

Cultural Significance and Current Conservation Practices of the Ganga's Ecosystem and Environment

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Abstract The Ganga, a most sacred river traverses from the Himalayas to the Indian Ocean, is revered as a deity by Hindus because it is a source for survival for millions of people in the Indian sub-continent. Over the years, the natural characteristics of this sacred river have disturbed due to several reasons, including unplanned urbanization, industrialization, construction of hydropower projects and executing modern agricultural practices in its floodplain and upper reaches in the fragile Himalayan ecosystem. Being a freshwater ecosystem, the Ganga sustains some unique aquatic fauna and flora, including Ganga shark, Mugger crocodile, and the Ganga river dolphins. In view of embracing sustainability of the Ganga's natural ecosystem, the Government of India has enacted laws; however, the Ganga remains polluted. With this backdrop, the present study aims to revisit and analyze various cultural, social, ecological and environmental issues associated with this most sacred river in India. Based on the analysis of existing information the possible intervention requires to be initiated for river sustainability in the human-dominated landscape is suggested.

Keywords: *The Ganga, cultural milieu, ecosystem, environment, policy development, river sustainability, river management*

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1. Introduction

Historically, rivers being the major sources of fresh water they have been attracting human beings to settle down in their banks. Over the centuries of social and cultural groupings of humans in the banks of major rivers give way to evolve the cultural diversity [1,2,3]. In Indian sub-continent, the Ganga traverses from the Himalayas to the Ganga Sagar before meeting the Indian Ocean, is venerated as a mother by Hindus and over the years millions of people settled in its banks and floodplains [4]. It is a source of survival, which nurtures millions of people by providing various provisioning, regulating and cultural ecosystem services. However, the same people who derived countless benefits from the Ganga, over the years, have begun to disrupt its natural characteristics in view of meeting their unlimited desires [5]. This situation has transformed the once clean river into an extremely polluted dirty stream at several places, which is even not fit for bathing [6].

The rampant urbanization, industrialization, and modern agricultural activities in the Ganga's floodplain and construction of hydropower projects in its upper reaches in the fragile Himalayan ecosystem have aggravated the intensity and scale of degradation of the Ganga's ecosystem [7,8,9,10].

At present, the Ganga suffers from ever-escalating ecological stresses, which threaten the health, prosperity, and spirituality of millions, though immense diversity and vastness of its tributaries make generalization difficult [11]. Realizing the adverse effects of polluted Ganga, the Government of India (GOI) has been attempting to maintain the health of the Ganga since 1956 when the parliament passed the River Boards Act, and again in 1985 the Ganga Action Plan was launched to clean it for posterity. Despite the efforts taken in the past to keep the Ganga clean round the year, it remains overloaded with harmful pollutants, except the monsoon season [12,13].

There are many issues associated with the sustainability of the Ganga's ecosystem and environment. Worldwide, water is considered a most critical resource in the 21st century due to its increasing demands and decreasing supplies [14]. Hence, maintaining the sustainability of the Ganga's ecosystem requires holistic analysis of ongoing human impacts and future risks. Being a lifeline of millions of people, which obtains a substantial ecological diversity, the Ganga is an obvious choice for studying the environmental sustainability of rivers in the human-dominated landscape. Though there are studies on the Ganga's status, the comprehensive study on its ecosystem and environment all through the Ganga transverses still lacks. Moreover, a range of policy initiative has been taken up recently for the sustainability of the Ganga's

ecosystem, which needs to be analyzed. With this backdrop, the present study aims to revisit and examine various cultural, social, economic, ecological, environmental, and biological issues associated with this most sacred river, which supports millions of human beings. The study further discusses the efforts initiated by the GOI concerning the sustainability of the Ganga's ecosystem and environment. Based on the analysis of information it also suggests the possible interventions require to be initiated for river management in the human-dominated landscape.

2. Methodology

An extensive literature survey was carried out for the collection of information on the Ganga's ecosystem and environment and human dependency on its resources. Literatures related to anthropogenic impacts and degradation of the Ganga's ecosystem and environment were also collected. The literature searched from different sources includes scientific journals, books, reports, conference materials and online databases. The academic literature databases were consulted, which include EBSCO, JSTOR, and Science Direct. The relevant documents were screened out from the voluminous results as found on the internet search engines mainly Google, Google Scholar, and Scribd. Specific search terms such as Ganga biodiversity, Ganga ecosystem, livelihood generation from the Ganga, Ganga degradation, pollution in Ganga, anthropogenic pressures on the Ganga, were explored. Since the Digital India campaign of the Government of India helps in providing services and information by improving the online infrastructure, the websites of relevant ministries were also explored for the collection of information. Besides websites, the literature survey was extended to the collection of newspapers reports, as they were the source of most of the latest information on the policy initiatives and their implementations, as taken up by the federal and state governments in India.

