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Conservation planning for the Ganga River: a policy conundrum

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ABSTRACT

River conservation planning is complicated by its inherent connectivity, variations in habitat features and difficulties in conserving entire rivers. Economic and social constraints in human-dominated river systems, such as the Ganga, further complicate planning. A multistage systemic analysis was performed to identify policy gaps and recommend the most suitable conservation strategy for the Ganga. A critical review of Indian legislation impacting the Ganga was carried out to examine conservation issues from a policy perspective. Thereafter, existing conservation planning approaches were reviewed to identify the most strategic option. The analysis suggests that the disregard for river connectivity, lack of protection, and incoherent sectoral policies hinder river conservation in India. Strategic prioritisation and zonation of the Ganga along the principles of prohibition, restriction and regulated resource use and creation of 'optimal sites' for biodiversity conservation under multiple management zones was recommended. Improving institutional design and capacity would enhance sectoral coordination and policy integration.

KEYWORDS

River conservation; systematic conservation planning; protected areas; sectoral coherence; policy integration

Introduction

Rivers, streams, and associated wetlands are integral components of freshwater ecosystems (Revenga et al., 2005). Despite their small global distribution (<1%), they harbour the richest diversity of species and habitats (Abell et al., 2008; Collen et al., 2014; Ormerod et al., 2010). Conservative estimates indicate that these ecosystems support at least 9.5% of all animal species (Balian et al., 2008), nearly 6% of all described species (Dudgeon et al., 2006) and a third of all vertebrate species (Strayer & Dudgeon, 2010). The patterns and processes of interactions among these species and between species and their habitats account for numerous ecosystem services, such as freshwater provision, food, and groundwater recharge, which are critical to the survival and wellbeing of all life forms (Carrizo et al., 2013). These services can only be maintained when freshwater ecosystems are functionally intact and supported through appropriate conservation measures (Baron et al., 2002).

Among freshwater ecosystems, rivers are highly threatened by a range of spatial and temporal factors (Guo et al., 2019; Linke et al., 2011). Moreover, linkages between hydrological connectivity and ecological processes (Tockner & Stanford, 2002) make it challenging to formulate an integrated system of conservation that encompasses landscape functions and guides policy formulation and management strategies (Poff et al., 2003). This is because conservation efforts must account for off-stream disturbances in addition to in-stream threats (Linke et al., 2011). Furthermore, the application of systematic conservation approaches used extensively for terrestrial habitats (Linke et al., 2007; Saunders et al., 2002) is also a barrier to the protection of river ecosystems.

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For river conservation to be effective, it should be inclusive and supported with the best available science that guides policy and management (Meffe, 2002). This is challenging for large river systems, such as the Yangtze, Amazon, and Ganga, which extend over vast geo-climatic and administrative regions and contribute to the infeasibility of conserving entire rivers as a singular system (Abell et al., 2007). This issue is even more complex in human-dominated areas, where social and economic constraints imposed by the dependent human populations restrict the feasibility of protecting entire rivers and their catchments (Nel et al., 2009) or the inclusion of all habitat features inside large protected areas (PAs) (Chessman, 2013). Nonetheless, there is an urgent need for systematic conservation planning for rivers to guide policy and to implement targeted measures to legally protect riverine habitats and their biodiversity (Hermoso et al., 2011).

The present study was carried out in the context of the Ganga River, which extends for approximately 2,525 km across five Indian states and with a drainage basin extending into 11 Indian states (Figure 1). This vast landscape (Ramakrishnan, 2003) is unique and is revered as 'the archetype', 'the quintessence', and 'the source' of sacred waters in Hindu mythology (Eck, 2003). These cultural and religious links often hinder conservation efforts for the river and its basin (Drew, 2012). The Ganga traverses varied geomorphological features that, when coupled with climatic variations, provides a continuous gradient of habitats for various life forms and harbours a unique assemblage of flora and fauna (Table 1). Apart from its rich biota, the river also supports a population of about 650 million people (GoI, 2011) across 26.3% of India's geographical area, resulting in one of the highest human population density globally (Table 1). Owing to this, the river faces significant threats, such as alteration of its banks by agriculture, sand mining, reduced water flow and depth due to water abstraction and diversion through

Figure 1. Passage of the Ganga River (Source: WII-GACMC, 2018).

Table 1. Characteristic features of the Ganga River.

