

India's lost rivers and rivulets

Anwasha Borthakur¹ · Pardeep Singh^{2,3}

¹ Centre for Studies in Science Policy, Jawaharlal Nehru University (JNU), New Delhi 110067, India

² Department of Chemistry, Indian Institute of Technology-Banaras Hindu University (IIT-BHU), Varanasi 221005, India

³ Department of Environmental Studies, PGDAV College, University of Delhi, New Delhi 110065, India

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Abstract The manuscript highlights the tragedy of India's extinct or near-extinct rivers and rivulets (i.e. very small rivers or streams) passing through some of the major Indian cities. These rivers were once considered healthy and sound systems supporting the population of a city by sustaining important sectors such as agriculture, pisciculture, transportation, industries, recreation among several others. Our motive is to attract attention of the scientific community, policymakers, government and non-governmental organizations and native dwellers towards this grave concern, where once sound ecosystems are today being damaged beyond the opportunity of rejuvenation. We have considered the instances of six Indian rivers and rivulets: the Bharalu and Bahini (Guwahati), Varuna and Assi (Varanasi) and Mula and Mutha (Pune). Today, most of these rivers are reduced to mere 'nallahs' or 'sewers' due to rapid, unplanned and haphazard developmental activities and urbanization processes ubiquitous in major Indian cities. For instance, River Assi in Varanasi is, today, almost no more. Encroachment is a common problem on all these river banks which results in extraordinary reduction in the width of the rivers and rivulets. As a consequence, the water flows to the banks of the rivers in no time even during a short rainfall episode. The deteriorating river systems in India pose major challenges to the sustenance of cities situated along them. Most of the pollution prevention initiatives by the central or the state governments are directed towards the major rivers such as the Ganga, practically ignoring the equally vital rivulets.

Although local governments of most of these cities have undertaken initiatives to address the associated problems, the outcome of the same is highly dubious.

Keywords Rivers · Rivulets · India · Encroachment · Water pollution

1 Introduction

Rivers are the arteries of any civilization. All major civilizations in the world commenced from the land of major rivers. Indus Valley extended from the east of River Jhelum to the upper Sutlej. Mesopotamia encompasses the land between the Euphrates and Tigris rivers. A river carries the essence of a place, its history and its cultural heritage besides sustaining important systems such as agriculture, pisciculture, transportation, industries, recreation and many others. India is the land of many rivers. Traditionally, to a large extent, Indian rivers find its place in the literary, art and cultural works of its dwellers. Many historic and celebrated Indian novels and poetry revolve around its major rivers. More recently, Indian rivers have been a major focus of interest of the research community from the prospective of hydrology, geomorphology, seismology, pollution studies and so on. One important aspect of Indian rivers is that, in many places in the country, river water is still used for direct consumption. This particular facet calls for the maintenance of high quality of river waters in terms of their both wholesomeness and estheticity (Bhargava 1998). Further, in the global picture, India is identified as a country where water scarcity is expected to grow considerably in the coming decades (Bandyopadhyay and Perveen 2003). Therefore,

✉ Anwasha Borthakur
anweshacug@gmail.com

Pardeep Singh
psingh.rs.apc@itbhu.ac.in

conservation of our river system is of utmost significance in order to address the constant water crisis experienced by this country. Again, rivers in India have potential to provide solution to the unending energy crisis in the country. For instance, these rivers can be enriched with floating solar panels in order to power small villages and towns situated in the vicinity of the rivers. In a first of its kind in India, a joint endeavour undertaken by Arka Renewable Energy College in Kolkata and New Town Kolkata Development Authority (funded by the Ministry of New and Renewable Energy) resulted in the installation of floating solar power in Rajarhat, Kolkata, with an aim to produce a minimum of 14 MWh of solar power annually.¹ As an emerging photovoltaic technique, floating solar panels can aid in the reduction in non-renewable fossil fuel-based energy sources (including coal and oil), which currently represent the largest energy source in the world causing global warming and pollution (Gerosa et al. 2016). Thus, India's river system has multifaceted features which could be explored further for maximum potential benefits.