3. Results and Discussion

3.1. Cultural significance of the Ganga

The Ganga is regarded as a mother by Hindus hence it is considered the most sacred river in India. There are ample mythological stories interwoven with the holiness of this holiest river. Hindus believe that it is brought from heaven to earth by prince Bhagirath with a belief to purify the souls of his brothers who incinerated by the Vedic sage Kapil. Since then it is considered as a crossing point between earth and heaven, hence the last rite after death is performed in the Ganga. The body is cremated in its banks, and the ashes are spread in its sacred water. In case the Ganga is not approachable, dropping a few drops of its water in the mouth of the body before cremation is considered equally important for making the path for heavenly abode. The pilgrims collect its water to take home where they use it for performing various rituals.

The historical importance of the Ganga is as old as the Hindu civilization. Apart from performing the last rite, many celebrations are performed in the Ganga. The

Kumbha is one of these celebrations, which is organized every 12 years at the Haridwar and Allahabad, the sacred cities through which the Ganga traverses. The term Kumbha signifies the 'immortal pot of nectar'. According to the Hindu mythology, the demons and gods jointly produced the nectar of immortality by churning the sea. Due to some disputes, the gods ran away with the immortal pot of nectar who then chased by the demons. During the chase of 12 days, a few drops of nectar fell at the four places namely Haridwar, Allahabad, Nasik, and Ujjain. Haridwar and Allahabad lie in the banks of the Ganga, and because of receiving heavenly nectar these places are believed to have acquired supernatural powers. In view of soaking such mystical powers and also to get rid of all the sins, devotees assemble here at every 12 years to participate in the ritualistic bathing. Besides, when the planet Jupiter enters Aquarius, and the Sun enters Aries, the 'Ardh Kumbh' means 'half Kumbh' is also organized at every six years. It is also believed a sacred Hindu pilgrimage.

Traditionally, thousands of pilgrims assemble at different places in the banks of the Ganga including Har-Ki-Paidi at Haridwar and Dashashwamedh Ghat at Varanasi, to participate in the Ganga's evening prayers every day (Figure 1). The auspicious occasion of the Ganga's descent on earth from the heaven is celebrated during summer, mainly in June. Apart from the Ganga's prayers, the pilgrims take a dip in the holy river with a strong belief to wash all their sins. During Shrawan month that corresponds to about mid-July to mid-August, the Kanwar pilgrimage takes place in which a large number of people from different parts of India visit Haridwar, Rishikesh and Gangotri wearing saffron colored clothes and walk barefooted to collect the holy water from the chosen pilgrimage destinations. The collected holy water is later offered at their local Shiva temple.



Figure 1. Cultural significance: Devotees assembled for evening prayers of the Ganga at Haridwar - Photo by CP Kala

3.2. Ganga as a Source of Survival and Livelihood

The Ganga originates from the Gangotri glacier and flows through approximately 2525 km before meeting into the ocean at the Bay of Bengal. The Ganga river basin spans over 1,086,000 sq km of India, Nepal, and

Bangladesh, of which 8,61,404 sq. km in India constituting 26% of India's land mass, and supporting about 43% of India's population. The Ganga basin is the most populous river basin of the world as it supports over 448.3 million people in India alone [15]. Besides a source of drinking water and irrigation, the soil drains from the mountains to the plains make its floodplains very fertile for the agricultural purpose. Many crops are grown along the Ganga, which include rice, wheat, millets, sugarcane, sesame and number of vegetables [8,16]. Fishing adds in the livelihood generation. The Ganga water sold in the market has higher prices than the ordinary water.

Traditionally, the Ganga's current has been used as a means for alternative transports, especially for big logs [3]. Many industries, including jute industry in West Bengal and leather tanneries at Kanpur in Uttar Pradesh, are established along the Ganga. Presently, river rafting is increasing as adventure tourism [17]. In the upper reaches, the Ganga flows through a narrow and steep bed. This increases its potential for harnessing hydropower. At present, two types of projects are running on the Ganga; hydropower in the upper reaches and the irrigation (canal system) in the downstream middle reaches [7,18]. Seven hydropower projects above 10 MW are under operation on the Ganga, and seven are under construction. The first irrigation project namely upper Ganga canal having 10,500 cusec capacity was constructed more than a century ago at Haridwar. In the early 1970s, 5800 cusec capacity canal was constructed which is known as Eastern Ganga Canal and later on the middle Ganga canal having 10,260 cusec capacity was constructed at Bijnore for irrigation [6].

