TOWARDS PARTICIPATORY RIVER GOVERNANCE

Community-Based Conservation in the **Ganga River**

VOLUME III

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EXECUTIVE SUMMARY

The Ganga River sustains approximately 500 million people, generates over 40% of India's GDP, and holds profound cultural, ecological, and economic importance, declared as the National River in 2008.

The basin features diverse ecosystems across Himalayan, Gangetic Plains, and deltaic zones, supporting agriculture (64.14% land use), fisheries (2.82 million fisherfolk in 3,795 villages), tourism, and crafts, but faces threats like flow alterations, pollution, overfishing, sand mining, and biodiversity loss including Gangetic dolphins. Socio-economic profiles vary from high densities (e.g., Bihar 1,106 persons km-2) to lower densities in Uttarakhand, poverty (highest in Jharkhand), and livelihoods tied to floodplains, with riverine communities (e.g., Mallah, Tharu STs, PVTGs) dependent on fishing, agriculture, and migration. Livelihood systems along the river are diverse and strongly dependent on hydrological regimes. Key activities include agriculture, fisheries (supporting 2.82 million fishers across 3,795 villages), river transport, tourism, and small-scale industries. Income levels vary longitudinally along the river, reflecting differences in productivity and infrastructure. However, these livelihoods are increasingly vulnerable to environmental degradation, including altered flows, pollution, and climate variability. Industrial and economic activities across the basin range from tourism in Uttarakhand to intensive agriculture and manufacturing in Uttar Pradesh, mineral-based industries in Jharkhand, and diversified agro-industrial and trade systems in West Bengal. Traditional crafts (e.g., silk weaving, pottery) also contribute to local economies and cultural continuity. The rural–urban interface represents a critical transformation zone, with rapid urban expansion (up to 270% increase in built-up areas) leading to hydrological disruptions, loss of wetlands, and increased pollution loads. Inadequate sanitation infrastructure and industrial discharges further degrade water quality, affecting both ecosystems and human health. Due to multiple communities, varying dependencies and demands the river is facing multiple challenges. To address these challenges, the study adopts a community-based conservation framework, emphasizing stakeholder participation as central to river governance. The approach integrates a PESTEL analysis (Political, Economic, Social, Technological, Environmental, Legal) and included five key components i.e., stakeholder identification and engagement, establishing and strengthening local participation in conservation and development decision making through institutionalization of the Ganga Prahari cadre, livelihood interventions aligned with conservation needs, assessment of socio-ecological linkages and mainstreaming biodiversity conservation in village level development planning through microplanning.

Stakeholders across 50 categories in five states (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal) were classified using attributes like influence/power (low-high), legitimacy, interest, role, position (support/opposition), location, activity (passive/active), dependence, knowledge, and leadership. Salience scores (e.g., $D=a^2b^2c^2$) prioritized primary stakeholders like District Administrations (4.36-5.20), Forest Departments (5.20), and local communities (3.74-4.36); state-specific tables detail variations (e.g., Uttarakhand: Religious groups 3.74; Bihar: Environment Dept 5.20). Mobilization reduced silos via consultations, integrating forest departments, pollution boards, PRIs, NGOs, and civil society.

Site-specific livelihood interventions included 193 trainings with 4,880 participants, targeted towards livelihood resilience and reduced extractive dependence via Sustainable Livelihoods Approach (SLA): eco-products (incense 696, sewing 2,239, handicrafts 210), food processing (703), sustainable farming (319), others (herbal soaps 123, leadership 40). Gender-disaggregated: High female in stitching/food (e.g., 670/703 food processing). Zonal targeting (e.g., HBZ II/III priority), aligned with traditions/resources, linked to conservation (e.g., bird guides, green energy). The interventions were mainly aimed at economic resilience, skill diversification (aquaculture, beekeeping, bamboo), and incentives for stewardship.

Ecosystem services of the Ganga River were assessed using participatory mapping approach. Through household surveys, stakeholder consultations, and mapping exercises, the approach enables identification of ecologically sensitive zones and resource-use patterns. This process strengthens evidence-based microplanning, enhances community engagement, and supports decentralized governance by aligning conservation priorities with socio-economic realities and ecosystem service dependencies. Mapping exercises identified critical resource-use zones such as fisheries, irrigation areas, grazing lands, and wetlands, enabling recognition of ecologically sensitive and high-dependence areas. The approach improved understanding of socio-ecological linkages by integrating local knowledge with field data, highlighting variability in dependence across locations and livelihoods. It also supported evidence-based microplanning, prioritization of conservation interventions, and alignment of development with river health, demonstrating that participatory tools are essential for inclusive governance and targeted biodiversity conservation planning.

The role of environmental education and outreach in promoting participatory conservation of the Ganga River and its biodiversity is crucial. Through localized and mass awareness programmes, including school workshops, teacher training, interpretation centres, exhibitions, radio talks, social media, puppet shows, and publications, the initiative successfully enhanced environmental literacy and community engagement across the Ganga basin. A total of 185 awareness workshops, 106 interpretation corners, and multiple outreach campaigns sensitized nearly one crore people. Significant improvements in students' knowledge and conservation awareness were recorded, demonstrating that experiential and community-based environmental education can effectively support sustainable river conservation and participatory river governance.

To mainstream biodiversity conservation in village level development planning, a total of 10 site-specific microplans were developed for the villages located along mainstem Ganga River. For HBZ II of the Ganga River, microplans of two villages namely Daranagar in Bijnor and Niwadi Khadar, in district of Bulandshahr, have been prepared. For HBZ III, microplans of three villages, namely Chittupur and Molnapur in Varanasi and Sonbarsha in Chandauli district have been prepared. For Zone IV, microplans for Khawaspur in district Bhagalpur and Rasalpur in district Samastipur of Bihar state, for Zone V microplan for village Saidpur, district Sahibganj of Jharkhand and Zone VI one village Nayachar, district

Nadia, West Bengal. Microplan for village Deer Forest, district Mursidabad, West Bengal located upstream Zone VI was also prepared. Key issues and challenges were identified for each site. Across Zones II to VI, a consistent pattern emerges of intensive riverbank and riverbed agriculture, characterized by heavy use of chemical fertilizers and pesticides, leading to habitat degradation, water pollution, and loss of aquatic biodiversity. Riverbed cultivation and expansion into active channels disturb breeding grounds and ecological balance, particularly noted in Zones II and III. A major cross-cutting issue is poor sanitation and waste management, including open defecation, dumping of household and market waste, and discharge of untreated wastewater, all contributing to declining water quality. Degradation of riparian vegetation due to agriculture, grazing, and fuelwood extraction is also widespread. Livelihood dependence on river resources—fishing, agriculture, and related activities—is high across all zones, but alternative livelihood options remain limited, resulting in overexploitation of natural resources. In Zones V and VI, unsustainable fishing practices, including fine-mesh nets and harmful methods (chemicals/electric current), further threaten aquatic species such as fish, turtles, and the Ganges River Dolphin. To address these issues, microplans across Zones II–VI follows a common framework integrating awareness, institutional strengthening, livelihood development, sanitation, sustainable agriculture, and biodiversity conservation. However, priorities vary by local conditions, such as pilgrimage, agriculture, or fishing dependence, ensuring targeted interventions. This zone-specific approach enhances ecological sustainability and livelihood resilience, making conservation efforts more context-relevant and effective in the Ganga basin.

On basis of the outcomes and lessons learnt following actions are recommended for effectively engage stakeholders and promote behavioural change for efficient Ganga conservation:

1. Embed stakeholder engagement mechanisms within formal governance structures, ensuring sustained participation of local communities, Panchayati Raj Institutions, and civil society in planning and decision-making. Regularly assess outcomes of stakeholder engagement and conservation interventions to enable iterative improvements and context-specific strategies.
2. Expand coverage, enhance capacity-building, and formalize linkages with government schemes to sustain long-term community stewardship.

3. Prioritize participation of Scheduled Tribes, PVTGs, women, and economically weaker groups in conservation programmes to ensure equitable benefit sharing and improved outcomes.
4. Develop and scale livelihood options aligned with local ecological contexts (e.g., sustainable fisheries, eco-tourism, traditional crafts) to reduce pressure on river resources while ensuring economic security.
5. Promote multi-source livelihood models in Ganga villages combining agriculture, fisheries, livestock, and non-farm activities to reduce over-dependence on a single resource.
6. Encourage river-compatible livelihoods such as sustainable fisheries, floodplain agriculture, eco-tourism, and traditional crafts already identified in the basin.
7. Integrate low-input and climate-resilient agriculture (reduced chemical use, crop diversification) in river-adjacent villages to reduce runoff pollution.
8. Facilitate direct market access for products such as fish, horticulture produce, and handicrafts through convergence such as NRLM, PMKVY, and other line agencies, and initiatives e.g., Jalaj initiative.
9. Establish village-level producer groups or cooperatives to enhance bargaining power and income stability.
10. Form village-level producer groups or cooperatives to boost bargaining power and income security. Scale up microplanning approaches to integrate biodiversity conservation with local development planning across all Ganga districts.
11. Embed biodiversity conservation actions into village level development planning, including wetland restoration, plantation, waste management, and sustainable resource use. Ensure that river health indicators are treated as development indicators at village level.
12. Institutionalize participatory mapping of ecosystem services (fisheries, irrigation, grazing, wetlands) to guide planning decisions and prioritise conservation areas. Embed systematic assessment of ecosystem services (e.g., fisheries, irrigation, wetlands, grazing) into Gram Panchayat and district planning processes to ensure that development decisions explicitly account for ecological dependencies and trade-offs. This will strengthen link between community well-being with river ecosystem functions through structured data collection and analysis.

13. Recognize Ganga Praharis as advisory members or technical resource persons in Gram Panchayat committees, District Ganga Committees and district planning forums, particularly in environment, water, and sanitation planning to provide ground-level inputs. Ensure their participation in Gram Sabha meetings during planning and review stages through facilitation of structured communication channels between Ganga Praharis and district administration and other agencies.
14. Build capacity of Panchayats, SHGs, and community groups to co-manage natural resources with technical support from Ganga Praharis and government agencies.
15. Embed the developed environmental education model comprising experiential learning, teacher capacity building, and interpretation-based infrastructure, within formal education systems across the Ganga basin. This includes mainstreaming modules into school curricula, expanding teacher training through continuous professional development, and scaling low-cost interpretation platforms (e.g., Jalmala Samvaad) to ensure sustained and standardized delivery of conservation education.
16. Move beyond short-term knowledge assessments by developing longitudinal monitoring frameworks to evaluate behavioural change, community engagement, and conservation outcomes. This should include periodic follow-ups with students, teachers, and communities, integration of measurable indicators of pro-environmental behaviour, and use of data-driven approaches to refine programme design and policy integration.

17. Enhance the reach and effectiveness of conservation education by integrating community-led approaches, culturally relevant communication tools (e.g., street plays, local campaigns), and digital platforms. Strategic partnerships with government agencies, local institutions, and community groups should be reinforced to ensure co-ownership, while aligning conservation messaging with local livelihoods and socio-cultural contexts to drive sustained public participation.
18. Policy instruments with integration of biodiversity conservation with sustainable livelihood strategies (e.g., fisheries, agriculture, eco-tourism, traditional crafts) should be promoted that can reduce trade-offs between conservation and subsistence by embedding economic incentives and diversification pathways.
19. Policies should be able to recognize the role of cultural values, traditional knowledge, and social structures in shaping environmental behaviour. They should be context-sensitive and tailored to local socio-cultural settings to enhance acceptance and effectiveness.
20. Policies and schemes Recognize and manage trade-offs between development, livelihoods, and conservation by promoting integrated planning approaches that identify synergies across sectors.


विन्ध्याट भवन
Ganga

Chapter 01

INTRODUCTION TO GANGA RIVER

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Summary

The Ganga River represents a highly complex socio-ecological system that integrates hydrological processes, biodiversity, cultural values, and economic dependencies, sustaining nearly 500 million people while supporting one of the most densely populated and agriculturally productive regions globally. The basin contributes significantly to India's economy, accounting for over 40% of national GDP, and encompasses diverse ecosystems across the Himalaya, Gangetic plains, and coastal regions. These ecological gradients shape spatial variability in human dependence, with limited direct reliance in upper reaches and intensive dependence in floodplains and deltaic zones for agriculture, fisheries, and allied livelihoods. The basin supports rich biodiversity, including endemic and threatened species, alongside deeply embedded cultural and religious traditions. The river holds profound spiritual significance, particularly in Hinduism, and underpins pilgrimage, tourism, and traditional practices. Agriculture dominates land use, covering 64.14% of the basin, supported by fertile alluvial soils and extensive irrigation systems. Livelihoods are diverse and include farming, fisheries, livestock rearing, river transport, crafts, and tourism, with strong dependence on monsoon-driven hydrology and ecosystem services.

Communities along the Ganga comprise a heterogeneous mix of Scheduled Tribes, Particularly Vulnerable Tribal Groups, and river-dependent caste groups, whose livelihoods are closely tied to natural resources. Socio-economic conditions vary significantly across basin states, with high population densities, disparities in income, literacy, and poverty levels, and differing resource access shaping community structures and vulnerabilities. Rapid urbanisation and land-use change have intensified pressures on the river system, altering hydrological regimes, degrading water quality, and disrupting ecological connectivity. Industrialisation, agriculture, and infrastructure development contribute to pollution, habitat loss, and resource depletion, while climate variability, groundwater depletion, and geomorphological dynamics further influence river processes. Key environmental challenges include flow regulation by dams and barrages, pollution from domestic and industrial sources, overexploitation of resources, biodiversity decline, invasive species, and habitat fragmentation.

Both natural and anthropogenic drivers govern system dynamics, including monsoonal variability, cryospheric processes, sediment transport, and human-induced pressures such as urbanisation, irrigation, and land-use conversion. These interacting drivers shape ecological integrity and ecosystem service delivery across the basin. In response, the study adopts a community-based conservation framework that positions local communities as active stakeholders and co-managers of river ecosystems and focuses on development of a science-based strategy for the long-term participation of multiple stakeholders, especially local communities, in biodiversity conservation in Ganga River. For which, detailed objectives were formulated: (1) identification of stakeholders of Ganga River and development of stakeholder specific strategies for engaging them in Ganga conservation, (2) assessment of the dependence of local communities on Ganga River to identify interlinkages between local communities and river ecosystem, (3) establishment of Ganga Prahari cadre along the Ganga River to motivate and engage local residents-particularly women and marginalized groups-in river conservation initiatives, (4) development of site-specific livelihood development strategies, based on need and feasibility assessments, to provide livelihood opportunities that are closely aligned with the region's socio-cultural traditions and ecological context, and (5) development of microplans for the select villages to mainstream biodiversity conservation and strengthen inter-departmental coordination along the Ganga River. The approach integrates stakeholder identification, institutional strengthening through the Ganga Prahari programme, livelihood-linked conservation interventions, assessment of socio-ecological linkages, and

village-level microplanning. A PESTEL-based analytical framework is employed to systematically evaluate political, economic, social, technological, environmental, and legal dimensions influencing conservation outcomes. The overarching aim is to develop a science-based, participatory strategy that aligns biodiversity conservation with livelihood sustainability and inclusive governance across the Ganga River basin.

1.1. Introduction

The Ganga River is not merely a fluvial system but a critical socio-ecological lifeline sustaining approximately 500 million people (Sanghi and Kaushal, 2013; Kumar, 2025). Beyond its hydrological significance, the river has profoundly shaped the civilizational ethos, belief systems, cultural practices, and livelihood structures of the Indian subcontinent (Kumar, 2017). Its natural resource base has historically structured the socio-economic organization of populations residing both within and beyond the Gangetic basin (Singh, 2008; Salahuddin and Nomani, 2021). Recognizing its unparalleled ecological, cultural, and national importance, the Government of India declared the Ganga as the National River in 2008. Owing to its sacred status and deep cultural-aesthetic associations, the river is reverentially addressed as Maa Ganga (Mother Ganga). The basin not only home to about 600 million people but also over 40% of the country's GDP is generated in this region (World Bank, 2015).

The Ganga River basin encompasses a mosaic of terrestrial, riparian, and aquatic ecosystems, supporting diverse floral and faunal assemblages, including several endemic and threatened species, alongside rich local and Indigenous cultural traditions (Nale et al., 2017; Chakraborty, 2021). This ecological heterogeneity is attributable to the river's passage through distinct biogeographical zones—namely the Himalaya, the Gangetic Plains, and the coastal regions. Patterns of human dependence on the river vary across these zones. In the Himalayan reaches, direct economic reliance on the river channel is relatively limited, whereas in the Gangetic Plains and coastal stretches, communities are heavily dependent on the river for sustenance, agriculture, fisheries, and other livelihood activities. The Ganga River Basin constitutes one of the most densely populated and agriculturally productive regions globally (Sonam and Jain, 2022; Saxena and Rao, 2024). Major cropping systems include rice, wheat, and sugarcane, complemented by small-scale livestock rearing, horticulture, and tourism-based enterprises, all of which are intrinsically linked to the river's freshwater resources and fertile alluvial soils (Rahaman, 2021).

The Ganga holds exceptional religious and spiritual significance, particularly within Hinduism. Its cultural centrality is extensively documented in ancient Indian scriptures, including the Vedas and the Puranas. Regarded as a divine maternal entity, the river is associated with theological narratives describing its descent from heaven to Earth to alleviate human suffering and grant moksha (salvation). Numerous annual festivals and ritual observances celebrate the sanctity of the river and reaffirm its enduring cultural relevance. In addition to pilgrimage-based activities, the Ganga and its tributaries facilitate diverse tourism sectors such as rafting, boating, angling, and riverside camping, thereby generating alternative livelihood opportunities for local communities. The basin's agrarian economy remains fundamentally dependent on the river's perennial water supply and nutrient-rich alluvial deposits. Furthermore, the river functions as a vital inland navigation corridor for both subsistence mobility and commercial transportation (Singh and Singh, 2019). Overall, the socio-economic configurations, livelihood dependencies, and cultural traditions of riparian communities exhibit spatial variability along the river's longitudinal gradient—

from the Himalayan headwaters to Ganga Sagar—reflecting the dynamic interplay between ecological settings and human systems.

1.1.1. Local communities residing in Ganga adjacent districts

Districts situated along the main stem of the river and its floodplains host a complex mosaic of constitutionally recognized Scheduled Tribes (STs), Particularly Vulnerable Tribal Groups (PVTGs), and river-dependent ethnic communities.

In the upper Ganga districts of Uttarakhand (e.g., Uttarkashi, Tehri Garhwal, Pauri Garhwal, Haridwar), the principal Scheduled Tribes include the Tharu, Bhotiya (including Shauka/Rang subgroups), Jaunsari, Bhoksa, and Raji (Banrawat). The Raji are classified as a Particularly Vulnerable Tribal Group (PVTG) due to their small population size and historically forest-based subsistence patterns (Rana, 2024). Livelihood systems combine agro-pastoralism, forest resource use, wage labour, and limited trade. Scholarly ethnographic accounts describe the Bhotiya as historically engaged in trans-Himalayan trade prior to border closure in 1962 (Rawat and Panwar, 2025). In Ganga-adjacent districts of Uttar Pradesh, notified Scheduled Tribes include Tharu, Kharwar, Kol, Chero, Baiga, Bhoksa, and Agaria (Census of India 2011). Along the middle floodplains, numerous river-dependent caste communities such as the Mallah, Nishad, Kevat, Bind, and Kashyap derive livelihoods from inland fisheries, boat navigation, sand mining, and flood-recession agriculture (Kelkar, 2021). While not classified as STs, these groups are categorized under Other Backward Classes (OBCs) or Extremely Backward Classes (EBCs) in state lists. In Bihar's Ganga districts, Scheduled Tribes notified by the Government of India include Santhal, Oraon, Munda, Ho, Kharwar, Kharia, Bhumij, Asur, Birhor, Mal Paharia, and Sauria Paharia. Many of these tribes are concentrated in southern and eastern plateau districts but are also present in Ganga floodplain districts through migration and resettlement (Census of India 2011; Vyas, 2024). The Birhor, Asur, and Sauria Paharia are designated as PVTGs. Riverine communities such as Mallah (including Sahni subgroup), Bind, Kevat, and Nonia are prominent along the Ganga and its wetlands (mauns and chaurs). Studies by the National Fishworkers' Forum and Inland Fisheries Research Institutes indicate that these communities remain economically marginalized and dependent on common property fisheries (FAO India Fisheries Profile, 2020). The Musahar, although classified as a Scheduled Caste rather than a Scheduled Tribe, are widely documented as one of the most socio-economically deprived groups in Bihar's Ganga plains. In Sahibganj district of Jharkhand along the Ganga, major Scheduled Tribes include Santhal, Munda, Oraon, Ho, Mal Paharia, Sauria Paharia, Birhor, and Asur, several of which are notified as PVTGs (Census 2011). These communities practice rainfed agriculture, forest produce collection, and wage labor (Prasad et al., 2024). In West Bengal's Ganga districts (e.g., Murshidabad, Nadia, Hooghly), notified Scheduled Tribes include Santhal, Bhumij, Munda, Oraon, Mahali, Lodha (Kheria), Sabar, and Bedia. The Lodha and Sabar are recognized as PVTGs. Additionally, riverine ethnic groups such as Kaibarta (Keot/Jalia Kaibarta) and Rajbanshi are engaged in fishing, floodplain cultivation, and estuarine livelihoods (Mal & Khatun, 2022).

1.1.2. Socio-economic profile of communities residing in Ganga states

Ganga River flows through one of the most densely populated areas in the world with a population density of 520 persons per sq.km. Among the Ganga states, the population density is highest in West Bengal and lowest in Uttarakhand (Table 1.1). Population living below poverty line is highest in Jharkhand and

lowest in Uttarakhand (Figure 1.1). The GDP per capita is highest in Uttarakhand and lowest in Bihar, which is also the lowest in the country (Figure 1.2). These varying socio-economic conditions along with availability and accessibility of natural resources has led to a medley of community composition present along the Ganga River.

Uttarakhand comprises 13 districts over 53,483 sq km, with a population of 10,086,292 (5,137,773 males; 4,948,519 females) and a density of 189 persons per sq km. Major rivers include the Ganga and Yamuna systems i.e., Alaknanda, Bhagirathi, Mandakini, Kali, Ramganga, Tons, and Kosi. Literacy stands at 78.82% (male 87.4%; female 70.01%). Annual rainfall averages 1,550 mm. Net irrigated area is 345,020 ha with cropping intensity of 161%. Major crops include wheat, paddy, maize, manduwa, urad, gram, pea, sugarcane, pulses, and oilseeds. Forest area is 3.47%. Livestock population is 44.27 (Table 1.1).

Uttar Pradesh spans 240,928 sq km across 71 districts, with a population of 199,812,341 (104,480,510 males; 95,331,831 females) and a density of 829 persons per sq km. Rivers include the Ganga, Yamuna, Gomti, Ram Ganga, Ghagra, Betwa, and Ken. Literacy is 67.68% (male 77.28%; female 57.18%). Annual rainfall averages 844.1 mm. Net irrigated area is 13.313 million ha with cropping intensity of 153.54%. Major crops are paddy, wheat, barley, millet, maize, urad, sugarcane, and oilseeds. Forest area is 1,657,023 ha. Livestock population is reported as 68.0 million (Table 1.1).

Bihar covers 94,163 sq km across 38 districts, supporting 104,099,452 people (54,278,157 males; 49,821,295 females) with a high density of 1,106 persons per sq km. Major rivers include the Ganga, Gandak, Kosi, Bagmati, Burhi Gandak, and Mahananda. Literacy is 61.80% (male 71.20%; female 51.50%). Annual rainfall averages 1,164.4 mm. Net irrigated area is 33.51 lakh ha and cropping intensity is 142%. Major crops include sugarcane, potato, tobacco, oilseeds, onion, cauliflower, and pulses. Forest area is 621,635 ha. Livestock population is 36.5 million (Table 1.1).

Jharkhand extends over 79,716 sq km with 24 districts and a population of 32,988,134 (16,930,315 males; 16,057,819 females), yielding a density of 414 persons per sq km. Major rivers include the Damodar, Subarnarekha, and Ganga. Literacy stands at 66.41% (male 76.84%; female 55.42%). Annual rainfall averages 1,220.7 mm. Net irrigated area is 2.01 lakh ha with cropping intensity of 130.7%. Major crops include paddy, wheat, maize, pulses, oilseeds, and horticultural crops. Forest area is 2,376,578 ha. Livestock includes cattle (7,658,721), buffaloes (1,343,494), sheep, goats, pigs, and poultry (Table 1.1).

West Bengal covers 88,752 sq km across 19 districts and has a population of 91,276,115 (46,809,027 males; 44,467,088 females) with a density of 1,028 persons per sq km. Major rivers include the Ganga (Hooghly), Teesta, Damodar, Mahananda, and Mayurakshi. Literacy is 76.26% (male 81.69%; female 70.54%). Annual rainfall averages 1,712.9 mm. Net irrigated area is reported as 79,312 (thousand ha) with a high cropping intensity of 188.5%. Major crops include rice, jute, tea, mustard, pulses, potato, and sugarcane. Forest area is 1,173,669 ha (Table 1.1).

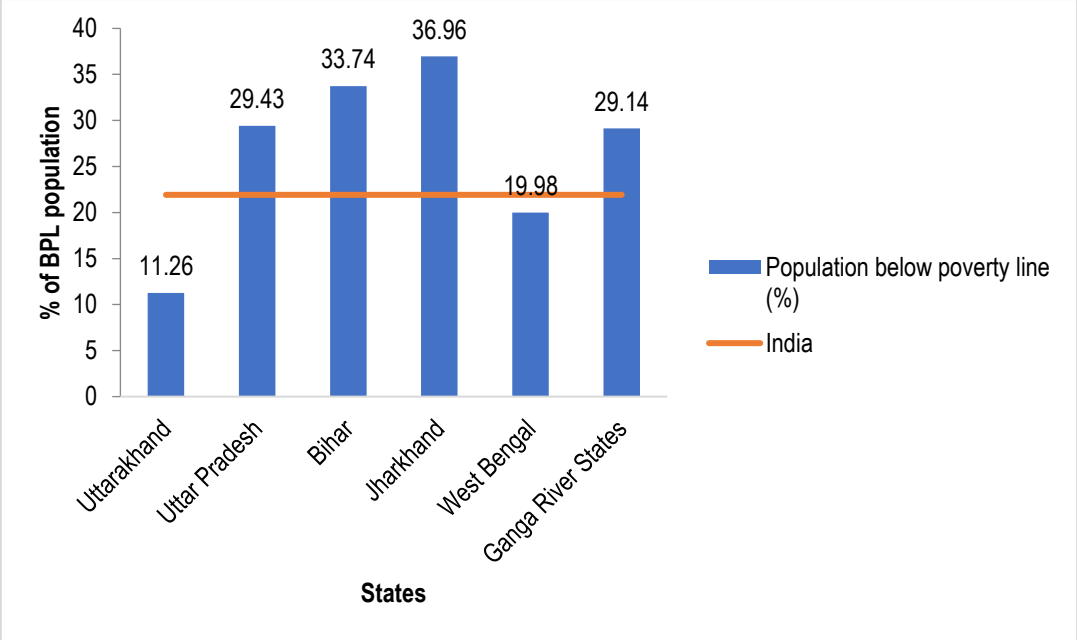

Figure 1.1. Population below poverty line in the Ganga states against the national average

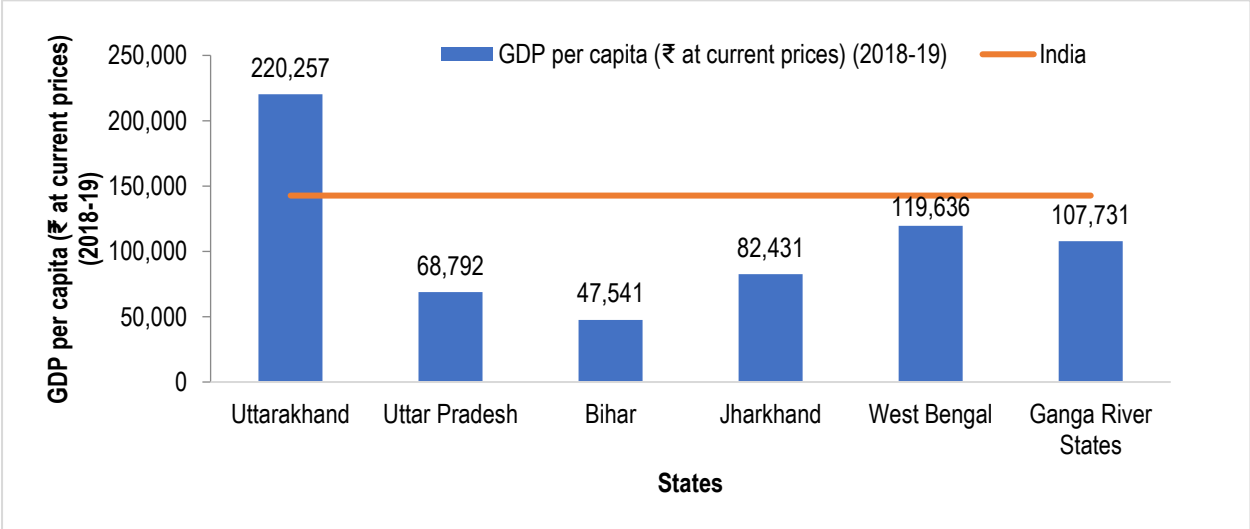

Figure 1.2. GDP per capita of the Ganga states in comparison with the national average

Table 1.1. Demographic profile of Ganga states

State	No. Of Districts	Area (Sq Km)	Population	Population Density (Per Sq. Km)	Literacy Rate %	Annual Rainfall	Net-Irrigated Area	Cropping Intensity (%)
Uttarakhand	13	53483	10086292	189	78.82	1550	34.5 Lakh hectare	161

Uttar Pradesh	71	2,40,928	19,98,12,341	829	67.68	844.1	13.313 million hectares	153.54
Bihar	38	94,163	10,40,99,452	1,106	61.8	1164.4	33.51 lakh hectare	142
Jharkhand	24	79,716	3,29,88,134	414	66.41	1220.7	2.01 lakh hectare	130.7
West Bengal	19	88,752	9,12,76,115	1,028	76.26	1712.9	79312 (th h)	188.5

1.1.3. Key livelihood practices

Districts along the Ganga River support diverse livelihoods reliant on its floodplains, including irrigated agriculture, capture fisheries, aquaculture, sand and gravel extraction, river transport, small-scale industries, and pilgrimage services. These activities hinge on monsoon-driven hydrology, sediment deposition, and intact wetlands, but face risks from dam-induced flow alterations, pollution, excessive sand mining, groundwater overuse, and climate extremes like floods and droughts (Panta, 2019). Fishing dominates for riverine communities, serving as the main livelihood for 2.82 million fisher folks. Total number of fishing villages in the Ganga River stretch is 3,795, which covers five states and 47 districts (Das et al., 2022). Agriculture, especially rice, wheat, sugarcane, and riverbed farming, supports broader populations in the Ganga plains, with secondary activities like wage labor (6.64%), livestock rearing (1.8%), and small industries (weaving, pottery) providing diversification. Monthly incomes vary by river stretch: upper Ganga (₹5,950), middle (₹8,430), and lower (₹11,274), driven by fish yields, market access, and infrastructure. Riverbed farming in Kanpur district generated ₹5.9 million for 89 households in 2010-11, while pilgrimage sites boost indirect livelihoods through tourism, ferries, and trade, contributing billions annually (Panta, 2019).

1.1.4. Industries along the Ganga River

The socio-economic structure of the Ganga basin reflects a complex interaction between tourism, agriculture, industry and traditional livelihoods. These sectors provide critical employment and economic opportunities but also generate environmental pressures including pollution, water abstraction, habitat alteration and waste generation. Across the entire river corridor, from Gangotri in the Himalaya to the Ganga delta, numerous artisan and craft communities sustain traditional knowledge systems linked to riverine cultural landscapes. Craft traditions such as weaving, pottery, wood carving, silk production and ritual art have evolved alongside religious and cultural practices associated with the river. Many of these craft products have received Geographical Indication (GI) status, reflecting their cultural significance and regional identity within the Ganga basin economy. Such traditional livelihoods provide supplementary income sources and play an important role in maintaining cultural continuity in riverine settlements.

The upper Ganga basin in Uttarakhand is characterized by a tourism-oriented economy supported by pilgrimage tourism, adventure tourism and ecosystem-based services. The region hosts major spiritual centres including Gangotri, Badrinath, Kedarnath and Yamunotri, forming the Char Dham pilgrimage

circuit, one of the largest pilgrimage routes in India. Recent studies indicate that pilgrimage tourism in the Char Dham region has expanded significantly, with annual visitors increasing from around 1 million in the early 2000s to over 3 million in recent years, with nearly 5 million pilgrims recorded in 2023 (Kuniyal et al., 2025). Tourism constitutes a major economic driver in the state, contributing over one-third of Uttarakhand's economic activity and employment generation through direct and indirect sectors such as hospitality, transport, handicrafts and adventure tourism (Dhasmana and Bhandari, 2022). Rishikesh, located on the upper Ganga, has developed as a global hub for yoga tourism and river-based recreation, including rafting, trekking and wellness tourism. These activities generate substantial seasonal employment for river-dependent communities and support local service economies. Alongside tourism, the upper basin economy includes hydropower generation, pharmaceuticals, fast-moving consumer goods manufacturing and horticulture. Mountain agriculture and horticulture, particularly temperate fruit cultivation such as apples, pears and peaches, form an important component of rural livelihoods. Traditional pastoral communities such as the Bhotia tribe in Uttarkashi and Chamoli maintain wool weaving and carpet production traditions that contribute to local economies and cultural heritage. However, rapid tourism growth has also intensified ecological pressures in the fragile Himalayan landscape, highlighting the need for sustainable tourism management and carrying capacity assessments in river headwater regions (Kuniyal et al., 2025).

The middle Ganga basin, particularly in Uttar Pradesh, represents the agricultural heartland of the Indo-Gangetic plains. Fertile alluvial soils, extensive irrigation networks and favourable agro-climatic conditions have enabled the region to become one of the most productive agricultural zones in South Asia. Major crops include rice, wheat, sugarcane and pulses, forming the backbone of the state's rural economy (Sannigrahi et al., 2021). The expansion of intensive agriculture following the Green Revolution has significantly increased crop production and cropping intensity across the Gangetic plains. Uttar Pradesh also hosts a diverse industrial base including: (1) agro-processing and sugar industries, (2) leather and footwear manufacturing, (3) textile and handloom industries, (4) engineering goods and electronics manufacturing, (5) fertilizer and chemical industries. Cities such as Kanpur, Agra, Varanasi and Noida function as major industrial clusters within the basin. Agro-based industries such as sugar mills are closely integrated with regional agriculture and contribute significantly to rural employment. Livestock, fisheries and forestry also play an increasingly important role in the rural economy. Recent economic estimates show that the livestock sector alone contributes about 7% of Uttar Pradesh's Gross State Domestic Product, highlighting the growing importance of allied agricultural sectors (https://invest.up.gov.in). Despite economic diversification, agriculture remains the primary livelihood source for a large proportion of the basin population, reinforcing the dependence of regional economies on river-fed irrigation systems and fertile floodplain ecosystem.