	Upper stretch	Middle stretch	Lower stretch
States	Uttarakhand	Uttar Pradesh	Uttar Pradesh Bihar Jharkhand West Bengal
Density (persons/km^2)	189	829	950
Biogeographic Province(s)	West Himalaya 2B	Upper Gangetic Plain 7A	Lower Gangetic Plain 7B,East Coast 8B
Representative Aquatic Species	Eurasian otter (*Lutra lutra*) Gharial (*Gavialis gangeticus*) Golden Mahaseer (*Tor putitora*)	Gangetic dolphin (*Platanista gangetica gangetica*) Smooth-coated otter *(Lutrogale perspicillata)* Gharial Sarus crane (*Antigone antigone*) Bata fish (*Labeo bata*)	Gangetic dolphin Lesser adjutant stork (*Leptoptilos javanicus*) Northern river terrapin (*Batagur baska*) Saltwater crocodile (*Crocodylus porosus*) Hilsa (*Tenualosa ilisha*)
Threats to the biodiversity	• Structural changes in river's morphology • Loss of connectivity • Sand mining	• Cultivation on river islands and sand bars • Water abstraction • Unsustainable resource extraction • Industrial and domestic discharge • Poaching	• Altered flow regime • Alteration of the riverbank • Unsustainable fishing • Poaching • Industrial and domestic discharge.

dams and barrages, and pollution from industrial and domestic discharges (WII-GACMC, 2018). These anthropogenic activities have caused changes in the riverine ecosystem and hampered ecological processes (Nautiyal, 2010), necessitating urgent strategic actions.

In 2017, the High Court of Uttarakhand state issued an order declaring the Ganga to be a legal person in an attempt to protect the river (Indian Courts, 2017). This order was later overruled by the Supreme Court of India on grounds of the river's transboundary nature. Despite this, the Government of India (GoI) has renewed emphasis on restoration of the Ganga, promoting science-based conservation approaches with due consideration of stakeholders. However, the multiplicity of regulatory tools and policies governing the river, across various sectors, and an absence of a river policy conforming strict protection for the river, highlights the need for this review. The study was also driven by the need to explore ways to ensure maximum conservation benefits in view of social and economic constraints. Therefore, we sought to draw conclusions and formulate recommendations for informed decision-making for the conservation of the Ganga and other river systems in human-dominated landscapes through critical examination of:

(a) National policies and other legislation impacting the Ganga, to determine their efficacy in its conservation; and
(b) Global scenarios of river conservation planning, to identify the most strategic option for the Ganga.

Methods

The study adopted a multistage approach to the systemic analysis (Coral, 2018). The first stage aimed to gauge river conservation issues from a policy perspective; hence, Indian policies and other legislation concerning the allocation of river resources and their impacts on its ecology and biodiversity were reviewed (Table 2). We followed a grounded theory approach (Glaser & Strauss, 1967), a systematic method consisting of rigorous analysis and conceptualisation of data that aims to construct theoretical interpretations (Charmaz & Belgrave, 2019). This approach adopted from a myriad of other qualitative methods is a dominant paradigm for socio-political research (Hughes & Jones, 2003) and is effective for the understanding of contextual elements (Orlikowski, 1993). Following a holistic solution-based approach, it is investigator-directed and based on structured information gathering and analytical processes (DePoy & Gitlin, 1994). Using this approach, we gathered information pertaining to water allocation and use, aquatic biodiversity, and riverine protection, and identified gaps in river conservation therein. Ethnograph 6.0 software was used to facilitate the categorisation of policy issues.

The protected status of the Ganga and its focal species were evaluated to determine the role of existing legal instruments in Ganga conservation. The location and extent of PAs along the river were taken from WII-GACMC (2018). Global distribution ranges for focal species were obtained from the

Table 2. Policy and legislative tools applicable to rivers in India.