3.3. Ganga Ecosystem and Environment

The Ganga is considered pious and has historical importance because of several reasons. In 1896, Ernest H. Henkin observed that the Ganga harbours bacteriophages, which kill harmful germs, especially bacteria, and hence its water remains clean [19]. The cities and towns located in its floodplain not only draw its water but also dispose of the wastewater generated into the river [7]. The filth disposes of in its tributaries finally pollute the Ganga. Many industries including tanneries, fertilizer, petrochemical, pesticides, pharmaceuticals, pulp and paper, sugar, textile, bleaching, dyeing, cement, packaging, printing, electronics, electrical, thermal, metallurgical, and automobile along the Ganga discharge industrial effluent in it. During lean season, the Ganga's flow becomes extremely low due to the diversion of water through Upper and Lower Ganga canals and also storing water for hydropower projects. This degrades the quality of water to such an extent that it is not even suitable for bathing [6,7].

3.3.1. Biodiversity

Although, about 70% of the planet earth covers by water the contribution of freshwater is only 2.5 %, of which just 1 percent is easily accessible as much of it traps in glaciers and snowfields. In general, to feed 6.8 billion people only 0.007 % of the planet's water is available [20]. Because of its intrinsic properties, the freshwater forms a unique habitat for a large number of specialized species. Being the freshwater, the Ganga supports some unique

aquatic fauna and flora. Fishes are found in almost all across the Ganga, though the species are different in different areas. About 140 fish species inhabit in the Ganga from Gangotri to Kanpur, of these 63 fish species live in the mountain section, 122 species in the plains of the Upper Ganga and 46 fish species are common in both the areas [21]. *Schizothorax richardsonii*, *Schizothorax plagiostomus*, *Schizothoraichthys progastus*, *Tor putitora*, *Tor chelynoideis*, *Pseudecheneis sulcatus*, *Glyptothorax indicus* and *Glyptothorax lineatum* are some of the important fish species in the mountain section of the Ganga. Featherbacks, barbs, walking catfish, gouramis, and milkfish are common in the Bengal region. Ganga shark (*Glyphis gangeticus*), a critically endangered species, is also found in the river.

Mugger crocodile (*Crocodylus palustris*), the gharial (*Gavialis gangeticus*), smooth-coated otter (*Lutrogale perspicillata*), porpoise, turtles, and the Ganga River dolphins or the freshwater dolphins (*Platanista gangetica gangetica*) are the well-known species inhabited in the Ganga. About 100 species of algae are reported from the upper reaches of the Ganga, which increases to 180 nearby Farakka in West Bengal [22]. A total 48 species of aquatic birds, 51 species of insects, 15 species of mollusk, 12 species of freshwater turtles, and 4 crustaceans are reported to occur in the upper Ganga [23]. *Trionyx gangeticus* and *Natrix piscator* are among the reptilian fauna survive in the lower region of the Ganga [24]. The saltwater crocodile (*Crocodylus porosus*) and the water monitor lizards (*Varanus salvator*) live in the lower Ganga region near the Bay of Bengal, and they hunt on both land and water.

Hilsa or ilisa (*Tenualosa ilisha*) is mainly found in the last stretch of the Ganga, as it comes here for breeding. The last stretch of Ganga in the Sunderban is called as Satmukhi (literally meaning a hundred mouths) as it flows down through several distributaries. Padma river is one of the major distributaries of the Ganga, which is known to nurture 80 species of fishes [25], of these *Bagarius bagarius* and *Channa punctata* are the dominant fish species in terms of their numbers [26]. The Ganga river basin also supports a large number of terrestrial animals who depend directly and indirectly on the Ganga and its floodplains. A good population of the tiger (*Panthera tigris*) lives in the Sundarbans area of the Ganga delta.

3.3.2. Ganga Water Quality

The Central Pollution Control Board of India monitors the Ganga water quality hence it has set up 57 water quality monitoring stations on the main stem of the Ganga from Uttarakhand to West Bengal. In these stations, seven major quality parameters such as temperature, pH, conductivity, dissolved oxygen, biochemical oxygen demand, total coliforms, and faecal coliforms are monitored. The Ganga surface water temperature exhibits seasonal pattern, and it ranges from 3.0 to 37⁰C. In 1991, the pH being about 8.0 throughout the stretch of the Ganga water indicates its slight alkaline nature [27], however within two decades in 2011 it changes from 6.7 to 9.1 [6] (Table 1).