In the lower basin, Bihar's economy is largely agriculture-dominated, with crops such as rice, maize, wheat and pulses forming the basis of rural livelihoods. Agro-processing industries including sugar mills, dairy processing and tobacco manufacturing support value addition in agricultural supply chains. The state also hosts important traditional craft economies, notably Bhagalpur silk weaving and Madhubani painting, which represent globally recognized cultural industries and provide alternative livelihoods for artisan communities. Jharkhand's economy differs from the agrarian plains through its strong mineral-industrial base. The state contains rich deposits of coal, iron ore and other minerals, supporting heavy industries such as steel manufacturing. Major industrial establishments including Bokaro Steel Plant and Tata Steel form the core of the state's industrial economy. Despite industrialization, large sections of the

population depend on agriculture, forest resources and small-scale enterprises, highlighting the coexistence of extractive industries and traditional livelihood systems. The Ganga basin in West Bengal forms part of the lower deltaic system and supports a highly diversified economy, including agriculture, fisheries, industry and trade. Major economic sectors include: (1) textile and jute industries, (2) petrochemicals and engineering industries, (3) information technology and services, (4) fisheries and aquaculture, (5) tea production and horticulture. The state benefits from strategic trade infrastructure including major ports at Kolkata and Haldia, extensive railway networks and inland waterways that facilitate regional and international trade. Inland navigation along National Waterway-1 (Ganga–Bhagirathi–Hooghly system) has further enhanced trade connectivity in the basin. The region also supports significant craft-based economies, including terracotta art, Durga idol making and Jamdani textile weaving, which contribute to cultural tourism and local employment.

1.1.5. Rural-urban interface

The rural- urban interface along the Ganga River constitutes a dynamic socio-ecological mosaic, shaped by rapid settlement expansion, agricultural intensification, and concentrated service and industrial growth in riparian towns. Recent basin-scale land-use analyses reveal a substantial increase in built-up areas (with settlements expanding by approximately 270% in some regions over recent decades), accompanied by shifts in settlement mean-centers of tens of kilometers. This pattern intensifies urban pressures on formerly rural floodplain and wetland zones (Hasan et al., 2026).

Two interrelated demographic trends define this interface. First, the basin sustains exceptionally high population densities, exceeding national averages, with many Ganga-adjacent districts maintaining large rural populations that increasingly exhibit peri-urban livelihoods and land-use practices. Second, small- and medium-sized towns along the river are expanding more rapidly than metropolitan centers, fostering diffuse peri-urban corridors where municipal infrastructure, governance, and land-use planning often fail to keep pace with growth. These dynamics are corroborated by government basin assessments and national population datasets (CWC & NRSC, 2014).

From a hydrological and biophysical standpoint, the conversion of floodplain croplands, wetlands, and riparian vegetation to impervious surfaces disrupts runoff timing, groundwater recharge, and sediment dynamics. Process-based modelling and empirical studies in the basin demonstrate that such land-use changes elevate hydrograph peaks, diminish wetland buffering capacity, and amplify nutrient and sediment fluxes into the channel. These alterations degrade habitat quality for aquatic biota and heighten flood risks for downstream settlements (Anand et al., 2018).

Water quality and sanitation represent critical challenges at the urban-rural interface. Many expanding towns lack comprehensive sewer networks and depend on drains that discharge directly into the river or its floodplains, while industrial effluents and diffuse agricultural runoff exacerbate pollutant loads. In response, national river-management agencies have prioritized urban river management plans, emphasizing sewage connectivity, decentralized treatment systems, and land-use regulations in floodplain zones to curtail pollutant inputs and safeguard ecosystem services (IITs, 2013).

Socioeconomic impacts are varied. Peri-urban households frequently access non-farm employment and improved services, yet they contend with tenure insecurity, deteriorating local water quality, and diminished access to traditional provisioning services such as fisheries and floodplain grazing. These

heterogeneous outcomes demand integrated policy frameworks that integrate spatial planning (to direct urban expansion away from critical wetlands and high-value habitats) with investments in decentralized sanitation, flood-resilient infrastructure, and livelihood transition programs. Modelling and water-quality surveys along the river's longitudinal gradient indicate that coordinated interventions at district and inter-district scales deliver the greatest benefits for both human well-being and river health (Richards et al., 2022).

1.2. Key issues faced by Ganga River

(1) Flow alteration and fragmentation by dams, barrages and irrigation diversions. Large numbers of barrages and storage structures on the Ganga and its tributaries interrupt longitudinal connectivity, alter seasonal flow regimes (reduced low flows, modified flood peaks), and fragment habitats essential for migratory and life-history stages of aquatic biota. These alterations have been quantified in basin hydrology models showing increased flow from snow-fed headwaters but declining flows in many lower reaches and non-perennial tributaries due to regulation and withdrawals (Anand et al., 2018).

(2) Groundwater-surface water interactions and baseflow decline. Multiple isotope- and observation-based studies indicate that groundwater contributes substantially to Ganga summer baseflow in the plains; ongoing groundwater depletion and intensive pumping reduced baseflow, amplifying low-flow severity and seasonal stress on aquatic ecosystems. This link is a major mechanism by which land-use and irrigation pressure modify river hydrology (Mukherjee et al., 2018).

(3) Studies show shifts in monsoon intensity and glacier/snow dynamics in the Himalayan headwaters; while glacier melt is important locally, changes in monsoon variability and extreme rainfall jointly increase flow variability with higher flood peaks in some years and prolonged low flows in others, raising ecological and management challenges (Jain and Singh, 2020).

(4) Intensive sand and gravel extraction and channel engineering changes lead to hydro-morphological changes in the Ganga River, bedforms, increase turbidity and sediment transport dynamics, and destroy spawning and foraging habitats for fish and turtles (Kumar, 2015; Sinha and Prasad, 2020).

(5) Pollution (sewage, industrial effluent, pesticides) degrades water quality and biotic communities. Studies show polluted stretches and high loads of biochemical oxygen demand (BOD), nutrients and toxic pollutants in mainstem affected habitat quality, cause fish kills, and limit recovery of sensitive taxa (Simon and Joshi, 2022; Sah et al., 2024; Singh et al., 2025a; Singh et al., 2025b). Recent WII-NMCG reporting and environmental case records document remaining pollution hotspots.

(6) Freshwater biodiversity in India is among the most threatened globally; in the Ganga mainstem, reductions in fish diversity and abundance are linked to flow alteration, pollution, overfishing and habitat loss (Rai et al., 2024). The Gangetic dolphin shows range contraction and population stress from entanglement, noise and vessel strikes, prey depletion and habitat fragmentation (Rai et al., 2023).

(7) Intensive, often illegal fishing (including gillnets and dynamiting in parts) reduces large-bodied and commercially important species, alters food-webs, and increases bycatch of non-target species (including dolphins and turtles) (Kumar et al., 2023; Das et al., 2025).

(8) Changes in flow, temperature and pollution facilitate invasions and disease outbreaks that further stress native assemblages; altered thermal regimes from reduced baseflow and warmer summers

reduce habitat suitability for cold-water and oxygen-sensitive taxa (Singh et al., 2022; Singh et al., 2025).

1.3. Key Drivers of Change

1.3.1. Natural drivers

1.3.1.1. Hydro-climatic Variability

The Ganga basin is dominated by the South Asian monsoon, delivering 80–85% of annual precipitation during June–September. Inter-annual and intra-seasonal monsoon variability drives fluctuations in river discharge, sediment transport, nutrient fluxes, and floodplain connectivity. Floods sustain fish spawning, rejuvenate wetlands, and enrich floodplain soils for agriculture, while droughts reduce habitats for species like the Gangetic dolphin, impacting fisheries and irrigation (Sharma et al., 2025).

1.3.1.2. Himalayan Cryospheric Processes

Upper Ganga flows rely on snowmelt (up to 90% in pre-monsoon months) and minor glacial melt (<10% basin-wide annually) from central Himalayan catchments. Cryospheric changes, including glacial retreat and altered snow accumulation, modify lean-season baseflows, thermal regimes, sediment yields, aquatic habitats, and pre-monsoon water for biodiversity and agriculture (Mukherjee et al., 2018; Jain and Singh, 2020).

1.3.1.3. Geomorphological Dynamics and Sediment Regimes

The sediment-laden Ganga exhibits meandering, channel migration, avulsions, bank erosion, and diara/char island formation. Sediment deposition builds fertile alluvial soils supporting Indo-Gangetic agriculture, though shifts erode banks, displace communities, and reshape riparian habitats (Raff et al., 2023).

1.3.1.4. Floodplain and Wetland Connectivity

Hydrological links between the main channel and wetlands (oxbows, marshes, side channels) boost productivity, serving as fish nurseries, refugia during floods, and sources for fisheries, fodder, and recharge. Disruptions alter fish recruitment and livelihoods (Mukherjee and Pal, 2021).

1.3.1.5. Ecological Succession and Biotic Interactions

Riparian succession, predator-prey dynamics, and migrations shape biodiversity, with floods resetting stages to maintain heterogeneity for endemics. This supports artisanal fisheries, agriculture, and traditional uses (Chakraborty, 2021).

1.3.2. Human induced drivers

1.3.2.1. Domestic sewage, untreated liquid and solid discharge, agricultural runoff and industrial effluent

Rapid urbanisation and incomplete sewerage infrastructure in many district towns cause high loads of organic matter, pathogens and nutrients, driving high BOD/coliform counts and eutrophication in downstream stretches (Sharma and Kaushik, 2018; Modi et al., 2023). Industrial clusters (tanneries,

sugar, paper, distilleries, chemical units) discharge metals, persistent organics and high-strength effluent where treatment/monitoring is weak; these create localized “hotspots” of ecological and human-health risk in affected districts. High fertilizer use and agrochemical runoff elevate nitrogen/phosphorus loads and introduce agrochemicals into river reaches, altering primary productivity and aquatic food webs in agricultural districts. Mismanaged municipal solid waste, ritual offerings and growing microplastic inputs create benthic contamination, block drains and harm biota at local scales (Clayton et al., 2025).

1.3.2.2. Barrages, dams and irrigation canals

Large barrages and extensive canal networks fragment longitudinal connectivity, reduce low-season flows, alter seasonal flood pulses and trap sediment with cascading effects on habitat, fisheries and sediment delivery to downstream districts. There are nine major dams and barrages on the Ganga River that divert the water from the mainstem i.e., Garhwal-Rishikesh-Chilla Hydroelectric Project, Dehradun, Maneri Bhali Project First Phase, Uttarkashi, Tehri Dam, Koteshwar Dam, Tehri Garhwal, Bhimgoda Barrage, Haridwar (Uttarakhand), Narora Barrage, Bulandshahr, Madhya Ganga Barrage, Bijnor (Uttar Pradesh) Kanpur Barrage, Kanpur, Farakka Barrage, Murshidabad and Malda (West Bengal). Intensive irrigation and groundwater abstraction. Heavy irrigation demand draws down aquifers and decouples groundwater–surface water exchange; large groundwater extraction and altered recharge regimes reduce dry-season baseflow in many plains’ districts (Maina et al., 2024).

1.3.2.3. Channel modification and land use change

Unregulated sand extraction lowered bed elevations, destabilized banks, deepened channels, reduced floodplain connectivity and destroyed spawning/foraging habitats (Gupta and Patel, 2025). These impacts can be observed at district scales along the main stem and tributaries. Conversion of floodplain and riparian wetlands to agriculture, housing and infrastructure reduces natural buffering, increases storm runoff and pollutant fluxes, and constrains the river’s lateral mobility in many districts (Modi et al., 2023).

1.4. Aim

To develop a science-based strategy for the long-term participation of multiple stakeholders, especially local communities, in biodiversity conservation in Ganga River.

1.4.1. Objectives

To achieve the aim following objectives were formulated:

(1) Identification of stakeholders of Ganga River and development of stakeholder specific strategies for engaging them in Ganga conservation.
(2) Assessment of the dependence of local communities on Ganga River to identify interlinkages between local communities and river ecosystem.
(3) Establishment of Ganga Prahari cadre along the Ganga River to motivate and engage local residents-particularly women and marginalized groups-in river conservation initiatives.

(4) Development of site-specific livelihood development strategies, based on need and feasibility assessments, to provide livelihood opportunities that are closely aligned with the region's socio-cultural traditions and ecological context.
(5) Development of microplans for the select villages to mainstream biodiversity conservation and strengthen inter-departmental coordination along the Ganga River.

1.5. Approach

To meet the twin goals of conservation of the riverine habitats and aquatic species, and enhancement of local communities' well-being, it is imperative to ensure their participation in conservation. Hence, the project has adopted a community-based conservation paradigm, in which the riverine communities are not considered just mere beneficiaries but co-managers and stewards of the Ganga River and its tributaries. We used PESTEL approach by examining Political, Economic, Social, Technological, Environmental, and Legal factors that may influence Ganga conservation (Figure 1.3). Our approach consisted of the following five components which are sequential yet overlapping:

1.5.1. Stakeholder identification and mobilization

A comprehensive list of stakeholders was prepared from all the states Ganga is flowing through. Consultative meetings and preliminary dialogues were carried out with the identified stakeholders to inform them about the goals and activities of the project and to understand their values and perception of the concerned river. Following this, on the basis of power, interest and salience and our interaction with them, stakeholders were engaged through various specifically tailored activities. Awareness, sensitization, consultation, cultural activities and workshops were aimed at the stakeholders with developmental mandate, to mainstream conservation in their decision making and planning. Activities like cleanliness, plantation, rescue and rehabilitation, ecological survey and monitoring involved interested volunteers from various stakeholders, especially local communities, in elicit actions for ensuring habitat restoration and conservation. The skills of these motivated and interested individuals were enhanced with regular capacity building and training workshops.

1.5.2. Institutionalization of community-based conservation through establishment of Ganga Prahari cadre

Institutionalization of volunteer groups by formalizing its structure and governance helps in ensuring sustainability and effectiveness of the initiative and achieving larger impact. Following the identification and mobilization of stakeholders, a need was felt to provide a platform and recognition to the self-driven and motivated individuals spearheading stewardship for river conservation. Hence, Ganga Prahari programme was created to provide an impetus to the community's contribution to conservation and amplify impact through social force. No strict criteria were set for the selection of the Ganga Praharis, except for a drive and passion for river conservation, leadership skills, and geographical, demographic and knowledge representation. Site-level consultative meetings and workshops were held in select villages along the select rivers to identify Ganga Praharis (GPs). Recommendations from government departments and line agencies were also considered for potential GPs. Youth, women and social welfare

groups like National Cadet Corps (NCC), National Service Scheme (NSS), Mahila Mangal Dal, Yuva Mangal Dal, Nehru Yuva Kendra Sangathan (NYKS) and Ganga Vichar Manch were also reached out to identify potential GP. Special attention was given to include women and other marginalized groups. The identified GPs were made familiar with the goals and objectives of GP programme through orientation workshops. Dedicated and thematic training workshops by NMCG-WII team made sure to improve the capacity of the GPs and keep them proactive. GPs were also involved in project activities and NMCG-WII team supported them in their initiatives, whenever possible. Through linkages with line agencies, government departments, NGOs and other organizations, opportunities to GPs were given to participate in relevant activities organized by other stakeholders and to build network.

1.5.3. Livelihood intervention to link livelihoods and conservation

Once suitable individuals were identified as Ganga Praharis and their regular participation was ensured through the programme, it was realized that not everyone has enabling conditions to participate despite good intentions. Securing participation from weak, suppressed and marginalized sections in conservation was a challenge given the lack of social and financial capital, and trade-off between conservation and subsistence. Hence, it was thought to build economic incentives that make conservation a rational choice by through livelihood security and improving their capability. To identify potential themes for livelihood activities that are in tune with the local ecological and cultural settings, a need-based assessment was conducted to understand the views, needs and choices of local communities, and availability of raw material and market. Through consultative meetings and surveys, local livelihood related schemes, relevant governmental and private projects and resource persons for training were identified in the area.

Liaising with concerned governmental departments and line agencies like state forest departments, department of rural development, block and district administration, National Rural Livelihood Mission (NRLM), NYKS, Pradhan Mantri Kaushal Vikas Yojna (PMKVY), Rural Self-employment Training Institute (RSETI), NGOs was done for collaboration in livelihood trainings and linking them with trained individuals and groups. In case of presence of established markets, market linkages were created through linkages and Jalaj initiative to ensure the sustainability of these initiatives after the training phase.

1.5.4. Understanding of social-ecological linkages between natural resources of Ganga River and its contribution to well-being

Through questionnaire survey and participatory mapping of ecosystem services, information on dependence of local communities on natural resources and ecosystem services of Ganga River Basin was collected. Representative villages for data collection were selected on the basis of the location of the villages, distance from river, demographic and socio-economic conditions of the villages and river stretch. Secondary data was collected from records and website of concerned departments to supplement the primary data. Households for sampling from these representative villages were randomly selected and minimum 10% of the population were targeted for the interviews.

1.5.5. Microplanning for linking village development with river health

Strengthening of local institutions and decentralization of governance is the key to ensure long term success of participatory management of natural ecosystem and equitable sharing of benefits from local resources. To further cement the long-term association of local communities with conservation actions, different strategies were developed using microplanning approach. Village-level microplans, aimed at reconciling aspirations and needs of the local communities with conservation of river and its biodiversity, were developed.

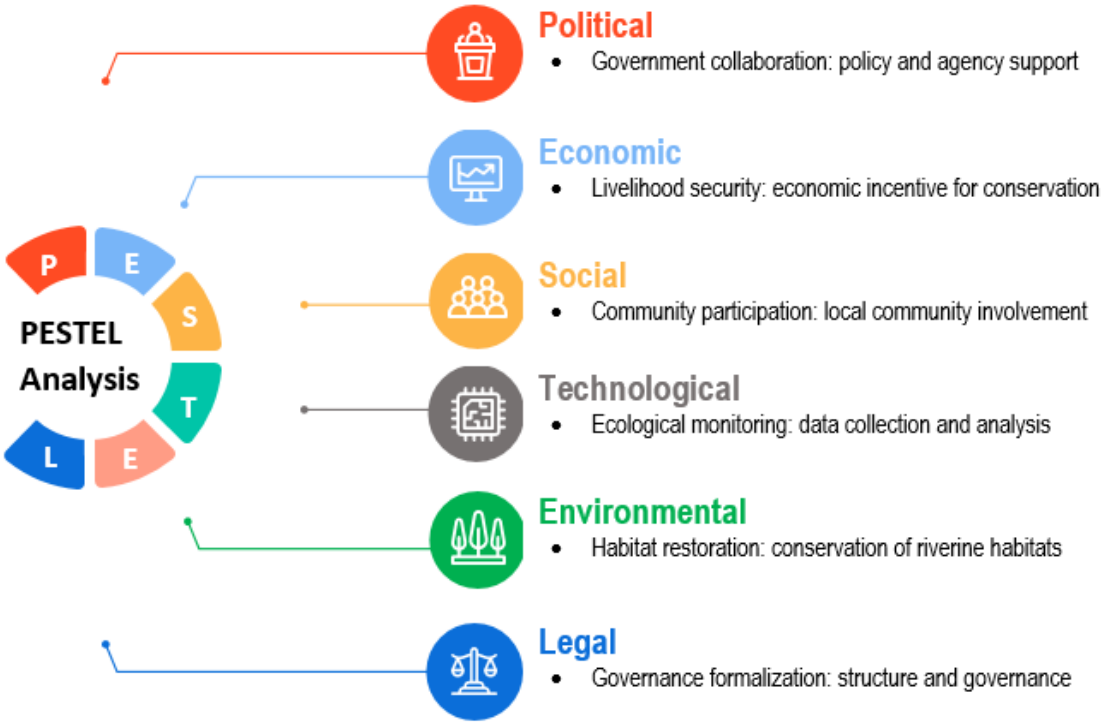

Figure 1.3. Approach to mobilize stakeholders to contribute towards conservation of the Ganga River using PESTEL analysis

Chapter 02

STAKEHOLDER MOBILIZATION FOR EFFECTIVE CONSERVATION ACTIONS

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Summary

The stakeholder mobilization framework for the Ganga River is grounded in the recognition that effective river conservation in complex socio-ecological systems requires inclusive, multi-level participation rather than purely regulatory or technological approaches. The Ganga basin supports an extensive and densely populated socio-economic landscape, where ecological degradation is intrinsically linked to livelihood practices, cultural behaviours, and governance structures. Consequently, stakeholders including local communities, fishers, farmers, industries, religious institutions, and government agencies, play a central role in shaping both pressures on the river and opportunities for conservation. The chapter conceptualizes stakeholder engagement as foundational to river governance, emphasizing that participatory approaches enhance policy legitimacy, improve compliance, and integrate local ecological knowledge into decision-making. It underscores that communities are not passive beneficiaries but active co-managers, whose long-term dependence on river resources positions them as critical actors in biodiversity conservation and pollution mitigation.

The methodological framework combines systematic stakeholder assessment with adaptive engagement strategies. Stakeholder identification was conducted through reconnaissance surveys across multiple administrative scales, supported by consultations with local communities, governance bodies, and civil society organizations. A snowball sampling approach enabled expansion of stakeholder networks, while structured questionnaires and repeated interactions facilitated assessment of stakeholder dependence, perceptions, and interlinkages. This process ensured triangulation using field observations, administrative data, and literature, thereby enabling a robust understanding of stakeholder dynamics. Stakeholders were classified using a salience-based analytical framework incorporating three attributes: power (decision-making influence), legitimacy (institutional or social validity), and interest (degree of dependence on the river). Each attribute was quantitatively scored, and an integrated salience index was derived to prioritize stakeholders. This approach allowed differentiation among actors and informed context-specific, power-aware engagement strategies for river governance. The engagement strategy was designed through iterative scoping, pilot testing, and multi-stakeholder consultations. A six-step "Lock-and-Key" model structured the mobilisation process, beginning with stakeholder identification and line agency mapping, followed by strategy formulation, analysis of inter-stakeholder relationships, implementation of engagement interventions, and outcome evaluation. This sequential yet adaptive framework enabled the transition from fragmented participation to coordinated, long-term governance mechanisms. Operationalization of stakeholder engagement integrated diverse methods, including structured consultations, socio-economic surveys, focus group discussions, sensitization workshops, and technical training programmes. These were complemented by community-driven actions such as cleanliness campaigns, plantation drives, and awareness initiatives, along with communication through media and institutional networks. Collectively, these interventions aimed to embed conservation within local governance systems and everyday practices.

The outcomes demonstrate a highly heterogeneous stakeholder landscape across Ganga basin states, with a total of 50 stakeholder groups identified and categorized into primary, secondary, and tertiary levels based on their roles and influence. State-specific analyses reveal variations in stakeholder interest, power distribution, and salience, reflecting differing governance contexts. High-salience actors are predominantly government institutions and regulatory bodies, while local communities, NGOs, and sectoral actors often exhibit comparatively lower influence despite significant dependence on river resources. In terms of engagement outputs, 3,886 activities were conducted across five states, involving

131,813 participants. Consultative meetings formed the core mechanism for aligning community priorities with institutional frameworks, supported by livelihood programmes and awareness initiatives. These efforts contributed to strengthening participatory governance, enhancing capacity for biodiversity conservation, and fostering shared responsibility for river stewardship. The results demonstrate that structured stakeholder mobilization supported by systematic assessment, participatory frameworks, and adaptive engagement strategies provides a critical pathway for bridging the gap between policy intent and on-ground implementation, thereby advancing resilient and inclusive conservation of the Ganga River ecosystem.

2.1. Introduction

Conservation of the Ganga River requires more than regulatory enforcement or technological interventions; it demands meaningful stakeholder participation across scales of governance and society. The Ganga is far more than a physical river system; it is a socio-ecological lifeline sustaining nearly half a billion people across India and Bangladesh. It sustains one of the most densely populated and agriculturally productive regions in the world (Sanghi & Kaushal, 2014; Kumar et al., 2006; Erenstein et al., 2010). Given this scale of human dependence, environmental pressures on the river are deeply embedded within livelihood systems, cultural practices, land use decisions, and waste management behaviours.

Stakeholders of Ganga River, including local communities, fishers, farmers, religious institutions, industries, tourism operators, and governance bodies, interact with the river daily, shaping its ecological condition through resource extraction, waste disposal, ritual activities, and economic production (Ambastha et al., 2007; Huntjens et al., 2017). Research on river basin governance emphasises that without stakeholder engagement, conservation policies often remain weakly implemented, particularly in large, socio-ecologically complex systems (Pahl-Wostl, 2019). Participatory governance enhances policy legitimacy, improves compliance, and integrates local ecological knowledge into formal decision-making processes, thereby increasing the effectiveness and sustainability of interventions. In biodiverse and culturally significant landscapes such as the Ganga basin, local communities are not merely beneficiaries of conservation outcomes but key actors in shaping them (Nale et al., 2017). Their long-term presence, livelihood dependence, and traditional knowledge systems position them as critical partners in biodiversity conservation and pollution mitigation. Evidence from environmental governance studies shows that co-management approaches and stakeholder-inclusive frameworks lead to more adaptive, equitable, and resilient river management outcomes (Reed et al., 2009; Pahl-Wostl et al., 2012). Therefore, integrating stakeholder participation into Ganga conservation is not optional but foundational. Aligning ecological restoration goals with socio-economic realities, cultural values, and institutional capacities is essential to ensure that conservation moves beyond policy formulation toward sustained behavioural and systemic change across the basin.

The stakeholder mobilisation programme along the Ganga main stem has been implemented in sequential phases. The first phase focused on establishing stakeholder networks, conducting baseline assessments, and initiating engagement along the Ganga River. Building on this foundation, the second phase strengthened and scaled participation within the main stem while the broader conservation programme expanded geographically toward major tributaries. The present chapter documents

stakeholder identification, assessment, and engagement outcomes under Phase II along the Ganga main stem.

Hence, this chapter identifies the key stakeholder groups associated with the Ganga River and analyses their roles, interests, and potential contributions in strengthening biodiversity conservation and sustainable river governance. In addition to stakeholder mapping, it documents the engagement activities undertaken to enhance participation, improve policy literacy, and foster shared responsibility for river stewardship. By examining both identification and engagement processes, the chapter highlights how collaborative approaches can bridge the gap between policy intent and on-ground implementation, thereby advancing long-term ecological resilience in the Ganga basin.

2.2. Aim

To elicit the participation of stakeholders in the biodiversity conservation of the Ganga River.

2.2.1. Objectives

1) To identify key stakeholders across the Ganga River and analyze their roles in biodiversity conservation.
2) To develop stakeholder-specific strategies for effective engagement in the conservation and management of biodiversity in the Ganga River.

2.3. Approach

2.3.1. Stakeholder identification

To identify the stakeholders of Ganga River, reconnaissance surveys were conducted across villages, blocks, and districts along the river corridor to identify stakeholders operating at community, administrative, and institutional levels. Formal and informal consultations were held with local communities, government agencies, and non-governmental organizations to map ecological linkages with the river and institutional responsibilities. Structured meetings were organized with Gram Pradhans, Panchayat members, Block and Village Development Officers, Panchayat Secretaries, NGO representatives, and community members. Given the Ganga's multidimensional governance landscape, a snowball sampling approach was employed to expand the stakeholder network through referrals (Figure 2.1) (Atkinson & Flint, 2001; Reed et al., 2009).

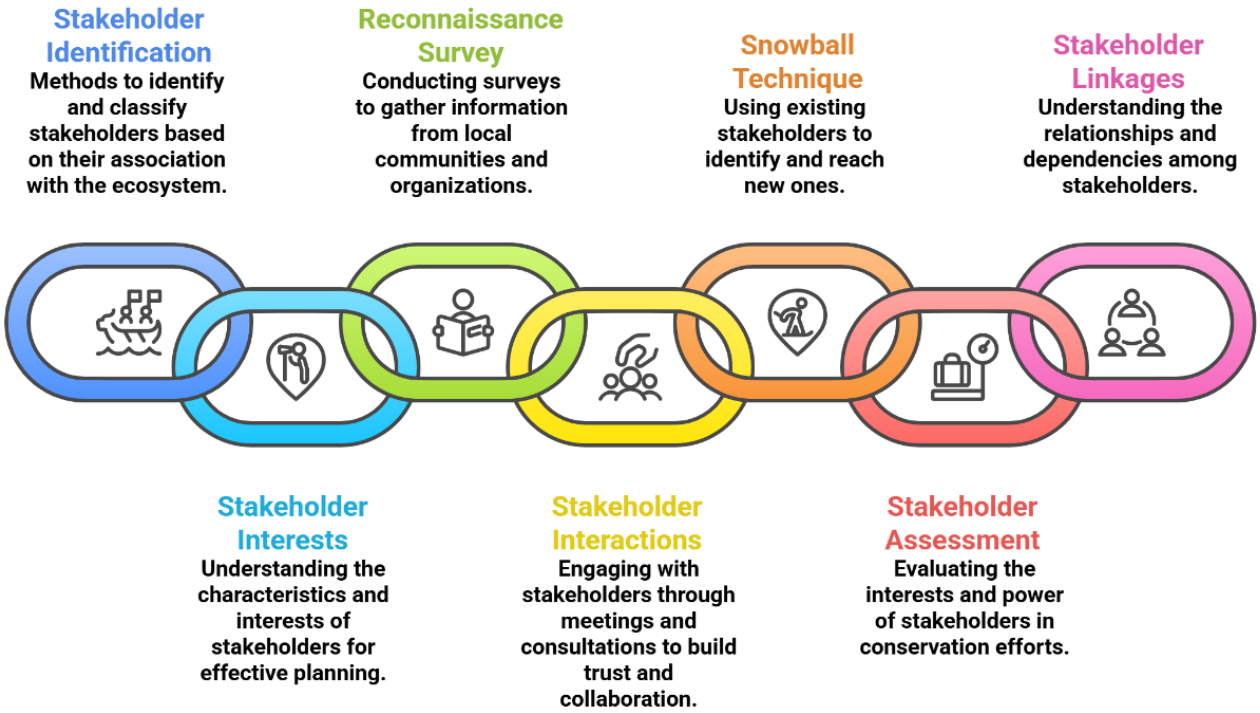

Figure 2.1. Approach to identify and classify stakeholders in the Ganga River

2.3.2. Stakeholder analysis

Repeated engagements enabled assessment of stakeholder interest, influence (power), and willingness to participate in river cleanliness and biodiversity initiatives. Structured questionnaires examined river resource dependence, governance perceptions, and inter-stakeholder linkages, with findings triangulated through field observations, administrative records, and published literature. This integrative assessment moves beyond stakeholder listing toward analysing power dynamics and relational networks, providing a grounded framework for inclusive, adaptive, and context-specific conservation strategies in the Ganga River basin (Figure 2.1).

Stakeholders were classified using a salience-based framework grounded in three core attributes: power, legitimacy, and interest, to assess their relative influence in Ganga River governance (Nastran, 2014). Power captured the capacity to shape decisions or resource allocation, legitimacy reflected the institutional or moral basis of stakeholder claims, and interest represented the degree of ecological, economic, or cultural dependence on the river system. Each stakeholder group was scored on a scale of 1 (low) to 3 (high) for all three attributes ((Figure 2.1). An integrated salience index (D) was then computed as (Figure 2.2):

$$D = \sqrt{a^2 + b^2 + c^2}$$

where *a* denotes interest, *b* power, and *c* legitimacy.

This quantitative prioritisation enabled systematic differentiation among stakeholder groups, supporting evidence-based engagement strategies and more inclusive, power-aware approaches to biodiversity conservation and river governance in the Ganga basin.

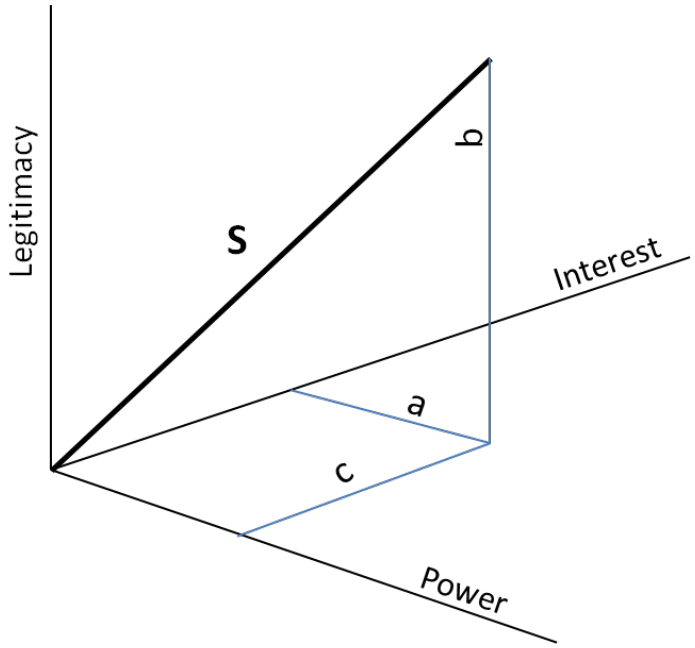

Figure 2.2. Approach to define salience of stakeholders (adopted from Nastran, 2014)

2.3.3. Engaging stakeholders in Ganga biodiversity conservation

The participation strategy was developed through a combination of literature review and an initial scoping exercise. Multiple consultation meetings and workshops were organised with a range of stakeholders, including representatives from government and private institutions, to introduce the project objectives and understand their respective areas of interest. In addition, informal interactions with local communities were conducted to capture on-ground perspectives, identify biodiversity threats, and gather insights into local drivers of ecological degradation and potential interventions (Figure 2.3, Table 2.1). To operationalise stakeholder mobilisation for biodiversity conservation in the Ganga River, we developed and implemented a six-step "Lock-and-Key" model (Figure 2.3). The model conceptualises ineffective conservation, characterised by limited stakeholder engagement, as a systemic "lock" that can be unlocked through sequential, coordinated interventions. The framework begins with stakeholder identification, involving systematic recognition of actors and clarification of their respective stakes. This is followed by line agency mapping, which identifies active governmental and institutional bodies aligned with the conservation vision. A context-specific participation strategy is then formulated, guided by stakeholder attributes including power, legitimacy, and interest. The fourth stage, interlinkage investigation, analyses relationships among stakeholders to enhance coordination and minimise conflict. These preparatory steps culminate in strategy implementation, comprising structured consultations, capacity-building initiatives, and community engagement activities. Finally, outcome assessment evaluates effectiveness and informs adaptive management.

