainage basins of the world. A comparison made among the 16 major drainage basins of the world. The table depicts a considerable spatial variation of population sustainability and density per sq.km. in different drainage basins. In fact, the population sustainability of a river primarily appears a function of the human geography, historical gravity, cultural heritage and social profile of the people inhabiting a drainage basin.

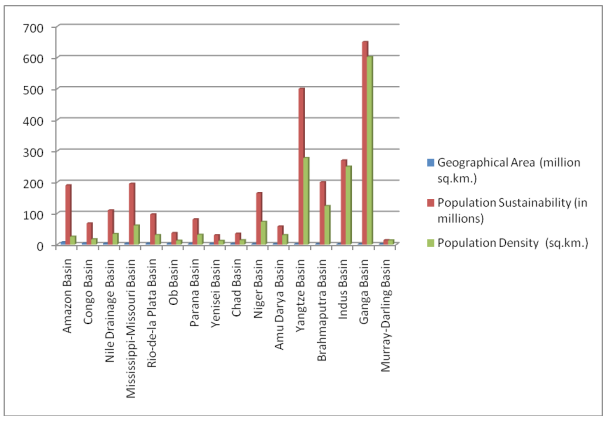


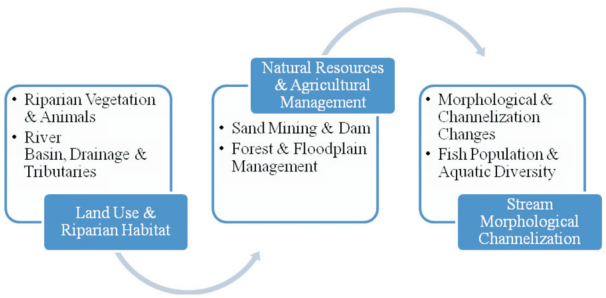
Fig. 3. Geographical Extent of Ganga Basin with Largest Rivers

Source: www.wri.org and Computed by the Researchers.

Another major drainage basin of Congo River has a geographical area of 4 million^2 km with a total population of only 68 million persons. The average population density is only 17 persons per sq.km. Nile, the longest river in the world has a drainage basin of 3.25 million sq.km. It has a population of 110 million persons with an average density of 34 persons. Yangtze basin of China is strictly comparable to the Ganga drainage basin. Yangtze Basin is 1.8 million^2 km (Krysanova *et al.*, 2010) and supports a population of 500 million persons with an average density of 278 persons per sq.km. Yangtze basin also has a high demographic, agricultural and industrial sustainability. However, Ganga basin stands distinctly above all the major drainage basins in its socio-economic sustainability and environmental impact (Nomani, 2011).

DISCUSSION

The Ganga basin has modest geographical and hydrographic attributes; it has a demographic distinction of being the largest populated river basin in the world. Ganga plains are more in-depth along the Himalayan Axis and Shallower along the Central Indian Highland Craton. As a result of it, the groundwater potentials are much higher along the deeper Himalayan Axis. The amplitude of relief in the Ganga Plain varies from 300 metres at Haridwar to nearly 25 metres above mean sea level in the deltaic region.



***River Health Assessment (RHA) Protocols & Tools*:** The River health assessment (RHA) protocols and tools applied universally for the ecological fitness of the river such as catchment health, floodplain health, channel health, flow health, quality health and biotic health indicators. Human intervention by constructions of dams, excess water abstraction, channel diversion and several other factors contribute to the depletion of diverse flora and fauna of a river (Yang *et al.*, 2020).

On the other hand, the Development of River Health Index (RHI) by involving a multi stakeholding approach and community participation. The Methodology and Manual apply to the ecological and morphological factors (Nomani, 2004).

It encompasses land use, riparian vegetation/ animals, agriculture practices, forest cover, sand mining, and construction in the floodplain. The stream features, reach length, stream width/depth, sampling reach area, velocity, canopy cover, stream morphological types, channelization, dams, drains/ river tributaries, quality and quantity of groundwater, Ranney wells, water quality, bottom substrate, fish population and aquatic insects are some other benchmarks of the RHI (Singh et al, 2018).