In 1991, the conductivity, which reflects the mineral/ionic status of the aquatic system, was 22.47-222.0 µmhos/cm in the mountainous region, 460 – 796 µmhos/cm in middle

region between Mirzapur to Ghajipur and 75-354 $\mu\text{mhos/cm}$ from Munger to Farakka. This shows that the conductivity which ranged from 22.47 to 796 throughout the Ganga in 1991 exceeded to 49-10,240 $\mu\text{mhos/cm}$ in 2011 [6,27]. Generally, dissolved oxygen is considered as an important parameter to reflect the overall health of the river and wetland areas. It was relatively high in the upper reaches (10.4 mg/l at Rudraprayag), but between Mirzapur and Ghajipur (3.8 mg/l at Ghajipur) and further down to Farakka it was found low in 1991. Fortunately, the dissolved oxygen is recorded 4-14.3 mg/l in 2011. The biochemical oxygen demand in 1991 was estimated 0.1 mg/l at Badrinath and 56-78.9 mg/l between Mirzapur and Ghajipur [27]. In 2011, biochemical oxygen demand fluctuated between 0.2 to 11.0 mg/l. The total coliform in the Ganga water is estimated $5-25 \times 10^5$ MPN/100 ml, and faecal coliform $5-11 \times 10^5$ MPN/100 ml [6].

3.3.3. Degradation of the Ganga Ecosystem

Though the Ganga is still regarded and worshipped as a deity, it experiences a high level of pollution and related threats to its ecosystem. The human congregations to its basin keep on inflating due to exponential population growth. The poor management of urban and industrial areas flourished in the Ganga basin has deteriorated its water quality. In addition, turning away of a substantial volume of water for irrigation and construction of dams for power generation in the upper reaches of the Ganga decline the water flow in the downstream, which subsequently limit its assimilative ability from pollutants [7]. The main sources of pollutants in the river are municipal wastewater, industrial waste and leaching of pesticides in the river used for farming [3,28,29]. The polluted water loaded with heavy metals and pesticides is pumped back for irrigation along the Ganga's floodplain, which contaminates the farms produce.

The cities located along the Ganga discharge 2,723 million liters per day (mld) of domestic sewage in it [6]. However, this figure may be higher as it is based on the water supplied in the cities and often all the water that is used—much is groundwater—is not supplied by the management. There is a large gap (55%) between sewage generation and treatment, which keeps on increasing because of growing population even after adding up the capacity of treatment plants [30]. In 2015, a study reports that against a treatment capacity of about 1,027 mld, approximately 3,636 mld sewage was discharged in the Ganga [31].

The tanneries at Kanpur discharge effluents containing hazardous chemicals, such as cadmium, chromium, arsenic, mercury, nickel, sulfuric acid and methane [32]. In Varanasi, the Ganga remains contaminated by heavy metals such as cadmium, chromium, nickel and lead with their high concentration in the downstream [33]. The heavy metals are also released into the Ganga from its tributaries, which make the downstream water quite poisonous. Drinking of such contaminated water leads to potential health risk [34]. In Bihar, many brick kilns are constructed along the Ganga's banks. Within Patna city, there are 596 brick kilns and majority of them are along the Ganga's bank. They generate heavy volume of waste material, which is being deposited on the Ganga's banks leading to alter its natural course and also pollute its water

[35]. During festive occasions, immersion of idols into the Ganga made up of Plaster of Paris, which is not dissolved timely, put additional stress. The chemical dyes used to colour the idols contain poisonous elements, which may cause cancer [36,37]. Ardh-Kumbh and Maha-Kumbh, being the largest gatherings of humans in the Ganga basin, add up pollution in the Ganga [38].

The Ganga's banks being used as cremation ground a large amount of ash along with half-burnt bodies are dumped into its water. Merely two cremation grounds, Manikarnika Ghat and Harish Chandra Ghat at Varanasi, annually dump 16,000 tonnes of ash, 300 tonnes of half-burnt bodies and 33000 bodies into the Ganga [39]. Though, electric crematoriums have been established in the Ganga's banks but people, generally, prefer to follow traditional cremation practice which is believed more auspicious. Accordingly, the dead body is burnt on the pyre of wood while chanting prayers and mantras despite the fact that the cost of traditional cremation practice is higher (Rs 5000-6000) than the electric cremation (about Rs 600). Millions of trees are required for this purpose. Since the dead body is burnt to ashes by burning woods, it emits CO_2 , a green house gas source of global warming [40].

The level of different types of pollutants in the Ganga has mounted a severe pressure on its aquatic flora and fauna. Apart from pollution, siltation in river basins and overexploitation of aquatic fauna, especially fishes, are the causes of concern for sustainability of its ecosystem. About 42% of the total fish population in the lower Ganga (e.g., Padma river) has been threatened due to water pollution, habitat loss, indiscriminate killing of juvenile fishes, and destruction of breeding sites [25]. Annually, a total of 729×10^6 tons of sediments is mobilized through a narrow zone of this river. The river sedimentation, which is climatically controlled, is predicted to produce 2000 km long, 2 – 40 km wide and 25 - 50 m thick ribbon-shaped symmetrically skewed fine sand body [41]. Construction of dams on the river creates obstacles in natural mobility of sediments. In such places, the continuous accumulation of sediments in the river bottom ultimately reduces the river depth and widens its surface areas. In rainy season, the human habitation in the proximity of the riverside suffers from deluge due to increase in river water level and inadequate depth of river to keep it flowing. Subsequently, the river water spreads and damages vast swathes of land, people and property. Moreover, the excess water is released by the dam authorities, which also create havoc in the downstream.