A largely ignored segment of the 'River System Studies' in India is the country's 'Rivulets'. 'Rivulet' means a very small river or stream.² Together with major Indian rivers, the contribution of Indian rivulets in sustaining a healthy ecosystem can never be ignored. But studies focusing on various aspects of these rivulets, many of which flow through some of the major cities in the country, are surprisingly low. Many of the rivulets are responsible for draining off a city's excess water into the nearby major river and maintaining a proper inflow–outflow balance. Nevertheless, it has been observed that the only time these rivulets create interests and come into limelight is when a major city is inundated under water due to poor drainage system. Here, we argue that it is essential to provide appropriate importance to the rivers and rivulets in a country in order to sustain a sound river system. A healthy and sound river system has immense potential to avert many disaster events frequented in the recent decades in India. The next section is an attempt to rediscover some rivers and rivulets in Indian cities which are either already lost or at the verge of extinction. We also try to identify the significance of these rivers and rivulets in sustaining the well-being of the city and major challenges to these two important ecosystems.

2 Tales of India's lost rivers and rivulets

2.1 The Bharalu and the Bahini, Guwahati

The story of India's lost rivers goes a long way. A majority of them are nothing but rivulets or small tributaries of

major rivers. For instance, River Bharalu and its Rivulet Bahini, which flow through the city of Guwahati in Assam, are live examples. The River Bharalu, after flowing a few kilometres from its origin in the foothills of Meghalaya (the Khasi Hills), bifurcates into two rivulets: the Basistha (which flows towards Deepor Beel, a Ramsar Site³) and the Bahini (which flows through the city of Guwahati and eventually drains into the Brahmaputra). The entire water of the Guwahati city should, ideally, pass through the Bharalu and the Bahini and ultimately fall into the mighty Brahmaputra. However, today, both the Bharalu and the Bahini are reduced to mere 'nallahs' or 'sewers' due to rapid, unplanned and haphazard developmental activities and urbanization processes ubiquitous in the city. Notably, a segment of the water-carrying rivulet in Guwahati is known as 'Mora Bharalu'. In the native Assamese language, 'Mora' means 'Dead'. So the term 'Mora Bharalu' refers to a dead rivulet in the form of 'Dead Bharalu' where the rivulet barely exists today. It signifies that the death of a river is already observed by the dwellers of the city. Thus, as the largest city in the region, Guwahati (famously called the 'Gateway to North-East India') observes an unprecedented growth in the recent times leading to some destructive environmental consequences.

The repercussion of haphazard urbanization is evident in Guwahati, especially during the monsoon, when the city is subjected to artificial flooding episodes almost every year. Particularly, the Bharalu catchment area in the city has undergone rapid urbanization, resulting in unabated encroachment and discharge/dumping of solid and liquid wastes, thereby severely degrading the river system. According to a report by the Guwahati Development Department (affiliated to the Government of Assam), the city is anyway prone to flooding because of its very topography. The report reveals that the topography of Guwahati city is 'bowl-shaped' with some areas lying at the lowest points of the bowl.⁴ This leads to involuntary stagnation of water over a short period of time during the heavy rainfall in monsoon. Further, the city receives floodwater from the nearby hills of the state of Meghalaya. Guwahati's own rainwater together with the incoming floodwater from Meghalaya aggravates the stagnant water crisis in the city. Therefore, a hassle-free and swift flow through the city's two rivers, Bharalu and Bahini, is essential in order to maintain a proper inflow and outflow balance.

¹ <http://www.vikrimsolar.com/projectsandservices/pdf/wbindia.pdf>.

² As per the Oxford English Dictionary.

³ Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. See <http://www.ramsar.org/>.

⁴ See http://www.gmda.co.in/dainage/short_long_term_measures.pdf.