Sustainability of Ganga Basin: It is a highly favourable catchment to command area ratio, which makes the Ganga drainage basin a unique land of high socio-economic sustainability. Ganga drainage basin is the largest populated area in the whole world, and it is also the most significant contiguous agricultural area in the world. The large Ganga basin has one of the highest agrarian densities in the world. The socio-economic sustainability and agricultural intensity of the Ganga basin is comparable only with the Yangtze basin of China. The average land-use concentration in the Ganga Basin is nearly 200 per cent. The land-use strength has considerably increased due to widespread agricultural reforms. Raising two crops in a year is a common sight in most of the agriculturally operational Basin. However, there are several places, particularly in western Uttar Pradesh in the

Upper and Middle Ganga-Yamuna Doab, where even three crops raised in a year. The districts of Saharanpur, Muzaffarnagar, Bijnor, Meerut, Ghaziabad, NOIDA, Bulandshahr and Aligarh have made enormous agricultural advancements in the Command Area (Tripathi *et al*., 2017). The vicinity of these districts to the National Capital Region of Delhi provides perennial marketing incentives to the agricultural growth and intensity in the region. There is the growing agrarian expansion in the Ganga Basin. The net inundated area in the Basin exceeds 37,000,000 hectares which comprise nearly 59 per cent of the irrigated area of India. Ganga basin has the largest gross irrigated and gross cropped area in India. The irrigation in the Basin from groundwater sources exceeds 140 billion cubic metres annually. Globally about 60 per cent irrigation is met by surface water of the rivers. As against this, in India, about 67 per cent irrigation is done by groundwater mining. Hence, the groundwater sources of the Ganga Basin are also under tremendous pressure.

Potentials and Problems of Social Sustainability: It is crucial to note that although the Yamuna is the longest tributary of Ganga; it is least liable to the floods. The Yamuna flows through the lowest rainfall areas in the entire Ganga Basin. If it is so, and as it is so, one can convincingly infer that the floods in the Ganga Basin have greater meteorological control than either topographic or geomorphic control (Sapkota *et al*., 2013). However, it remains an undeniable fact that all three physical factors have their role in the flood determination. The anthropogenic factors of deforestation for agricultural land reclamation also lead to severe soil erosion, siltation and consequent floods in the middle and lower Ganga basin (Nomani, 2019). The average population density in the Basin exceeds 600 persons per sq.km. The highest population density is in the Gangetic state of Bihar, where it exceeds over 1,100 persons^2 km. As Bihar is amongst the least urbanized states of India with average urbanization of nearly 15 per cent, the rural and agricultural density in Bihar is the highest in the world. The frequency of the farming population in Bihar is near twice the agricultural density of Yangtze River in China. These high densities, on the one hand, might depict very high sustainability of our Ganga basin. The rapid population growth in the Ganga basin has resulted in agricultural development, urbanization and extensive use of water for irrigation, industry and public supply. The stretches of the Gang River polluted with Sewage, untreated industrial discharges and chemical run-off from agricultural fields. Hence, Ganga Basin, despite a distinctly high potential, is overlain with excessive land-use pressures.

CONCLUSION

It appears that RHA and RHI associated with a culturally sensitive river such as River Ganga in India need a move beyond top-down technocratic approach. There is glaring evidence of literature which propose a community-based comprehensive RHA and RHI model. The Ganga Basin produces a vast agricultural surplus amid food insecurity. A population and land-use perusal of the Ganga Basin reveals that Indian agriculture still largely remains a labour intensive and water-intensive practice. We have not yet groomed into capital intensive agriculture by increasing the sprinkle and drip irrigation methods of higher water use efficiency. India's large farmers should compulsively adopt the capital intensive and water conservative drip and sprinkle irrigation. Therefore we need to harness the socio-economic relevance of Ganga along with its spiritual reverence. A radical shift in behavioural approach regarding the water conservation *vis-à-vis* social sensitization and consumerist perception is need of time. The inclusive spaces for collaboration and public participation bridge the gap between science and sacred ecology.

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