These six interconnected stages function as a structured pathway for transforming fragmented engagement into long-term, inclusive, and resilient conservation governance of the Ganga River ecosystem.

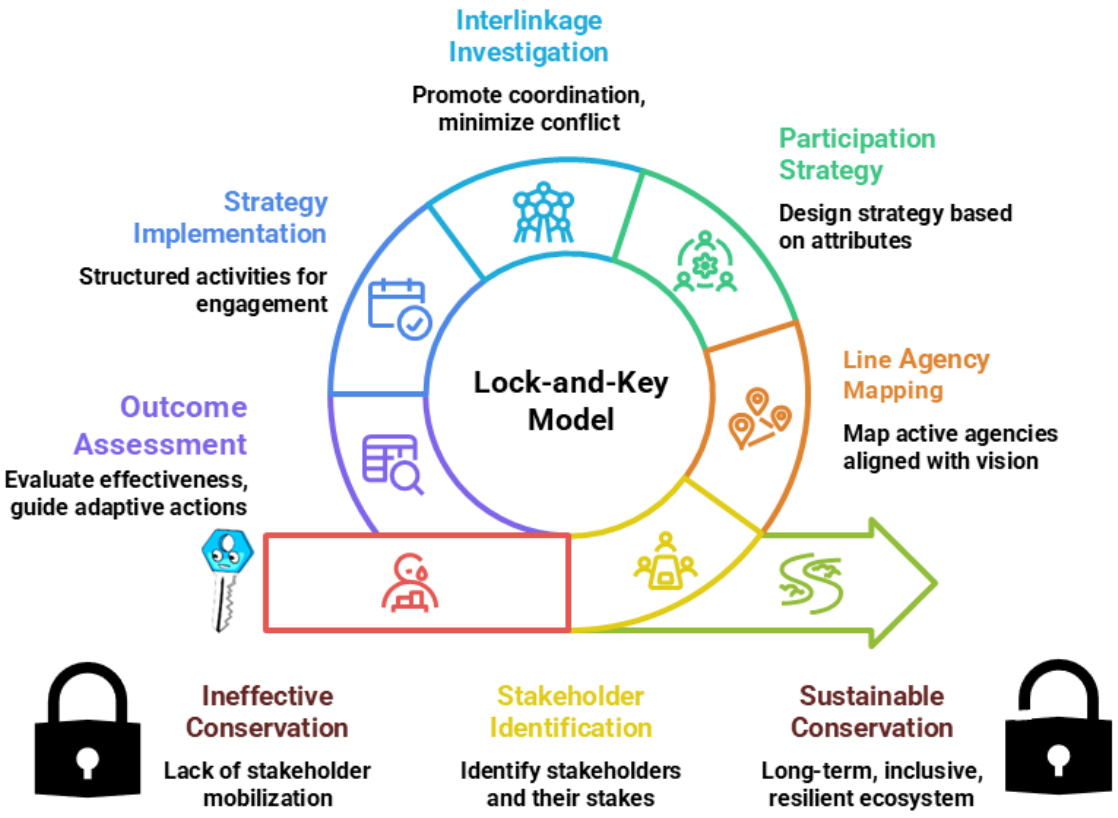

Figure 2.3. Strategy to engage stakeholders in Ganga Conservation

Building on the six-step model, implementation integrated multi-modal stakeholder engagement to operationalise biodiversity conservation in the Ganga River. Structured consultations, socio-economic surveys, and focus group discussions informed local priorities, while sensitisation workshops and technical trainings strengthened community capacity in ecological monitoring, species conservation, and conservation-linked livelihoods. Community-led cleanliness drives, plantation initiatives, and awareness campaigns translated mobilisation into on-ground action. Complementary outreach through print and electronic media, publications, and sustained communication channels ensured broader dissemination and institutional coordination (Figure 2.4). Together, these interventions embedded conservation within local practice and governance structures, reinforcing participatory and resilient river stewardship.

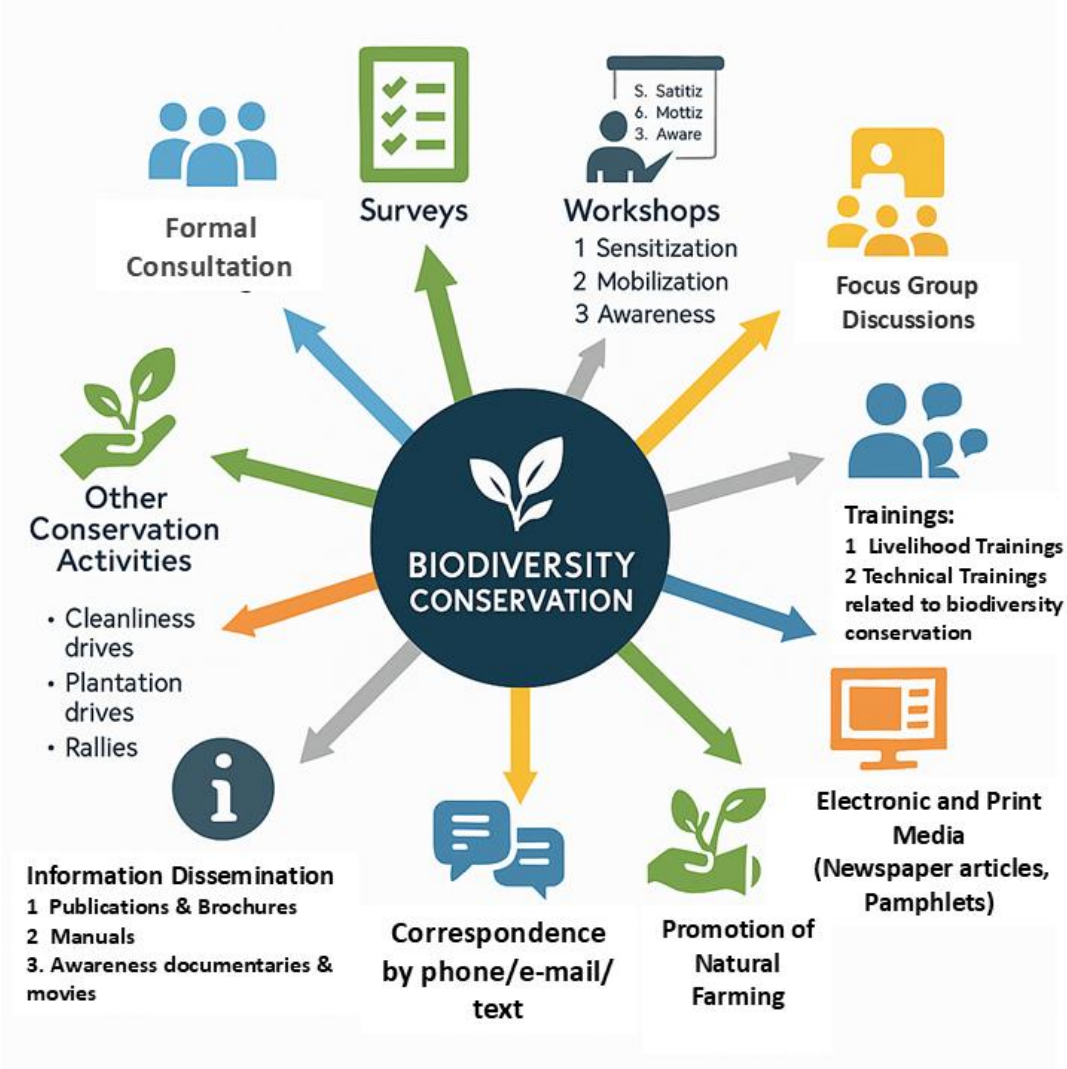

Figure 2.4. Stakeholder engagement activities conducted

2.4. Results

2.4.1. Stakeholders of the Ganga River

The Ganga River basin encompasses diverse socio-cultural, economic, and ecological settings, resulting in a varied stakeholder landscape. Across the five Ganga basin states, 50 distinct stakeholder groups were identified based on their functional association with river resources and conservation processes. These groups were categorised into primary, secondary, and tertiary stakeholders according to their relative levels of interest, influence, and role in decision-making and implementation within integrated conservation planning frameworks (Table 2.1). Given the institutional and administrative variations across states, stakeholder composition and salience were analysed separately for each state to ensure context-specific interpretation of governance dynamics.

2.4.1.1. Uttarakhand

In Uttarakhand, 32 stakeholder groups were identified and classified into 18 primary, nine secondary and five tertiary actors. A strong concentration of stakeholder interest was observed, with the majority of groups (n = 18) exhibiting high levels of engagement, and only a small number demonstrating moderate

(n = 4) or low (n = 1) interest. A similarly concentrated distribution of influence was recorded: 17 groups were characterized by high decision-making power, whereas nine were assessed as having moderate to low influence. The highest salience scores (5.20) were assigned to core governance institutions, including the Uttarakhand Forest Department, District Ganga Committee, Water and Sanitation Department and State Project Management Unit, as well as Municipal Corporations and national-level entities such as the National Mission for Clean Ganga and the Ministry of Environment, Forest and Climate Change (MoEF&CC). In contrast, the lowest salience scores (3) were attributed to non-governmental organizations and actors within the tourism sector, reflecting comparatively limited authority within the prevailing river conservation governance structure (Table 2.2).

2.4.1.2. Uttar Pradesh

In Uttar Pradesh, 32 stakeholder groups were identified and classified into 22 primary, three secondary, and five tertiary actors. A predominance of high stakeholder interest was observed (n = 23), with two groups demonstrating moderate engagement and five exhibiting low levels of interest. The distribution of influence was similarly concentrated: 19 groups were assessed as having high decision-making power, eight as moderate, and three as low. The highest salience score (5.20) was attributed to the Uttar Pradesh State Forest Department, District Ganga Committee, Ganga Task Force and State Project Management Groups (primary stakeholders), as well as the Nehru Yuva Kendra Sangathan (secondary) and the Ministry of Environment, Forest and Climate Change (MoEF&CC) (tertiary), reflecting their combined influence, legitimacy and interest in river governance. In contrast, the lowest salience score (3.00) was assigned to local industries and inland waterways authorities (primary stakeholders), together with the Armed Forces (tertiary), indicating comparatively limited prioritization within the state's Ganga conservation framework (Table 2.3).

2.4.1.3. Bihar

In Bihar, 25 key stakeholder groups were identified, comprising 19 primary, four secondary, and one tertiary actor. Interest levels were unevenly distributed, with nine groups demonstrating high interest, four moderate, and 11 relatively low engagement. In terms of influence, 14 stakeholders exhibited high power to affect biodiversity and habitat outcomes, seven had moderate power, and three showed limited influence. The highest salience score (5.20) was recorded for the Ministry of Environment, Forest and Climate Change (MoEF&CC), the Environment, Forest and Climate Change Department, and the Bihar State Pollution Control Board, reflecting their combined authority, legitimacy, and commitment to river governance. In contrast, the Disaster Management Department (2.45), Inland Waterways Authority (3.32), and actors such as the Electricity Supply Department, local industries, and the tourism sector (3.00) displayed comparatively low salience in relation to Ganga biodiversity conservation (Table 2.4).

2.4.1.4. Jharkhand

In Jharkhand, 27 stakeholder groups were identified, including 17 primary, six secondary, and four tertiary actors. A majority (20 groups) demonstrated high interest in Ganga conservation, while two showed moderate and five relatively low interest. Nineteen stakeholders possessed high decision-making power, whereas four each were categorized as having moderate and low influence. The highest salience score (5.20) was recorded for seven stakeholder groups: the Department of Forest, Environment and Climate Change, District Ganga Committee, State Project Management Group (SPMG), and Swachh Bharat Mission–Rural (primary stakeholders); the District Administration (secondary); and Educational

Institutions and the Ministry of Environment, Forest and Climate Change (tertiary). In contrast, local industries (secondary; 1.73), as well as NGOs and the Department of Water Resources (primary; 3.00), exhibited comparatively low salience in relation to biodiversity conservation and river governance (Table 2.5).

2.4.1.5. West Bengal

In West Bengal, 30 stakeholder groups were identified, comprising 14 primary, 12 secondary, and four tertiary actors. Fourteen groups demonstrated high interest in Ganga conservation, an equal number showed moderate interest, and two exhibited low interest. In terms of influence, 11 stakeholders held high power, 15 moderate power, and four relatively low power in shaping conservation and governance outcomes. The highest salience score (5.20) was recorded for the National Mission for Clean Ganga and the Ministry of Environment, Forest and Climate Change (tertiary stakeholders). In contrast, comparatively lower salience scores (3.00) were observed for the Inland Waterways Authority, Panchayati Raj Institutions, local communities, and NGOs (primary stakeholders), as well as the Mining Sector and the Department of Disaster Management and Civil Defence (secondary stakeholders), indicating more limited prioritization in biodiversity-focused river governance (Table 2.6).

2.4.2. Stakeholder engagement activities

A total of 3,886 stakeholder engagement activities were conducted across 53 districts of five Ganga basin states and additional 13 others districts of small tributaries, reaching 131,813 participants, to institutionalise participatory biodiversity conservation and strengthen community resilience (Figure 2.5). The highest concentration of activities was recorded in consultative meetings, followed by livelihood development and awareness programmes.

Consultative meetings (n = 1,458) functioned as organised governance edges, enabling communities to articulate conservation priorities, resource dependencies, and local challenges, while facilitating alignment with government departments through policy convergence, technical support, and coordinated implementation. Evidence-based planning was supported through socio-economic surveys (n=72), assessing community dependence on riverine ecosystem services, and participatory mapping exercises (n=63), enabling ecosystem service evaluation and identification of ecologically sensitive zones. Sensitisation workshops (n = 141) were conducted to enhance ecological awareness, strengthen understanding of biodiversity values, and promote responsible environmental behaviour. Orientation and training workshops (n = 39) focused on practical skill development. These included preparing local participants as first responders to assist forest departments during rescue operations and building technical capacity in rural technology interventions such as sustainable aquaculture, beekeeping, horticulture diversification, bamboo enterprises, improved livestock management, utilisation of invasive species (e.g., water hyacinth), Integrated Nutrient and Pest Management (biofertilisers and biopesticides), rainwater harvesting, solar energy adoption, composting, wastewater treatment, plastic recycling, and human–wildlife conflict mitigation strategies.

Livelihood development activities (n = 691) strengthened economic diversification through hands-on training in stitching, herbal shampoo and soap production, candle and LED making, food processing, bakery and millet-based products, herbal colour preparation, bamboo crafts, water hyacinth product development, and dhoop and agarbatti manufacturing. These interventions enhanced income resilience while fostering conservation-linked community ownership.Behavioural reinforcement was achieved

through awareness and sensitisation programmes (n=663), special days celebration (n=160), cleanliness drives (n=208), and ecologically planned plantation drives (n=86), where site-appropriate native species were planted to enhance riparian stability and habitat quality. Exposure visits and river walks (n=62) further deepened ecological understanding through experiential learning (Table 2.7).

These engagement activities strengthened institutional–community linkages, enhanced technical preparedness, diversified livelihoods, reduced ecological pressures, and embedded biodiversity stewardship within local socio-economic systems across the Ganga states.

Figure 2.5. Spatial distribution of stakeholder mobilization activities along Ganga River

Table 2.1. Attributes used to classify the stakeholders of Ganga River

Sl. No.	Attribute	Question	Categories
1.	Influence, Power	1. Does the stakeholder influence the Ganga or get affected by presence and condition of Ganga?	Affect/affected
		2. What is the influence of the stakeholder on Ganga River and its biodiversity?	Indirect/direct
		3. What is the scale of impact?	Low/medium/high
2.	Importance	1. Are the stakeholder's needs and interests a priority?	Yes/no
3.	Legitimacy	1. Do stakeholders have legitimate demands?	Yes/no
		2. How legitimate are the demands?	Low/medium/high
4.	Role	1. What is the role of stakeholder in Ganga River conservation and cleanliness?	Dependent on resource/decision maker/designer/passively involved
5.	Position, Compatibility	1. What is the stakeholder's position in relation to Ganga conservation and cleanliness?	Support/opposition Co-operative/competitive
6.	Location	1. What is the location of stakeholder along the Ganga River?	Name of Ganga state and stretch
		2. What is the distance of stakeholder from the river?	Distance from main Ganga stem
7.	Activity	1. How stakeholder involved in Ganga conservation and cleanliness activities?	Passive/active
		2. Does Ganga biodiversity affect stakeholder or vice versa?	Yes/no
		3. Does stakeholder have an indispensable role for the Ganga conservation?	Primary/ secondary/tertiary
8.	Institutional level	1. On what level stakeholder is connected with the Ganga River?	Local on-site, local off-site
9.	Interest	1. On what level is the stakeholder's interest and influence on Ganga biodiversity and cleanliness?	Low/medium/high
10.	Dependence	1. What is stakeholder's possible contribution to Ganga conservation and cleanliness?	Low/medium/high
		2. What is the level dependence of stakeholder on Ganga River and its biodiversity?	Low/medium/high

11.	**Knowledge**	1. How much does the stakeholder know about the Ganga River biodiversity and its values?	Low/medium/high
12.	**Leadership**	1. Does the stakeholder lead any group, related to Ganga River?	Yes/no

Table 2.2. The stakeholder attributes' estimates and their salience in Uttarakhand state

Sl. No.	Stakeholder	Type	Interest (a)	Power (b)	Legitimacy	Legitimacy score (c)	Impact	Position	Salience $D=\sqrt{(a^2+b^2+c^2)}$
1.	**District Administration**	Primary	1	3	Yes	3	2	+/-	4.36
2.	**Forest Department**	Primary	3	3	Yes	3	3	+	5.20
3.	**Religious group**	Primary	1	3	Yes/no	2	3	+/-	3.74
4.	**NGOs**	Primary	1	2	Yes/no	2	2	+/-	3.00
5.	**District Ganga Committee**	Primary	3	3	Yes	3	2	+	5.20
6.	**Village Panchayat**	Primary	3	3	Yes/no	2	3	+/-	4.69
7.	**Nagar Panchayat**	Primary	3	3	Yes/no	2	3	+/-	4.69
8.	**Fisheries Department**	Primary	2	2	Yes	3	3	+/-	4.12
9.	**Agricultural Department**	Primary	3	2	Yes/no	2	3	+/-	4.12
10.	**Animal Husbandry**	Primary	2	2	Yes	3	3	+/-	4.12
11.	**Mining Department**	Primary	3	3	Yes/no	2	3	-	4.69
12.	**Water and sanitation**	Primary	3	3	Yes	3	3	+/-	5.20
13.	**Local communities**	Primary	3	1	Yes	3	3	+/-	4.36
14.	**Tourism sector**	Primary	1	2	Yes/no	2	3	+/-	3.00
15.	**Irrigation Department**	Primary	3	3	Yes/no	2	3	+/-	4.69
16.	**Hydropower**	Primary	3	3	Yes/no	2	3	-	4.69
17.	**Local Institutions**	Primary	3	1	Yes	3	2	+/-	4.36
18.	**SPMG**	Primary	3	3	Yes	3	3	+	5.20

19.	**Educational/Research Institutes**	Secondary	3	2	Yes	3	3	+	4.69
20.	**Armed forces**	Secondary	1	1	Yes	3	1	+	3.32
21.	**NYKS**	Secondary	2	2	Yes	3	1	+	4.12
22.	**Training institutes**	Secondary	1	1	Yes	3	1	+	3.32
23.	**Department of Rural Development**	Secondary	1	1	Yes	3	3	+	3.32
24.	**Municipal Corporations**	Secondary	3	3	Yes	3	2	+/-	5.20
25.	**SRLM**	Secondary	1	2	Yes	3	2	+	3.74
26.	**Small Businessmen/Vendors**	Secondary	3	1	Yes/no	2	3	+/-	3.74
27.	**Media**	Secondary	2	3	Yes/no	2	2	+	4.12
28.	**UREDA**	Tertiary	1	2	Yes	3	1	+	3.74
29.	**NMCG**	Tertiary	3	3	Yes	3	3	+	5.20
30.	**MoEF&CC**	Tertiary	3	3	Yes	3	3	+	5.20
31.	**Ministry of Rural Development**	Tertiary	1	3	Yes	3	3	+	4.36
32.	**Other ministries**	Tertiary	3	3	Yes/no	2	3	+/-	4.69

Table 2.3. The stakeholder attributes' estimates and their salience in Uttar Pradesh state

Sl. No.	Stakeholder	Type	Interest (a)	Power (b)	Legitimacy	Legitimacy score (c)	Impact	Position	Salience $D=\sqrt{(a^2+b^2+c^2)}$
1.	**District Administration**	Primary	2	3	Yes	3	2	+	4.69
2.	**Forest Department**	Primary	3	3	Yes	3	3	+	5.20
3.	**Religious group**	Primary	3	2	Yes/no	2	3	+/-	4.12
4.	**Local industries**	Primary	3	1	No	1	2	-	3.32
5.	**NAPS**	Primary	3	3	Yes/no	2	3	+/-	4.69
6.	**NGOs**	Primary	3	2	Yes/no	2	2	+/-	4.12
7.	**District Ganga Committee**	Primary	3	3	Yes	3	3	+	5.20

8.	**Ganga Task Force**	Primary	3	3	Yes	3	3	+	5.20
9.	**Village Panchayat**	Primary	3	3	Yes/no	2	3	+/-	4.69
10.	**Nagar Panchayat**	Primary	3	3	Yes/no	2	3	+/-	4.69
11.	**Fisheries Department**	Primary	3	3	Yes/no	2	3	+/-	4.69
12.	**Agricultural Department**	Primary	3	2	Yes/no	2	3	+/-	4.12
13.	**Animal Husbandry**	Primary	2	2	Yes/no	2	3	+/-	3.46
14.	**Mining Department**	Primary	3	3	No	1	3	-	4.36
15.	**Municipal Corporations**	Primary	3	3	Yes/no	2	3	+/-	4.69
16.	**Water and sanitation**	Primary	3	3	Yes/no	2	3	+/-	4.69
17.	**Local communities**	Primary	3	1	Yes/no	2	3	+/-	3.74
18.	**Tourism sector**	Primary	3	2	Yes/no	2	3	+/-	4.12
19.	**SPMG**	Primary	3	3	Yes	3	3	+	5.20
20.	**Irrigation dept.**	Primary	3	3	Yes/no	2	3	+/-	4.69
21.	**Hydropower**	Primary	3	3	Yes/no	2	3	+/-	4.69
22.	**Inland waterways**	Primary	1	3	No	1	3	-	3.32
23.	**NYKS**	Secondary	3	3	Yes	3	1	+	5.20
24.	**SRLM**	Secondary	1	2	Yes	3	2	+	3.74
25.	**NEDA**	Secondary	1	2	Yes	3	1	+	3.74
26.	**Educational/Research Institutes**	Tertiary	3	2	Yes	3	3	+	4.69
27.	**Armed forces**	Tertiary	1	1	Yes	3	1	+	3.32
28.	**MoEF&CC**	Tertiary	3	3	Yes	3	3	+	5.20
29.	**Ministry of Rural Development**	Tertiary	1	3	Yes	3	3	+	4.36
30.	**Other ministries**	Tertiary	3	3	No	1	3	+/-	4.36

Table 2.4. The stakeholder attributes' estimates and their salience in Bihar state

Sl. No.	Stakeholders	Type	Interest (a)	Power (b)	Legitimacy	Legitimacy score (c)	Impact	Position	Salience $D=\sqrt{(a^2+b^2+c^2)}$
1.	Local Communities	Primary	3	1	Yes/no	2	1	+/-	3.74
2.	NGOs	Primary	3	1	Yes/no	2	2	+/-	3.74
3.	Research Institutes, Universities, Colleges, Schools	Tertiary	3	2	Yes/no	2	2	+/-	4.12
4.	Media	Secondary	2	2	Yes/no	2	2	+/-	3.46
5.	District Administration	Primary	2	3	Yes	3	1	+	4.69
6.	Department of Agriculture	Primary	2	3	Yes/no	2	1	+/-	4.12
7.	Animal and Fish Resources Department	Primary	3	3	Yes/no	2	1	+/-	4.69
8.	Disaster Management Department	Secondary	1	1	Yes/no	2	1	+/-	2.45
9.	Energy Department	Secondary	1	2	Yes/no	2	1	+/-	3.00
10.	National Thermal Power Corporation	Primary	1	3	Yes/no	2	2	+/-	3.74
11.	Environment, Forest and Climate Change Department	Primary	3	3	Yes	3	1	+	5.20
12.	Mines & Geology Department	Primary	1	3	Yes/no	2	1	+/-	3.74
13.	Panchayati Raj Department	Primary	1	3	Yes/no	2	1	+/-	3.74
14.	Bihar State Pollution Control Board	Primary	3	3	Yes	3	1	+	5.20

15.	**Planning and Development Department**	Secondary	1	3	Yes/no	2	2	+/-	3.74
16.	**Rural Development Department**	Primary	2	2	Yes/no	2	2	+/-	3.46
17.	**Water Resources Department**	Primary	1	3	Yes	3	1	+	4.36
18.	**Inland Waterways Authority of India**	Primary	1	3	No	1	1	-	3.32
19.	**Central Ground Water Board**	Primary	1	3	Yes/no	2	1	+/-	3.74
20.	**SPMG**	Primary	3	3	Yes/no	2	1	+/-	4.69
21.	**Community based institutions**	Primary	3	2	Yes	3	2	+	4.69
22.	**Religious groups**	Primary	3	3	Yes/no	2	1	+/-	4.69
23.	**Local industries**	Primary	1	2	Yes/no	2	1	+/-	3.00
24.	**Tourism Sector**	Primary	1	2	Yes/no	2	1	+/-	3.00
25.	**MoEF&CC**	Tertiary	3	3	Yes	3	3	+	5.20

Table 2.5. The stakeholder attributes' estimates and their salience in Jharkhand state

Sl. No.	Stakeholders	Type	Interest (a)	Power (b)	Legitimacy	Legitimacy score (c)	Impact	Position	Salience $D=\sqrt{(a^2+b^2+c^2)}$
1.	**Department of Forest, Environment and Climate Change**	Primary	3	3	Yes	3	3	+	5.20
2.	**District Ganga Committee**	Primary	3	3	Yes	3	3	+	5.20
3.	**Local institutions**	Primary	2	1	Yes	3	1	+	3.74
4.	**Local Communities**	Primary	3	1	Yes/no	2	3	+/-	3.74
5.	**Panchayati Raj Institutions**	Primary	3	2	Yes/no	2	3	+/-	4.12
6.	**NGOs**	Primary	2	1	Yes/no	2	2	+/-	3.00
7.	**Inland Waterways Authority**	Primary	3	3	No	1	3	-	4.36

8.	**SPMG**	Primary	3	3	Yes	3	2	+	5.20
9.	**SBM Rural**	Primary	3	3	Yes	3	2	+	5.20
10.	**State Pollution Control Board**	Primary	1	3	Yes	3	1	+	4.36
11.	**Religious Groups**	Primary	3	3	Yes/no	2	3	+/-	4.69
12.	**Fisheries Department**	Primary	3	3	Yes/no	2	3	+/-	4.69
13.	**Department of Agriculture, Animal Husbandry and Cooperative**	Primary	3	3	Yes/no	2	3	+/-	4.69
14.	**Mining Department**	Primary	3	3	No	1	3	-	4.36
15.	**Department of Drinking Water and Sanitation**	Primary	3	3	Yes/no	2	3	+/-	4.69
16.	**Department of Water Resources**	Primary	1	2	Yes/no	2	3	+/-	3.00
17.	**Irrigation Department**	Primary	3	3	Yes/no	2	3	+/-	4.69
18.	**District Administration**	Secondary	3	3	Yes	3	3	+	5.20
19.	**Electronic and Print Media**	Secondary	3	3	Yes/no	2	3	+/-	4.69
20.	**Local Industries**	Secondary	1	1	No	1	1	-	1.73
21.	**Local Businesses**	Secondary	3	2	Yes/no	2	3	+/-	4.12
22.	**SRLM**	Secondary	3	2	Yes	3	3	+	4.69
23.	**Tourism sector**	Secondary	1	3	Yes/no	2	3	+/-	3.74
24.	**Educational Institutions**	Tertiary	3	3	Yes	3	2	+	5.20
25.	**MoEF&CC**	Tertiary	3	3	Yes	3	3	+	5.20
26.	**Ministry of rural development**	Tertiary	1	3	Yes	3	3	+	4.36
27.	**Other ministries**	Tertiary	3	3	Yes/no	2	3	+/-	4.69

Table 2.6. The stakeholder attributes' estimates and their salience in West Bengal state

Sl. No.	Stakeholder	Type	Interest (a)	Power (b)	Legitimacy	Legitimacy score (c)	Impact	Position	Salience

									$D=\sqrt{(a^2+b^2+c^2)}$
1.	**Agricultural Department**	Primary	3	2	Yes/no	2	3	+/-	4.12
2.	**Fisheries Department**	Primary	3	2	Yes/no	2	3	+/-	4.12
3.	**Irrigation Department**	Primary	3	3	Yes/no	2	3	+/-	4.69
4.	**Inland Waterways Authority of India**	Primary	2	2	No	1	2	-	3.00
5.	**Shipping Corporation**	Primary	2	3	No	1	3	-	3.74
6.	**Religious groups**	Primary	3	2	Yes/no	2	3	+/-	4.12
7.	**Central Groundwater Board, Eastern Region**	Primary	3	3	Yes/no	2	3	+/-	4.69
8.	**Panchayati Raj institutions**	Primary	2	1	Yes/no	2	3	+/-	3.00
9.	**District Ganga Committee**	Primary	3	2	Yes	3	2	+	4.69
10.	**Local communities**	Primary	2	1	Yes/no	2	3	+/-	3.00
11.	**District Administration**	Primary	2	3	Yes	3	3	+	4.69
12.	**West Bengal Pollution Control Board**	Primary	3	2	Yes	3	3	+	4.69
13.	**NGOs**	Primary	2	1	Yes/no	2	2	+/-	3.00
14.	**Thermal power plants**	Primary	3	3	Yes/no	2	3	+/-	4.69
15.	**Mining sector**	Secondary	2	2	No	1	3	-	3.00
16.	**University/Colleges/ Research Institutions**	Secondary	2	1	Yes	3	2	+	3.74
17.	**State Project Management Group**	Secondary	2	2	Yes	3	3	+	4.12
18.	**West Bengal Forest Department**	Secondary	2	3	Yes	3	3	+	4.69
19.	**Tourism sector**	Secondary	3	2	Yes/no	2	3	+/-	4.12
20.	**Kolkata Municipal Corporation**	Secondary	3	3	Yes/no	2	3	+/-	4.69
21.	**East Kolkata Wetland Management Authority**	Secondary	2	2	Yes	3	2	+	4.12

22.	**West Bengal Coastal Zone Management Authority**	Secondary	3	3	Yes/no	2	3	+/-	4.69
23.	**Local industries**	Secondary	2	2	Yes/no	2	1	+/-	3.46
24.	**West Bengal Renewable Energy Development Agency**	Secondary	3	2	Yes	3	1	+	4.69
25.	**SRLM**	Secondary	1	2	Yes	3	2	+	3.74
26.	**Department of Disaster Management and Civil Defense**	Secondary	1	2	Yes/no	2	2	+/-	3.00
27.	**Print and Electronic Media**	Tertiary	2	2	Yes/no	2	3	+/-	3.46
28.	**NMCG**	Tertiary	3	3	Yes	3	3	+	5.20
29.	**MoEF&CC**	Tertiary	3	3	Yes	3	3	+	5.20
30.	**Other Ministries**	Tertiary	2	3	Yes/no	2	3	+/-	4.12

Table 2.7. Stakeholder engagement activities conducted in the five Ganga states

Sl. No.	Stakeholder Engagement Activities	Uttarakhand		Uttar Pradesh		Bihar		Jharkhand		West Bengal		Total	
		No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants
1.	Awareness and Sensitization Activities	84	2307	453	37774	70	7406	41	3230	15	461	**663**	**51178**
2.	Cleanliness Drives	17	410	163	5292	16	522	11	320	1	55	**208**	**6599**
3.	Consultative Meetings	67	964	970	10183	250	2180	91	598	80	785	**1458**	**14710**
4.	Ecological Monitoring			6	14							**6**	**14**
5.	Field Visits / River Walks	5	167	46	761	1	5	2	86	8	32	**62**	**1051**
6.	Livelihood Development Activities	48	953	439	9642	126	3327	48	1206	30	550	**691**	**15678**
7.	Orientation and Training Workshops	9	772	15	649	10	732	4	365	1	49	**39**	**2567**
8.	Participatory Mapping Activities	20	147	37	811	0	0	4	123	2	40	**63**	**1121**
9.	Plantation Drive	9	183	65	3046	7	485	3	141	2	39	**86**	**3894**
10.	Rescue & Rehabilitation			11	90							**11**	**90**
11.	Sensitization Workshops	12	257	126	5811	3	420					**141**	**6488**
12.	Socio-economic Survey	7	59	57	633	2	24	6	186			**72**	**902**
13.	Special Occasions and Days celebration	11	677	157	15294	39	1409	6	304	8	511	**221**	**18195**
14.	Others	17	1276	130	7129	7	386	6	518	3	17	**163**	**9326**
Total		**306**	**8172**	**2675**	**97129**	**531**	**16896**	**222**	**7077**	**150**	**2539**	**3884**	**131813**

2.4.3. Stakeholder participation patterns in Ganga biodiversity conservation

Participation patterns further indicate that engagement was strongly community-centred while remaining institutionally supported. Across the Ganga basin, a total of 131,942 stakeholders participated in conservation engagement activities, reflecting broad multi-level involvement. Participation was dominated by local communities (n=62,524), indicating strong grassroots mobilisation. Conservation volunteers, including Ganga Praharis (n=20,257) and Bal Ganga Praharis (n=14,223), constituted a substantial share of engagement, underscoring decentralised stewardship mechanisms. Educational institutions (n=13,618) and visitors (n=10,493) contributed significantly to outreach and awareness diffusion (Table 2.8). Institutional participation spanned forest departments, administrative bodies (district administration, block administration), Panchayati Raj institutions, and line agencies, demonstrating cross-scale governance involvement. The participation profile reveals a community-centred yet institutionally supported engagement architecture for biodiversity conservation in the Ganga basin.