Policy or legislative tool	Ministry	Focus
National Water Policy (GoI, 1987; GoI, 2002; GoI, 2012)	MoJS	Economic
Policy on Hydropower Development (GoI, 1998)	MoP	Economic
National Waterways Act (GoI, 2016)	MoS	Economic
Indian Fisheries Act (GoI, 1897)	MoA	Economic and Regulation
Wild Life (Protection) Act (GoI, 1972)	MoEFCC	Conservation and regulation
Water (Prevention and Control of Pollution) Act (GoI, 1974)	MoEFCC	Regulation
Water (Prevention and Control of Pollution) Cess Act (GoI, 1977)	MoEFCC	Economic and Regulation
Environment (Protection) Act (GoI, 1986)	MoEFCC	Conservation and regulation
National Environment Policy (GoI, 2006)	MoEFCC	Regulation
National Biodiversity Action Plan (GoI, 2008)	MoEFCC	Regulation
Wetland (Conservation and Management) Rules (GoI, 2010; GoI, 2017)	MoEFCC	Regulation

MoJS—Ministry of Jal Shakti; MoP—Ministry of Power; MoS—Ministry of Shipping; MoA—Ministry of Agriculture; MoEFCC—Ministry of Environment, Forest and Climate Change

IUCN Red List website and plotted using GIS to identify their occurrence along the Ganga. The intersection of the distribution range of species with the PAs was then calculated to determine the percentage of their range under legal protection.

The second stage involved the identification of strategies for conservation planning approach for the Ganga. This was undertaken using a 'systems thinking' approach (Arnold & Wade, 2015; Coral & Bokelmann, 2017; Richmond, 1994) through literature review, and consultations with experts (Maani, 2013). This approach was adopted because it identifies solutions or alternatives for complex situations involving multiple stakeholders/actors and their interests by exploring a web of factors across different systems and their mutual interplay.

An extensive literature search was carried out using Google Scholar and Publish or Perish (Version 5.29.5793.6409). The keywords for the search included but were not limited to: 'aquatic biodiversity', 'freshwater ecosystems', 'riverine ecosystems', 'riverine diversity', and 'systematic conservation planning'. This generated almost 1,000 scientific peer-reviewed articles, book chapters, and conference proceedings, which were screened according to their level of relevance for systematic conservation planning for rivers. Peer-reviewed articles published on or after 2000 were selected for the synthesis, reducing the number of articles to 200. These were then segregated based on global, regional, and Indian contexts and their feasibility of implementation in the Ganga, resulting in 54 papers specifically pertaining to river conservation planning. Twenty peer-reviewed articles with novel approaches were selected (Table 3). Discussions with experts from state forest departments, project management groups, local administrators of the Ganga states, social scientists, ecologists, and policy planners were held to review the feasibility of conservation planning approaches for the Ganga.

Results

Policy issues related to river conservation

Water as an entity has been the focus of laws and regulations since the advent of civilisations. However, the protection of rivers as an ecosystem was largely ignored until the late 20th century. The USA was the first country to legalise river protection through its Wild and Scenic Rivers Act (1968) (Nevill, 2007). India, a country with many large river systems, still lacks a river policy, leading to weak institutional arrangements and inadequate management. The policies applicable to Indian rivers are spread across various government sectors, resulting in a range of issues in policy design and implementation (Table 2). These policy issues were grouped into three broad categories using the Grounded Theory approach.

Connected nature of rivers

The Ganga Basin is a system of connected rivers and streams that drain to the mainstem and account for 60% of its water (Paul, 2017). Along with enhancing flow, these tributaries serve as breeding grounds and refugia for aquatic species, highlighting the importance of maintaining connectivity within the basin. However, these tributaries also drain pollutants into the Ganga, reducing the river's capacity to carry out a range of functions, such as pollution abatement, nutrient cycling and water filtration. Therefore, restoration of the Ganga requires a holistic approach that considers the cumulative impacts of associated systems and dependent species.

The GoI's National Water Policy (NWP) (GoI, 1987, 2002, 2012) and Wetland (Conservation and Management) Rules (GoI, 2010, 2017) focus on water allocation, pollution abatement, and flood control while promoting livelihoods and research on freshwater biodiversity and ecology. The National Water Policies (GoI, 2002, 2012) highlights the importance of ecological water needs and the conservation of river corridors. However, these policies have not addressed river connectivity. The National Environment Policy (NEP) (GoI, 2006) is the only policy that acknowledges the connected nature of rivers and has strategised an action plan for the integrated

Table 3. Studies with novel approaches to systematic conservation planning for freshwaters.