Rightly so, there was a time when the free flowing River Bharalu in Assam provided potable water to thousands of people living on its banks. It was also a source of diverse varieties of freshwater fishes for the people residing in the surrounding areas. Similarly, the Bahini too had been a prolific rivulet. However, in the recent years, Guwahati's ever-growing population accompanied by the city's waste disposal crisis and the encroachment activities contributes to Bharalu being listed by the Central Pollution Control Board (CPCB) as one of the 71 most polluted rivers in India.⁵

Likewise, encroachment alongside the Bahini has extraordinarily reduced the breadth of the rivulet. Though officially the breadth of the Bahini was supposed to be 40 ft, it has been reduced to 5–10 ft at various places⁶ resulting in the submersion of the surrounding areas during the rainy days. Similarly, the width of the Bharalu is reduced from an average of 30 to 20 m due to encroachment activities.⁷ The Bahini and the Bharalu's fate as mere sewers is both unfortunate and worrisome for the city of Guwahati.

2.2 The Varuna and the Assi, Varanasi

River Varuna and Assi are the two tributaries of the Ganga flowing through the city of Varanasi. The city derives its name from these two rivers. The Varuna and Assi have great historical and mythological significance. In Buddhist Jataka tales, Mahabharata and Purana, description of these two rivers could be found. The present situation of both the Varuna and Assi illustrates an unfortunate scenario. Unplanned urban and industrial developmental activities result in both the rivers becoming mere 'nallahs' or 'sewers' carrying sewage water and effluents through the city of Varanasi. The project report of Varanasi Development Authority (VDA) reveals that Varuna is currently the core disposal body of 65 % of drainage of the district. Singh et al. (2014) state that the Varuna receives huge quantities of untreated sewage, agriculture run-off with pesticides, fertilizers, etc., from the catchment areas leading to severe degradation of water quality. Further, a large number of industrial and commercial units are located near the banks of both Varuna and Assi. For instance, dye industries are omnipresent on the bank of River Varuna. Without stringent environmental monitoring and assessment, many times, the untreated effluents from these units are disposed

off directly into these rivers. Sewers opening up into the rivers are a common sight in the city.

Apart from the liquid waste, the banks of the rivers are open dumping ground of the solid waste generated in the city which eventually ends up entering the Varuna and Assi, especially during the monsoon. The banks of both the Varuna and Assi are the dirtiest sights in the city of Varanasi with extreme solid and liquid waste pollution. Considering the intense level of pollution and encroachment, some reports argue that the River Assi exists no more and it is merely a 'drain' today.^{8,9}

Encroachment is another concern in need of immediate policy attention in the city of Varanasi. Varanasi is a major tourist attraction in India with thousands of Indian and foreign tourists visiting the temple city every year. Thus, the city provides lucrative financial opportunities to a number of migrants who often end up encroaching the banks of the rivers Varuna and Assi. They build their makeshift houses on the river banks. Moreover, they use the river for defecation purposes, causing harm to themselves and the environment. The encroachment activities result in significant reduction in the width of both the rivers. As a consequence, the water flows to the banks of the rivers in no time even during a short rainfall episode. The deteriorating state of the Varuna and Assi is intensifying during the last decades and needs immediate stringent policy interventions in order to avert unplanned and unauthorized developmental activities along the banks. It is high time one should realize that the survival of the city of Varanasi depends largely on the health of the Varuna and Assi. With River Assi almost dead, measures should immediately be undertaken to safeguard the Varuna. Preventing the haphazard urban development including the encroachment of the river banks, proper solid waste disposal mechanism and environmental monitoring towards effluent treatment facilities of the industries is essential in order to prevent further destruction of the river systems in the city.

2.3 The Mula and the Mutha, Pune

Both the Mula and the Mutha originate from the Sahyadri Mountain, and the city of Pune is situated at the confluence of these two rivers (Gaurav 2010). Pune is one of the fastest growing cities in India and the sixth largest metropolis in the country. The significant but haphazard growth of the city on the banks of the Mula–Mutha is causing serious threat to the river system in absence of a rigorous

⁵ See http://www.pcbassam.org/rfcc/BHARALU/Bharalu%20City%20Sanitation%20Plan_Draft%20Final.pdf.

⁶ See <http://timesofindia.indiatimes.com/city/guwahati/GMDA-orders-diversion-of-Bahini-River-to-check-flashfloods-in-Zoo-Road-Beltola/articleshow/11014765.cms>.