Table 2.8. Distribution of stakeholder participation across categories in Ganga biodiversity conservation activities

Sl. No.	Stakeholders	Participation
1.	District Administration	764
2.	Ganga Praharis	20257
3.	Media	458
4.	State Government	256
5.	Visitors	10493
6.	Local Business	605
7.	Bal Ganga Praharis	14223
8.	Fishermen	2185
9.	Inline Agencies	1661
10.	Pravasi Ganga Prahari	97
11.	Block Administration	423
12.	Educational Institutions	13618
13.	Forest Department	2127
14.	Panchayati Raj	725
15.	Local Communities	62524
16.	Others	1526
	Total	**131942**

2.4.4. Stakeholder engagement in high biodiversity zones

High Biodiversity Zones (HBZs), identified in Phase-I of the project, represent ecologically sensitive stretches characterised by high species richness, critical habitats, and strong human–river interactions. Given their ecological significance and vulnerability to anthropogenic pressures, sustained stakeholder engagement in these zones is essential to strengthen conservation outcomes, reduce localised environmental stress, and promote community engagement in conservation.

Across the six High Biodiversity Zones (HBZs), a total of 3,180 stakeholder engagement activities were conducted, reaching 112,788 participants. The highest number of activities was undertaken in HBZ II with 1375 activities and HBZ III (n=996), followed by HBZ IV (n=443), HBZ V (n=232) (Table 2.3). In terms of activities, awareness and sensitisation programmes (n=44,848) recorded the highest participation, followed by Livelihood Development Activities (n=13,273) and consultative meetings (n=12,005). HBZ III demonstrated particularly high participation in awareness programmes(n=25,974) and special occasions (n=7,811), while HBZ II showed a strong concentration of consultative meetings (No. of activities; n=574) and livelihood-linked interventions (n=350). Cleanliness drives and sensitisation workshops were also more prominent in HBZ II and HBZ III compared to other zones (Table 2.9).

While engagement was comparatively higher in HBZ II and HBZ III due to the presence of major urban–industrial clusters along the Ganga in Uttar Pradesh, activities in the other HBZs were strategically aligned with local ecological priorities and conservation needs. The spatial distribution of engagement reflects a calibrated response to varying ecological sensitivities and anthropogenic pressures across the river basin. As a result, these zones required intensified engagement efforts focusing on awareness, institutional coordination, livelihood diversification, and pollution mitigation.

Table 2.9. Stakeholder engagement activities in High Biodiversity Zones (HBZs) along the Ganga River

Stakeholder Engagement Activities in High Biodiversity Zones	HBZ I		HBZ II		HBZ III		HBZ IV		HBZ V		HBZ VI		Total	
	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants	No. of Activities	No. of Participants
Awareness and Sensitization Activities	15	524	167	8120	206	25974	64	6647	43	3271	12	312	**507**	**44848**
Cleanliness Drives	2	47	68	2772	86	2293	9	235	11	320			**176**	**5667**
Consultative Meetings	10	59	574	6270	291	2789	216	1812	95	616	33	459	**1219**	**12005**
Field Visits / River Walks			22	266	14	319	1	5	2	86	5	26	**44**	**702**
Livelihood Development Activities	9	240	350	6839	65	2177	92	2495	53	1272	15	250	**584**	**13273**
Orientation and Training Workshops	6	657	5	230	8	329	8	648	4	365			**31**	**2229**
Participatory Mapping Activities	6	42	20	229	9	120			4	123	2	40	**41**	**554**
Plantation Drive	1	5	24	409	35	2508	7	485	3	141	1	25	**71**	**3573**
Ecological Monitoring and Rescue activities			8	40	9	64							**17**	**104**
Sensitization Workshops	4	80	25	2947	86	2506	3	420					**118**	**5953**
Socio-economic Survey	1	2	29	364	17	217	2	24	6	186			**55**	**793**
Special Occasions and Days celebration			69	5774	65	7811	35	1288	6	304	5	216	**180**	**15393**
Others	5	586	14	861	105	5421	6	346	5	467	2	13	**137**	**7694**
Total	**59**	**2242**	**1375**	**35121**	**996**	**52528**	**443**	**14405**	**232**	**7151**	**75**	**1341**	**3180**	**112788**

2.5. Outcomes of stakeholder engagement

The stakeholder mobilisation interventions generated multidimensional outcomes that extended beyond activity metrics, contributing functionally to participatory governance, institutional convergence, and community-led stewardship within the Ganga River system.

(1) **Institutionalisation of participatory governance:** The stakeholder assessment and salience-based classification enabled clearer identification of power centres, legitimacy anchors, and high-interest stakeholders across five Ganga states. This facilitated targeted stakeholder engagement strategies and reduced coordination gaps among statutory agencies, district administrations, Panchayati Raj institutions, and line agencies. The six-step "Lock-and-Key" model transformed fragmented engagement into a sequenced and adaptive participation pathway, strengthening vertical and horizontal governance linkages across the basin.

(2) **Consolidation of community-centred stewardship:** Participation patterns reveal a strong bottom-up mobilisation structure, with local communities (n=62,524 participants) forming the core of conservation engagement. The active involvement of Ganga Praharis (n=20,257) and Bal Ganga Praharis (n=14,223) institutionalised decentralised stewardship mechanisms and embedded biodiversity goals within local socio-cultural narratives. This transition from passive beneficiaries to active custodians reflects a measurable strengthening of ownership and vigilance in river-dependent populations.

(3) **Targeted Engagement in High Biodiversity Zones**: Focused engagement in High Biodiversity Zones (HBZs) reflects a phased evolution of conservation strategy. In Phase I, ecologically sensitive stretches were systematically identified and delineated as priority zones along the main stem. Phase II transitioned from identification to implementation, concentrating on focused engagement in HBZs, particularly HBZ II and HBZ III, and demonstrated adaptive mobilisation responsive to ecological sensitivity and anthropogenic pressure. The concentration of consultative meetings, livelihood interventions, and awareness programmes in these zones strengthened localised conservation responses and enhanced institutional preparedness in ecologically critical stretches of the river.

(4) **Strengthening cross-scale institutional convergence**: Engagement activities fostered collaboration with forest departments, pollution control boards, district administrations, line agencies, educational institutions, and civil societies, etc. By integrating 50 stakeholder categories across five states, the framework reduced institutional silos and enhanced coherence in biodiversity-related interventions. This cross-scale alignment improved responsiveness to local ecological priorities, particularly within High Biodiversity Zones (HBZs).

(5) **Integration of livelihood security with conservation goals:** Livelihood development activities and rural technology interventions strengthened economic resilience while reducing ecological pressures. Skill diversification in sustainable aquaculture, beekeeping, bamboo enterprises, organic farming inputs, and invasive species utilisation aligned income generation with ecological restoration objectives. This linkage between livelihood enhancement and conservation participation reinforced long-term sustainability and reduced dependence on extractive or river-degrading practices.

(6) **Enhancing women's agency and livelihood resilience:** In Phase I, women's participation increased through livelihood and awareness interventions, enhancing their visibility, confidence, and involvement in river-related decision-making. In Phase II, this engagement matured into independent action, with women autonomously leading conservation activities and adopting acquired skills as

alternative livelihoods. This shift from supported participation to self-driven stewardship strengthened both income resilience and biodiversity conservation outcomes.

(7) **Behavioural and attitudinal transformation:** Repeated awareness programmes, sensitisation workshops, and experiential learning platforms fostered qualitative shifts in ecological perception. Communities increasingly associate biodiversity conservation with cultural identity, river health, and long-term livelihood security. Participation in cleanliness drives, plantation activities, and monitoring initiatives indicates movement from awareness to action, reflecting the embedding of conservation ethics within everyday practice.

(8) **Enhanced adaptive governance capacity:** The integration of socio-economic surveys, participatory mapping, and stakeholder salience scoring generated evidence-based planning tools that informed strategy refinement. Feedback loops between communities and state agencies strengthened trust and improved policy relevance. This adaptive governance architecture positions the Ganga basin for more resilient and inclusive biodiversity management.

2.6. Conclusion

Stakeholder mobilisation along the Ganga main stem illustrates the evolution of participatory river governance through a structured, phased approach. The first phase established the foundational planning, mapping stakeholders, building initial networks, conducting baseline assessments, and delineating High Biodiversity Zones (HBZs) along ecologically sensitive stretches of the river. This diagnostic and network-building stage created the institutional and community involvement necessary for sustained engagement.

Building on this foundation, subsequent efforts consolidated and deepened participation along the main stem, transitioning from identification to intensified implementation. The salience-based stakeholder classification clarified power relations and legitimacy structures across five basin states, enabling more strategic engagement of high-influence stakeholders while strengthening inclusion of river-dependent communities. This reduced institutional fragmentation and enhanced convergence among govt. agencies, district administrations, Panchayati Raj institutions, and civil society actors.

Participation patterns reflect a governance model anchored in grassroots mobilisation and supported by multi-level institutions. Strong involvement of local communities and decentralised volunteer networks institutionalised stewardship at the local scale. Women's participation evolved from livelihood-linked inclusion during the initial phase to more autonomous conservation leadership and independent income generation, reinforcing both social and ecological resilience.

The prior identification of HBZs enabled spatially targeted mobilisation in ecologically critical stretches, particularly where anthropogenic pressures were high. Concentrated consultative, livelihood, and awareness interventions in these zones translated spatial prioritisation into adaptive, localised conservation action.

The programme demonstrates how an initial phase focused on stakeholder identification and zone delineation can mature into an integrated model of participatory governance that links institutional coordination, community ownership, gendered empowerment, and spatial prioritisation. This progression provides a scalable pathway for sustaining biodiversity conservation along the Ganga main stem within a complex and densely inhabited river basin.


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Chapter 03

GANGA PRAHARI PROGRAMME: FOSTERING STEWARDSHIP

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Summary

The Ganga Prahari programme is a structured, community-based conservation mechanism designed to institutionalize local stewardship within the Ganga River basin. It is embedded within a broader participatory framework that recognizes riverine communities as co-managers of biodiversity rather than passive beneficiaries. The programme was conceptualized following systematic stakeholder identification and mobilisation processes, which revealed the need for a formal platform to sustain and scale voluntary conservation efforts. Accordingly, the Ganga Prahari cadre was established to provide institutional recognition,56rganizationnal structure, and continuity to motivated individuals engaged in river conservation. Selection of Ganga Praharis was intentionally inclusive and flexible, based primarily on demonstrated commitment, leadership potential, and representation across geographic, demographic, and knowledge dimensions, with particular emphasis on inclusion of women and marginalized groups.

Operationalization of the programme involved site-level consultations and multi-stakeholder engagement, including collaboration with government departments, local institutions, and community-based organizations such as NCC, NSS, NYKS, and village-level groups. Identified Praharis were oriented through structured training and capacity-building interventions led by the NMCG–WII team, enhancing their competencies in conservation practices, ecological awareness, and community mobilization. Continuous engagement was ensured through their involvement in on-ground activities such as cleanliness drives, plantation, biodiversity monitoring, rescue and rehabilitation, and awareness campaigns, thereby translating stakeholder participation into tangible conservation outcomes. A total of 4,989 Ganga Praharis were registered in the five Ganga states i.e., Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal of which, 66.17% (n = 3,301) were female, indicating a strong predominance of female participation in the programme. State-wise distribution indicates that Uttar Pradesh contributed the largest share at 47.38% (n = 2,364), followed by West Bengal (17.92%) and Bihar (17.72%), where male participation slightly exceeded female participation. Uttarakhand accounted for 10.50%, while Jharkhand contributed 6.47%, with females forming the majority in most states. Ganga Prahari presence across High Biodiversity Zones (HBZs) was highest in HBZ II (22.87%), largely driven by female representation (19.70%). Substantial presence was also observed in HBZ III (18.30%) and HBZ IV (16.46%), where male representation slightly exceeded female representation. HBZ V accounted for 7.21% and HBZ VI for 6.32%, while HBZ I recorded the lowest presence at 2.58%.

A critical dimension of the programme is its integration with livelihood enhancement strategies to address socio-economic constraints that limit participation in conservation. The report highlights that lack of financial and social capital often restricts engagement of vulnerable groups; therefore, livelihood interventions were designed to align economic incentives with conservation objectives. These included need-based assessments, skill development, institutional linkages with schemes such as NRLM and PMKVY, and facilitation of market access through initiatives like Jalaj, ensuring long-term sustainability of conservation-linked livelihoods.

The Ganga Prahari framework is further supported by systematic assessment of social-ecological linkages through surveys and participatory mapping, which capture community dependence on ecosystem services and inform site-specific interventions. This evidence base feeds into microplanning processes that integrate biodiversity conservation with village development planning, strengthening decentralized governance and long-term community engagement. The Ganga Prahari programme represents an institutional innovation within river basin management, operationalizing participatory

conservation through a combination of stakeholder engagement, capacity building, livelihood integration, and localized planning. It demonstrates a scalable model for embedding conservation within socio-economic systems, thereby enhancing ecological resilience while supporting community well-being across the Ganga basin.

3.1. Introduction

Community-based conservation (CBC) has emerged as a central paradigm in natural resource management, integrating local ecological knowledge with scientific management while aligning biodiversity protection with human well-being (Berkes, 2004; Brooks et al., 2013). Studies demonstrate that conservation outcomes improve when communities are empowered through institutional support, clearly defined roles, and sustained capacity development (Oldekop et al., 2010; Gutiérrez and Lewis, 2012). Such approaches are particularly relevant in large river basins, where ecological integrity and human livelihoods are deeply interconnected.

Freshwater ecosystems are among the most threatened globally, experiencing accelerated biodiversity decline due to pollution, hydrological modification, habitat fragmentation, and climate change (Arthington et al., 2010; Tickner et al., 2020). These pressures compromise fisheries, ecosystem services, and water security for river-dependent populations. Although participatory approaches have been emphasized in global sustainability frameworks since the Brundtland Report (1987) and the Rio Earth Summit (1992), the integration of community knowledge and participation into formal river conservation actions remains uneven (Parlee et al., 2021). The long-term success of grassroots conservation initiatives depends on sustained institutional support, adaptive management, and continuous skill development (Pretty, 2002; Cornwall, 2008).

The Ganga basin represents a complex socio-ecological system where these challenges converge at an unprecedented scale. Recognizing the need to integrate biodiversity conservation within community networks, the Wildlife Institute of India (WII), under the umbrella of National Mission for Clean Ganga (NMCG), introduced the Ganga Praharis – Guardians of the River initiative as part of the Ganga Biodiversity Conservation Project. During its first phase (2016–2019), the programme focused primarily on the main stem of the Ganga, establishing a cadre of trained community volunteers to support community participation, biodiversity monitoring, conservation of priority aquatic species, and awareness generation. This phase emphasized institutional integration, field-based learning, and strengthening grassroots stewardship along the river stretch.

In the second phase, initiated in 2020, the programme expanded to major tributaries while simultaneously strengthening the network and related activities along the Ganga mainstem. The expansion reflected a deliberate scaling of the participatory model across diverse ecological and socio-cultural contexts, while deepening monitoring efforts, capacity enhancement, and community–institutional linkages in previously established locations. Alongside technical training, livelihood skills were substantially enhanced to promote economic resilience among riverine communities. Livelihood-oriented modules not only supported income generation but were explicitly integrated with biodiversity-focused sessions, where participants were sensitised to the ecological significance of freshwater species and the role of biodiversity in sustaining river health. Through this convergence of livelihood development and

conservation literacy, individuals were not only economically empowered but also motivated to associate themselves as Ganga Praharis, strengthening the programme's social base.

Through workshops, hands-on training, and continuous engagement, Ganga Praharis developed competencies in ecological survey methods, aquatic species rescue and rehabilitation, habitat assessment, and community outreach. Beyond their technical contributions, they function as catalysts of behavioral change, strengthening social capital and integrating conservation within local governance systems. By following a phased trajectory, initial consolidation (2016–2019) followed by expansion and reinforcement from 2020 onward, the initiative represents an adaptive community-based model aimed at achieving an Aviral (continuous) and Nirmal (unpolluted) Ganga through sustained, locally anchored stewardship.

3.2. Aim

To build and empower grassroots communities for sustainable leadership and actively work on the conservation of the Ganga River.

3.3. Approach

3.3.1. Identification of Ganga Praharis

The identification of Ganga Praharis along the main stem of the Ganga followed a participatory and community-centered approach to ensure that the cadre was firmly grounded in local ecological and cultural contexts. The process began with consultative meetings and village-level interactions across riparian settlements, where district and block officials, village leaders (Pradhans/Mukhiyas), and community representatives were introduced to the objectives of the Ganga Biodiversity Conservation Project. These interactions created a platform for dialogue and helped identify individuals who demonstrated commitment toward river conservation and community engagement.

Outreach efforts extended to Government departments, Panchayati Raj officials, local institutions and youth collectives, including Mahila Mangal Dal, Yuva Mangal Dal, Nehru Yuva Kendras, Ganga Vichar Manch, and State Forest Departments. Engaging these networks facilitated the inclusion of individuals already active in social service or environmental initiatives. Selection criteria emphasized a minimum age of 18 years, residence within riparian communities along the rivers, demonstrated concern for the river's ecological health, and the ability to inspire others. To encourage early engagement, the complementary Bal Ganga Praharis initiative provided opportunities for schools and younger participants.

As the programme matured in Phase II, previously inducted Ganga Praharis, who joined the initiative in Phase I, also played a catalytic role in expanding the network. Through peer-to-peer outreach, community meetings, and informal social interactions, existing members motivated other villagers to join the initiative, creating a chain of local participation driven by trust and shared responsibility. This organic expansion strengthened community ownership and enhanced the social legitimacy of the programme across riparian settlements.

Selected individuals were formally registered and profiled through a centralised database maintained by the Wildlife Institute of India (WII). Orientation programmes and trainings were conducted to enhance ecological understanding and field-based skills, focusing on biodiversity monitoring, conservation of

priority aquatic species, river health assessment, awareness generation, and promotion of sustainable livelihood practices. Interactive learning sessions encouraged participants to define their roles, ranging from biodiversity observers to community mobilisers, thereby reinforcing clarity of purpose and collective commitment to the conservation of the Ganga River (Figure 3.1).

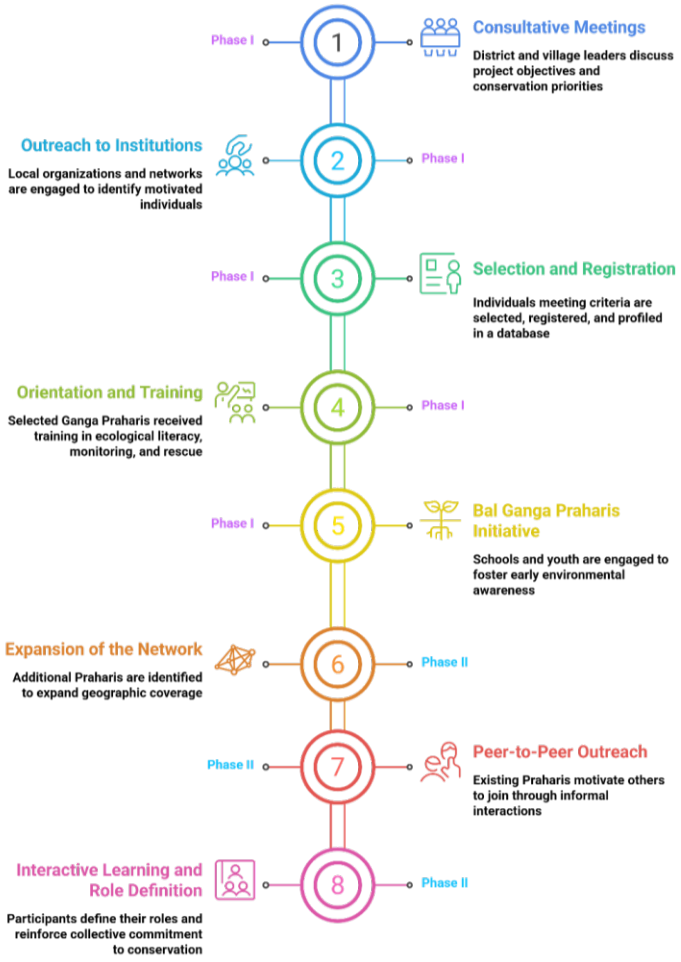

Figure 3.1. Steps involved in Ganga Prahari's identification and capacity building

3.3.2. Roles of Ganga Praharis

The role of a Ganga Praharis is defined through a set of core stewardship functions that integrate ecological action with community engagement. During the initial implementation phase (2016–2019), Ganga Praharis were involved in biodiversity monitoring, documentation of priority aquatic fauna, and facilitation of rescue operations during stranding or entanglement events as first responders. They contributed to biodiversity conservation at local level by identifying emerging threats and supporting context-specific problem-solving within riparian communities. Ganga Praharis also organised and participated in plantation and riverbank cleanliness campaigns, promoting habitat restoration and reducing anthropogenic pressures along river stretches. A central dimension of their role involves community mobilisation and awareness generation, fostering behavioural shifts toward environmentally responsible practices and strengthening collective accountability for river health. Ganga Praharis also act

as mediators linking local communities with institutional stakeholders. Through this bridging role, they enhance communication, improve sensitivity towards conservation priorities, and ensure that interventions are socially grounded. Their participation in village-level micro-planning further integrates local ecological knowledge into conservation, development, and livelihood strategies.

The effectiveness of these defined roles during the first phase enabled their replication during the second phase (from 2020 onward) across major tributaries. The transferability of core functions, ecological monitoring, biodiversity protection, community mobilization, institutional linkage, and participatory planning demonstrates the robustness and scalability of the Ganga Prahari model at a basin scale. This framework supports coordinated, community-anchored conservation across the Ganga River system (Figure 3.2).

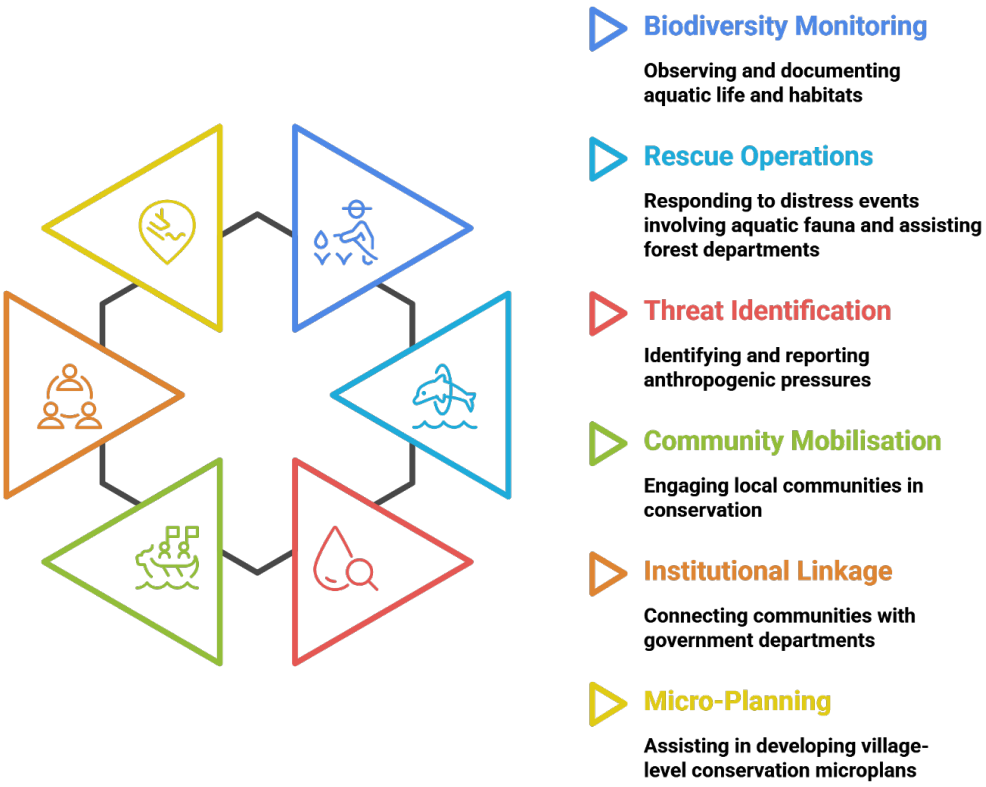

Figure 3.2. Roles and responsibilities of Ganga Praharis

3.4. Results

3.4.1. Ganga Prahari profile

During Phase I, a total of 1,290 Ganga Praharis were identified and mobilised along the main stem of the River Ganga. This initial cadre formed the foundation of a structured community-based conservation network focused on priority stretches of the river.

In the subsequent expansion phase, the same cadre was strategically strengthened and scaled across all five Ganga basin states. Ganga Praharis are present in 63 districts (51 Ganga districts and 12 other districts situated along small tributaries) along mainstem Ganga River (Figure 3.3). Rather than initiating a parallel structure, the programme built upon the original cohort, consolidating training, institutional

linkages, and community outreach mechanisms. As a result, the network expanded substantially, increasing the total number of Ganga Praharis (n=4989) in Phase II. Of these, 66.17% (n = 3,301) were female, while 33.83% (n = 1,688) were male, indicating a strong predominance of female participation in the programme. State-wise distribution indicates that Uttar Pradesh contributed the largest share at 47.38% (n = 2,364), followed by West Bengal (17.92%) and Bihar (17.72%), where male participation slightly exceeded female participation. Uttarakhand accounted for 10.50%, while Jharkhand contributed 6.47%, with females forming the majority in most states (Table 3.1).

Ganga Prahari presence across High Biodiversity Zones (HBZs) was highest in HBZ II (22.87%), largely driven by female representation (19.70%). Substantial presence was also observed in HBZ III (18.30%) and HBZ IV (16.46%), where male representation slightly exceeded female representation. HBZ V accounted for 7.21% and HBZ VI for 6.32%, while HBZ I recorded the lowest presence at 2.58% (Table 3.1).

Age-wise distribution reflects a predominantly youthful and working-age cadre, with 59.53% (n = 2,970) in the 21–40 years category and 25.42% (n = 1,268) below 20 years, anchoring the programme within younger demographic segments capable of sustained engagement. Participation from the 41–60 years group (13.31%) contributes experiential depth, while limited representation above 60 years (1.74%) supports intergenerational continuity. The dominance of younger cohorts indicates strong potential for behavioural change, community mobilisation, and long-term conservation sustainability (Table 3.1).

The educational profile establishes a broad socio-educational spectrum. Higher secondary (22.67%) and graduate-level (21.75%) participants form a substantial proportion, providing literacy and analytical capacity for ecological monitoring and documentation. Representation at secondary and upper primary levels further strengthens outreach capacity. Importantly, the inclusion of illiterate (5.47%) and minimally educated individuals underscores that river stewardship is not confined to formal academic qualifications but is also rooted in lived ecological knowledge and community experience (Table 3.1). The age and education patterns reflect an inclusive model that integrates youth engagement, moderate educational capacity, and grassroots knowledge to support resilient, community-based river conservation.

The occupational composition reveals strong participation from socially embedded and river-dependent communities. Homemakers/housewives formed the largest group (28.05%), followed by students (24.70%) and unemployed individuals (12.17%), indicating substantial engagement from household-based and youth groups. River-proximate livelihood-linked categories were also well represented, including occupations such as agriculture and allied activities (8.88%), fishers (3.85%), boatmen (2.51%) and business/self-employed participants (8.00%) highlight direct ecological dependence within the cadre. Additional participation came from private/contractual employment (5.23%) and daily wage labourers (4.05%), while formal institutional roles such as government employees (0.22%) and Panchayati Raj officials and local politicians (0.20%) remained limited. This reflects a community-rooted stewardship model, characterised by strong representation from household actors, youth, and river-dependent livelihoods, reinforcing the programme's grassroots and socially embedded conservation planning (Table 3.1).

Figure 3.3. Presence of Ganga Praharis in the districts located along Ganga River

Table 3.1. Profile of Ganga Praharis along the Ganga River

Profile Categories		Subcategories	No. of Ganga Praharis	Percentage
		Total	**4987**	
Gender		Female	3301	66.19
		Male	1688	33.85
State	**Bihar**	Female	367	7.36
		Male	517	10.37
	Jharkhand	Female	265	5.31
		Male	58	1.16
	Uttar Pradesh	Female	1632	32.73
		Male	732	14.68
	Uttarakhand	Female	418	8.38
		Male	106	2.13
	West Bengal	Female	617	12.37
		Male	275	5.51
Ganga Praharis in High	**HBZ 1**	Female	88	1.76
		Male	41	0.82
	HBZ 2	Female	983	19.71

Biodiversity Zones		Male	158	3.17
	HBZ 3	Female	444	8.90
		Male	469	9.40
	HBZ 4	Female	347	6.96
		Male	474	9.50
	HBZ 5	Female	282	5.65
		Male	78	1.56
	HBZ 6	Female	139	2.79
		Male	174	3.49
Age Category	21-40		2968	59.51
	41-60		664	13.31
	Above 60		87	1.74
	Below 20		1268	25.43
Education	Illiterate		273	5.47
	Literate		146	2.93
	Primary		506	10.15
	Upper Primary		679	13.62
	Secondary		797	15.98
	Higher Secondary		1130	22.66
	Graduation		1085	21.76
	Post-Graduation		268	5.37
	Doctorate		16	0.32
	Professional degree		67	1.34
	Vocational Course		20	0.40
Occupation	Agriculture & Allied activities		443	8.88
	Boatmen		125	2.51
	Business/Self Employed		399	8.00
	Daily wage laborer		202	4.05
	Fishers		192	3.85
	Government Job		11	0.22
	Homemaker/Housewife		1399	28.05
	Panchayati Raj officials & Local Politicians		10	0.20
	Private/Contractual Job		261	5.23
	Retired Pensioners		2	0.04
	Social Services		104	2.09
	Student		1232	24.70
	Unemployed		607	12.17

3.4.2. Priority engagement domains of Ganga Praharis in river stewardship

Ganga Praharis expressed diverse conservation interests along the Ganga River (Figure 3.4), underscoring the multi-dimensional character of community-based river stewardship. Awareness

generation emerged as the dominant area of interest across both male and female Ganga Praharis, reinforcing the centrality of behavioural outreach and community mobilisation within the conservation framework.

Female Ganga Praharis demonstrated particularly strong interest towards cleanliness drives and plantation initiatives, reflecting a leading role in maintaining riparian integrity and restoring degraded river stretches. Livelihood-oriented activities also recorded substantial engagement, especially among female Ganga Praharis, highlighting the integration of ecological protection with local economic resilience. Cultural initiatives further illustrate the social embeddedness of river conservation within traditional and community practices. Technically intensive activities such as ecological surveys, rescue and rehabilitation of aquatic fauna, and socio-economic assessments, reported comparatively lower engagement interest and were more frequently undertaken by male Ganga Praharis. These differentiated patterns indicate complementary functional roles within the conservation planning, while also revealing opportunities to broaden inclusivity in technical and monitoring-oriented interventions. The distribution of interests reflects a socially grounded and operationally diverse conservation model along the Ganga River.

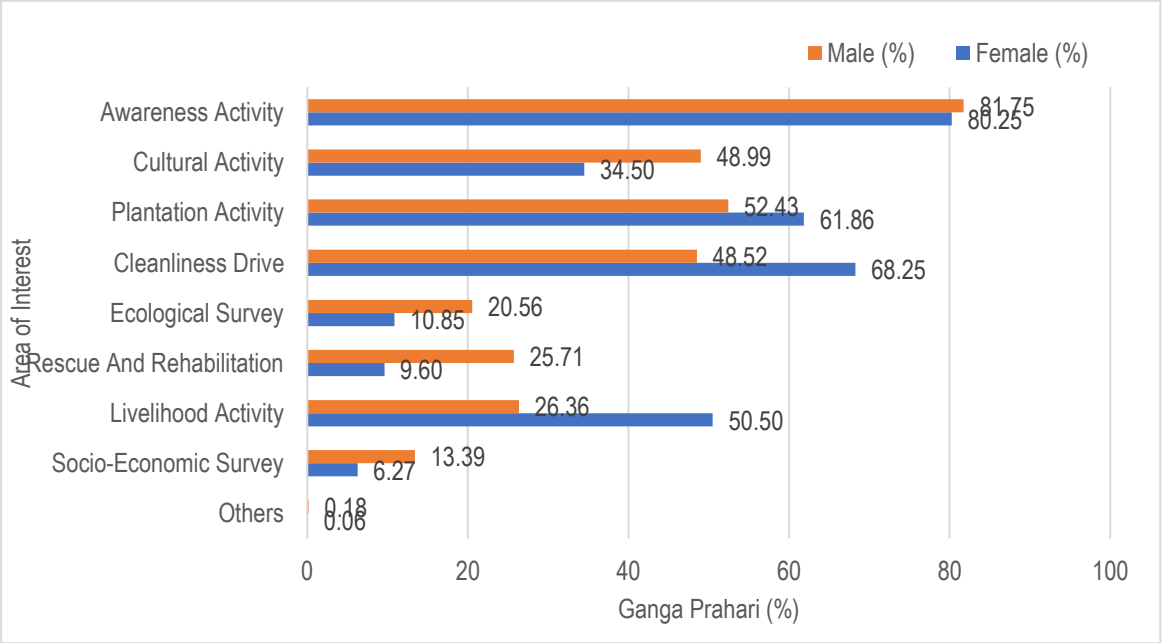

Figure 3.4. Areas of conservation interest expressed by Ganga Praharis

3.4.3. Capacity Building of Ganga Praharis in the Ganga River

Capacity-building across the five Ganga states evolved as a sustained effort to strengthen community-led river stewardship rather than a series of isolated interventions. Ecological literacy was reinforced through hands-on exposure to biodiversity monitoring, rescue and rehabilitation practices, participatory data collection, and community mobilisation. Engagements in leadership and participatory planning enhanced the ability of Ganga Praharis to coordinate locally and engage constructively with administrative systems.

Across the five Ganga states, 2,772 activities were conducted, engaging 20,257 Ganga Praharis (Table 3.2). Consultative meetings (n=857) were prominent, reflecting continuous dialogue and decentralised

coordination at the grassroots. Livelihood-oriented engagements (n=559) were equally substantial, underscoring the alignment of ecological restoration with income security. Awareness and sensitisation efforts (n=504) formed a recurring foundation, complemented by cleanliness drives (n=183), plantation campaigns (n=75), and environmental observance events that embedded conservation into everyday community practice.

Technical exposure through orientation workshops (n=34), participatory mapping (n=24), socio-economic assessments (n=46), ecological monitoring (n=17), and field-based learning (n=43) further deepened conservation competencies. These engagements consolidated a cross-state network of locally anchored conservation actors, advancing a socially embedded and scalable model of river stewardship across the Ganga landscape (Table 3.2).