References	Approaches
Roux et al. (2002)	Complementarity algorithm to derive an efficient solution
Abell (2002)	Conservation planning taking into account key habitat requirements of focal species, species adaptation to hydrologic regimes and threats.
Dunn (2003)	Conservation needs to be founded on national legislation and policies. Landscape values and riverine functions should be incorporated in planning.
Cullen (2003)	National inventory to guide the comprehensive, adequate and representative freshwater reserve system.
Fitzsimons and Robertson (2005)	A strategic and iterative process based on comprehensive, adequate and representativeness for development of freshwater reserve systems.
Higgins et al. (2005)	Highlighted the use of freshwater ecosystem classification in systematic framework
Hamilton and Gehrke (2005)	Acknowledged complementarity-based methods as key to conservation planning.
Abell et al. (2007)	Framework for reserves that embeds freshwater focal areas and critical management zones within catchment management zones.
Moilanen et al. (2008)	Conservation prioritisation using subcatchment/catchment-planning units and connectivity incorporated consistent with the ecology of target species.
Linke et al. (2008)	Estimation of river conservation values using complementarity based algorithms and irreplaceability values incorporating connectivity
Nel et al. (2009)	Overarching systematic conservation planning goals by establishing surrogates for diversity and ecological integrity, developing complementarity based algorithms.
Beger et al. (2010)	Conceptual framework that explicitly accounts for the connectivity between the terrestrial, marine, and freshwater realms.
Hermoso et al. (2011)	Ecologically meaningful spatial conservation priorities using the probability of occurrence of species. Representativeness and persistence of species used as features to identify optimum set of areas for maintaining biodiversity.
Linke et al. (2011)	Conservation planning using comprehensive, adequate, representative and efficient reserve system as protection strategy, by choosing 'freshwater focal areas' that contain the actual features to be protected with active involvement of stakeholders.
Nel et al. (2011)	Spatially explicit priority areas for conserving rivers, wetlands and estuaries and referred to as Freshwater Ecosystem Priority Areas.
Linke et al. (2012)	Systematic river conservation planning using modified MARXAN incorporating connectivity and catchment condition. A landscape measure of catchment disturbance to direct the conservation plan to the least-disturbed area.
Bush et al. (2014)	Predicted species distributions in systematic reserve design for rivers under climate change.
Hermoso et al. (2015)	Catchment multizone plan, prioritising the allocation of zones subject to different management regimes, and considering species' needs.
Thieme et al. (2016)	Potential of PAs evaluated based on their geospatial attributes and spatial relationship to threats. PA drainage network location and size affect freshwater conservation potential.
Li et al. (2017)	Applied systematic conservation framework and modified MARXAN to accommodate multidirectional and interbasin connectivity targets for freshwater conservation.

management of river basins. Adhering to the NEP's mandate, the National Ganga River Basin Authority (NGRBA) was constituted in 2009 under the Environment (Protection) Act (EPA) (GoI, 1986) but was later dissolved subsequent to the formation of the National Ganga Council (NGC) on 7 October 2016 (GoI, 2016a). Concurrently, the National Mission for Clean Ganga (NMCG) was formed via the same notification as the nodal agency with powers under the EPA in all matters pertaining to the conservation and management of the river. This notification of the Ministry of Jal Shakti (MoJS)[1] is the first legislation that addresses river connectivity and presses the need to maintain natural seasonal variations in the flow of the Ganga and its tributaries. Recently, a gazette order on e-flow (GoI, 2018), *vide* EPA, was notified to protect the 'wholesomeness' of the river. It proposes 20% monthly average flow during dry periods (November to March), 25% during the lean period (October, April, and May), and 30% during the high-flow season (June to September) in the upper Ganga basin and in the confluences of its head tributaries up to Haridwar (Uttarakhand). It also prescribes the minimum volume of water to be released from the four major barrages between Haridwar and Kanpur (Uttar Pradesh). However, this order neither considers the habitat requirements of aquatic species nor accounts for the flow enhancement from tributaries when calculating the e-flow.

Inadequate protection

As a part of its commitment to various international environmental agreements, the GoI has promulgated several legislative tools for conservation, namely, the Wild Life (Protection) Act (WPA) (GoI, 1972), EPA, and NEP, which recognises various categories of PAs, Ramsar sites, Biosphere Reserves, and World Heritage Sites. India has 870 PAs covering 5% of the country (WII-ENVIS, 2019). However, rivers, an integral part of faunal habitats, are not represented in this national database and are protected incidentally only when they flow inside terrestrial PAs. For example, the notification of Gangotri National Park, Rajaji National Park and Hastinapur Wildlife Sanctuary (HWLS) has guaranteed legal protection status to only those stretches of the Ganga that are part of the terrestrial PAs. This holds true at the global scale as well (Herbert et al., 2010). For example, the upper Coppename River in South America has received protection because of its location inside the Central Suriname Nature Reserve (UNEP-WCMC, 2000).