The real estate business in many places thrives on the mining of sand, gravel, boulders and pebbles from the river beds [42]. Since there is a huge business in sand extraction for construction purposes, the state government is empowered to make rules for regulating the grant of prospecting licenses, mining leases and the purposes connected therewith under the Mines and Minerals (Development and Regulation) Act, 1957. However, there is rampant and illegal mining of sand from the Ganga's flood plains that causes instability in river systems, alteration of floodplain, disturbances in river flow, pressure on benthic population and changes of channels [43,44]. Rampant sand mining affects the Ganga's ecosystem and environment, physically, biologically and chemically.

Table 1. Changes in major properties of the Ganga within last two decades

Sl. No	Properties	In 1991 (Mathur, 1991) [27]	In 2011 (CPCB, 2013) [6]
1	Conductivity	22.47 to 796	10,240 μ mhos/cm
2	pH	8.0	8.0 to 9.1
3	Dissolved oxygen	3.8 mg/l - 10.4 mg/l	4 to 14.3 mg/l
4	Biochemical oxygen demand	0.1 mg/l to 56–78.9 mg/l	0.2 to 11.0 mg/l

Overexploitation of aquatic fauna has direct bearings on their population. Hundreds of Gangetic dolphins are killed every year because the oil extracted from their blubber is used as a fish attractant in India and Bangladesh [45]. Its population, which is fragmented due to construction of dams and other irrigation-related projects, is susceptible to inbreeding and vulnerable to other threats because of restriction on their movements, especially during summer when water is low. Since the dams disturb the migration and life cycle of other aquatic fauna, the food web is disturbed and dolphins do not receive sufficient food [46]. Over the years, dolphin has been locally extinct from many parts of the Ganga and it categories as an endangered species by IUCN, which reflects the poor health of the Ganga.

The Ganga is not untouched from the global environmental change. The Himalayas has warmed by 1.5°C from 1982 onwards, which is considerably higher than the global average [47]. This increase in temperature is one the reasons of enhancing the rate of melting of glaciers across the Himalayas. The rate of recession of Gangotri glacier, which is a major source of the Ganga, is 22-27 m per year over past few decades [48]. Obviously, shrinking of glaciers in the Himalayas is a major threat to the Ganga's continued existence. Threats of global environmental change is not only restricted to the first stretch of the Ganga but its last stretch, the Sunderbans, suffers from heavy land erosion. Over the last 25 years, the 200 year old Ghoramara Island in South 24 Pargannas has shrunk from 120 sq. km to 5 sq. km in size [49]. Besides, the low oxygen availability and high sedimentation rates in the Bay of Bengal are due to high erosion rates in the Himalayas [50]. The Ganga's ecosystem, at present, faces various serious threats, including water pollution, freshwater-biodiversity loss, invasive species expansion, climate change, and land-use changes.

3.4. Upholding the Ganga's Sustainability

The Ganga being a life saving entity it is imperative to save the Ganga from degradation. The GOI has been attempting to maintain the sustainability of the Ganga and other rivers since 1956 when the parliament passed the River Boards Act. Though the issue related to water primarily falls under the jurisdiction of the respective states, the regulation and management of the Ganga, being an inter-state river, also comes under the jurisdiction of the Central Government. In 1970s, the environmental and ecosystem sustainability has given priority by enacting and promulgating Acts such as Wildlife Protection Act 1972, the Water (Prevention and Control of Pollution) Act 1974 and the Water Cess Act 1977. A more

comprehensive Act was passed in 1986, the Environment Protection Act, in order to protect the environment and also to set standards for environmental sustainability. In view of conserving all life forms, the Biological Diversity Act was enacted in 2002 (Table 2).

To reduce the pollution pressures, exclusively in the Ganga and also to clean it for posterity, the GOI launched the Ganga Action Plan (GAP) in 1985. Accordingly, the Central Ganga Authority was established as the apex body for policy formulation and its implementation. On November 4, 2008, the Ganga was declared as the national river of India. Subsequently, the National Ganga River Basin Authority (NGRBA) was constituted on February 20, 2009 in order to develop strategic plans for conservation and cleaning up of the Ganga. A part of the river Bhagirathi, which forms the upper reaches of the Ganga, was declared as an eco-sensitive zone in 2010 in view of maintaining sustainability of the fragile mountain ecosystem through which the Ganga flows down in the first stretch of its place of origin.