Table 3.2. Capacity building activities by WII team for Ganga Praharis along Ganga River

Sl. No.	Capacity Building Activities	No. of Activities	Ganga Praharis Participants
1	Awareness and Sensitization Activities	504	3078
2	Cleanliness Drives	183	1427
3	Consultative Meetings	857	4945
4	Ecological Monitoring & Rescue Activities	17	49
5	Field Visits / River Walks	43	134
6	Livelihood Development Activities	559	5575
7	Orientation and Training Workshops	34	1437
8	Participatory Mapping Activities	24	116
9	Plantation Drive	75	521
10	Sensitization Workshops	98	381
11	Socio-economic Survey	46	122
12	Special Occasion and Days Celebrations	191	1381
13	Others	141	1091
Total		**2772**	**20257**

3.4.4. Ganga Praharis as catalysts of community-led conservation

Ganga Praharis function as community-based guardians of the Ganga River, translating capacity-building into sustained conservation action. Following structured training and institutional support, they actively engage riverine communities in biodiversity protection while promoting alternatives that reduce unsustainable dependence on river resources. Livelihood diversification, including organic farming, handicrafts, eco-tourism, and vocational skill development, has been supported in collaboration with the Wildlife Institute of India (WII), linking ecological protection with economic resilience.

Beyond ecological restoration, Ganga Praharis integrate conservation within the social and cultural practices of riverine settlements. Awareness and sensitisation programmes, and cultural activities like Ganga aarti ceremonies reinforce behavioural change and local stewardship. In alignment with the objectives of National Mission for Clean Ganga (NMCG), they organise cleanliness drives, sensitisation programmes, plantation initiatives, and public outreach activities that extend conservation values across generations. These efforts have generated measurable conservation outcomes, including monitoring of

aquatic fauna, facilitation of rescue and rehabilitation operations, and timely responses to local ecological threats. By integrating ecological monitoring, livelihood interventions, and community engagement, Ganga Praharis have evolved into catalysts of community-led river conservation across the Ganga River landscape.

3.4.4.1. Conservation- related activities conducted by Ganga Praharis

Conservation activities conducted by Ganga Praharis across the five Ganga states, covering a total of 49 districts of five Ganga states and four other districts situated along small tributaries, demonstrate a measurable transition from facilitated engagement to autonomous, community-led stewardship (Table 3.3). A total of 1,505 input activities were organised with institutional support, mobilising 64,300 participants and strengthening technical capacity, ecological literacy, and local coordination. These engagements functioned as catalytic platforms, enabling skill transfer and peer-led diffusion of conservation practices within riverine communities. Then, Ganga Praharis independently organised 1,685 output activities, engaging 88,280 participants, signalling association of local ownership and operational confidence (Figure 3.5).

Awareness initiatives (n=1181) dominated the activities conducted by Ganga Praharis highlighting the significance of behavioural outreach. Ecological monitoring (n=342) and rescue operations (n=210) expanded notably, reinforcing field-based biodiversity surveillance. Cleanliness drives (n = 413) and plantation programmes (n = 238) sustained direct ecological restoration, while special occasions and days' celebration (n = 276) integrated conservation within social and cultural frameworks. Livelihood-oriented activities (n = 73) further linked ecological protection with local economic resilience. Importantly, several Ganga Praharis who received trainings subsequently emerged as trainers (n=25) themselves, delivering capacity-building sessions across multiple locations and amplifying the programme's outreach through peer-led instruction. Also, some trained individuals went on to join other community-based conservation projects (n=50), extending the programme's influence beyond its original framework and strengthening broader conservation networks. Selected Ganga Praharis (n=150) are actively engaged as dolphin watchers, contributing to dolphin monitoring initiatives along the Ganga. They assist the Forest Department in waterbird census operations and support rescue and rehabilitation activities for aquatic and riparian fauna and assisted in preparation of People Biodiversity Register (PBR). Ganga Praharis have also become participating members of District Ganga Committees, contributing to river-related planning and decision-making processes, while a few (n=2) have been elected as Gram Pradhans in their respective villages. This progression reflects not only strengthened ecological competence but also expanded civic leadership, positioning Ganga Praharis as influential actors within both conservation and local governance systems (Table 3.3).

The shift from supported to self-organised activities reflects institutional growth within the Ganga Prahari network. This progression illustrates how structured facilitation can catalyse durable, decentralised stewardship capable of sustaining river conservation across complex socio-ecological landscapes.

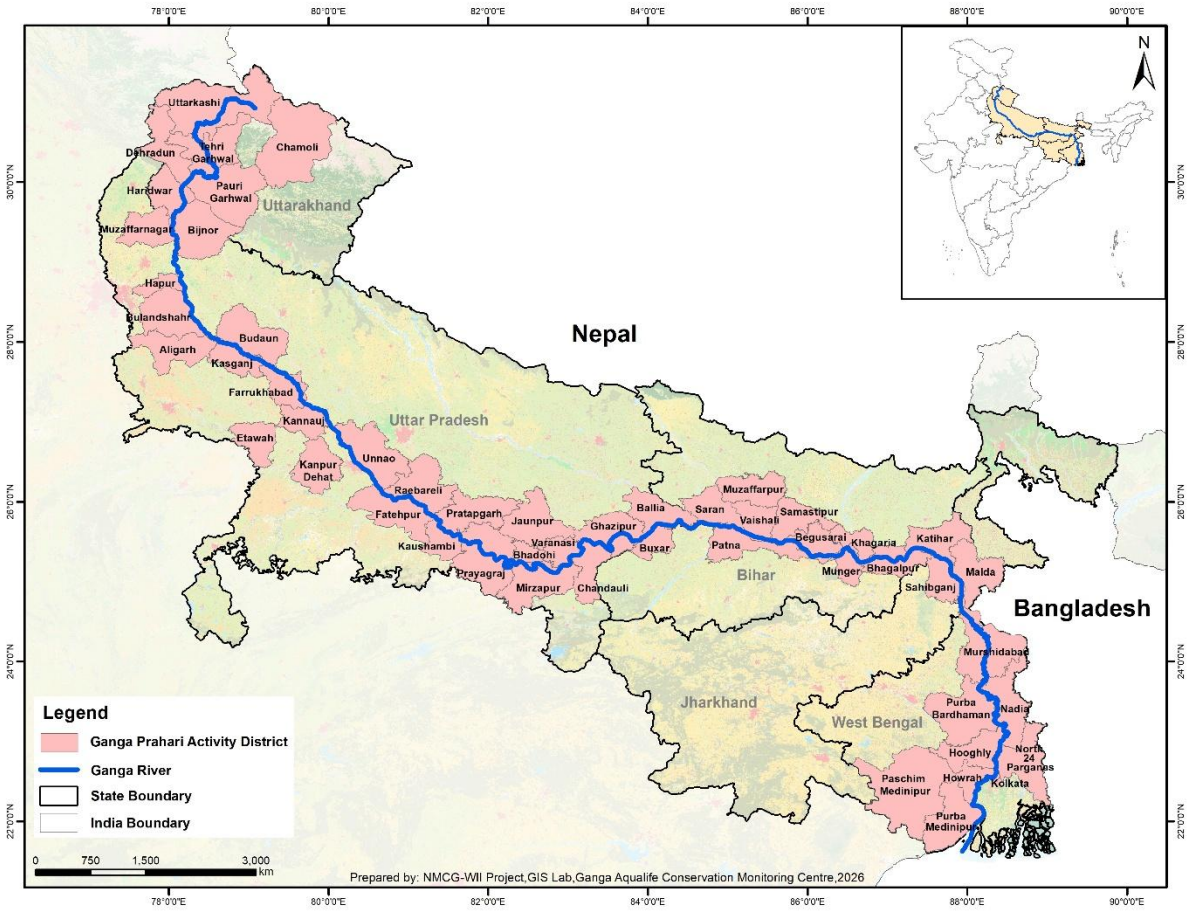

Figure 3.5. Spatial distribution of conservation- related activities conducted by Ganga Praharis

3.4.5. Conservation activities across High Biodiversity Zones

A spatial disaggregation of activities conducted by Ganga Praharis across HBZs further illustrates differential intensity of engagement (Table 3.4). The highest concentration of conservation effort was recorded in HBZ III (n = 1,027 activities) and HBZ V (n = 462 activities), indicating strong mobilisation within ecologically sensitive stretches. HBZ IV (n = 519) and HBZ II (n = 323) also demonstrated substantial engagement, while HBZ VI (n = 219) and HBZ I (n = 37) reflected comparatively lower activity intensity (Table 3.4).

Awareness activities dominated across all zones, particularly in HBZ III and HBZ V, where large-scale mobilisation emphasise on behavioural outreach in biodiversity-rich habitat. Ecological monitoring and rescue operations were most prominent in HBZ III and HBZ IV, reinforcing field-based surveillance in priority conservation landscapes. Cleanliness drives and plantation programmes were widely distributed, with higher frequencies in HBZ III and HBZ V, supporting habitat restoration and pollution mitigation in critical habitats.

Special occasions and days celebrations were notably concentrated in HBZ V, indicating strong social mobilisation within culturally active zones. Participation in externally organised programmes and livelihood-oriented activities also showed greater intensity in HBZ III and HBZ V, suggesting integration of conservation with institutional networks and economic resilience in these biodiversity hotspots. The distribution highlights a strategic concentration of conservation efforts in ecologically significant stretches

while maintaining functional presence across all six biodiversity zones, reinforcing a spatially differentiated yet basin-connected stewardship framework (Table 3.4).

Table 3.3. Activities organized by Ganga Praharis with support from WII and independently

Sl. No.	Type of Activities	With support		Independently		Total	
		No. of Activities	Participants	No. of Activities	Participants	No. of Activities	Participants
1.	Awards & Achievements	2	12	21	3554	23	3566
2.	Awareness Activities	721	46538	460	28949	1181	75487
3.	Cleanliness Drives	230	3077	183	3476	413	6553
4.	Consultative Meetings	44	584	30	776	74	1360
5.	Covid Awareness	42	818	102	23101	144	23919
6.	Cultural Activity	9	125	7	560	16	685
7.	Ecological Monitoring	27	351	315	1491	342	1842
8.	Livelihood Development Activities	40	1373	33	721	73	2094
9.	Participation in activities organized by other organizations	8	353	101	9563	109	9916
10.	Plantation Programme	86	1451	152	3756	238	5207
11.	Rescue & Rehabilitation	72	444	138	812	210	1256
12.	Socio-economic Survey	7	70			7	70
13.	Special Occasion and Days Celebrations	179	7579	97	9566	276	17145
14.	Others	38	1525	46	1955	84	3480
	Total	**1505**	**64300**	**1685**	**88280**	**3190**	**152580**

Table 3.4. Activities conducted by Ganga Praharis in High Biodiversity Zones of the Ganga River

Sl. No.	Type of Activities	HBZ I		HBZ II		HBZ III		HBZ IV		HBZ V		HBZ VI		Total	
		No. of Activities	Participants	No. of Activities	Participants	No. of Activities	Participants	No. of Activities	Participants	No. of Activities	Participants	No. of Activities	Participants	No. of Activities	Participants
1.	Awards & Achievements	1	4			11	3423	4	11	1	11	1	1	**18**	**3450**
2.	Awareness Activities	6	406	142	5139	326	12844	169	11326	220	29115	86	1905	**949**	**60735**
3.	Cleanliness Drives	2	43	50	811	188	3130	41	636	67	790	17	221	**365**	**5631**
4.	Consultative Meetings	3	42	8	133	15	367	7	51	17	249			**50**	**842**
5.	Covid Awareness	5	97	16	1916	38	966	20	2412	30	1304	6	717	**115**	**7412**
6.	Cultural Activity			1	151	10	138	3	226					**14**	**515**
7.	Ecological Monitoring	3	5	18	39	94	871	101	501	21	90	51	103	**288**	**1609**
8.	Livelihood Development Activities	4	10	1	37	32	628	2	23	11	673	4	84	**54**	**1455**
9.	Others	3	12	6	791	41	892	16	1296	4	100	1	51	**71**	**3142**
10.	Participation in activities organized by other organizations	3	161	4	149	44	3447	14	418	12	2025	1	266	**78**	**6466**
11.	Plantation Programme	6	41	27	812	75	1254	57	1634	28	587	8	126	**201**	**4454**
12.	Rescue & Rehabilitation	1	1	26	153	71	515	65	299	14	80	22	90	**199**	**1138**
13.	Socio-economic Survey					1	6			2	5			**3**	**11**
14.	Special Occasion and Days Celebrations			24	746	81	2754	20	842	35	6169	22	841	**182**	**11352**
Total		**37**	**822**	**323**	**10877**	**1027**	**31235**	**519**	**19675**	**462**	**41198**	**219**	**4405**	**2587**	**108212**

3.4.6. From volunteers to institutions: sustaining Ganga Prahari efforts through societies

The establishment of the 11 Ganga Prahari societies marks a critical step in institutionalizing the conservation interventions initiated under the Ganga Prahari programme. Unlike short-term projects, the societies were created to sustain conservation efforts over the long term, providing a governance platform that consolidates river stewardship and strengthens linkages with state agencies (Table 3.5). Its primary aim is to ensure continuity of biodiversity monitoring, species rescue support, awareness campaigns, and ecological restoration, integrating these activities within locally governed institutional structures. By formalizing community action, the society transforms voluntary conservation into an enduring pillar of river governance.

Table 3.5. List of registered Ganga Prahari Societies

Sl. No.	Name	Districts	State
1	Banaras Ganga Prahari Paryavaran Society, Domri,	Varanasi	Uttar Pradesh
2	Ganga Paryawas Ganga Prahari Sewa Samiti, Dhaka,	Varanasi	Uttar Pradesh
3	Maa Ganga Prahari Trust	Varanasi	Uttar Pradesh
4	Kashi Ganga Prahari Parwaran Samajik Sewa Samiti, Sarsaul	Varanasi	Uttar Pradesh
5	Prayag Urja Samiti, Beekar, Bheeta	Prayagraj	Uttar Pradesh
6	Sangam Ganga Sewa Samiti, Kanjasa	Prayagraj	Uttar Pradesh
7	Aawahan Ganga Prahari Nukkad Natak Samiti, Chatnag- Jhunsi	Prayagraj	Uttar Pradesh
8	Ganga Prahari Paryawaran Evam Samajik Vikas Samiti, Jhunsi	Prayagraj	Uttar Pradesh
9	Ganga Prahari Baraila Jheel Jeev Raksha sah Sodh Sansthan, Baraila	Vaishali	Bihar
10	Ganga Prahari Nature Conservation Society, Naugachhia	Bhagalpur	Bihar
11	Srishti Ganga Prahari Environment and Welfare Society	Bhagalpur	Bihar

The registered societies are increasingly being recognised for independently advancing community engagement and biodiversity conservation initiatives. For example, *Srishti – Ganga Prahari Environment and Welfare Society* was selected, after a competitive national selection process, for Cohort 3 of Changelooms: Youth Leaders in Climate Action (YLCA), a flagship leadership programme initiated by Pravah in partnership with ComMutiny -The Youth Collective. The programme supports youth-led climate action initiatives through structured mentoring, residential workshops, field visits, and long-term institutional engagement. Also, a Ganga Prahari associated with the same society was selected as a Bodhi Fellow (2025–2028) under the Bihar Development Committee (BDC) Impact Foundation Fellowship Programme. The three-year full-time fellowship provides financial support, mentoring,

residential trainings, and structured performance review to strengthen social entrepreneurship and community-based conservation leadership. This recognition reflects the growing institutional credibility and leadership capacity emerging from the Ganga Prahari network. As part of these engagements, the society received grant support to implement community-based interventions, while also benefiting from sustained mentoring, review platforms, and institutional capacity strengthening. This reflects the increasing reliability of Ganga Prahari societies as locally rooted yet nationally connected actors in climate-responsive river conservation.

3.5. Outcomes

The Ganga Prahari programme has generated substantive ecological, social, and institutional outcomes along the Ganga River, demonstrating the effectiveness of structured community-based stewardship.

(1) Institutionalisation of Community Stewardship

The initiative successfully transitioned from a volunteer-based network to a semi-institutionalised conservation framework. The establishment of Ganga Prahari societies has strengthened governance continuity, ensuring that conservation actions, such as biodiversity monitoring, rescue operations, and awareness campaigns, persist beyond project cycles.

(2) Strengthened Ecological Vigilance in priority stretches

Ganga Praharis have emerged as first responders in documenting aquatic fauna, reporting threats, and facilitating rescue and rehabilitation. Regular monitoring and habitat-focused interventions have enhanced on-ground ecological vigilance across priority river stretches. The presence of trained Ganga Praharis across High Biodiversity Zones enhanced on-ground responsiveness in ecologically sensitive areas, strengthening surveillance and field-level support systems.

(3) Behavioural Mainstreaming of Conservation

Conservation practices have been integrated into daily social and cultural life through awareness campaigns, plantation initiatives, cleanliness drives, and culturally embedded activities. This has fostered a shift from episodic participation to routine environmental responsibility within riparian communities.

(4) Cross-sectoral integration of conservation and livelihoods

By aligning income-generating skills with ecological awareness, the initiative fostered a model where economic resilience and biodiversity protection reinforce one another, reducing pressure on river resources.

(5) Inclusive and Gender-Responsive Leadership

The strong representation of marginalised communities, women and youth reflects an inclusive conservation model. Their leadership in outreach, plantation, and community mobilisation has broadened the social base of river stewardship and enhanced intergenerational continuity.

(6) Creation of peer-led knowledge networks

The emergence of community trainers and conservation facilitators enabled horizontal expansion of skills and practices, reducing long-term dependence on external technical agencies

(7) Strengthened Community–Institution Interface

By functioning as intermediaries between local communities and government agencies, Ganga Praharis have improved communication, trust, and coordination. Participation in District Ganga Committees meetings and collaboration with government departments positioned Ganga Praharis as connectors between community knowledge systems and formal governance mechanisms. The progression of some members into elected positions such as Gram Pradhans reflects increased community trust and the mainstreaming of environmental leadership within village governance. This bridging role has enhanced responsiveness to ecological threats and aligned local action with national river conservation objectives.

These outcomes indicate that the programme has moved beyond awareness generation to establishing a socially, operationally active, and institutionally connected model of river conservation along the Ganga.

(8) Integration of community actors into formal conservation and institutional sustainability

Engagement of Ganga Praharis in dolphin monitoring, waterbird census surveys, and assistance in rescue activities demonstrates their incorporation into structured biodiversity conservation workflows along the Ganga. Concurrently, the establishment and external recognition of registered Ganga Prahari societies provide an institutional architecture capable of independently conceptualizing and implementing conservation initiatives, strengthened through mentoring and targeted grant partnerships. These developments link field-level ecological participation with durable organizational capacity, reinforcing sustainable stewardship of the river system.

3.6. Conclusion

The Ganga Prahari programme along the Ganga River demonstrates how community-based conservation can evolve from externally supported mobilisation to sustained, locally anchored stewardship. By aligning ecological training, participatory governance, and livelihood diversification, the initiative has embedded conservation practice within the social behavior of riparian communities. This integration has strengthened local ecological vigilance, enhanced responsiveness to biodiversity threats, and fostered sustained behavioral change beyond episodic interventions. What began as facilitated action under the Wildlife Institute of India matured into autonomous practice, with Ganga Praharis undertaking biodiversity monitoring, aquatic species rescue, community mobilisation, and institutional coordination with increasing operational confidence.

The evolution from facilitated engagement to locally coordinated action indicates that structured institutional support can catalyze durable, decentralized conservation capacity. The emergence of Ganga Prahari societies further consolidates this trajectory, providing continuity, accountability, and a governance interface capable of sustaining long-term river stewardship.

The socially inclusive composition of the cadre, characterized by strong participation of women, youth, and river-dependent communities including fishers, boatmen and farmers, enhances adaptive capacity and reinforces intergenerational continuity in conservation leadership. By integrating ecological responsibility within everyday community behavior and attitude while maintaining alignment with national river restoration priorities, the programme offers a transferable model for participatory freshwater governance. The Ganga Prahari framework advances a pathway toward sustained, community-driven conservation of the Ganga River, demonstrating how grassroots stewardship can contribute meaningfully to large-scale ecological resilience.


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Chapter 04

LIVELIHOOD INTERVENTIONS TO ENSURE LONG-TERM PARTICIPATION OF LOCAL COMMUNITIES IN CONSERVATION ACTIONS

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Summary

The chapter focuses on livelihood interventions as a critical enabling mechanism to secure sustained participation of local communities, particularly marginalized and economically vulnerable groups, in river conservation. It recognizes that despite positive intent, participation in conservation is often constrained by limited financial and social capital, as well as inherent trade-offs between subsistence needs and conservation responsibilities. To address this, the approach explicitly integrates economic incentives with conservation objectives, thereby reframing conservation as a rational and viable livelihood choice.

A systematic, need-based assessment was undertaken to identify context-specific livelihood opportunities aligned with local ecological conditions, socio-cultural practices, resource availability, and market potential. This involved consultative meetings, household-level interactions, and surveys to capture community preferences, existing skill bases, and access to raw materials and value chains. Concurrently, mapping of ongoing governmental schemes, private sector initiatives, and local resource persons enabled the identification of institutional convergence opportunities for livelihood promotion. The intervention framework emphasizes institutional linkage-building as a core strategy. Strategic collaborations were established with line departments and agencies including state forest departments, rural development institutions, district and block administrations, and national programmes such as the National Rural Livelihood Mission (NRLM), Pradhan Mantri Kaushal Vikas Yojana (PMKVY), Rural Self-Employment Training Institutes (RSETI), and Nehru Yuva Kendra Sangathan (NYKS). These partnerships facilitated skill development, technical training, and access to financial and infrastructural support systems, thereby strengthening livelihood capacities of individuals and community groups. To ensure post-training sustainability, the approach incorporated market linkage development, including integration with existing supply chains and initiatives such as the Jalaj programme. This reduced the risk of livelihood failure due to market disconnection and enabled income continuity beyond the intervention phase. The framework thus moves beyond short-term capacity building toward establishing economically viable and self-sustaining livelihood systems.

A total of 193 livelihood training programmes were conducted along the Ganga River across five states—Bihar (25), Jharkhand (17), Uttar Pradesh (124), Uttarakhand (19), and West Bengal (8). Uttar Pradesh accounted for the highest number of trainings (124), representing approximately 64% of the total trainings conducted, followed by Bihar (25), Uttarakhand (19), Jharkhand (17), and West Bengal (8). Among the different training categories, Sewing & Stitching constituted the largest share with 78 trainings, distributed across Bihar (18), Jharkhand (14), and Uttar Pradesh (46). A total of 4,880 individuals were trained across 17 different livelihood categories. Of these, 388 participants were male and 4,455 were female (approximately 91% female participation). Male participation was observed more in technical skill trainings such as electrician. A total of 172 training programmes were conducted in High Biodiversity Zones (HBZs), benefitting 4,340 participants. Across all HBZs, Zone II recorded the highest number of trainings (84 programmes) and beneficiaries (1,694 individuals), followed by Zone III with 33 trainings covering 996 participants. Zone IV and Zone V accounted for 23 (699 participants) and 19 (582 participants) trainings respectively, while Zone VI recorded 8 trainings covering 276 beneficiaries. Zone I had comparatively fewer interventions (5 trainings; 93 participants).

Overall, the livelihood intervention strategy operationalizes a conservation–development nexus by embedding biodiversity conservation within local economic systems. By enhancing livelihood security, reducing vulnerability, and strengthening institutional and market linkages, the approach creates enabling

conditions for long-term community stewardship of river ecosystems. This integrated model underscores that durable conservation outcomes in socio-ecologically complex systems like the Ganga basin are contingent upon aligning ecological goals with livelihood resilience and socio-economic realities.

4.1. Introduction

Effective biodiversity conservation in human-dominated landscapes increasingly depends on integrating conservation goals with the livelihood needs of adjacent communities (Babu, 2023). Conservation initiatives that neglect local socioeconomic realities commonly face low compliance, covert resource use, and eventual failure; conversely, interventions that deliberately strengthen or diversify local livelihoods can create incentives for pro-conservation behaviour, reduce pressure on wild resources, and enable durable stewardship arrangements (e.g., sustainable livelihoods frameworks) (Chambers and Conway, 1991).

A typology of livelihood interventions relevant to conservation includes: (a) direct income substitutes (e.g., alternative livelihoods that require less investments but provide security and improved life quality; (b) incentive mechanisms that internalize conservation values (e.g., Payments for Ecosystem Services (PES), performance-based contracts); (c) market-linkage and value-chain support that increases returns from sustainable resource use; and (d) capacity building and co-management that strengthen local institutions and rights to benefits (e.g., community forestry, co-management agreements) (Ingram et al., 2014). The evidence base demonstrates mixed but promising outcomes: PES and community-benefit schemes can reduce destructive practices where institutions are strong and benefit-sharing transparent, but they require careful design to avoid elite capture and perverse incentives (Mishra et al., 2017).

Contemporary best practice emphasises participatory co-design, adaptive implementation, and explicit attention to equity and gender. Co-design processes, where communities, practitioners and scientists jointly define objectives, metrics, and benefit-sharing rules, increase local ownership and improve ecological and social outcomes by aligning interventions with local priorities and knowledge systems. Monitoring that is based on socio-economic indicators with biodiversity metrics is essential to detect trade-offs and allow adaptive corrections (Khanyari et al., 2023). Scaling livelihood-centred approaches demands attention to governance, finance and market realism. Long-term financing (blended finance, secure PES streams, public-private partnerships) and legal recognition of user rights underpin durable incentives; while enabling policies that connect small producers to markets increase returns from sustainable practices. Finally, rigorous evaluation using mixed methods — combining counterfactual impact designs with qualitative institutional analysis — is necessary to build the empirical base on when, where and how different livelihood interventions produce conservation gains. The rest of this chapter examines design principles, implementation pathways, and empirical examples to guide practitioners and researchers in operationalising livelihood-driven conservation strategies (Ingram et al., 2014; Kumar et al., 2023).

This chapter frames livelihood interventions as purposive, context-sensitive measures that (i) reduce the direct dependence of households on biodiversity-sensitive assets, (ii) increase the perceived, tangible benefits of conservation to local people, and (iii) build local capacity and institutions to manage commons sustainably. The Sustainable Livelihoods Approach (SLA) provides a practical analytical scaffold as it conceptualizes household well-being in terms of assets (natural, human, social, physical, financial),

vulnerability contexts, and livelihood strategies, highlighting entry points where conservation-oriented livelihood support can alter incentives and risk profiles.

4.2. Aim

To develop sustainable livelihood models tailored for communities residing along the Ganga River.

4.2.1. Objectives

1) Establish a participatory platform that motivates and engages local residents-particularly women and marginalized groups-in river conservation initiatives.
2) Provide livelihood opportunities that are closely aligned with the region's socio-cultural traditions and ecological context, ensuring that economic activities support both community well-being and the health of the river ecosystem.

4.3. Approach

Livelihood development interventions, including skill development and capacity enhancement, were undertaken to motivate river-dependent and socio-economically marginalized communities to actively engage in conservation processes. To address local needs in a context-specific manner, site-specific livelihood strategies were formulated based on an assessment of available natural resources, existing skills and traditional knowledge systems, and patterns of seasonal or permanent migration. Natural resource-based livelihoods comprised activities directly associated with freshwater ecosystems, such as fishing, boating, riverbed cultivation, and river island farming. In contrast, other occupations—such as daily wage labour, and employment in the private or government sectors—were not directly dependent on local natural resources. Migration for livelihood purposes was primarily directed toward nearby towns and metropolitan centres and occurred in both seasonal and permanent forms.

To ensure equitable representation across socio-economic strata in conservation initiatives, regular sensitization meetings, awareness programmes, and focused interpersonal interactions were conducted in selected villages. A systematic needs assessment was undertaken involving Village Panchayat members, women, men, youth, farmers, and fishing communities to ascertain preferred training areas, existing skill sets, and availability of raw materials. Field surveys further identified potential livelihood schemes, relevant projects, technical resource persons, and local availability of inputs required for training implementation. Based on site-level needs assessments conducted across selected locations in the Ganga River Basin, and considering the availability of local raw materials and market access, site-specific alternative livelihood training modules were designed. Skill development was recognized as a critical instrument for enhancing technical competence, improving productivity, fostering self-reliance, and building entrepreneurial confidence. These capacity-building interventions contributed to developing a locally skilled workforce equipped with updated knowledge and adaptive competencies. Trainings were categorized into three major domains: (i) Sustainable and Eco-friendly Product Development; (ii) Food Processing and Value Addition; and (iii) Handicrafts, Services, and Rural Enterprises. These programmes also functioned as effective incentives for community participation in conservation efforts, with particular emphasis on women's engagement.

To sustain the efforts established livelihood centres and trained Ganga Praharis were linked with existing markets through developing demand-supply chains and outlets known as Jalaj. Institutional linkages were established with relevant agencies, including the Forest Department, district and block administrations, National Rural Livelihood Mission (NRLM), Nehru Yuva Kendra Sangathan (NYKS), Pradhan Mantri Kaushal Vikas Yojana (PMKVY), USHA Foundation, Rural Self-Employment Training Institutes (RSETI) of lead banks, non-governmental organizations, and other training institutions to facilitate structured skill development. Additionally, market linkages were developed through convergence with governmental and non-governmental livelihood schemes to enhance long-term sustainability. Livelihood centres were established in selected villages following the Sustainable Livelihood Framework approach. These centres also functioned as community platforms, facilitating stakeholder interaction, strengthening institutional convergence, and promoting awareness on biodiversity conservation and river cleanliness. Targeted measures ensured meaningful participation of women and marginalized groups (Figure 4.1).

4.4. Results

4.4.1. Livelihood interventions across Ganga states

A total of 193 livelihood training programmes were conducted along the Ganga River across five states—Bihar (25), Jharkhand (17), Uttar Pradesh (124), Uttarakhand (19), and West Bengal (8). Uttar Pradesh accounted for the highest number of trainings (124), representing approximately 64% of the total trainings conducted, followed by Bihar (25), Uttarakhand (19), Jharkhand (17), and West Bengal (8). Among the different training categories, Sewing & Stitching constituted the largest share with 78 trainings, distributed across Bihar (18), Jharkhand (14), and Uttar Pradesh (46). Incense stick & candle making was the second most frequently organized programme with 31 trainings, primarily concentrated in Uttar Pradesh (23) and Uttarakhand (6), with additional sessions in Bihar (1) and West Bengal (1). Food processing and value addition accounted for 28 trainings, predominantly conducted in Uttar Pradesh (18) and Uttarakhand (9), with one training in Bihar (Table 4.1, Figure 4.2).

Skill-based artisanal trainings such as Handicraft (14 trainings) were delivered mainly in Uttar Pradesh (10), West Bengal (3), and Bihar (1). Health and wellness (8 trainings) and Herbal colour making (4 trainings) were implemented exclusively in Uttar Pradesh. Herbal soap and detergent making (4 trainings) were organized in Bihar (2), Jharkhand (1), and Uttar Pradesh (1). Environmentally oriented and technical skill trainings such as Sustainable farming (9 trainings) were conducted across Bihar (2), Jharkhand (1), Uttar Pradesh (2), and West Bengal (4). Additional technical trainings included LED bulb making (3 trainings) in Uttar Pradesh (2) and Uttarakhand (1), Green energy (1 training) in Uttar Pradesh, and Electrician (1 training) in Uttar Pradesh. Capacity-building programmes such as Leadership (2 trainings) and SHG account maintenance (1 training) were limited in number and primarily concentrated in Uttar Pradesh and Uttarakhand. Creative textile-based training such as Tie and Dye, Block Printing and Patch Work (3 trainings) were conducted in Uttar Pradesh (2) and Uttarakhand (1). Basic computer training (1) was conducted in Uttar Pradesh (Table 4.1).

The livelihood interventions were designed and conducted with a thematic emphasis on women-centric, home-based enterprises such as sewing, incense stick making, and food processing, to enable trainees to initiate their own work/ small businesses without much dependence on market and outside funding.

A total of 4,880 individuals were trained across 17 different livelihood categories. Of these, 388 participants were male and 4,455 were female (approximately 91% female participation). The largest number of beneficiaries was recorded under sewing & stitching, with 2,239 participants, all of whom were women. Similarly, women-dominated participation was observed in incense stick & candle making (696 total; 688 female), Food processing and value addition (703 total; 670 female), handicraft (210 total; 203 female), Health and wellness (166 total; all female), herbal colour making (111 total; all female), Herbal soap and detergent making (123 total; 116 female), packaging material making (21 total; all female), SHG account maintenance (10 total; all female), and tie and dye, block printing and patch work (71 total; all female). In contrast, male participation was observed more in technical skill trainings such as electrician (10 participants; all male) and green energy (20 participants; all male). LED bulb making (64 participants) had a higher male representation (53 male; 11 female). Electrician, LED bulb making and bird guide training (50 participants) also showed male predominance (42 male; 8 female), indicating gender differentiation in mobility-oriented livelihoods. Basic computer training (27 participants) recorded moderate gender representation (16 male; 11 female), while leadership training (40 participants) included 8 males and 32 females. Sustainable farming (319 participants) showed relatively balanced participation compared to other sectors, with 184 male and 98 female trainees (Table 4.2).

The livelihood interventions were largely oriented toward local communities' economic empowerment, particularly through household-based micro-enterprise models. Technical and field-oriented trainings exhibited comparatively higher male participation. The gender-disaggregated participation patterns reflect deliberate targeting of women in income-generating activities, especially in stitching, food processing, and cottage-industry-based enterprises.

4.4.2. Livelihood trainings conducted in High Biodiversity Zones

The Table 4.3 presents a consolidated account of livelihood training programmes conducted across six High Biodiversity Zones (HBZs). The data include the number of training programmes organized under each thematic category and the total number of beneficiaries trained. Overall, 172 training programmes were conducted, benefitting 4,340 participants. Across all HBZs, Zone II recorded the highest number of trainings (84 programmes) and beneficiaries (1,694 individuals), followed by Zone III with 33 trainings covering 996 participants. Zone IV and Zone V accounted for 23 (699 participants) and 19 (582 participants) trainings respectively, while Zone VI recorded 8 trainings covering 276 beneficiaries. Zone I had comparatively fewer interventions (5 trainings; 93 participants).

The livelihood training portfolio demonstrates a strategic emphasis on skill-intensive, low-investment, and locally adaptable enterprises, particularly sewing & stitching, incense stick and candle making, and food processing. The high concentration of trainings in Zones II and III suggests targeted capacity building in priority districts. Additionally, the inclusion of green energy, sustainable farming, and bird guide training reflects integration of conservation-oriented livelihood approaches. Overall, the training interventions have reached a substantial beneficiary base (4,340 individuals), with a diversified skill spectrum designed to enhance income generation opportunities while aligning with sustainable development objectives.