A recent study found that PAs along the Ganga provide relatively undisturbed habitats and are repositories of focal aquatic species (WII-GACMC, 2018). Approximately 50% of the river still harbours populations of species of conservation significance (WII-GACMC, 2018) and yet less than 10% of the entire river is protected. There are six PAs along the Ganga, four of which are terrestrial and accord incidental protection to the river (Figure 2). The other two PAs, Varanasi Turtle Sanctuary and Vikramshila Gangetic Dolphin Sanctuary (VGDS), are riverine PAs created solely to protect aquatic species. The VGDS is a 65 km stretch between Sultanganj and Kahalgaon in Bihar state, primarily created for Gangetic dolphins but provides protection to other aquatic species as well. In addition, an 85-km stretch of the river from Brijghat to Narora in Uttar Pradesh state was declared a Ramsar site as it harbours good populations of migratory waterbirds and the Gangetic dolphin, nevertheless, in India Ramsar sites are not accorded the same degree of protection as PAs.

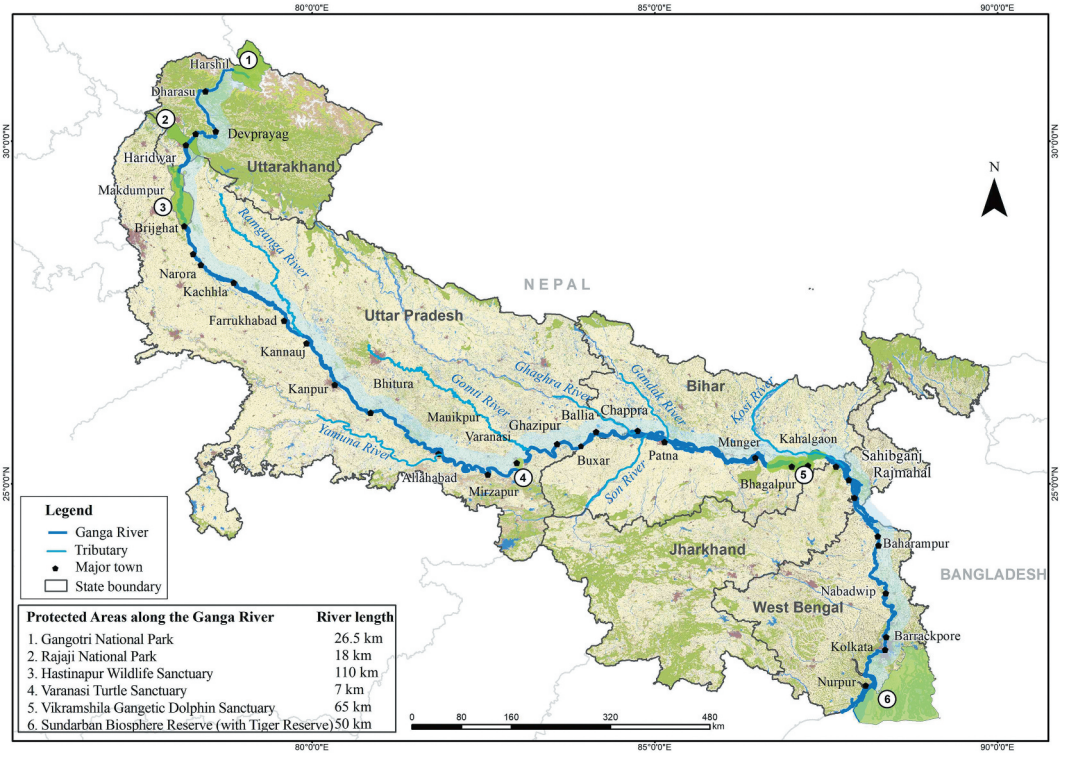

Figure 2. PAs along the Ganga River (Source: WII-GACMC, 2018).

Table 4. Protection status of the species and their range along the Ganga River.