⁷ <http://www.assamtribune.com/scripts/detailsnew.asp?id=jun2612/city05>.

⁸ See <http://www.downtoearth.org.in/blog/gangas-burden-of-pollutants-from-kanpur-to-varanasi-45382>.

⁹ <http://timesofindia.indiatimes.com/city/varanasi/Source-of-salvation-languishing-in-neglect/articleshow/17672069.cms>.

environmental monitoring system. Further, the city is a hub of several industries such as agro and food processing, information technology, biotechnology, automobile and so on. The rapid growth of the city together with its industrial development is a major cause of pollution in the Mula and Mutha River. For instance, Gaurav (2010) argues that the main reason for Mutha River being polluted is the release of untreated raw sewage. Although the industries claim that they treat their effluent before releasing it to the rivers, the efficiency of many such 'effluent treatment plants' is dubious. Thus, both the rivers are vulnerable to intense pollution as they carry municipal and industrial wastes and run-offs from agricultural lands.

As the previous cases of rivers Bharalu, Bahini, Varuna and Assi, encroachment is a major concern on the bank of the Mula–Mutha as well. The bank of the rivers provides shelter to migrants and urban poor who use the river for their daily purposes. The immersion of idols during the festive season, especially during the Ganesh Chaturthi, is another concern creating severe pollution to the rivers and their banks. Further, the city of Pune has abundant but uneven intracity water distribution system.¹⁰ This results in the generation of large volume of sewage or wastewater as usage of water is directly proportional to the amount of sewage generated. Today, the unesthetic sight of the Mula–Mutha in Pune is both unfortunate and perturbing.

3 Conclusions and recommendations

The tales of India's lost rivers and rivulets are indeed distressing. Many of these rivers and rivulets flow through some of the major cities in the country. The river and rivulet ecosystems, which once provided the dwellers with water and food besides contributing significantly to sectors such as agriculture, pisciculture and transportation, are now at the verge of extinction at several places. The rapid and haphazard urbanization and industrial development are significant factors responsible for such depletion. The growth of Indian cities in the last few decades has been remarkable. As financial centres, Indian cities attract a large population from the nearby suburban and rural areas. All foremost Indian cities have a large migrant base residing on the banks of the major rivers and rivulets. Many establish their businesses on the banks of these rivers. Encroachment of river banks is a major challenge for the local authorities of most Indian cities. Besides creating significant pollution, the river bed is destroyed in the process and it could not perform its intended function. In addition to significant urban and industrial pollution, encroachment activities could be attributed as the single

largest threat for sustaining a healthy and sound river system in Indian cities. It has been observed that encroachments significantly reduce the width of the rivers and rivulets converting them into mere 'sewers' as in the case of River Bharalu and rivulet Bahini in Guwahati. Similarly, River Assi in Varanasi is, today, almost no more. As a consequence, the water flows to the banks of the rivers in no time even during a short rainfall episode.

Some rivers have been core disposal bodies of sewage and effluent from the urban and industrial activities. River Varuna in the city of Varanasi is a live example. River Varuna receives sewage from twenty-two municipal drainages located on both sides of its 15-km-long passage through Varanasi city (Singh and Dwivedi 2007). All the rivers considered for the study purpose (Bharalu, Bahini, Varuna, Assi, Mula and Mutha) are subjected to significant challenges from indefinite solid waste disposal activities on their banks. Both solid and liquid waste create major pollution crisis in the whole river system.