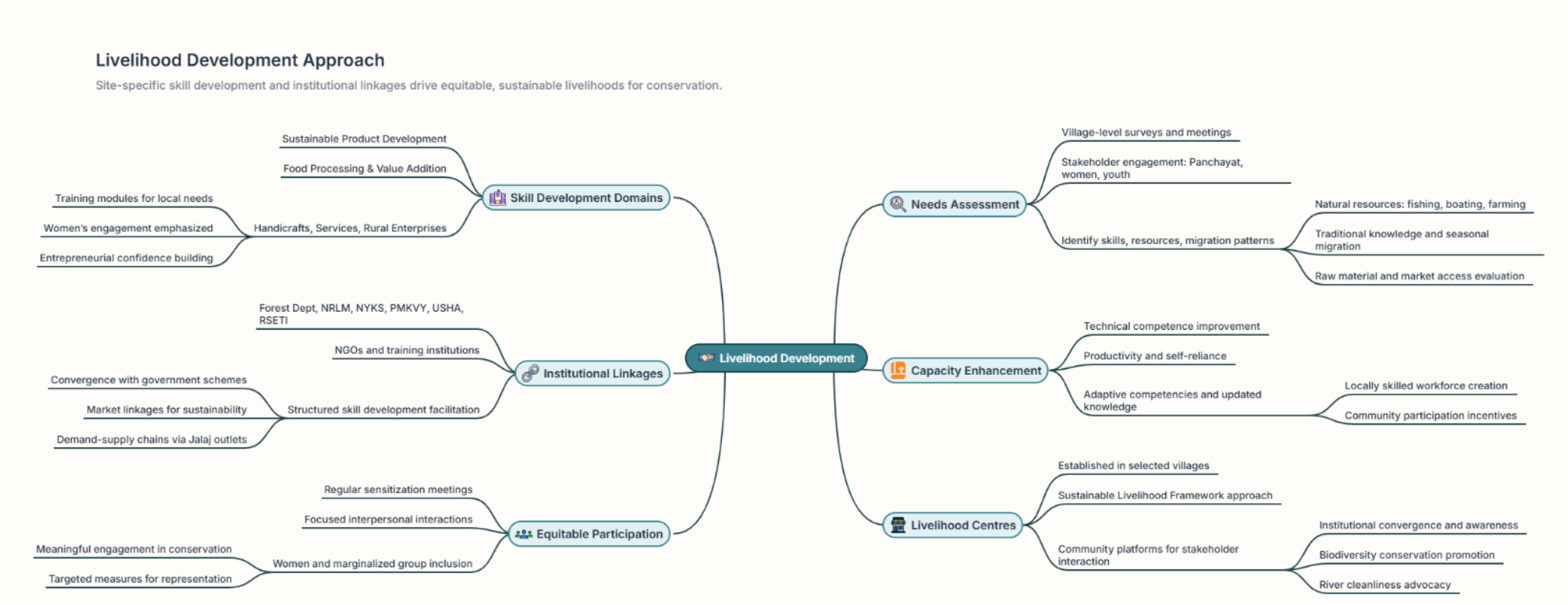

Figure 4.1. Framework developed for livelihood development for communities residing along Ganga River

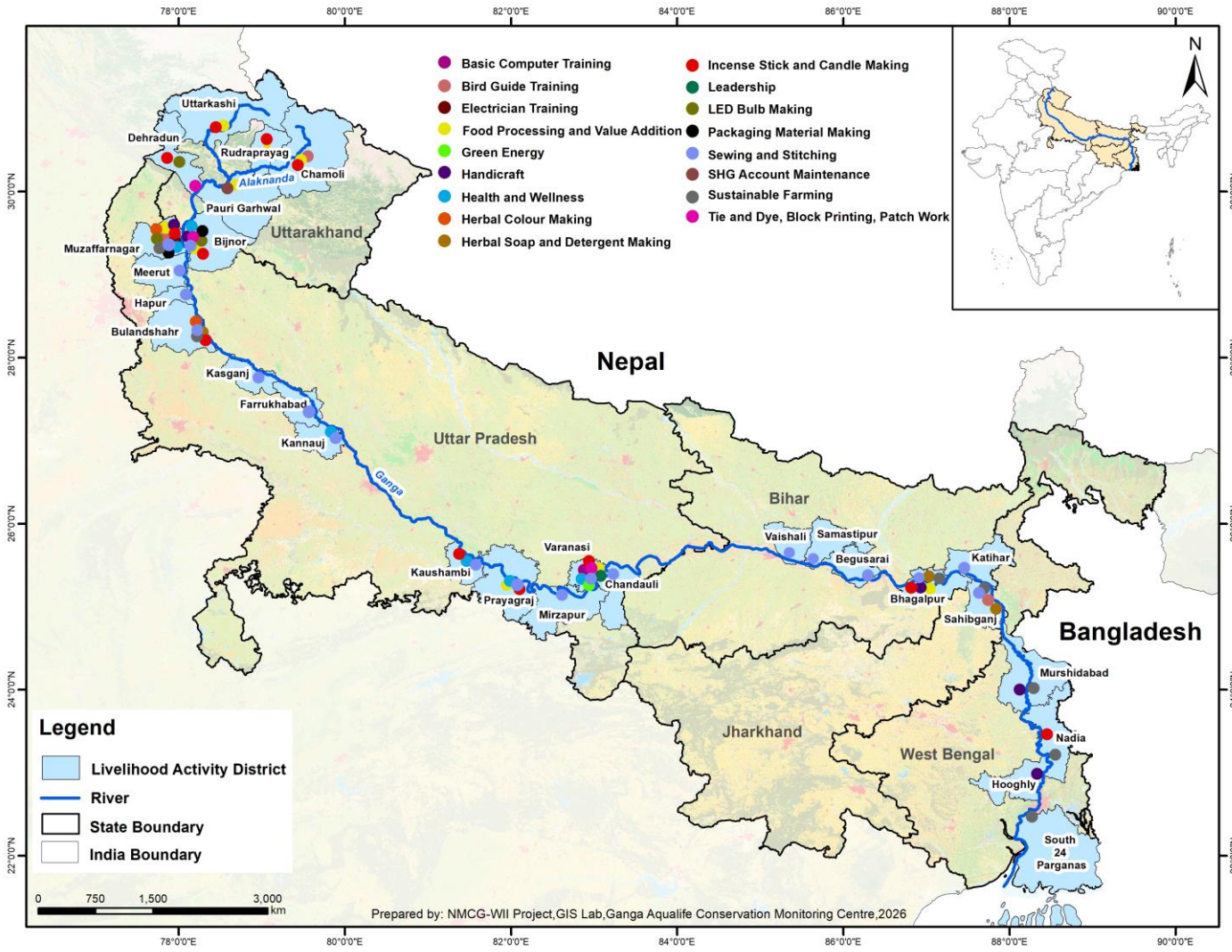

Figure 4.2. Spatial distribution of livelihood trainings conducted along Ganga River

Table 4.1. Livelihood trainings conducted in states through that Ganga River flows

Sl. No.	Livelihood trainings	Uttarakhand		Uttar Pradesh		Bihar		Jharkhand		West Bengal		Total no. of trainings	Total no. of people trained
		Trainings	People trained	Trainings	People trained	Trainings	People trained	Trainings	People trained	Trainings	People trained		
1.	Basic computers			1	27							**1**	**27**
2.	Bird Guide Training	1	17	1	11			1	22			**3**	**50**
3.	Electrician			1	10							**1**	**10**
4.	Food processing and value addition	9	282	18	396	1	25					**28**	**703**
5.	Green energy			1	20							**1**	**20**
6.	Handicraft			10	144	1	14			3	52	**14**	**210**
7.	Health and wellness			8	166							**8**	**166**
8.	Herbal colour making			4	111							**4**	**111**
9.	Herbal Soap and Detergent Making			1	35	2	48	1	40			**4**	**123**
10.	Incense stick & candle making	6	97	23	531	1	25			1	43	**31**	**696**
11.	Leadership			2	40							**2**	**40**
12.	LED bulb making	1	30	2	34							**3**	**64**
13.	Packaging material making			2	21							**2**	**21**
14.	Sewing & Stitching			46	1241	18	579	14	419			**78**	**2239**
15.	SHG account maintenance	1	10									**1**	**10**
16.	Sustainable farming			2	29	2	72	1	37	4	181	**9**	**319**
17.	Tie-Dye, Block printing and Patch work	1	25	2	46							**3**	**71**

	Total	**19**	**461**	**124**	**2862**	**25**	**763**	**17**	**518**	**8**	**276**	**193**	**4880**

Table 4.2. Number of local people including youth and women trained under various livelihood skills

Sl. No.	Type of trainings	No. of people trained	Male	Female
1	Basic computers	27	16	11
2	Bird Guide Training	50	42	8
3	Electrician	10	10	0
4	Food processing and value addition	703	33	670
5	Green energy	20	20	0
6	Handicraft	210	7	203
7	Health and wellness	166	0	166
8	Herbal colour making	111	0	111
9	Herbal Soap and Detergent Making	123	7	116
10	Incense stick & candle making	696	8	688
11	Leadership	40	8	32
12	LED bulb making	64	53	11
13	Packaging material making	21	0	21
14	Sewing & Stitching	2239	0	2239
15	SHG account maintenance	10	0	10
16	Sustainable farming	319	184	98
17	Tie and Dye, Block printing and Patch work	71	0	71
Total		**4880**	**388**	**4455**

Table 4.3. Livelihood trainings conducted in High Biodiversity Zones

Sl. No.	Type of livelihood trainings	High Biodiversity Zones												Total trainings	Total people trained
		I		II		III		IV		V		VI			
		No. of Training	No. of people trained	No. of Training	No. of people trained	No. of Training	No. of people trained	No. of Training	No. of people trained	No. of Training	No. of people trained	No. of Training	No. of people trained		
1	Basic computers					1	27							**1**	**27**
2	Bird Guide Training			1	11					1	22			**2**	**33**
3	Electrician			1	10									**1**	**10**
4	Food processing and value addition	1	11	13	252	5	144	1	25					**20**	**432**
5	Green energy					1	20							**1**	**20**
6	Handicraft			10	144			1	14			3	52	**14**	**210**
7	Health and wellness			4	61	3	80							**7**	**141**
8	Herbal colour making			4	111									**4**	**111**
9	Herbal Soap and Detergent Making			1	35			2	48	1	40			**4**	**123**
10	Incense stick & candle making	1	17	16	272	7	259	1	25			1	43	**26**	**616**
11	Leadership					2	40							**2**	**40**
12	LED bulb making	1	30	2	34									**3**	**64**

13	Packaging material making			2	21									**2**	**21**
14	Sewing & Stitching			27	692	13	402	16	515	16	483			**72**	**2092**
15	SHG account maintenance	1	10											**1**	**10**
16	Sustainable farming			2	29			2	72	1	37	4	181	**9**	**319**
17	Tie and Dye, Block printing & Patch work	1	25	1	22	1	24							**3**	**71**
	Total	**5**	**93**	**84**	**1694**	**33**	**996**	**23**	**699**	**19**	**582**	**8**	**276**	**172**	**4340**

4.4.3. Thematic distribution of the livelihood trainings

The thematic orientation of the interventions reflects a strong emphasis on women-centric, micro-enterprise-based, and resource-linked livelihood models.

(1) Women-Centric Home-Based Enterprises

The most dominant thematic category comprised household-based production activities designed to enhance women's income generation capacity. Sewing & Stitching emerged as the largest intervention, with 78 trainings leading to 2,239 beneficiaries, all of whom were women. This indicates both scale and targeted outreach toward women's self-employment. Incense stick & candle making involved 31 trainings and trained 696 individuals (688 women; 8 men), demonstrating strong female engagement in small-scale cottage industries. Food processing and value addition, delivered through 28 trainings, benefited 703 individuals (670 women; 33 men), indicating significant uptake in agro-based enterprise development. Handicraft (14 trainings; 210 participants, 203 women) and Tie & Dye, Block Printing and Patch Work (3 trainings; 71 participants, all women) further strengthened artisanal and craft-based income avenues. Collectively, these themes account for the majority of beneficiaries and reflect strategic prioritization of low-investment, locally adaptable, and market-linked livelihood options suitable for women and Self-Help Groups (SHGs).

(2) Herbal and Eco-Friendly Product Development

A cluster of trainings focused on environmentally sustainable and nature-based product development: herbal soap and detergent making (4 trainings; 123 participants, 116 women), herbal colour making (4 trainings; 111 participants, all women), health and wellness (8 trainings; 166 participants, all women), packaging material making (2 trainings; 21 participants, all women). These interventions integrated traditional knowledge with marketable green products, promoting eco-friendly enterprises while strengthening women's entrepreneurship. Participation patterns indicate near-exclusive involvement of women in these themes.

(3) Agriculture and Natural Resource-Based Livelihoods

Livelihoods directly linked to natural resources were promoted through: sustainable farming (9 trainings; 319 participants) with relatively balanced participation (184 men; 98 women), indicating shared engagement in agricultural production systems. Bird guide training (3 trainings; 50 participants) with male predominance (42 men; 8 women), reflecting gendered participation in ecotourism and field-based conservation-linked activities. These interventions support diversification of income sources aligned with ecological sustainability and conservation-compatible livelihoods.

(4) Technical and Energy-Oriented Skill Development

Technical skill enhancement programmes were comparatively fewer but targeted employability in emerging sectors: LED bulb making (3 trainings; 64 participants; 53 men, 11 women), green energy (1 training; 20 participants; all men), electrician (1 training; 10 participants; all men), basic computers (1 training; 27 participants; 16 men, 11 women), participation in these themes showed male predominance, indicating gender differentiation in technical and energy-based skill domains. However, the inclusion of women in LED and computer training suggests gradual diversification.

(5) Institutional and Leadership Capacity Building

Capacity strengthening for community-level governance and financial management was addressed through: leadership training (2 trainings; 40 participants; 32 women, 8 men), SHG account maintenance (1 training; 10 participants; all women). Although limited in number, these trainings contributed to strengthening institutional capacity, particularly among women-led Self-Help Groups.

4.5. Conclusion

The livelihood training interventions conducted across the Ganga basin states (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal) represent a structured, gender-responsive, and conservation-aligned approach to community-based biodiversity management. A total of 193 trainings benefitting 4,880 individuals were implemented, with a strong predominance of women participants (~91%). The design and thematic orientation of these trainings align with established frameworks in community-based conservation (CBC), sustainable livelihoods, and gender-inclusive natural resource governance. The Sustainable Livelihoods Framework (Tambe, 2022) emphasizes diversification of income sources to reduce dependency on ecologically sensitive resources. The predominance of sewing & stitching (2,239 beneficiaries), incense stick & candle making (696 beneficiaries), and food processing and value addition (703 beneficiaries) reflects deliberate promotion of low-capital, home-based micro-enterprises. Such interventions reduce extraction pressure on riverine biodiversity by offering alternative income streams, particularly in regions where communities traditionally depend on fisheries, sand mining, or riparian agriculture.

Empirical evidence suggests that alternative livelihood programmes can reduce direct anthropogenic pressure on threatened species when they are economically viable and socially embedded (Roe et al., 2015; Wright et al., 2016). In riverine systems like the Ganga, biodiversity remains vulnerable to unsustainable resource use. By enhancing income security through non-extractive enterprises, these trainings likely contributed to reduced opportunity costs of conservation participation. The results demonstrated strong female participation across most household-based livelihood categories. Women constituted nearly all participants in sewing & stitching, handicrafts, herbal products, packaging material making, SHG account maintenance, and tie-dye/block printing activities. Gender mainstreaming in conservation is widely recognized as critical for improving ecological outcomes (Agarwal, 2009; Leisher et al., 2016). Women's economic empowerment enhances household resilience, increases investment in education and health, and strengthens social capital within Self-Help Groups (SHGs). Studies indicate that women's participation in natural resource governance improves compliance with conservation norms and strengthens collective action (Agarwal, 2010; Westermann et al., 2005). The integration of leadership training (40 beneficiaries) and SHG account maintenance further supports institutional strengthening—an essential determinant of long-term conservation success.

Trainings in herbal soap and detergent making, herbal colour production, health and wellness products, and sustainable farming represent environmentally compatible enterprise models. These interventions align with the concept of green livelihoods and bioeconomy transitions (UNEP, 2018). By promoting natural inputs and environmentally benign production systems, the programme integrates conservation ethics within income generation. Sustainable farming (319 participants with relatively balanced gender participation) is particularly significant. Agroecological practices have been shown to enhance biodiversity, soil health, and climate resilience (Pretty et al., 2018). In riparian landscapes, sustainable agriculture reduces chemical runoff and sedimentation, thereby benefiting aquatic ecosystems. Bird

guide training (50 participants) represents a direct conservation-linked livelihood through ecotourism. Community-based ecotourism has demonstrated positive conservation outcomes when local stakeholders derive tangible benefits from biodiversity protection (Stronza et al., 2019). Such skill development strengthens stewardship incentives for avifauna and riverine habitats. Technical trainings, including LED bulb making, green energy, electrician skills, and basic computer literacy diversify employment opportunities, particularly among male youth. Renewable energy promotion aligns with climate mitigation and reduced reliance on fossil-fuel-based systems (IRENA, 2020). Though male-dominated, inclusion of women in LED and computer training indicates gradual cross-sectoral integration. Energy-efficient technologies indirectly contribute to biodiversity conservation by lowering household energy demand from biomass sources. Reduced dependence on fuelwood extraction has documented benefits for forest and riparian ecosystems (Cooke et al., 2008).

Although limited numerically, leadership and SHG account maintenance trainings strengthen community governance structures. Social capital, defined by networks, trust, and collective norms, is a key predictor of conservation effectiveness (Ostrom, 1990). By building managerial and financial capacity, these interventions increase the probability of sustained microenterprise viability and long-term conservation engagement. The observed gender differentiation, women in home-based enterprises and men in mobility-intensive technical roles reflects socio-cultural norms prevalent in rural Ganga districts. From a policy standpoint, this distribution demonstrates adaptive programming sensitive to local socio-economic realities. However, future iterations could incorporate deliberate cross-gender skilling strategies to avoid occupational segmentation and enhance equity. In High Biodiversity Zones, 172 trainings benefitted 4,340 individuals, with Zones II and III receiving the highest intervention intensity. Targeted capacity-building in ecologically sensitive landscapes is consistent with spatial conservation prioritization principles (Margules & Pressey, 2000). Concentrating livelihood diversification efforts in biodiversity-rich zones enhances social acceptance of conservation measures and mitigates conflict between protection mandates and subsistence needs. The livelihood training interventions demonstrate alignment with globally recognized conservation-development paradigms: livelihood diversification, gender-inclusive governance, green enterprise promotion, renewable energy integration, and spatial targeting of high biodiversity zones. By training 4,880 individuals across 17 skill categories, the programme operationalized conservation-compatible economic empowerment at scale. Evidence from conservation science indicates that when alternative livelihoods are economically viable, socially embedded, and institutionally supported, they enhance local stewardship and reduce anthropogenic pressures on biodiversity (Roe et al., 2015; Stronza et al., 2019). The strong participation of women, emphasis on micro-enterprises, and integration of nature-based livelihoods suggest a strategically designed intervention capable of strengthening long-term community participation in biodiversity conservation across the Ganga basin.

In conclusion, the integrated livelihood development approach adopted under the programme demonstrates that conservation and socio-economic advancement in riverine landscapes are mutually reinforcing objectives rather than competing priorities. By grounding interventions in site-specific needs assessments, strengthening local capacities through targeted skill development, fostering inclusive community sensitization, establishing structured market linkages, and embedding sustainability within all livelihood activities, the initiative has created a coherent framework that enhances income security while promoting biodiversity conservation and river stewardship. The convergence with local governance bodies, training institutions, conservation agencies, and market platforms has ensured institutional

sustainability and scalability of interventions. Overall, the approach has strengthened community ownership, improved adaptive capacity among marginalized river-dependent populations, and contributed to long-term ecological resilience and sustainable development outcomes along the river basin (Figure 4.3).

Figure 4.3. Integrated livelihood development framework for enhancing equity, skills, market access, and sustainability in river-dependent communities

Chapter 05

EXPLORING THE PEOPLE–RIVER CONNECT ALONG THE GANGA RIVER: INSIGHTS FROM PARTICIPATORY MAPPING OF ECOSYSTEM SERVICES

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Summary

Freshwater ecosystems like the Ganga River system provide essential ecosystem services that are vital for human well-being. These services encompass a range of benefits, from provisioning resources like food and clean water to regulating services such as flood control and water purification. While the benefits of freshwater ecosystems are substantial, they face significant threats from human activities, including pollution, habitat destruction, and climate change. The degradation of these ecosystems poses a threat to their ability to sustain these services, necessitating a comprehensive understanding of their value and the pressures they face. This highlights the urgent need for sustainable management practices to preserve these vital resources for future generations.

Sustainable and equitable riverscape management entails accounting for the differential impact of anthropogenic modifications across stakeholders, particularly the socially and economically vulnerable riverside communities. The study, conducted under the NMCG-WII Ganga Biodiversity Conservation Initiative, examines how village-level economic constituents depend upon and access the riverine ecosystem services of the Ganga River, the drivers of change and their impact at the grassroots. Based on literature review, key informant interviews and reconnaissance surveys, 22 key ecosystem services were identified — 12 provisioning, six regulation and maintenance, and four cultural services. The extent of provisioning services was primarily high to medium for the Middle and Lower Ganga stretches, while the extent was primarily low to medium for the Upper Ganga stretch. With respect to regulation and maintenance services, the extent for provision of habitat for biodiversity and regulation of micro climate was high across all three stretches, while soil fertility and soil formation was high for only the middle and lower stretches. For cultural services, the extent was high for all three stretches.

Participatory mapping of ecosystem services was carried out to assess the grassroots level perceived dependency on the ecosystem services provided by the Ganga River, such as the biotic and abiotic resources, cultural and religious services, and dependence of agriculture, livestock and other village-level economic constituents upon the riverine resources. Villages were identified based on location and distance vis-à-vis natural and anthropogenic riverscape features, distance of village habitation from riverbank (hills – 1km; plains – 2km), and accessibility. Focus group discussions guided by a structured questionnaire were held in each village, wherein participants were asked to map the location and use of resources, as well as changes observed over time, including the causes. Representation from all village economic and social constituents was sought. Information not captured in maps was noted to make the mapping more contextual. A qualitative analysis of the collected data was conducted to identify the extent and trends in ecosystem service availability, drivers of change, and the impact of river development initiatives.

Participatory mapping of ecosystem services was carried out in 82 villages in along the Ganga River and select wetlands, spanning 35 districts and five states, viz. Uttarakhand (n=15), Uttar Pradesh (n=41), Bihar (n=9), Jharkhand (n=4) and West Bengal (n=13). In the Upper Ganga stretch (origin of the headwater streams, viz. Bhagirathi and Alaknanda, to Haridwar), 15 villages across six districts of Uttarakhand were surveyed; in the Middle Ganga stretch (Haridwar to Ganga-Gomti confluence), 40 villages across 13 districts of Uttar Pradesh; and in the Lower Ganga stretch (Ganga-Gomti confluence to the mouth of the Ganga River at Gangasagar), 27 villages across 16 districts of Uttar Pradesh (n = 1), Bihar (n = 7), Jharkhand (n = 1), and West Bengal (n = 7). A total of 1,022 individuals participated in the mapping, of which 762 were males and 260 were females. Keeping the riverside communities in mind,

16 key ecosystem services were identified and assessed, viz. consumptive use of surface water and groundwater for drinking, domestic use, irrigation and livestock, biotic [fishing, fuelwood, non-timber forest products (NTFPs), grazing, and fodder] and abiotic (sand mining) resource extraction, waste management (sewage disposal), soil fertility, provision of habitat for biodiversity, and cultural services like religious value and tourism.

Ganga River supports a wide range of ecosystem services that underpin the livelihoods, cultural identity, and ecological resilience of riverside communities across its upper, middle, and lower stretches. The study highlighted strong spatial variability in ecosystem service dependence, shaped by geomorphology, hydrology, infrastructure, and socio-economic transitions. Provisioning services such as water, agriculture, fisheries, livestock, and natural resources exhibit clear upstream–downstream gradients. In the Upper Ganga, communities rely on springs, streams, and small-scale irrigation systems, with increasing vulnerability to climate variability and seasonal water scarcity. In the Middle Ganga, groundwater dominates domestic and irrigation use, supported by canal systems but increasingly stressed due to over-extraction and contamination. In the Lower Ganga, water use is strongly influenced by flow regulation through the Farakka Barrage and tidal dynamics, with downstream regions facing salinity intrusion, reduced sediment supply, and a shift toward aquaculture-based livelihoods. Agricultural systems intensify downstream, transitioning from subsistence and horticulture in upland regions to intensive multi-cropping in the plains, and further toward diversified and salinity-constrained systems in deltaic areas. Livestock systems similarly shift from extensive grazing-based practices upstream to stall-fed and input-dependent systems downstream, reflecting land-use change and declining common property resources. Fisheries evolve from low-intensity, culturally regulated systems in upper reaches to commercially significant and diversified fisheries in lower estuarine zones, though increasingly impacted by flow regulation, pollution, and unsustainable practices. Regulation and maintenance services are under increasing pressure along the river. Hydrological alterations due to dams, barrages, and canal networks have disrupted natural flow regimes, sediment transport, and ecological connectivity, affecting both ecosystem functioning and livelihoods. Floodplains and wetlands continue to provide essential services such as groundwater recharge, soil fertility enhancement, and habitat provision, but are being degraded by pollution, encroachment, and land-use change. Importantly, waste assimilation emerges as a critical ecosystem service, wherein rivers, wetlands, and floodplains naturally process, dilute, and transform organic waste and pollutants—often compensating for the absence or inadequacy of sewage and industrial effluent treatment infrastructure. However, these systems are increasingly overloaded by untreated sewage, agricultural runoff, and industrial discharge, resulting in declining water quality, eutrophication, and loss of ecological integrity. While nature-based systems such as the East Calcutta Wetlands demonstrate the potential of ecological wastewater treatment, their capacity is under stress due to urban expansion and contamination. The river supports globally significant biodiversity, including species such as the Gangetic dolphin, gharial, freshwater turtles, and migratory birds, with key habitats located in river channels, wetlands, and estuarine ecosystems. However, these habitats are increasingly fragmented and degraded due to infrastructure development, pollution, and hydrological alterations. Cultural services remain a defining feature of the Ganga River, with the river functioning as a sacred and cultural lifeline. Major pilgrimage centres, confluences, and festivals, ranging from the Char Dham Yatra in the upper reaches to the Kumbh Mela in the middle stretch and the Gangasagar Mela in the lower stretch, highlight the river's multi-scalar cultural significance. These cultural landscapes also generate

substantial livelihoods through tourism, ritual services, and associated economic activities, though increasing pressure is leading to waste accumulation and environmental degradation.

Grassroots assessments highlight that in the Upper Ganga stretch, communities rely primarily on surface water from mountain streams for drinking, domestic use, and irrigation. Surface water for drinking and domestic use was reported as high by 66.7% of villages, while 60% reported high use of surface water for irrigation. Livestock-related services were also significant, with 66.7% of villages reporting high use of grazing and fodder resources, and forest-based resources such as fuelwood and NTFPs used at high extent by 73.3% of villages. Cultural services were highly prominent, with religious value and tourism reported at high extent by 80% of villages. In the Middle Ganga stretch, groundwater emerged as the most extensively used resource, with 97.5% of villages reporting high use of groundwater for drinking and 90% for irrigation, reflecting the intensive agricultural systems of the Gangetic plains. In the Lower Ganga stretch, provisioning services were generally used at moderate to high extent, with groundwater for drinking (85.2%), groundwater irrigation (70.4%), and fishing (85.2%) reported at high extent. Across the entire Ganga River, groundwater for drinking (78% of villages) and irrigation (69.5%) were widely used, while livestock-related services were generally reported at moderate levels. Cultural services such as religious value and tourism were reported at high extent by about 39% of villages, highlighting the continued cultural and spiritual importance of the river.

Perceptions of trends indicate widespread declines in several provisioning ecosystem services along the river. In the Upper Ganga stretch, surface water for drinking and irrigation declined in 80% and 73.3% of villages, respectively, while fishing declined in 93.3%. Livestock grazing and fodder resources also showed declining trends, although groundwater services were largely perceived as stable. Cultural services such as tourism and religious value were perceived to be increasing. In the Middle Ganga stretch, declining trends were reported across most provisioning services, including surface water for drinking (92.5% decreasing) and groundwater for drinking (100% decreasing), along with widespread declines in fuelwood, NTFPs, and fisheries. Regulation and maintenance services were also perceived to be declining in several locations, while sewage disposal increased in 77.5% of villages. In the Lower Ganga stretch, groundwater for drinking declined in 74.1% of villages and fuelwood in 70.4%, while fishing declined in 44.4% of villages; however, surface water irrigation and livestock water remained stable in several locations. Across the entire Ganga River, surface water for drinking declined in 76.8% of villages, groundwater for drinking in 74.4%, and fishing in 69.5%, indicating growing pressures on river-dependent livelihoods. In contrast, sewage disposal increased in 68.3% of villages, reflecting rising anthropogenic pressures, while cultural ecosystem services such as tourism (51.2% increasing) and religious value (39.0% increasing) remained stable or showed positive trends.

Overall, the Ganga River reflects a transition from an ecologically regulated, low-intensity system upstream to a highly modified, infrastructure-dependent, and economically integrated system downstream. While the river continues to sustain diverse ecosystem services and support millions of people, many provisioning and regulating services are perceived to be declining due to hydrological alteration, pollution, resource over-extraction, land-use change, and climate variability. These trends underscore the urgent need for integrated river basin management that balances ecological integrity with livelihood needs, strengthens nature-based solutions, and adopts community-sensitive, locally adaptive approaches to ensure sustained and equitable access to ecosystem services.

5.1. Introduction

Freshwater ecosystems like rivers and wetlands, both natural and artificial, provide a wide range of ecosystem services vital for human well-being. The Common International Classification of Ecosystem Services (CICES) categorizes these ecosystem services into (a) provisioning — products derived from ecosystem, (b) regulation and maintenance — benefits derived from the regulation of ecosystem processes and are necessary for the maintenance of all other ecosystem services, and (c) cultural — non-material benefits obtained from ecosystems.

Provisioning services from freshwater ecosystems include food (notably fisheries; Grizzetti & Poikāne, 2024), water for drinking, domestic use, agriculture, power generation, and industry (Bawra & Pawar, 2023), and raw materials for sectors such as pharmaceuticals and construction (Lynch et al., 2023 Regulatory services include flood control, water purification, and hydrological balance, with wetlands acting as natural filters, removing pollutants and improving water quality, and mitigating flood risks by absorbing excess rainfall (Ramachandra et al., 2024). Freshwater ecosystems also contribute to climate change mitigation by capturing and storing carbon (Ramachandra et al., 2024). Additionally, rivers like Ganga and Yamuna hold deep religious and cultural significance, which transcends their physical boundaries. These ecosystems also enhance the aesthetic value of landscapes, provide recreational opportunities, support tourism, and serve as living laboratories for scientific research and education.

While the benefits of freshwater ecosystems are substantial, they face significant threats from human activities, including pollution, habitat destruction, and climate change. The degradation of these ecosystems poses a threat to their ability to sustain these services, necessitating a comprehensive understanding of their value and the pressures they face. This highlights the urgent need for sustainable management practices to preserve these vital resources for future generations.

The Ganga River provides life sustaining ‘ecosystem services’ to multitudinal stakeholders across different scales — local, regional, national and global — exercising varying and often competing demands on the river and its resources, be it cultural, religious, social and economic. These services interact in complex and dynamic ways, often leading to both synergies and trade-offs among them. However, the trade-offs and synergies are not only among the ecosystem services, but also among the stakeholders as well, with anthropogenic interventions impacting the riverscape and benefitting some at the expense of others. A key stakeholder group that is chiefly affected by river development interventions such as propagation of hydropower generation, agriculture and tourism, construction of barrages, etc. are the local communities residing along these rivers.

Sustainable and equitable riverscape and basin management entails accounting for the differential impact of anthropogenic modifications across stakeholders, particularly the socially and economically vulnerable riverside communities. Traditional top-down assessment methods often exclude local communities, who are the primary custodians of these ecosystems and a key beneficiary of the services they provide, leading to the advent of ‘participatory research methods’ to understand ecosystem services from a grassroots perspective (Damastuti & de Groot, 2019). Participatory mapping of ecosystem services is a collaborative method that engages local communities in identifying and visualizing the services they depend on (Reilly et al., 2018). It enables stakeholders to share their knowledge, experiences, and values related to ecosystem benefits, fostering inclusive and place-based understanding (Wang & Dodd, 2024; Lim et al., 2021). Additionally, it allows stakeholders to express where they benefit from ecosystem services, which can be used to understand stakeholders’ values in the area and possible conflicts

between them. By engaging local communities as active participants rather than passive subjects, participatory mapping offers a significant advantage over traditional ecosystem services assessment, generating a more nuanced and inclusive understanding of ecosystem services (Burdon et al., 2019).

5.2. Aim

Identification of key ecosystem services provided by the Ganga River, and examine how village-level economic constituents depend upon and access riverine ecosystem services, the drivers of change and their impact at the grassroots

5.2.1. Objectives

1) To identify the ecosystem services by Ganga River and their extent.
2) To identify the ecosystem services availed by the riverside communities and the drivers of change.
3) To identify the perceived extent and trend in ecosystem services availed by the riverside communities.

5.3. Approach

5.3.1. Identification of the ecosystem services provided by the Ganga River and their extent

The ecosystem services provided by the Ganga River were identified via literature review, key informant interviews and reconnaissance surveys. An extensive review of existing literature was conducted wherein online scientific databases such as 'Science Direct', 'JSTOR', 'Wiley Online Library', 'Google Scholar', 'Springer', 'Academia', 'MDPI (Multidisciplinary Digital Publishing Institute)', etc. were searched. Peer reviewed journals such as Ecosystem Services, Ecological Economics, PloS one, Science, PNAS, Journal of Environmental Management, Environmental Science and Policy, Environmental Science and Technology, Applied Sciences, Journal of Environmental Biology, etc. were consulted. Terms such as 'freshwater ecosystem services', 'river ecosystem services', 'wetland ecosystem services', 'nature's benefits to people', etc. were sought in the keywords and abstracts of published scientific papers while browsing. Global environmental assessments, including the Millennium Ecosystem Assessment and reports by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), were reviewed for insights on freshwater ecosystem services and drivers of change. Government websites and news articles were also perused to identify river-specific developments and policy. Key informant interviews were conducted with researchers and scientists in the field of ecosystem services, and river and wetland conservation, and the local community. Site visits were undertaken to select villages along the river. CICES version 5.2 was used as a reference to classify the ecosystem services identified.