Species	Protection status		Extent of habitat in the Ganga (km)	Habitat protected (%)
	IUCN Red List	IWPA Schedule		
Platanista gangetica gangetica	EN	I	137.0	7.0
Lutrogale perspicillata	VU	II	187.0	8.9
Aonyx cinereus	VU	I	109.5	9.3
Lutra lutra	NT	II	18.0	8.0
Gavialis gangeticus	CR	I	137.0	8.1
Crocodylus palustris	VU	I	137.0	5.8
Rynchops albicolis	VU	NL	137.0	9.4

EN—Endangered; VU—Vulnerable; NT—Near Threatened; CR—Critically Endangered; NL—Not Listed

Lack of representativeness of riverine ecosystems in the PA network has also led to a mismatch between the degree of protection accorded to species and their habitats, which serves as a roadblock for protecting the species (Table 4). For example, the Gangetic dolphin, the national aquatic species of India, listed as Endangered in the IUCN Red List and placed on Schedule I of the WPA, is afforded full protection from hunting and poaching. However, most of its habitats are not accorded the same degree of protection, with the exception of 7% of its home range protected as the HWLS and VGDS (Table 4).

Incoherence in policy integration

The Aichi Biodiversity Target 11 calls for the protection of at least 17% of terrestrial and inland water resources. India, a signatory to the Convention on Biological Diversity has inadequate legislation for the protection of rivers. The failure to implement mandates of international treaties has been associated with the mismatch between policy elements of different sectors that govern the river (Roux et al., 2008). Inter-state rivers are subject to spatial mismatch in planning, as planning and implementation are based on state boundaries. In addition, rivers are subject to policies of multiple sectors, namely the MoJS, Ministry of Agriculture (MoA), Ministry of Power (MoP) and Ministry of Shipping, Road Transport and Highways (MoS) (Figure 3). The policies of these ministries focus on economic development through disparate water use. The Policy on Hydro Power Development (GoI, 1998) promotes the construction of dams to harness the hydroelectric potential of rivers, especially in the north and northeast India, with limited consideration of the need to maintain natural flows and processes. Recently, the National Waterways Act (GoI, 2016b) allowed for shipping and navigation in the river. One hundred and eleven inland National Waterways (NWs) have been notified, with five NWs already functioning, of which NW-1 is between the Haldia and Allahabad stretch of the Ganga and is a critical dolphin habitat.

In India, different ministries have formulated legislative tools as per their interests, but these policies fail to account for the ecological processes necessary to maintain the river ecosystem function. Moreover, these policies are at times in direct conflict with the EPA and WPA, especially in the stretches of the river that form part of the PAs. With NGC at the apex, a tiered structure (Figure 4) was constituted to promote inter-state and inter-sectoral coordination for the comprehensive planning and management of the Ganga. This tiered structure promotes coherence and addresses the inter-sectoral inconsistencies.

Planning scenario

To address the complexities in river conservation planning, conservationists have formulated different strategies, mostly focusing on the habitats of priority species and *inter alia* maintaining the flow of ecosystem services. Assessment of river conservation planning scenarios for the past two decades revealed strategic conservation through the declaration of PAs as the most widely accepted approach (Table 3). A paradigm shift in river conservation from species-centric to catchment-