To support and strengthen the Ganga cleaning and rejuvenation, the Ministry of Water Resources was renamed as the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWRRDGR) in 2014. The National Mission for Clean Ganga (NMCG), an autonomous body, which was originally formed by the Ministry of Environment, Forest and Climate Change on 12th August 2011, was shifted to the MoWRRDGR. The NMCG implements the policies made by the NGRBA [51].

On May 13, 2015, the GOI approved Rs 20,000 Cr for Namami Gange for 2015-20 which is in addition to Rs 2,037 Cr sanctioned in 2014. While safeguarding the Ganga's ecosystem and environment by setting up sewage treatment plants and drawing achievable schemes for ghat (set of steps descending to the river) development, solid waste management and biodiversity conservation, the GOI also plans to develop the Ganga as a means of transport and tourism destination. In the first phase, while beautifying its major banks the Ganga stretch between Varanasi and Hoogli will be made navigable by boats. Eventually, this plan is expected to cover 1,620 km of the Ganga's stretch by extending the same till Allahabad [52]. Introducing floating hotels, river cruises, moving sound and light show between Haridwar and Hoogli are the part of the Ganga rejuvenation plan which aims to merge the traditions with new technologies for development of sustainable tourism along the banks [53]. The Namami Gange program is also planned to free all villages fall under 1,632 gram panchayats along the Ganga banks from open defecation by 2022. Further, it proposes to incentivize the state governments to expand sewerage infrastructure in 118 unban habitations along the Ganga [54].

Table 2. Chronology of framing major policies, Acts and decisions for the Ganges management in the independent India

Sl. No	Year	Activity
1	1956	The Indian Parliament passed the River Boards Act
2	1972	Wildlife Protection Act
3	1974	Water (Prevention and Control of Pollution) Act
4	1977	Water Cess Act
5	1985	Ganga Action Plan
6	1986	Environment Protection Act
7	2002	Biological Diversity Act
8	2008, Nov 4	Declaration of the Ganga as National River
9	2009, Feb 20	Constitution of National Ganga River Basin Authority for developing strategic plans for conservation and cleaning up of the Ganga
10	2010	Declaration of upper reaches of the Ganga, a part of Bhagirathi catchment area, as an eco-sensitive zone
11	2011, August 12	Shifting of National Mission for Clean Ganga (NMCG), an autonomous body, from Ministry of Environment, Forest and Climate Change to the MoWRRDGR
12	2014	Adding up Ganga Rejuvenation in the name of the Ministry of Water Resources, which is now called as Ministry of Water Resources, River Development and Ganga Rejuvenation MoWRRDGR
13	2014	Cabinet approved to Rs 2,037 Cr for Namami Gange
14	2014, October 29	The Supreme Court of India directed all the polluting industries along the banks of the Ganga to adhere all environmental norms and empowered National Green Tribunal (NGT) to issue orders for closing down industries not following such norms
15	2015, May 13	Cabinet approved Rs 20,000 Cr for Namami Gange for 2015-20 which is in addition to Rs 2,037 Cr sanctioned in 2014
16	2016, Feb 1 st	NGT imposed complete ban on use of plastics in the first stretch of the Ganga from Goumukh to Haridwar
17	2016, July 7	To ensure clean water flow in the Ganga, the GOI launched 231 projects under NMCG at 100 locations in all five states through which the Ganga flows
18	2016, July 10	Use of vast network of postal services for marketing of the Ganga water at the doorstep of the needy people
19	2016, October 7	The GOI issued a notification for rejuvenation and protection of the Ganga which is called as River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016.
20	2017, March 20	The High Court of Uttarakhand declared that the Ganga has to be treated as a living human entity

The Supreme Court of India on October 29, 2014 directed all the polluting industries along the banks of the Ganga to adhere all environmental norms. Failing to install adequate anti-pollution measures to treat effluents will attract severe punishment and the National Green Tribunal (NGT) is empowered to issue orders for closing down such industries [55]. The NGT has also imposed complete ban on use of plastics in the first stretch of the Ganga from Goumukh to Haridwar with effect from February 1, 2016. As per the directives of NGT, hotels and other organizations discharging waste into the Ganga should be penalized Rs 5000 per day [56]. The NGT has also imposed ban on beach camping near the Ganga. The GOI also plans to establish Territorial Army battalions, the Ganga Eco-Task Force, specifically for keeping the Ganga clean [57].