5.3.2. Identification of the ecosystem services availed by the riverside communities, and their drivers of change, and perceived extent and trend

Participatory mapping of ecosystem services was used to assess the grassroots level perceived dependency on the ecosystem services provided by the Ganga River, such as the biotic and abiotic resources, cultural and religious services, and the dependence of agriculture, livestock and other village-level economic constituents upon the riverine resources. The impact of macro river development intervention at the grassroots was also examined.

River segments for participatory mapping were identified based on (a) river stretch, viz. upper, middle and lower stretch, identified based on the geomorphological characteristics and bio-geographic zones; (b) the presence of anthropogenic modifications to the riverscape such as dams, barrages, embankments, urban agglomerations, etc.; (c) the presence of natural riverscape features such as oxbow lakes, sandbanks, confluence, river islands, alluvion and diluvion of land, etc.; (d) biodiversity richness; and (e) vicinity to internationally and nationally recognised sites of conservation significance.

Villages were identified based on location and distance vis-à-vis natural and anthropogenic riverscape features, distance of village habitation from riverbank (1 km in the hills; 2 km in the plains), and accessibility. Natural riverscape features included confluences, ox-bow lakes, biodiversity richness (based on ecological survey and presence of protected areas, Ramsar wetlands, etc.), soil erosion (assessed based on the perusal of riverbank features on Google Earth), river islands, etc. Anthropogenic riverscape features included hydropower projects, barrages, urban centres, cultural/religious centres, etc.

Focus group discussions (FGDs) guided by a structured questionnaire were held in each village, wherein participants were asked to map the location and use of resources, as well as changes observed over time, including the causes (Braslow et al., 2016). The mapping was carried out using high-resolution Google Earth maps of the surveyed villages. The maps, which displayed a 2 km radius from the centre of the village habitation in the plains and a 1 km radius in the hills, were printed on A0 size (1m x 1m) paper. The mapping exercise was guided by a structured questionnaire, which was modified to make it locally relevant. The data was collected in the form of point (location of sources), line (routes or border marking), and polygon (enclosed resource area or attribute) data.

Representation from all village economic and social constituents was sought in the FGDs; wherever it was noted that a relevant stakeholder was absent, key informant interviews were conducted. Information not captured in maps was noted to make the mapping more contextual. Although participatory mapping provides valuable insights for understanding and managing ecosystem services, it also has limitations—including potential biases (Lim et al., 2021), hence, ground truthing via a transect walk from the village habitation to the river and a village survey was carried out. The data collected was analysed qualitatively to identify the extent and trends in ecosystem service availability, drivers of change, and their impact. A visual outline of the methodology is provided in Figure 5.1.

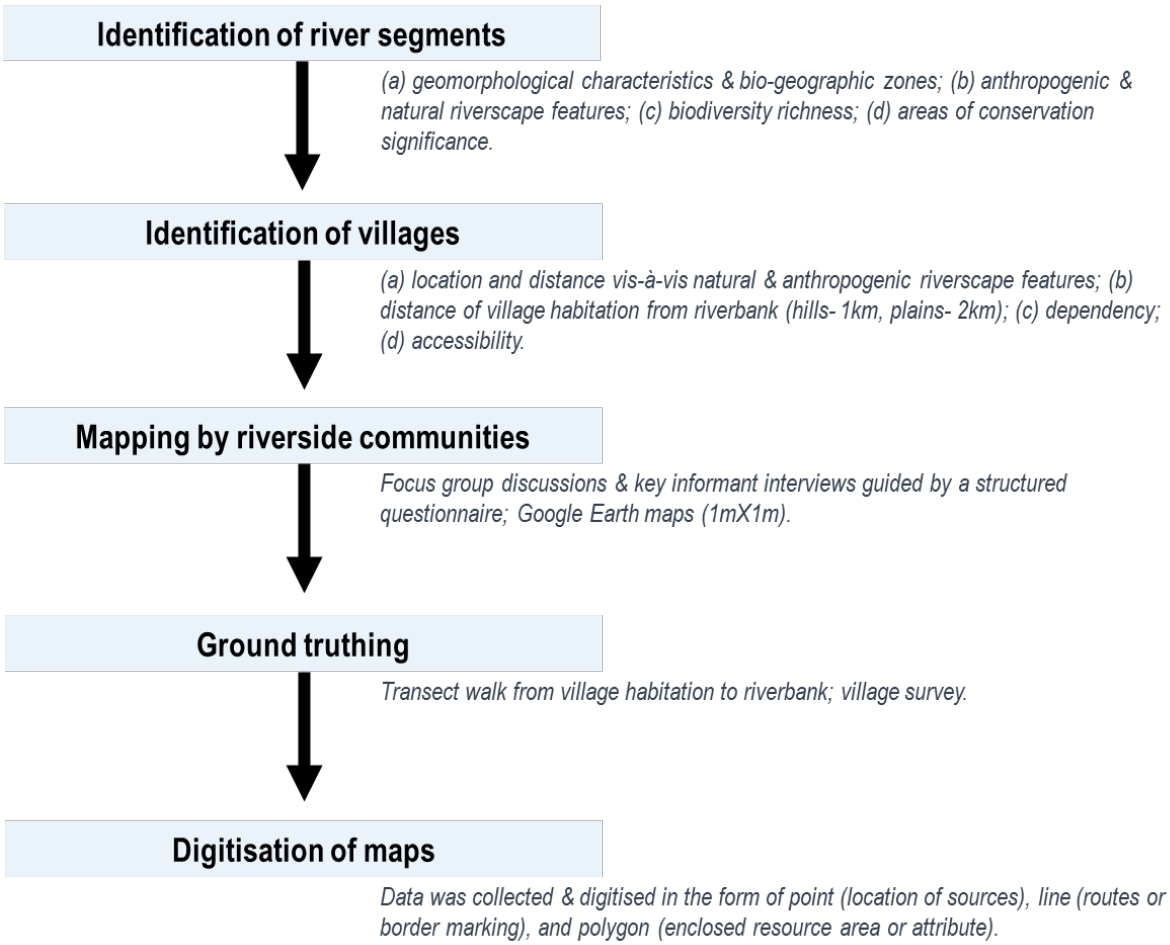


Figure 5.1. Approach adopted for participatory mapping of ecosystem services along the Ganga River

Owing to variations in geology, geomorphology, soil type, climate, biodiversity, and socio-economic conditions, the Ganga mainstem is classified into three stretches: Upper Ganga (origin of the headwater streams, viz. Bhagirathi and Alaknanda, to Haridwar), Middle Ganga (Haridwar to Ganga-Gomti confluence), and Lower Ganga (Ganga-Gomti confluence to the mouth of the Ganga River at Gangasagar) (WII-GACMC, 2018).

Key development projects identified on the Ganga River include seven hydropower projects in the Upper Ganga stretch, namely Maneri Bhali-I, Maneri Bhali-II, Tehri and Koteshwar on the Bhagirathi River, Vishnuprayag and Srinagar on the Alaknanda, and Chilla on the Ganga; a nuclear power plant, viz. Narora Atomic Power Station, in the Middle Ganga stretch; and five major barrages, viz. Bhimgoda (Haridwar district, Uttarakhand), Chaudhary Charan Singh Madhya Ganga (Bijnor district, Uttar Pradesh), Narora (Bulandshahr district, Uttar Pradesh), Lav Kush (Kanpur district, Uttar Pradesh), and Farakka (Murshidabad district, West Bengal), along with major pump canal projects such as Narayanpur (Mirzapur district, Uttar Pradesh) and Bhupauli (Chandauli district, Uttar Pradesh). Fourteen thermal power plants are located along the Ganga mainstem; with the exception of Panki (Kanpur, Uttar Pradesh), all are located in the Lower Ganga stretch with 10 in West Bengal and three in Bihar. Additionally, Dadri (Gautam Buddha Nagar district, Uttar Pradesh) and Harduaganj (Aligarh district, Uttar Pradesh) thermal power

plants, and Dadri Gas Power Station (Gautam Buddha Nagar district), in the Ganga basin, draw from the Upper Ganga Canal.

There are at least 54 Class-I cities and 30 Class-II towns located within 10 km of the river (Government of India, 2011). Key settlements include Uttarkashi, Joshimath, Devprayag, Rishikesh and Haridwar (Uttarakhand) in Upper Ganga, Bijnor, Farrukhabad, Kannauj, Kanpur, Prayagraj, Mirzapur and Varanasi (Uttar Pradesh) in Middle Ganga, and Ghazipur, Ballia (Uttar Pradesh), Buxar, Chhapra, Patna, Bhagalpur (Bihar), Sahibganj, Rajmahal (Jharkhand), Farakka, Murshidabad, Berhampore, Nabadwip and Kolkata Metropolitan Area (West Bengal) in Lower Ganga.

Major confluences identified along the Ganga River were Bhagirathi-Alaknanda (Devprayag) in Uttarakhand, Ganga-Yamuna (Prayagraj) and Ganga-Gomti (Varanasi district) in Uttar Pradesh, Ganga-Ghaghra (Saran district), Ganga-Son (Patna district), Ganga-Gandak (Vaishali district) and Ganga-Kosi (Katihar district) in Bihar, and Hooghly-Ajay (Purba Bardhman district), Hooghly-Damodar (Howrah district), Hooghly-Rupnarayan (Purba Medinipur district), and Hooghly-Haldi (Purba Medinipur district) in West Bengal.

Nine Protected Areas located along or near the Ganga mainstem, including Gangotri National Park, Rajaji National Park, State Animal Barahsingha Wildlife Sanctuary (formerly Hastinapur Wildlife Sanctuary), Dr. Bhimrao Ambedkar Wildlife Sanctuary, Kachhua Wildlife Sanctuary, Vikramshila Gangetic Dolphin Sanctuary, Udhwa Lake Bird Sanctuary, Jhilmil Jheel Conservation Reserve, and Gogabeel Community Reserve. Ramsar sites along the Ganga River include Haiderpur Wetland, Upper Ganga River, Gogabeel Community Reserve, Udhwa Lake Bird Sanctuary, the East Calcutta Wetlands and Sundarban Wetland. Other key wetlands identified were Jhilmil Jheel Conservation Reserve, Baraila Lake (Salim Ali-Jubba Sahni Bird Sanctuary), Kanwar Jheel (or Kabartal Wetland), Nagi Bird Sanctuary.

Participatory mapping of ecosystem services was carried out in 82 villages in along the Ganga River and select wetlands, spanning 35 districts and five states, viz. Uttarakhand (n=15), Uttar Pradesh (n=41), Bihar (n=9), Jharkhand (n=4) and West Bengal (n=13) (Figure 5.2; Table 5.1). A total of 1022 individuals participated in the mapping, of which 762 were males and 260 were females. In the Upper Ganga stretch, 15 villages across six districts in Uttarakhand were surveyed. In the Middle Ganga stretch, 40 villages spanning 13 districts in Uttar Pradesh were surveyed. In the Lower Ganga stretch, 27 villages across 16 districts in Uttar Pradesh (n=1), Bihar (n=7), Jharkhand (n=1) and West Bengal (n=7) were surveyed.

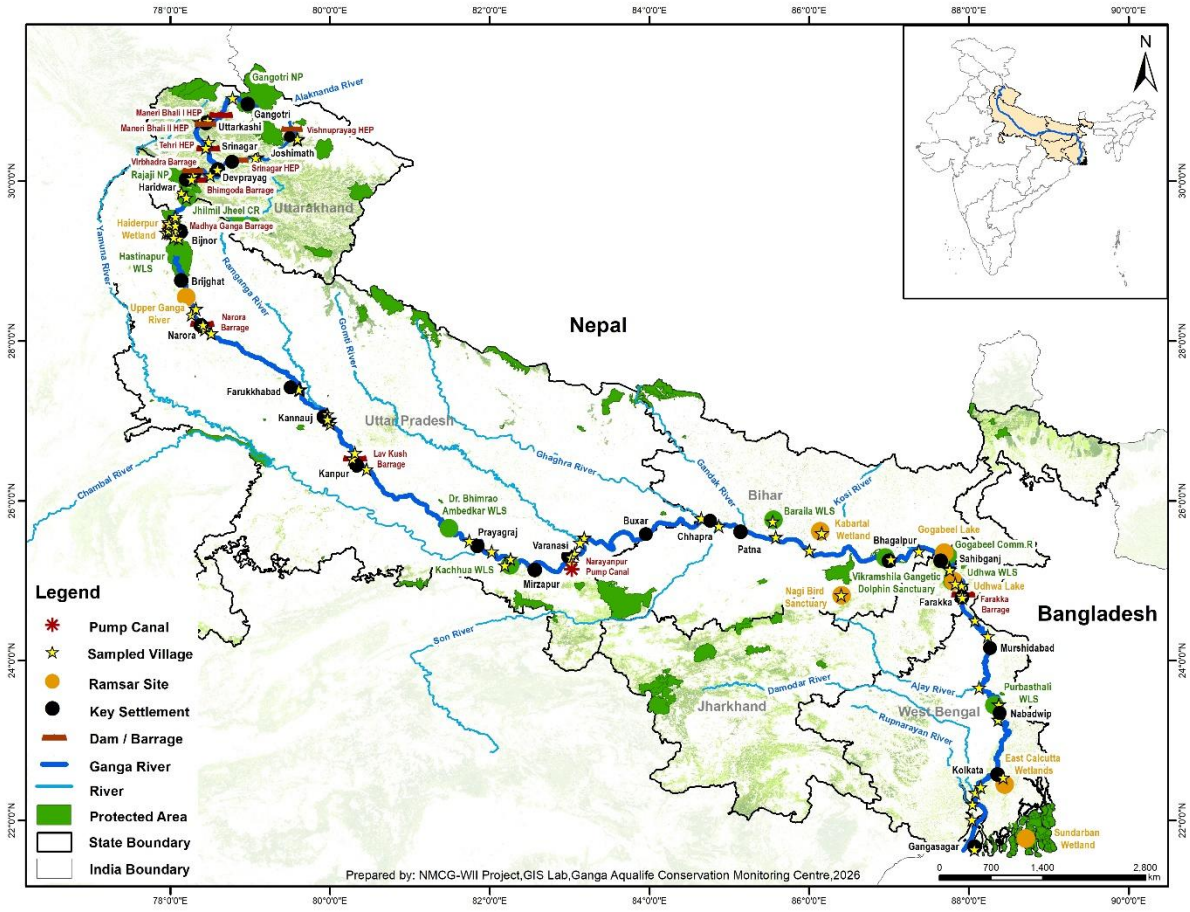


Figure 5.2. Villages surveyed along the Ganga River, along with the identified drivers of riverscape change

Table 5.1. An overview of the Ganga River and the villages surveyed

Ganga River Stretch	States	Districts surveyed	Villages surveyed	No. of participants	Description
Upper Ganga Stretch *(Origin of the headwater streams, viz. Bhagirathi and Alaknanda, to Haridwar in Uttarakhand)*	Uttarakhand	Chamoli, Haridwar, Pauri Garhwal, Rudraprayag, Tehri Garhwal, Uttarkashi	15 villages Langsi, Baragaon, Merag (Chamoli); Bisanpur, Dudhala Dayalwala (Haridwar); Kunao, Ganga Bhogpur Malla and Talla (Pauri Garhwal); Gholtir (Mawana), Shivanandi (Rudraprayag); Tiwad Gaon, Tungi, Kaudiyala (Tehri Garhwal); Dharali, Ganeshpur, Matli (Uttarkashi)	141	Upper Ganga riverscape is characterised by steep mountainous terrain of the Greater Himalaya (Himadri), Lower Himalaya (Himachal) and Outer Himalaya (Shivalik), and Terai landscape (where the Ganga River enters the Gangetic plains in Haridwar district), exhibiting pronounced altitudinal gradients. Bhagirathi and Alaknanda rivers, the two principal headwaters of the Ganga River, are glacial rivers and originate from the snouts of the Gangotri Glacier (Gaumukh), and Satopanth and Bhagirathi Kharak glaciers, respectively. These are joined by numerous tributaries of glacial origin, chief among them are the Dhauliganga (Vishnuprayag), Nandakini (Nandaprayag), Pindar (Karnaprayag), and Mandakini (Rudraprayag) that join the Alaknanda at the religiously significant Panch Prayags (the five sacred confluences in Garhwal Himalaya; mentioned in brackets next to the respective tributaries), and Bhilangana that joins the Bhagirathi at Tehri Dam reservoir. Bhagirathi and Alaknanda, meet at Devprayag (last of the five Panch Prayags), from whence the river is known as 'Ganga'. Key drivers of change in this stretch include seven hydropower plants, namely Maneri Bhali-I, Maneri Bhali-II, Tehri and Koteshwar on the Bhagirathi River, Vishnuprayag and Srinagar on the Alaknanda, and Chilla on the Ganga; Bhimgoda Barrage (Haridwar district, Uttarakhand), which is the headworks of the Upper Ganga Canal and Eastern Ganga Canal; urban centres like Uttarkashi (a religious centre and district headquarter in Uttarkashi district along Bhagirathi River), Srinagar (a district headquarter in Pauri Garhwal district along Alaknanda River), Rishikesh (an adventure, religious and spiritual centre in Pauri Garhwal, Tehri Garhwal and Dehradun districts along Ganga River) and Haridwar (a religious centre and district headquarter in Haridwar district along Ganga River); religious, spiritual, adventure and recreational tourism, particularly the *Char Dham Yatra*, *Kumbh Mela* and *Kavad Yatra*, and related developments such as road construction and urban sprawl; traditional and modern agricultural and horticulture practices, such as apple orchards in Harsil; three Protected Areas, namely Gangotri National Park, Rajaji National Park and Jhilmil Jheel Conservation Reserve. Villages were identified along the Bhagirathi, Alaknanda, Dhauliganga and Ganga rivers based on the proximity to the following: → River development projects: Maneri Bhali I and II HEP, Tehri HEP, Vishnuprayag HEP, Tapovan Vishnugad HEP, Virbhadra Barrage (Chilla HEP), and Bhimgoda Barrage → Urban centres: Uttarkashi, Joshimath, Devprayag, Rishikesh, and Haridwar → Confluences: Alaknanda-Dhauliganga, and Bhagirathi-Alaknanda → Protected Areas: Rajaji National Park, and Jhilmil Jheel Conservation Reserve

					→ Wetlands: Tehri Dam reservoir, and Jhilmil Jheel Conservation Reserve
Middle Ganga Stretch *(Haridwar, Uttarakhand, to Ganga-Gomti confluence, Uttar Pradesh)*	Uttar Pradesh	Bhadohi, Bijnor, Bulandshahr, Chandauli, Farrukhabad, Kannauj, Kanpur, Mirzapur, Muzaffarnagar, Prayagraj, Sambhal, Unnao, Varanasi	40 villages Sitamadhi Narepar (Bhadohi); Saifpur Khaddar, Chandranbhanpur Kishor, Rawali, Dharamnagari, Nawalpur, Kherki Hemraj, Vidhurkuti (Bijnor); Sherpur Bangar, Niwari Khader, Ramghat Khader (Bulandshahr); Katesar (Chandauli); Amethi Jadid, Sota Bahadurpur, Bhagua Nagla (Farrukhabad); Chaura Chandpur, Madaharpur, Gumtiya, Katri Gangpur, Katri Mehandipur, Daipur (Kannauj); Baniya Purwa, Kishanpur (Kanpur); Hakanipur Kalan (Mirzapur); Shukratal, Biharghar, Nizampur, Katiya, Kasampur Khola, Deval, Husainpur (Muzaffarnagar); Kuresar Kachhar, Leelapur Kalan, Chauktha Narvar (Prayagraj); Hardaspur, Ganga Bas, Bajhangi	493	Middle Ganga riverscape is characterised by alluvial floodplains with meander scars and oxbow lakes, as the Ganga River meanders through the upper Gangetic plains, supporting major irrigation projects (barrages and pump canals), extensive and intensive agricultural cultivation, religious and tourism centres, large cities, urban sprawl, and sites of cultural, historical and archaeological significance. The river meets with numerous tributaries of glacial, spring-fed and groundwater-fed origin; major tributaries include the Yamuna, Ramganga, Gomti, Garra and East Kali. Key urban centres along the river include Bijnor (a district headquarter in Bijnor district), Farrukhabad (a district headquarter and an industrial centre famous for its potato cold storages, textile bock printing and zardozi handicraft in Farrukhabad district), Kannauj (a district headquarter, a historical city, and an industrial centre famous for its traditional perfumes—'*Ittar*', in Kannauj district), Bithoor (a historical town and a religious centre famous for its Ganga Ghats and temples), Kanpur (a district headquarter, a historical city and an industrial centre famous for its tanneries and leather goods production in Kanpur Nagar district), Prayagraj (a district headquarter, a historical city and a religious centre famous for its celebration of the Kumbh Mela at the Ganga-Yamuna confluence—*Triveni Sangam*, in Prayagraj district), Mirzapur (a district headquarter, a historical city and an industrial centre famous for its carpet manufacturing in Mirzapur district), and Varanasi (a district headquarter, a historical city, an industrial centre known for its traditional silk weaving industry, and a religious, spiritual and cultural centre famous for its ancient Ganga Ghats, temples and mosques, Ganga Aarti, and *Banaras Gharana*—a prominent Indian classical music and dance school or stylistic lineage, in Varanasi district). Major development projects on the river are Chaudhary Charan Singh Madhya Ganga Barrage (headworks of the Madhya Ganga Canal in Bijnor district), Narora Barrage (headworks of the Lower Ganga Canal and Parallel Lower Ganga Canal in Bulandshahr district), and Lav Kush Barrage (drinking water supply to the Kanpur urban agglomeration in Kanpur district), along with major pump canal projects such as Narayanpur (Mirzapur district, Uttar Pradesh) and Bhupauli (Chandauli district, Uttar Pradesh). Narora Atomic Power Plant, a nuclear power plant in Narora (Bulandshahr district) draws water from the Ganga mainstem for cooling and discharges it into the Lower Ganga Canal/Parallel Lower Ganga Canal. Panki Thermal Power Station (Kanpur, Uttar Pradesh) draws water from the Lower Ganga Canal. Protected Areas along the river include Hastinapur Wildlife Sanctuary, Dr. Bhimrao Ambedkar Wildlife Sanctuary, and Kachhua Wildlife Sanctuary. Ramsar sites along the river include Haiderpur wetland and Upper Ganga River Ramsar.

			(Sambhal); Makka purwa (Unnao); Tatepur, Dhakawa (Varanasi)		Villages were identified along the Ganga, Solani and East Kali rivers based on the proximity to the following: → River development projects: Chaudhary Charan Singh Madhya Ganga Barrage, Narora Barrage, Lav Kush Barrage, and Narayanpur Pump Canal → Urban centres: Bijnor, Farrukhabad, Kannauj, Bithoor, Kanpur, Prayagraj, and Varanasi → Confluences: Ganga-Solani, Ganga-Kali, Ganga-Yamuna, and Ganga-Gomti → Protected Areas: Hastinapur Wildlife Sanctuary, and Kachhua Wildlife Sanctuary → Wetlands: Haiderpur wetland, and Upper Ganga River
Lower Ganga Stretch *(Ganga-Gomti confluence, Uttar Pradesh, to Gangasagar, West Bengal)*	Uttar Pradesh	Ghazipur	1 village Patana (Ghazipur)	20	Lower Ganga riverscape is characterised by alluvial floodplains with meander scars and oxbow lakes, as the Ganga River meanders through the lower Gangetic plains, and braided, deltaic channels in its lower and deltaic reaches. The river meets with numerous tributaries of glacial, spring-fed and groundwater-fed origin; major tributaries include the Ghaghra, Son, Gandak, Kosi, Mahananda, Ajay, Damodar and Rupnarayan. Key urban centres along the river include Ghazipur (a district headquarter, a historical city, and an industrial centre famous for rose-scented water, opium and alkaloids in Ghazipur district), Ballia (a district headquarter in Ballia district), Buxar (a district headquarter, a historical city, and a cultural centre in Buxar district famous for the Battle of Buxar), Chhapra (a district headquarter in Saran district), Patna (a district headquarter, a historical, cultural and religious centre, and an industrial centre witnessing a rise in brick kilns in Patna district), Begusarai (a district headquarter, and an industrial centre in Begusarai district), Munger (a district headquarter, a historical, cultural and religious centre, and an industrial centre famous for gun manufacturing in Munger district), Bhagalpur (a district headquarter, and an industrial centre famous for its silk and linen production and weaving in Bhagalpur district), Sahibganj (a district headquarter, and a colonial railway township in Sahibganj district), Rajmahal (an archaeological, historical and religious centre, particularly related to tribal culture and heritage, in Sahibganj district), Farakka (a barrage township in Murshidabad district famous for the Farakka barrage), Murshidabad (a historical city, and an industrial centre famous for its silk weaving industry in Murshidabad district), Berhampore (a district headquarter, a historic military outpost, and an industrial centre in Murshidabad district), Nabadwip (a historical, religious and intellectual centre in Nadia district), Serampore (a significant Danish settlement, a printing and publishing hub, and an industrial centre in Hooghly district), Howrah (a district headquarter, a historical and religious centre, and an industrial hub famous for its iron and steel, jute and textile industry in Howrah district), Kolkata (a district headquarter, a historical, cultural and religious centre, and an industrial hub famous for its leather, iron and steel, ship building, jute and textile industry in Kolkata district), and Gangasagar (a religious centre on Sagar Island in South 24 Parganas district, at the mouth of the Ganga River).
	Bihar	Begusarai, Bhagalpur, Jamui, Patna, Samastipur, Saran, Vaishali	9 villages Simariya, Jaimangal Garh (Begusarai); Gohritola, Khwaspur (Bhagalpur); Tola Haranja (Jamui); Haldi Chhapra (Patna); Dharnipatti (Samastipur); Godna Mathiya (Saran); Dulwar (Vaishali)	102	
	Jharkhand	Sahibganj	4 villages Maskalaiya, Ghat Jamni, Bagpinjra, Pranpur (Sahibganj)	123	
	West Bengal	Howrah, Kolkata, Murshidabad, Nadia, Purba Bardhaman, Purba Medinipur,	13 villages Chandipur (Howrah); Dhapa (Kolkata); Ambikanagar (Rail Colony), Beniagram, Giria Kismat, Chaitpur (Murshidabad);	143	

		South 24 Parganas	Ganjadanga, Panpara (Nadia); Sankhai (Purba Bardhaman); Geonkhali, Charkende Mari (Purba Medinipur); Itkhola, Gangasagar (South 24 Parganas)		Major development projects on the river are Farraka Barrage (central to the 1996 Ganga Water Sharing Treaty between India and Bangladesh, and headworks of the Farakka Feeder Canal); Syama Prasad Mookerjee Port (formerly Kolkata Port); and National Waterway 1 (from Prayagraj to Haldia), and supporting infrastructure in the form of jetties and terminals. Additionally, there are 13 thermal power plants that draw water from the Ganga and Hooghly, namely Barauni (Begusarai district), Barh (Patna district) and Kahalgaon (Bhagalpur district) in Bihar, and Bandel (Hooghly district), Budge Budge (South 24 Parganas district), Haldia (Purba Medinipur district), Hiranmaye (Purba Medinipur district), Sagardighi (Murshidabad district), Southern Generating Station (Kolkata district), Titagarh (North 24 Paraganas district), Farakka (Murshidabad district), Kasba GT (South 24 Parganas district) and Haldia GT (Purba Medinipur district) in West Bengal. Protected Areas along the river include Vikramshila Gangetic Dolphin Sanctuary, Gogabeel Community Reserve and Udhwa Lake Bird Sanctuary. Ramsar sites along and in the vicinity of the river include Gogabeel Lake Community Reserve, Udhwa Lake Bird Sanctuary, the East Calcutta Wetlands and Sundarban Wetland. Other key wetlands identified were Kanwar Jheel (or Kabartal Wetland) and Nagi Bird Sanctuary, both Ramsar sites, and Baraila Lake (Salim Ali-Jubba Sahni Bird Sanctuary), under intense anthropogenic pressure. Villages were identified along the Ganga, Budhi Gandak and Nagi rivers based on the proximity to the following: → River development projects: Farakka Barrage → Urban centres: Chhapra, Patna, Begusarai, Bhagalpur, Kahalgaon, Sahibganj, Farakka, Jiaganj Azimganj, Nabadwip, Santipur, and Kolkata Municipal Area → Confluences: Ganga-Gomti, Ganga-Ghaghra, Ganga-Son, Ganga-Kosi, Hooghly-Ajay, Hooghly-Damodar, Hooghly-Rupnarayan, and Hooghly-Haldi → Protected Areas: Vikramshila Gangetic Dolphin Sanctuary and Udhwa Lake Bird Sanctuary → Wetlands: Baraila Lake (Salim Ali-Jubba Sahni Bird Sanctuary), Kanwar Jheel (or Kabartal Wetland), Nagi Bird Sanctuary, Udhwa Lake Bird Sanctuary, Purbasthali Wetland, and the East Calcutta Wetlands

5.4. Results and discussion

5.4.1. Ecosystem services provided by the Ganga River

Ganga River provides a wide range of ecosystem services spanning provisioning, regulation and maintenance, and cultural services. The extent and importance of these ecosystem services was assessed by conducting an extensive literature review, surveying the river, and key informant interviews. Twenty-four key ecosystem services were identified — 13 provisioning, seven regulation and maintenance, and four cultural services (Table 5.2). The extent of provisioning services was primarily high to medium for the Middle and Lower Ganga stretches, while the extent was primarily low to medium for the Upper Ganga stretch. Consumptive use of water, viz. water for drinking, domestic use, agriculture (irrigation), livestock (drinking, bathing) and industry was high for the Middle and Lower Ganga stretches, while it was primarily low for Upper Ganga. Hydropower projects and nuclear power projects are only present in the Upper Ganga stretch and Middle Ganga stretch, respectively. In the Upper Ganga stretch, water for irrigation is primarily channelled from streams and springs in the mountains; however, Bhimgoda Barrage is the headworks for the Upper Ganga and Eastern canals. While there are no thermal power plants along the Upper Ganga and Middle Ganga stretches that draw water directly from the Ganga mainstem, three thermal power plants, namely Dadri Thermal Power Plant, Dadri Gas Power Station (Gautam Buddha Nagar district), and Harduaganj Thermal Power Plant (Aligarh district) draw water from the Upper Ganga Canal (headworks at Bhimgoda Barrage), and Panki Thermal Power Plant (Kanpur) draws water from the Lower Ganga Canal (headworks at Narora Barrage). With respect to regulation and maintenance services, the extent for provision of habitat for biodiversity, regulation of micro climate, water purification and waste management, and water cycle was high to medium across all three stretches, while soil fertility and soil formation was high for only the middle and lower stretches. Storm protection (through mangroves) is limited to the Lower Ganga. For cultural services, the extent was high for all three stretches.

Table 5.2. Ecosystem services provided by the Ganga mainstem and their extent

Ecosystem Services			Extent		
			Upper Ganga	Middle Ganga	Lower Ganga
Provisioning Services	*Consumptive use of water*	Drinking	•	●	●
		Domestic use	•	●	●
		Agriculture (irrigation)	●	●	●
		Livestock (drinking, bathing etc.)	●	●	●
		Industry	•	●	●
	Non-consumptive	Hydro power generation	●	○	○
		Nuclear power generation	○	●	○
		Thermal power generation	●	●	●

		Transportation	○	●	⬤
	Biotic & abiotic resource material	Fish and other aquatic fauna for food	●	⬤	⬤
		Fuelwood	•	●	⬤
		Riverine vegetation for multiple uses	•	●	●
		Riverbed material	●	⬤	⬤
Regulation & Maintenance Services		Provision of habitat for biodiversity	⬤	⬤	⬤
		Regulation of micro climate	⬤	⬤	⬤
		Soil fertility	•	⬤	⬤
		Soil formation (sediment deposition)	•	⬤	⬤
		Water purification and waste management	⬤	●	●
		Water cycle	⬤	●	⬤
		Storm protection (through mangroves)	○	○	⬤
Cultural Services		Tourism	⬤	⬤	⬤
		Religious/spiritual	⬤	⬤	⬤
		Aesthetic	⬤	⬤	⬤
		Heritage sites	⬤	⬤	⬤
Ecosystem Services: ○ → ***none;*** ● → ***little/sometimes;*** ⬤ → ***medium;*** ⬤ → ***large***					

5.4.2. Ecosystem services availed by the riverside communities and their drivers of change

Keeping the riverside communities in mind, 16 key ecosystem services were identified and assessed, viz. consumptive use of surface water and groundwater for drinking, domestic use, irrigation and livestock, biotic [fishing, fuelwood, non-timber forest products (NTFPs), grazing and fodder] and abiotic (sand mining) resource extraction, waste management (sewage disposal), soil fertility, provision of habitat for biodiversity, and cultural services like religious value and tourism. Springs and streams were considered as surface water, even though they are technically classified as groundwater-derived surface water. A stretch-wise summary of these ecosystem services and their drivers of change is provided in Table 5.3.

5.4.2.1. Provisioning services

(a) Water: Drinking and domestic use

Upper Ganga Stretch: Water for drinking and domestic use in the Upper Ganga stretch shows a strong altitudinal gradient. In mountain villages such as Dharali, Ganeshpur, and Matli, water is primarily sourced from mountain streams, springs, and high-altitude lakes, rather than the main river channel due to topographic constraints. For instance, in Dharali, water is supplied from the Saat Tal Lake system through pipelines, while in Ganeshpur, the perennial stream Ganesh Ganga Gad serves as the main source. However, these systems are highly vulnerable to seasonal variability, with reduced discharge during summer and pipeline damage during monsoon, affecting reliability. In Matli, it was reported that majority of the households face water shortages during summer, highlighting increasing pressure on local sources. In contrast, foothill and plains villages such as Kunao, Ganga Bhogpur Malla and Talla, Bisanpur, and Dudhala Dayalwala depend largely on groundwater (handpumps, borewells, piped supply) and canal systems derived from the Ganga at Bhimgoda Barrage. These systems provide relatively more reliable access but indicate a shift toward groundwater dependence, raising concerns about long-term sustainability. Thus, while mountain communities face physical scarcity and seasonal variability, downstream communities face resource depletion risks linked to over-extraction and infrastructure dependence.