The deteriorating river system in India poses major challenges to the sustenance of cities situated along them. Most of the pollution prevention initiatives by the central or the state governments are directed towards the major rivers such as the Ganga, practically ignoring the equally vital rivulets. Although local governments of most of these cities have undertaken initiatives to address the associated problems, the outcome of the same is highly dubious. Nevertheless, the rejuvenation efforts of rivulet Sasur Khaderi in Fatehpur district of Uttar Pradesh and Kali Bein (Doaba region) of Punjab could act as potential models towards resurrection of India's lost or near-lost rivers and rivulets, including the Bharalu, Bahini, Varuna, Assi, Mula and Mutha. For instance, reacting to a remote sensing report by the Uttar Pradesh government (which revealed critical groundwater level in the Fatehpur district) the local authorities decided to revive the Sasur Khaderi-2 rivulet, which had disappeared due to siltation, prolonged drought and encroachment (DTE 2013). The attempt proved successful as the authorities were able to restore a 46-km rivulet that originates from a lake in Thithaura village and then carves out its course through 42 villages before reaching the Yamuna. Similar to the Sasur Khaderi experience, another effort by a local environmentalist in Doaba region of Punjab to revive the river Kali Bein resulted in restoration of this 160-km-long tributary of River Beas.¹¹ The River Kali Bein, which was once reduced to a mere drain mainly due to dumping of different types of waste, today is a replenished body of water. These constructive illustrations could enlighten and encourage the scientific community, policymakers and general public towards

¹⁰ <http://cseindia.org/node/4267>.

¹¹ <http://www.thebetterindia.com/51513/balbir-singh-seechewal-punjab-river-cleaning/>.

possible restoration efforts of already deteriorated river and rivulet ecosystems in the country. On a positive note, the Bharalu, Varuna and Mula–Mutha are listed among the 445 rivers (in 29 States and 6 Union Territories in India) monitored by Central Pollution Control Board (CPCB), India, with the central aim of restoring and maintaining the wholesomeness of these water bodies (CPCB 2015). Further, the Pollution Control Board, Assam (PCBA) had recently submitted a proposal [under the centrally sponsored National River Conservation Plan (NRCP)] to the Union Ministry of Environment and Forests for the control of pollution and restoration of the Bharalu river stretch.¹² The ambitious Mula–Mutha river restoration plan of the Pune Municipal Corporation (PMC) is expected to be ready by the end of 2016 which will benefit a 44-km stretch of the Mula and Mutha rivers.¹³ Upon successful implementation of these restoration and pollution control efforts, significant possibilities arise towards attaining a healthy river ecosystem in the country. The only challenge lies in the timely and meticulous execution of these efforts in a country laden with significant time gap between the formulation and implementation of any policy measure (Borthakur 2016). The encroachment and pollution problems are observed to be never-ending processes in the context of India's rivers and rivulets. It is high time we take appropriate actions to safeguard our rivers and rivulets; otherwise, detrimental and disastrous consequences are evident.

On a constructive note, it is essential to safeguard a healthy river ecosystem in India in order to derive maximum potential advantage out of it. For instance, in the technological front, Indian rivers could be positively utilized for fulfilling the country's ever-increasing energy demand. In this framework, the current researches and subsequent advancements in technology in the field of solar power, especially floating photovoltaic devices, could prove vital in encouraging a clean energy sector in India. It is because solar energy is the only freely available source of renewable energy that comes directly from the sun and may be converted into heat or electricity (Shehzad et al. 2016). Invention of new solar harvesters, like dye-sensitized solar cells (DSSCs), has become increasingly significant in this context due to 'their simplicity, low production costs, eco-friendly nature, high conversion efficiency values (13 %) and good performance, even in diffuse light conditions' (Gerosa et al. 2016: 498). Further, substantial contributions by scientists such as Bella et al. (2016) who have, for the first time, demonstrated 'dye-sensitized solar

cells with super-hydrophobic architecture' as truly floating photovoltaic devices could throw light towards unexplored and promising areas of floating solar power technologies. Such technological interventions can aid in both pollution abatement and conservation of natural resources. For instance, such progresses in floating solar devices can substantially reduce underground coal mining-induced land subsidence which has large impacts on different components of natural environment (Howladar 2016). Thus, as vigorous and dynamic ecosystems, rivers and rivulets in India have massive potential to contribute to the sustainable development of the country. This calls for rejuvenation or restoration of India's lost or near-lost rivers and rivulets.

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¹² <http://www.assamtribune.com/scripts/detailsnew.asp?id=feb1116/at055>.

¹³ <http://timesofindia.indiatimes.com/city/pune/Mula-Mutha-revival-plans-to-roll-by-December/articleshow/52719658.cms>.