The MoWRRDGR also plans to involve more participation of public by taking religious leaders in confidence for the Ganga rejuvenation. Its autonomous body the NMCG plans to launch a sustainable partnership with 118 urban local bodies for keeping 500 m along the Ganga litter free. This practice will also provide employment to the unemployed local youths while keeping the Ganga pollution free. To ensure clean water flow in the Ganga, on 7th July 2016 the GOI launched 231 projects under NMCG at 100 locations in all five states through which the Ganga flows [58]. These projects will take care of development of sewage infrastructure, redevelopment of 'ghats' and crematoriums, plantation of tree and medicinal plants, trash skimmer and interceptors. Besides, these

projects will have to deal with conservation of biodiversity by establishing biodiversity centres and dissemination of awareness about NMCG by creating knowledge centres.

Since people prefer to follow traditional cremation practice through which the dead body is burnt on the pyre of wood, under Namami Gange programme the GOI plans to modernize 369 crematoria all along the Ganga so that the quantity of wood consumption can be reduced drastically. The newly designed wood-based crematorium has metal base elevated pyre structure attached with a chimney. This improved design facilitates better air circulation around the flames, which helps the combustion efficiency. These improved wood-based crematoria are not only cost effective but energy efficient, as well [59]. These newly designed crematoria will help in saving the trees and also mitigate the negative impacts of climate change by retaining the sink and reducing the source of CO₂.

Since there is a huge demand and market for the Ganga's holy water, to make it available at the doorstep of every family across the country, the vast network of postal services has been utilized from July 2016. The packaging of the Ganga water in bottles for distribution is being done at the source, Gangotri and Rishikesh, as in such places the water is less polluted. Apart from delivering at doorstep, the bottled Ganga water is sold out at the counter of major post offices. The order can be placed online through the portal indiapost.gov.in. This scheme, which launched on July 10, 2016, has received overwhelming response in many states including West Bengal [60]. The cost of 200ml and 500ml bottles Ganga water from Rishikesh is

Rs 15 and Rs 22, respectively. Besides to meet the need of people, this initiative helps to provide employment as packaging industry and resource for postal services.

Apart from government and non-government organizations, the Hindu cultural groups including spiritual leaders and priests seek to make the Ganga pollution free. During the Ganga evening prayers, when thousands of pilgrims assemble at different places in the banks of Ganga every day, the priests through decreeing persuade pilgrims to take oath for maintaining the Ganga's sanctity by keeping it pollution free. The similar practice is being followed by the priests on other auspicious occasions, as well, when a large number of pilgrims congregate to offer prayers and take a holy dip in the Ganga.

3.5. A way Ahead

Every year during monsoon, the hydrological cycle through which water reaches to atmosphere from the ocean by changing its forms from solid to liquid to gas, naturally clean the Ganga basin [61]. However, the construction of hydropower and other projects on the Ganga create some obstacles in its natural course of cleaning. The non-monsoon months are the major period that has to be taken care of for keeping the Ganga clean. Since the Ganga is a compound product of landscapes, unique ecological properties of the multiple sites, local valley constraints and climatic conditions of the catchment areas like other rivers elsewhere [62,63], execution of management interventions needs understanding at local site level, as well. There are possibilities that different stretches of the Ganga demand different management interventions.

There are schemes running parallel with the Namami Gange, which can contribute in keeping the Ganga unpolluted. For instance, the Clean India Mission can contribute significantly if the cities and towns are kept clean without discharging the sewage and polluted water into the Ganga. The drainage and waste management systems in the cities and towns should be placed in order. Complete ban on discharge of industrial effluents and polluted water, including sewage, into the Ganga can only keep it free from pollutants and facilitates in maintaining its sanctity.

The escalating gap between sewage generation and treatment should be sorted out by installing and adding up the capacity of treatment plants. Selection of treatment systems, its processes and technologies must be capable to meet the requirement. Sewage can be converted into manure for farming hence industrial effluents should not be mixed up with sewage. Proper management of sewage treatment systems and newly designed crematoria should be ensured. The Clean India Mission, which aims to keep the urban and rural areas clean, may be injurious for the Ganga's health if the sewage treatment systems are not placed in order. Various tributaries of the Ganga should also be made clean otherwise their drainage system will continue messing up the Ganga's health. Immersion of idols decorated with synthetic colors and made up of Plaster of Paris and any other environmental non-friendly material in the Ganga and its tributaries must be banned completely.

There is a need to prepare a directory of polluters for its entire stretch. This directory will help to keep close eye on

the polluters and monitor regularly the quality of water discharged in the river. Proper sanitation drive must be accomplished in the Ganga's flood plain where pilgrims congregate for performing cultural activities. Setting-up of portable toilets in such places those are equipped with innovative technology such as fecal sludge treatment and waterless urinal technology may help in discontinuing discharge of sledge into the river. Being portable such toilets can be shifted on a rise of water level. The design of such toilets should be friendly to the differently-abled people and women folks, as well.