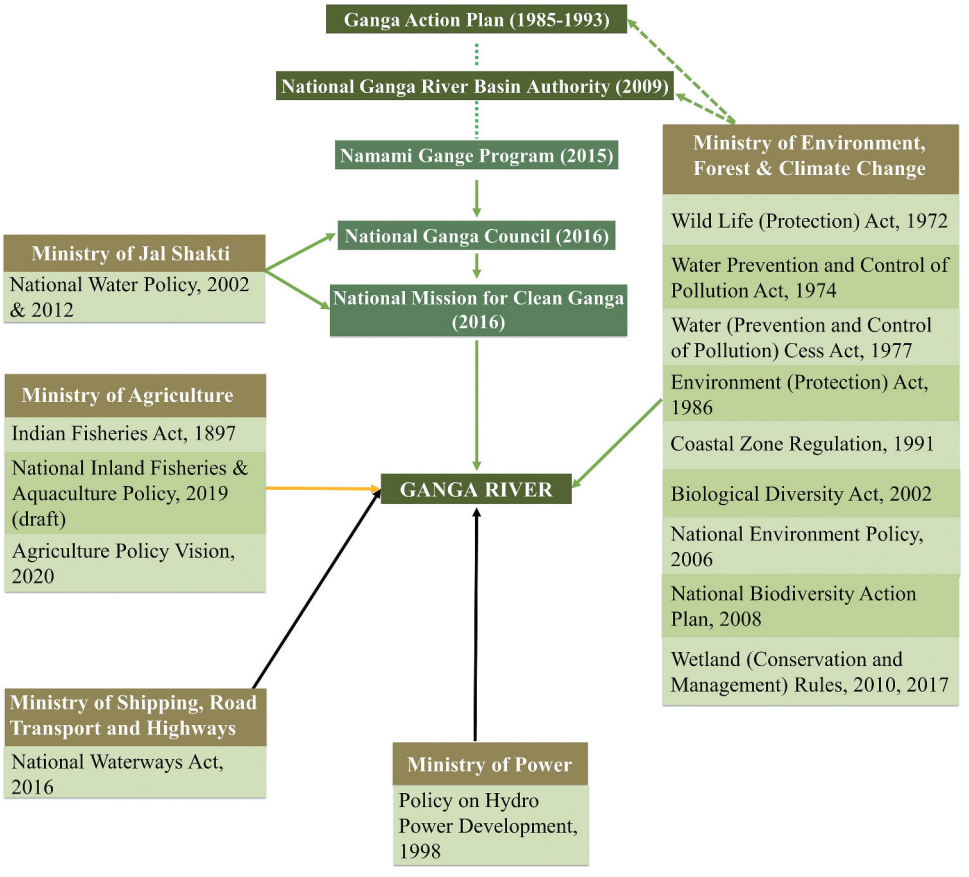

Figure 3. Sectoral policies and legislative instruments of the Government of India impacting Ganga River.
(Green arrow denotes positive relationship, yellow arrow denotes a moderately negative effect on the river, black arrow denotes exploitative effects, and arrows with dotted lines denote policies or action plans not in effect).

Figure 4. A five-tier governance structure for the Ganga River.

based planning approaches was also observed. These approaches have been partly successful in addressing many issues in river conservation, such as connectivity (Hermoso et al., 2015; Li et al., 2017; Linke et al., 2012, 2008), catchment characteristics (Linke et al., 2011; Moilanen et al., 2008), and, to some extent, climate change impacts (Bush et al., 2014; Ormerod, 2009).

However, the issue of large riverscapes that serve as multi-use areas, where societal wellbeing is directly linked to the sustained availability of river resources, has seldom been addressed. When

considering such large riverscapes, multi-zonation (Hermoso et al., 2015) of river stretches after prioritisation of optimal areas for conservation was found to be the most feasible approach. Prioritisation should be based on robust ecological data, considering multiple facets impacting the river, such as anthropogenic activities, biodiversity values, and habitat features (Nel et al., 2011). River stretches with good species assemblage and habitat conditions should be protected and other stretches need to be restored through community participation. Planning should be spatially integrative, taking account of the connectivity within and between watersheds (Wohl, 2018). This approach can be applied to large human-dominated riverscapes, ensuring careful optimisation of the trade-offs among social and ecological factors, and needs to be built into legislation governing these ecosystems.

Discussion

Conservation planning for the Ganga has significant social, economic, and cultural dimensions owing to the large human population living on its banks and beyond. A classic example of an interlinked social-ecological-cultural system (Cabello et al., 2015), conservation planning for the densely populated Ganga basin requires the identification of the most feasible conservation approach while maintaining the sanctity of this riverscape. Translation of conservation plans into actions is often hindered by a lack of coordination and cooperation among the various actors, as reflected in the sectoral policies. In the wake of impending climate uncertainties, which are expected to worsen the water crisis, policy and other legislative tools should cater to improving resilience and bringing a balance between ecological and societal needs. In addition, quantification and consideration of cultural values is important, as ignoring this aspect threatens the cultural identities of communities, causes the loss of traditional knowledge, and alienates a large section of stakeholders (Verschuuren, 2006).

Addressing this requires preliminary agreement on a common goal. The national goal of Ganga restoration, implemented through the Namami Gange Programme initiated in 2015, articulated this common goal. Achieving this requires policies to be grounded on scientific information, with a comprehensive and consultative approach to planning and implementation (Abell et al., 2007; Higgins et al., 2005) to maximise conservation benefits in view of social and economic constraints.

Based on the review undertaken, we conclude that in the case of the Ganga, conservation planning is complicated by the following policy scenarios. First, India lacks a comprehensive policy for the protection and sustainable use of rivers, resulting in a comparatively slower conservation response for rivers ecosystems as is evident from the fact that most PAs along the Ganga were accorded protected status incidentally and not by design. Moreover, the existence of only a few small and fragmented PAs covering about 277 km of the entire river emphasises weak implementation of global conservation targets at local scales.