Construction of dams in the upper reaches of the Ganga, whether small or big, should be regulated if not stopped completely in view of the fragile nature of Himalayan ecosystem. There are hydropower projects which propose to divert the river water into tunnels. Tunneling of river would not only alter the mountain properties due to use of detonators during construction but it will result in the loss of flora, fauna, fertile soil and minerals. Moreover, there is a need to ensure minimum flow of water in the river round the year in order to make the river functional. The purpose of Farakka dam in the state of West Bengal is being questioned due to huge siltation in the Ganga, which is blamed to accelerate the impacts of deluge in Bihar during rainy season [64]. There is a need of proper silt management policy. Monsoon brings flood in the river, every year. This increased quantity of water can be diverted and stored in reservoirs by constructing artificial lakes for use during lean period.

Provision for corporate social responsibility (CSR) as per the Companies Act 2013, which guides the corporate to set aside at least 2% of their average profit in the last 3 years for philanthropic activities, including environmental conservation, can facilitate in rejuvenating the health of the Ganga's ecosystem and environment. Fortunately, there has been a rise in average CSR expenditure by domestic and foreign firms from Rs 3.79 and 8.5 million respectively in 2011-12 to Rs 22.6 million and 19.5 million respectively in 2012-13 [65]. In 2014-15 financial year ended in March 2015, the country's top 50 companies claimed to have spent over Rs 46,000 million under CSR activities including healthcare, education, environment and clean India initiative [66]. However, the states through which the Ganga traverses received little CSR pay out. Encouraging companies to pay heed on the Ganga's present state of affairs may help to rejuvenate this most pious river.

The Mahatma Gandhi National Rural Employment Guarantee Act 2005 (MGREGA) as implemented by Ministry of Rural Development, which aims to enhance the livelihood security of people in rural areas by guaranteeing 100 days of wage employment in a financial year, can be used as an instrument for maintaining the Ganga's health. While providing employment to the rural people activities such as water conservation, watershed management, rejuvenation of traditional water bodies and afforestation have been carried out in the rural areas under MGREGA. These activities have direct bearings on the management of the Ganga's ecosystem. There is a fund for agricultural related expenditure in MGREGA under which the beneficiaries may be encouraged to adopt organic farming so that the harmful chemicals used as pesticides and fertilizers may not drain into the Ganga. Since the work is allocated yearly under MGREGA, the

continuous flow of funds for accomplishing yearly activity may reduce the Ganga water contamination [67].

The massive plantation drive needs to be initiated all across the country to mitigate the negative impacts of climate change [68], especially rising rate of melting of glaciers in the Himalayas which has direct link with the Ganga's existence. Frequent plantation should be done on the banks of the Ganga while organizing religious ceremonies [69]. The selection of native species for plantation should be based on the locality, altitude and geological conditions [70]. This will help to bind the soil from erosion and protect the communities living in its flood plain during monsoon. Plantation of useful plants, especially medicinal and aromatic plants, will help to generate livelihood and take care of people's health in need. Overexploitation of aquatic fauna should be stopped.

Lessons need to be learned from the deluge of 2013 in the Ganga's floodplains and its upper tributaries in Uttarakhand [4]. Setting up of structures for commercial, residential and industrial purposes or expansion of human habitation on either side of the Ganga's banks, especially in the active floodplains, must be banned. The sand mining from the Ganga's floodplain must be regulated in view of maintaining its ecosystem and biodiversity. Before granting license by the concerned state governments as per the Mines and Minerals (Development and Regulation) Act 1957, it is necessary to investigate the total volume of the sand, areas for sand collection, quantity of the sand to be collected, and adverse effects of sand collection, if any, on the Ganga's ecosystem.

Spreading benefits of clean Ganga among the masses and changing their behavior towards environmental conservation will help to reduce the ongoing pressures. Open defecation practices must be discouraged and street campaigns and cleanliness drives may be organized for better understanding. The information, education and communication material on such aspects may be developed and distributed among the communities. The ethical values of the Ganga should be incorporated in the syllabus of school as well as at the college level to disseminate awareness and create a sense of belongings in the young minds for saving the Ganga, which has been worshipped, historically. Awareness campaign among masses against environmental degradation, especially against pollution of air, water and land and deforestation should be taken up.

Maintaining the historic cultural significance of the holy Ganga is important. Apart from a lifeline for most populous river basin of the world and a freshwater ecosystem, the Ganga supports some unique aquatic fauna and flora. The planet earth will be deprived of some of the majestic animals such as mugger crocodile, the gharial, smooth-coated otter and the Ganga dolphins along with some of the unique biome if the concerted efforts are not taken up timely. Apart from this, the Ganga being a manifestation of a whole civilization needs continuous deliberations from the human beings for their own identity.

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