Second, the Indian policies applicable to rivers are scattered among various sectors that have resulted in a contradictory scenario. Water as a resource is subject to various uses and is the prime focus of several sectors. Conservation and restoration of the river should be the mandate of all sectoral policies, as in the absence of water—the prime resource that supports agriculture, industries, urban and rural development, and navigation—these sectors would not thrive. Yet, these policies are contextualised around different disciplinary settings that act as barriers to conservation (Roux et al., 2008). Moreover, these policies lack futurism, as they are not sustainable and are grounded to the issue of resource abstraction.

The Ganga has a multi-dimensional basin with complex land–water interactions, namely, the connectivity of the mainstem with upstream and downstream components, as well as with inputs from the surrounding terrestrial environment. Therefore, conservation planning should be at the landscape scale with site-specific implementation actions (Gilman et al., 2004; Margules & Pressey, 2000). PAs are the mainstay of modern conservation efforts; however, protecting whole rivers is not practical, especially large rivers such as the Ganga, which has a range of socio-economic roles.

Considering the enormous scale of the Ganga, we recommend strategic spatial prioritisation using the multi-zonation approach (Hermoso et al., 2015), based on the principles of prohibition, restriction, and regulation of resource use involving relevant stakeholders. A multi-pronged basin-level approach is required addressing the causative factors of riverine ecosystem degradation, followed by identification of river stretches that retain good species assemblage and their prioritisation for conservation. Prioritisation should set aside optimum habitats or 'optimal sites' for focal species or ecosystem service value based on ecological principles (Dunn, 2003), hydrologic regimes, species habitat requirements (Abell, 2002), and anthropogenic threats (McDonald et al., 2016) as biodiversity banks for proactive protection against future modifications (Roux & Nel, 2013).

These prioritised stretches should be brought under strict protection as National Parks and Wildlife Sanctuaries (IUCN Categories II and IV). The river stretches with high human influences should be managed through community involvement, by declaring these sites as Conservation Reserves (IUCN Category VI) or Ramsar sites.

To ensure sustainability, management actions need to be in sync with conservation and thus should be considered as a crucial component of planning (Game et al., 2013). Therefore, multiple management zones with site-specific management regimes should be in place, taking into account the resource use patterns by local communities. For example, prioritising habitat-enhancing conditions, such as efficient water usage, in consonance with the needs of focal species and agricultural demands, would help augment flows and enhance biodiversity value.

Conclusions

Large rivers in human-dominated landscapes are threatened by multiple stressors, necessitating the integration of science-based and policy-backed response actions to achieve conservation goals. However, fostering policy commitment towards river conservation requires appropriate research to fill knowledge gaps to address key issues.

The state of the current policy scenario for rivers in India is inadequate to reflect the international commitments as well as national conservation goals. The lack of consistency in sectoral policies and other legislative tools emphasises the need for inter-ministerial coordination to bring about a holistic policy or legal framework for the conservation of rivers. In the best-case scenario, India needs an overarching river policy that is inclusive of the ecological needs of the rivers, codifies institutional relationships among states, and delineates mechanisms for fostering cooperation. The implementation of this policy needs to have an adaptive approach in sync with novel practices from river science.

However, since promulgating and mandating a policy is a lengthy process, governing bodies should work on improving institutional design and capacities according to science-based policy recommendations. They should focus on bringing coherence amongst sectors by incorporating trade-offs that consider the requirements of riverine ecosystems as well as societal needs (Baron et al., 2002). Local governance in river basins should be strengthened through consultation, engagement, and empowerment of all stakeholders.

River management plans should be framed such that they incorporate multiple zone plans as this addresses two key obstacles to conservation planning, namely, connectivity and disturbances to ecological conditions (Linke et al., 2011). This should be backed by coherent river and inter-sectoral policies, since policies provide an enabling environment for ground-level implementation. Moreover, 'optimal sites' should be strictly protected under the WPA. This would ensure the conservation of focal habitats without impinging on the needs of local people and their cultural and religious values. Such an approach would restore ecological values in the selected sites while maintaining social and economic values in other areas.

Note

1. Previously Ministry of Water Resources

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Disclosure statement

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