Middle Ganga Stretch: Across the Middle Ganga stretch, groundwater is the primary source of drinking and domestic water, accessed through handpumps, submersible pumps, and piped supply systems. Spatial variability is strongly linked to geomorphic setting and proximity to water bodies. In villages located within floodplains and near active river channels or wetlands, groundwater levels are relatively shallow, often within 20–50 ft, enabling easy access and relatively reliable supply. In contrast, villages located away from the river or in interfluve (Bangar) regions report deeper groundwater levels (often exceeding 150–200 ft), reflecting over-extraction and declining recharge. In wetland-adjacent areas (e.g., near Haiderpur wetland), groundwater availability remains high due to sustained recharge; however, these areas are also vulnerable to contamination from stagnant water bodies and seepage. In densely populated and upstream urban-influenced stretches, groundwater quality is affected by industrial effluents and sewage infiltration. Additionally, the widespread use of ponds as sewage disposal sites in rural settlements leads to contamination of shallow aquifers. Seasonal flooding contributes to aquifer recharge but also facilitates the spread of contaminants. Thus, while access remains widespread, both quantity and quality are increasingly location-dependent, reflecting hydrological alterations and land-use pressures.

Lower Ganga Stretch: Water access across the Lower Ganga stretch is strongly shaped by geomorphic setting and hydrological regime. In villages located upstream of the Farakka Barrage and along active floodplains, groundwater accessed through handpumps and tube wells (typically 40 to 350 ft) is the primary source of drinking water. These areas benefit from relatively higher recharge due to seasonal flooding, though water quality issues such as iron contamination and localized seepage from sewage-disposed ponds are common. Surface water from rivers, wetlands, and ponds is used for bathing and washing but is rarely potable without treatment. In contrast, villages located downstream of the barrage within the Bhagirathi–Hooghly system, particularly in peri-urban and densely settled areas, rely on a combination of groundwater and treated surface water supplied through filtration plants. In tidal and estuarine zones (e.g., near river-sea confluences), salinity intrusion into both surface and groundwater sources significantly reduces water quality and potability, increasing dependence on treated supplies or transported water. Villages located near wetlands may experience better groundwater availability but also

face contamination risks due to stagnant water bodies. Seasonal flooding across both regions often disrupts water infrastructure, leading to temporary shortages and reliance on alternative sources.

(b) Water: Irrigation

Upper Ganga Stretch: Irrigation practices in the Upper Ganga stretch reflect significant variation across elevation zones. In mountain villages such as Ganeshpur and Matli, irrigation is primarily dependent on stream-fed systems (guls), which channel water from nearby perennial streams to agricultural fields. While these systems enable localised irrigation, they are highly sensitive to seasonal fluctuations and climate variability. In Matli, declining stream discharge during summer has resulted in water-sharing conflicts among farmers, indicating increasing stress on irrigation resources. Similarly, in Dharali, irrigation depends on water from high-altitude lakes (Saat Tal), which are affected by sedimentation and declining water levels, reducing irrigation reliability. In foothill and plains villages such as Bisanpur and Dudhala Dayalwala, irrigation is more intensive and relatively stable due to groundwater extraction through tube wells and canal irrigation networks originating from the Ganga. These systems support multi-cropping and high agricultural productivity, particularly in rice–wheat systems. However, this increased reliability comes at the cost of groundwater over-extraction and energy-intensive irrigation practices, raising sustainability concerns. Overall, irrigation systems transition from climate-sensitive, small-scale systems in mountains to infrastructure-driven, high-dependence systems in plains, each facing distinct but interconnected challenges.

Middle Ganga Stretch: Irrigation practices exhibit strong spatial differentiation based on proximity to rivers, barrages, canals, and wetlands. In villages located upstream of barrages and along active river channels, farmers directly abstract surface water using pumps, benefiting from relatively higher flow availability. Conversely, in villages located downstream of barrages, reduced river discharge limits direct access to surface water, leading to greater dependence on groundwater for irrigation. In canal command areas, including regions served by the Upper and Lower Ganga canal systems, irrigation is supplemented by sub-canals (rajwahas). However, canal supply is often irregular and insufficient, particularly during peak agricultural demand periods, prompting farmers to rely heavily on private tube wells. In wetland-adjacent areas, shallow groundwater and periodic inundation support irrigation but may also lead to waterlogging. In upland (Bangar) areas, where groundwater levels are deeper, irrigation costs are significantly higher due to energy requirements for pumping. Seasonal variability further influences irrigation practices—during dry periods, dependence on groundwater increases, while monsoon flooding supports soil moisture and recharge. Overall, irrigation systems reflect a transition from surface water dependence to groundwater-dominated regimes, with clear upstream–downstream and canal–non-canal disparities.

Lower Ganga Stretch: Irrigation systems vary across hydrological zones. In villages located upstream of Farakka and along main river channels, irrigation is supported by direct river abstraction, floodplain moisture retention, wetlands, and groundwater, enabling multi-season cropping. Seasonal floods play an important role in recharging aquifers and maintaining soil moisture. In canal-influenced zones and areas near distributaries, irrigation is supplemented by local canal systems and pump-based extraction. However, groundwater remains a dominant and reliable source. In contrast, villages located downstream of Farakka within the Bhagirathi–Hooghly riverscape depend heavily on regulated freshwater flows via the feeder canal and lift irrigation systems, which sustain agriculture but are subject to variability in supply. In tidal and coastal areas, irrigation is increasingly constrained by salinity ingress and fluctuating

freshwater availability, leading to reduced cropping intensity and shifts toward less water-intensive or salinity-tolerant practices. Thus, irrigation transitions from flood- and groundwater-supported systems upstream to regulated and salinity-affected systems downstream.

(c) Agriculture

Upper Ganga Stretch: Agriculture in the Upper Ganga stretch exhibits a clear transformation along the altitudinal gradient. In high-altitude villages such as Dharali, agriculture has largely shifted toward horticulture, particularly apple and cherry orchards, which occupy a significant proportion of cultivated land. Other crops include rajma (kidney beans), chawlai (amaranth), potato, and cauliflower, while traditional crops such as millets (phaphar, chena, kauni), mustard, pea, and hemp have declined. This transition has improved income but increased dependence on irrigation, chemical inputs, and market access, while also making agriculture vulnerable to climate variability and wildlife depredation (up to 30% crop loss). In mid-altitude villages such as Ganeshpur and Matli, a more diversified cropping system persists, including rice, maize, soybean, pigeon pea, finger millet in the Kharif season, wheat, barley, mustard, chickpea, potato in the Rabi season, and barnyard millet in the Zaid season. However, these systems face challenges such as declining irrigation water, erratic rainfall, and crop depredation by wild boar, monkeys, and langurs. In foothill and plains villages (Kunao, Bisanpur, Dudhala Dayalwala), agriculture is more intensive and dominated by rice–wheat systems, sugarcane, vegetables, and fodder crops, supported by irrigation infrastructure. This reflects a shift toward input-intensive, market-oriented agriculture, with associated environmental pressures such as soil degradation and water depletion.

Middle Ganga Stretch: Agricultural systems across the Middle Ganga stretch are intensive and spatially heterogeneous, shaped by soil type, hydrology, and access to irrigation. Cropping patterns include Rabi crops (wheat, mustard), Kharif crops (rice, maize, jowar, bajra), and Zaid crops (watermelon, muskmelon, pumpkin, gourds, pointed gourd), along with cash crops such as sugarcane and plantation crops like poplar, and horticultural crops such as mango. In floodplain (Khadar) regions and areas near river channels, soils are highly fertile due to regular sediment deposition, enabling intensive cropping and riverbed (Diara) cultivation of cucurbits. In contrast, upland (Bangar) regions have relatively lower soil fertility, requiring higher application of chemical fertilisers and organic manure. In wetland-adjacent areas, soil moisture and nutrient availability are relatively high, supporting diverse cropping, but waterlogging can constrain productivity. Agricultural intensification, particularly in canal-irrigated and groundwater-dependent areas, has led to increased use of agrochemicals. Across locations, farmers reported rising input costs, declining soil health in some areas, and increasing crop depredation by wildlife (notably in areas near forests and wetlands). Thus, agriculture reflects a dynamic interplay between geomorphology, hydrology, and anthropogenic inputs.

Lower Ganga Stretch: Agriculture in the Lower Ganga stretch reflects strong spatial variation. In upstream floodplain and Diara regions, fertile alluvial soils and regular sediment deposition support intensive multi-cropping systems, including rice, maize, jute, wheat, mustard, and vegetables such as onion, potato, cauliflower, tomato, brinjal, cucumber, and gourds. Seasonal cultivation on river islands and exposed riverbeds further enhances productivity. In upland and interfluve (Bangar) areas, soil fertility is relatively lower, requiring higher fertiliser inputs. In downstream and tidal regions, agriculture remains diversified but increasingly constrained by reduced sediment supply and salinity intrusion, particularly in low-lying coastal areas. Cropping patterns include rice, jute, pulses, vegetables, along with horticulture (mango, guava, litchi, coconut, banana, palm) and betel nut plantations in estuarine zones. In some downstream

locations, agricultural land is being converted to aquaculture (notably shrimp farming) due to salinity and changing economic incentives. Across all regions, intensive agrochemical use is common, contributing to soil degradation and water pollution. Agriculture thus reflects a gradient from highly fertile, sediment-driven systems upstream to constrained, salinity-influenced systems downstream.

(d) Livestock

Upper Ganga Stretch: Livestock systems in the Upper Ganga stretch vary significantly across ecological zones. In mountain villages such as Dharali, livestock primarily includes Badri cows, goats, and sheep, with grazing occurring in forests and alpine meadows. However, traditional pastoral practices, especially sheep rearing, have declined due to restrictions on access to high-altitude grazing areas and changing livelihood preferences. In mid-altitude villages such as Ganeshpur and Matli, livestock (cows, buffaloes, goats) plays an important role in supporting agriculture, particularly for ploughing and manure production. However, fodder collection often requires long-distance travel (up to 15–20 km) into forests, increasing labour burdens, especially for women. In foothill and plains villages such as Bisanpur and Dudhala Dayalwala, livestock systems are more sedentary and semi-intensive, with animals largely stall-fed using cultivated fodder. This reflects a transition from extensive grazing-based systems in mountains to controlled, input-dependent systems in plains. Across all zones, livestock is closely linked to agricultural systems, but faces challenges such as fodder scarcity, changing land use, and reduced grazing access, particularly in upstream areas.

Middle Ganga Stretch: Livestock rearing is a key livelihood component, closely linked to local ecological conditions. Across the region, cattle (cows and buffaloes) dominate, along with goats, sheep, pigs, and poultry. Water for livestock is sourced from rivers, ponds, wetlands, and domestic supply systems. In villages located near rivers and wetlands, livestock benefit from access to open grazing areas and natural water sources. However, in protected areas and wetland-adjacent zones, access to grazing lands has become restricted, leading to increased reliance on stall-feeding and cultivated fodder crops (e.g., jowar, bajra). In upland and densely populated areas, limited grazing land and declining common property resources have reduced livestock holdings in some cases. Crop residues (e.g., sugarcane leaves) and fodder crops supplement feed requirements. In areas with high livestock density (often linked to religious institutions), pressure on fodder and water resources is significant. Overall, livestock systems are transitioning from open grazing to semi-intensive and stall-fed systems, influenced by land-use change, conservation policies, and resource availability.

Lower Ganga Stretch: Livestock systems are closely linked to land use and resource availability. In villages located upstream and within floodplains, livestock benefit from open grazing on riverbanks, floodplain grasslands, and seasonal river islands (chars), supplemented by crop residues. These systems are relatively extensive and integrated with agricultural practices. In contrast, villages located downstream and near urban or aquaculture-dominated landscapes face reduced availability of common grazing lands, leading to a shift toward stall-feeding systems. Fodder is sourced from agricultural residues, cultivated fodder crops, and wetland vegetation such as grasses. In wetland-adjacent areas, livestock may access natural fodder resources, but access is often restricted due to conservation regulations. Across both regions, livestock depend on surface water sources (rivers, canals, ponds) for drinking. Declining grazing access and increasing input costs have contributed to reduced livestock holdings in some downstream areas, indicating a transition from traditional to more managed systems.

(e) Biotic resources: Fishing

Upper Ganga Stretch: Fishing in the Upper Ganga stretch is generally limited but ecologically significant. In high-altitude villages such as Dharali, fishing activity is minimal due to religious beliefs and low accessibility, although species such as brown trout (Salmo trutta fario) are present. In mid-altitude villages such as Ganeshpur and Matli, fish diversity is relatively high, including species such as snow trout (*Schizothorax richardsonii*), snow carp (*Schizothorax plagiostomus*), golden mahseer (*Tor putitora*), dark mahseer (*Tor chelynoides*), and catfish (*Pseudocenus sulcatus*). However, hydropower projects such as Maneri Bhali I and II have significantly altered river flow and disrupted fish migration, leading to declining upstream diversity. Additionally, reduced water levels during winter have made fish more accessible, potentially leading to overfishing. In foothill and plains villages such as Kunao and Bisanpur, fishing is more common and includes both subsistence and small-scale commercial activities, supported by better accessibility to the river and floodplains. However, fish populations are affected by pollution, flow regulation, and habitat modification. Overall, fishing reflects a gradient from low-use, culturally regulated systems in mountains to more economically driven systems in plains, with ecological pressures increasing downstream.

Middle Ganga Stretch: Fishing practices vary across hydrological zones and regulatory contexts. In main river stretches downstream of barrages, reduced flows and pollution have negatively impacted fish availability, leading to declining fisheries. In protected areas and religiously significant stretches, fishing is often restricted or prohibited, limiting livelihood opportunities from fisheries. In tributaries, local streams, and wetland fringes, subsistence fishing persists, with reported species including golden mahseer (*Tor putitora*), tor mahseer (*Tor tor*), rohu (*Labeo rohita*), Indian knifefish (*Chitala chitala*), pool barb (*Puntius sophore*), and shrimps. Wetland ecosystems also support fish diversity, though access is often regulated. Communities across locations reported declining fish populations due to water pollution, altered flow regimes, and habitat fragmentation. In addition, unsustainable fishing practices and restrictions in protected areas have reduced the viability of fisheries as a livelihood. Thus, fishing is increasingly localized and constrained, with significant spatial variation linked to ecological and institutional factors.

Lower Ganga Stretch: Fishing practices vary across riverine, wetland, and estuarine environments. In upstream river stretches and wetland-adjacent areas, fisheries are primarily freshwater-based, with key species including rohu, catla (*Catla catla*), tengra (*Mystus tengara* and other *Mystus* spp.), wallago (*Wallago attu*), and *garua bachcha* (*Clupisoma garua*), among others. These systems support both subsistence and small-scale commercial fisheries. In downstream stretches, particularly in the Bhagirathi–Hooghly and estuarine zones, fisheries are more diversified and commercially significant, encompassing freshwater, brackish, and estuarine systems. Important species include hilsa (*Tenualosa ilisha*), bhetki (*Lates calcarifer*), and shrimp such as tiger shrimp (*Penaeus monodon*) and whiteleg shrimp (*Litopenaeus vannamei*). Inland aquaculture is widespread, with cultured species including rohu, catla, mrigal (*Cirrhinus cirrhosus*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), and tilapia (*Oreochromis mossambicus*). The Farakka Barrage disrupts the upstream migration of hilsa, leading to reduced populations upstream and greater concentration in downstream and estuarine regions. Across the stretch, fisheries are further affected by pollution, altered flow regimes, and unsustainable fishing practices, including the use of fine-mesh nets.

(f) Biotic resources: Fuelwood and fodder

Upper Ganga Stretch: Fuelwood and fodder remain critical ecosystem services in the Upper Ganga stretch, particularly in mountain and mid-altitude villages. In Dharali, a significant proportion of

households depend on forest-derived fuelwood, while fodder is sourced from both forests and agricultural fields. In Matli, the collection of fodder and fuelwood often requires long-distance travel (15–20 km) into forest areas, reflecting increasing scarcity and labour intensity. Additionally, the use of non-timber forest products (NTFPs), including medicinal plants, has declined due to reduced traditional ecological knowledge (TEK) and changing livelihood patterns. In foothill and plains villages such as Bisanpur and Dudhala Dayalwala, dependence on fuelwood has decreased due to the adoption of LPG and alternative energy sources, while fodder is increasingly cultivated within agricultural fields. This indicates a transition from forest-dependent systems to agriculture-based resource systems. However, pressures on forest resources in upstream areas and changes in energy use patterns downstream highlight the need for sustainable resource management across the gradient.

Middle Ganga Stretch: Fuelwood and fodder availability varies with proximity to forests, wetlands, and agricultural systems. In wetland and forest-adjacent areas, natural vegetation provides grasses and biomass for fodder and thatching. Species such as kans (Saccharum spontaneum) and other reeds are commonly used. In agricultural landscapes, plantations of poplar and eucalyptus provide fuelwood, supplemented by crop residues and cow dung. In areas where access to forests and wetlands is restricted (e.g., Protected Areas), communities increasingly rely on cultivated fodder and market sources. In upland and intensively cultivated areas, shrinking common lands have reduced availability of grazing and fodder resources. This has led to increased pressure on agricultural residues and a shift towards stall feeding. Overall, traditional dependence on natural vegetation is gradually being replaced by managed and cultivated sources, reflecting changing land-use patterns and institutional constraints.

Lower Ganga Stretch: Fuelwood and fodder availability is influenced by access to natural vegetation and land-use patterns. In upstream floodplain areas, communities depend on riverine grasses (e.g., kans, munj), crop residues, and scattered trees, with floodplain vegetation playing a key role. In downstream and urban-influenced areas, access to natural vegetation is limited due to wetland conversion, aquaculture expansion, and infrastructure development, leading to increased reliance on plantation species, wetland vegetation, and market-based sources. In wetland-adjacent areas, grasses and aquatic vegetation provide important fodder resources, though access may be regulated. Overall, there is a shift from common property resource-based systems upstream to managed and market-dependent systems downstream.

(g) Abiotic resources

Upper Ganga Stretch: Abiotic resources such as sand, gravel, and stone are widely used for construction across the Upper Ganga stretch, but their extraction patterns vary spatially. In mountain villages such as Dharali, extraction is largely small-scale and subsistence-oriented, using locally available materials for housing and infrastructure. In mid-altitude villages such as Matli, reduced river flow due to upstream hydropower projects has exposed riverbeds, facilitating increased access to sediments and potential over-extraction. In foothill areas such as Kunao and Ganga Bhogpur Malla and Talla, larger-scale and sometimes mechanised sand mining occurs, particularly in areas with high sediment deposition. However, regulatory frameworks such as the Bhagirathi Eco-Sensitive Zone have restricted mining activities in certain upstream areas (e.g., Ganeshpur), highlighting the role of policy in shaping resource use. Overall, abiotic resource extraction reflects a transition from localised use in mountains to more commercialised extraction in foothills, with associated environmental implications.

Middle Ganga Stretch: Abiotic resource use, particularly sand and gravel extraction, is widespread across the Middle Ganga stretch. In riverbank and floodplain areas, local communities extract sand for construction purposes, often at small scales. In some stretches, particularly outside protected zones, mechanised extraction also occurs. In areas near barrages and altered flow regimes, sediment deposition patterns are modified, influencing availability of extractable material. While these resources provide economic benefits, extraction contributes to riverbank erosion, habitat degradation, and changes in channel morphology. In wetland-adjacent and Protected Areas, large-scale extraction is restricted; however, small-scale extraction persists. The cumulative impact of these activities includes reduced land stability, altered groundwater recharge, and impacts on agricultural land. Thus, abiotic resource use reflects a balance between local livelihood needs and ecological sustainability concerns.

Lower Ganga Stretch: Abiotic resource use reflects geomorphic conditions. In upstream and sediment-rich zones, active deposition supports sand and gravel extraction from riverbeds and shoals, providing livelihood opportunities but contributing to erosion and habitat degradation. In contrast, downstream stretches with reduced sediment load (due to upstream barraging) have limited sand deposition, reducing extraction potential. Instead, the river in these areas provides important transport and navigation services, particularly along the Bhagirathi–Hooghly (National Waterway-1), supporting movement of goods and people. Thus, abiotic services shift from material extraction upstream to transport and connectivity downstream.

5.4.2.2. Regulation and Maintenance Services

(a) Provision of habitat for biodiversity

Upper Ganga Stretch: The Upper Ganga stretch supports diverse ecosystems that provide habitats for a wide range of species. In mountain and mid-altitude regions, habitats support cold-water fish species (snow trout, mahseer), Eurasian otter, and riverine birds, as well as diverse forest flora. However, hydropower projects and altered flow regimes have fragmented habitats and disrupted ecological connectivity, particularly affecting fish migration (e.g., in Ganeshpur and Matli). In foothill and plains areas, biodiversity is influenced by agricultural expansion, pollution, and habitat modification, although protected areas such as Rajaji National Park and Jhilmil Jheel Conservation Reserve play an important role in conservation. Overall, habitat provision is under increasing pressure due to infrastructure development, land-use change, and hydrological alterations, with impacts varying across the altitudinal gradient.

Middle Ganga Stretch: The Middle Ganga stretch provides diverse habitats across river channels, floodplains, wetlands, and tributaries. Key species include Gangetic dolphin (*Platanista gangetica*), gharial (*Gavialis gangeticus*), mugger (*Crocodylus palustris*), smooth-coated otter (*Lutrogale perspicillata*), turtles, and numerous fish and bird species. Wetland ecosystems support species such as barasingha (*Rucervus duvaucelii*) and migratory waterbirds. In upstream and relatively less disturbed stretches, habitat quality is comparatively better, while downstream and urban-influenced stretches experience degraded conditions due to pollution and flow alteration. Wetland-adjacent areas serve as biodiversity hotspots but are also subject to access restrictions. Habitat degradation is linked to riverbed farming, sand mining, pollution, and altered hydrology, which affect breeding, nesting, and feeding sites. Community observations indicate declining biodiversity, particularly in areas with high anthropogenic

pressure. Thus, biodiversity distribution is closely tied to hydrological connectivity, land use, and conservation status.

Lower Ganga Stretch: The Lower Ganga stretch supports diverse habitats across river channels, floodplains, wetlands, and estuarine ecosystems, with clear spatial variation in species composition. In upstream freshwater reaches and floodplain–wetland complexes, habitats support key aquatic and semi-aquatic fauna including the Gangetic dolphin (*Platanista gangetica*), mugger, and freshwater turtles such as the Indian softshell turtle (*Nilssonia gangetica*), Indian roofed turtle (*Pangshura tecta*), and red-crowned roofed turtle (*Batagur kachuga*). These habitats are particularly important in protected stretches such as the Vikramshila Dolphin Sanctuary and along river islands, side channels, and oxbow lakes. Floodplain wetlands and lakes serve as critical habitats for resident and migratory birds, including storks, herons, and waterfowl, with internationally significant sites such as Kanwar Jheel (Bihar), Udhwa Lake Bird Sanctuary (Jharkhand), and Baraila Lake (Salim Ali–Jubba Sahni Bird Sanctuary) supporting high avifaunal diversity. These wetlands function as breeding, feeding, and stopover habitats along migratory flyways.

In downstream stretches (Bhagirathi–Hooghly and estuarine zones), ecosystems transition to brackish and tidal environments, supporting species such as hilsa, bhetki, and estuarine crustaceans. Wetlands such as the East Calcutta Wetlands (Ramsar Site) and Purbasthali Wetland provide critical habitats for fish, birds, and other aquatic organisms, while also supporting ecosystem functions such as wastewater assimilation. Further downstream, the river–sea interface connects to mangrove ecosystems of the Sundarbans, which serve as nurseries for fish and provide habitat for a wide range of aquatic and terrestrial species. However, across the stretch, habitat quality is increasingly threatened by hydrological alteration, pollution, salinity intrusion, and habitat fragmentation, affecting species distribution and ecological integrity.

(b) Soil fertility

Upper Ganga Stretch: Soil fertility in the Upper Ganga stretch is generally high due to natural sediment deposition from rivers and streams, particularly in mountain and mid-altitude villages such as Ganeshpur and Matli. These sediments replenish nutrients and support agricultural productivity. However, the shift toward horticulture in villages such as Dharali has increased reliance on chemical fertilisers and pesticides, potentially affecting long-term soil health. In foothill and plains villages, soil fertility remains high but is increasingly maintained through external inputs such as fertilisers and irrigation, reflecting intensive agricultural practices. While this enhances productivity, it also raises concerns about soil degradation, nutrient imbalance, and environmental sustainability. Thus, soil fertility transitions from naturally maintained systems in mountains to input-dependent systems in plains.

Middle Ganga Stretch: Soil fertility across the Middle Ganga stretch is strongly influenced by geomorphology and sediment dynamics. In floodplain (Khadar) regions, periodic flooding deposits nutrient-rich sediments, supporting high fertility and intensive agriculture. In contrast, upland (Bangar) regions have coarser soils with lower nutrient content, requiring significant fertiliser inputs. In downstream areas affected by barrages, reduced sediment transport limits natural nutrient replenishment, increasing dependence on chemical inputs. In wetland-adjacent areas, soils benefit from moisture retention and organic matter but may also face issues of waterlogging. Continuous cropping and heavy agrochemical use across regions are contributing to declining soil health. Thus, soil fertility reflects a gradient shaped by river dynamics, sediment flow, and agricultural practices.

Lower Ganga Stretch: Soil fertility is closely linked to sediment dynamics. In upstream floodplains, regular deposition of nutrient-rich sediments supports high fertility and intensive agriculture. In downstream and deltaic regions, reduced sediment supply due to the Farakka Barrage and upstream dams, combined with salinity intrusion, leads to declining soil quality. In wetland-adjacent areas, soils may retain moisture and organic matter but are vulnerable to waterlogging. Thus, soil fertility shows a clear gradient from sediment-enriched upstream systems to sediment-deficient and salinity-affected downstream systems.

(c) Waste management

Upper Ganga Stretch: Waste management in the Upper Ganga stretch is largely characterised by decentralised sewage disposal systems and limited treatment infrastructure. In mountain and mid-altitude villages such as Dharali, Ganeshpur, and Matli, households primarily rely on septic tanks and soak pits, with excess wastewater often draining into nearby streams, especially during monsoon periods. This leads to indirect discharge of untreated sewage into the Bhagirathi. Although overall sewage generation is relatively low in upstream villages, seasonal tourism increases wastewater loads, exacerbating localised pollution. In foothill and plains villages such as Bisanpur and Dudhala Dayalwala, higher population density results in greater volumes of untreated or partially treated sewage being discharged into drains, canals, and the river. Overall, the absence of adequate sewage treatment systems, combined with increasing human pressures, is contributing to declining water quality along the river, particularly in downstream areas.

Middle Ganga Stretch: Waste management practices vary but are generally inadequate across the region. In many villages, ponds and local water bodies function as sewage disposal sites, leading to contamination of water systems. During monsoon, overflow from these systems spreads pollutants into rivers and agricultural fields. In downstream and urban-influenced stretches, untreated sewage and industrial effluents significantly degrade water quality. Communities reported visible pollution, including discoloration and fish mortality. In tourism-intensive and religious sites, improper disposal of solid waste and ritual offerings contributes to environmental degradation. These conditions promote eutrophication and invasive species proliferation (e.g., water hyacinth). Overall, waste management challenges are linked to lack of infrastructure, high population pressure, and inadequate regulation, with impacts varying across upstream, downstream, and wetland-influenced areas.

Lower Ganga Stretch: Waste management challenges vary spatially. In upstream rural areas, domestic sewage and agricultural runoff are often discharged into rivers, ponds, and wetlands, leading to localized pollution. In downstream urban and industrial zones, pollution is more severe due to industrial effluents and large-scale sewage discharge, particularly along the Bhagirathi–Hooghly corridor. The East Calcutta Wetlands serve as a major nature-based wastewater treatment system, where treated wastewater supports fisheries and agriculture, though this system is increasingly under stress from urban expansion and contamination. Across regions, poor solid waste management, especially at ghats and during festivals, contributes to environmental degradation.

5.4.2.3 Cultural Services

Cultural ecosystem services along the Ganga River are deeply embedded in the religious, spiritual, and socio-cultural fabric of communities, with the river revered as *Maa Ganga* and shaping belief systems, rituals, and livelihoods along its course. Together, the Upper, Middle, and Lower stretches form a continuous cultural landscape, where ecological features are closely intertwined with religious practices,

identities, and traditions. While the Upper Ganga reflects strong pilgrimage linkages and sacred origins, the Middle Ganga represents one of the most culturally and spiritually significant riverine regions globally, and the Lower Ganga embodies a diverse continuum of cultural and livelihood values across floodplain and deltaic environments.

Upper Ganga Stretch: Along the Upper Ganga stretch, cultural services exhibit a clear spatial gradient from mountain villages to foothill and plains settlements, but remain central to community identity throughout. Villages such as Dharali, Ganeshpur, Matli, Kunao, Ganga Bhogpur Malla and Talla, Bisanpur, and Dudhala Dayalwala are closely linked to pilgrimage routes, ritual practices, and river-based cultural traditions. In upstream mountain villages such as Dharali, cultural significance is closely associated with the Gangotri pilgrimage route, with the nearby Gangotri Temple forming part of the Char Dham Yatra. Dharali also serves as a key node in the seasonal movement of the deity, with the winter abode of Goddess Ganga located at Mukhba village, reinforcing strong cultural ties between communities and the river. Pilgrimage-related activities provide important livelihood opportunities through homestays, local markets, and transport services, while also increasing seasonal pressure on local resources. In mid-altitude villages such as Ganeshpur and Matli, cultural practices include ritual bathing, cremation at river ghats, and local festivals such as Magh Mela and Panchkoshi Yatra, often centred around river confluences (*prayags*) and ghats that serve as focal points for religious and social gatherings. Further downstream, Devprayag holds exceptional significance as the confluence of the Bhagirathi and Alaknanda rivers, marking the origin of the Ganga and attracting pilgrims year-round for spiritual practices and offerings. In the foothills and plains, cultural services intensify around major religious centres such as Rishikesh and Haridwar, which are closely associated with villages like Kunao, Bisanpur, and Dudhala Dayalwala. These centres are global hubs of pilgrimage, yoga, and spiritual tourism, hosting daily rituals such as the Ganga Aarti, as well as large-scale religious gatherings including the *Kumbh Mela* and *Kavad Yatra*, which draw millions of devotees. Across the stretch, these cultural practices provide substantial livelihood opportunities and sustain rich cultural heritage. However, increasing tourism, infrastructure development, and environmental pressures are transforming traditional cultural landscapes, contributing to waste generation and resource stress. Overall, cultural ecosystem services in the Upper Ganga stretch remain highly resilient and integral to community identity, but require careful management to balance spiritual, economic, and ecological sustainability.

Middle Ganga Stretch: Along the Middle Ganga stretch, cultural services are strongly embedded across the riverscape, with clear spatial associations along confluence zones and major riverbank settlements, where ritual bathing, religious ceremonies, and festivals form central practices. A continuous sacred geography is evident through major urban centres and pilgrimage nodes such as Prayagraj, Varanasi, Kannauj, Bithoor, and Garh Mukteshwar along the river corridor. Among these, Prayagraj—situated at the Triveni Sangam, the confluence of the Ganga, Yamuna, and the mythical Saraswati—holds exceptional religious significance and is regarded as one of the holiest sites in Hinduism. Ritual bathing at this confluence is believed to cleanse sins and confer spiritual merit, making it a focal point of faith and pilgrimage.

Varanasi, one of the oldest continuously inhabited cities in the world, represents another major spiritual centre where the Ganga is revered as a living deity. Rituals such as the daily Ganga Aarti, cremation ceremonies at ghats like Manikarnika, and immersion practices underscore the river's central role in life–death cycles and the pursuit of moksha (liberation). The dense network of ghats, temples, and ashrams reinforces the city's enduring religious centrality. The cultural significance of the river is further amplified

by large-scale and cyclical religious gatherings. The Kumbh Mela at Prayagraj, held every six years, is among the largest human congregations globally, attracting millions of pilgrims for ritual bathing at the Sangam. The annual Magh Mela, along with festivals such as Kartik Purnima and Ganga Dussehra across riverbank settlements, sustains continuous engagement with the river. These events transform riverbanks into dynamic socio-cultural landscapes, characterised by temporary infrastructure, ritual performances, and religious discourse.

At more local scales, villages located near confluences, ghats, and sacred sites host periodic congregations during *Purnima* (full moon) and *Amavasya* (new moon), reflecting localized expressions of river-based spirituality. These practices are often embedded in oral traditions and mythological narratives from epics such as the *Mahabharata* and *Ramayana*, reinforcing the river's place within a broader civilizational memory.

Cultural services also underpin a wide range of livelihoods, including priesthood, ritual services, boat operations, hospitality (dharmshalas, ashrams, homestays), and the sale of religious goods. In addition, riverfronts, wetlands, and barrages provide recreational and aesthetic value, supporting activities such as boating, pilgrimage tourism, and birdwatching, particularly in wetland-adjacent areas. However, increasing tourist inflow and mass gatherings exert significant pressure on river ecosystems, leading to challenges such as solid waste accumulation, sewage discharge, and declining water quality. Despite these pressures, cultural connections to the river remain strong, reflecting a deep and enduring integration of ecological processes with spiritual, cultural, and socio-economic life across scales—from local village ghats to globally significant pilgrimage centres.

Lower Ganga Stretch: In the Lower Ganga stretch, the river is revered as a sacred entity, and its confluences, ghats, wetlands, and river–sea interface form important cultural nodes. In upstream and confluence zones, cultural practices are closely linked to riverbank settlements and tributary confluences, where ritual bathing, offerings, and seasonal festivals are integral to community life. Major riverine fairs such as the Sonepur Cattle Fair (at the Ganga–Gandak confluence) and the Dadri Mela (Ballia district) are among the largest traditional fairs in India, combining religious significance with trade, particularly livestock exchange. In the Rajmahal hills region, the Rajkiya Maghi Purnima Mela reflects the cultural and spiritual traditions of indigenous communities, particularly the Santhals, highlighting the integration of riverine ecosystems with tribal belief systems. These events demonstrate how riverscapes function as centres of cultural exchange, trade, and social cohesion.

In midstream and downstream stretches of the Bhagirathi–Hooghly system, the river continues to hold strong religious significance and is widely worshipped as the Ganga. Important cultural centres such as Nabadwip and Mayapur, located at the confluence of the Hooghly and Jalangi rivers, are globally recognised pilgrimage sites associated with the Vaishnav tradition and the headquarters of ISKCON. These centres attract large numbers of national and international pilgrims and are hubs of religious learning, festivals, and cultural dissemination.

Cultural significance culminates in the lower estuarine zone at Gangasagar (Sagar Island), where the river meets the Bay of Bengal. The Gangasagar Mela, held annually during Makar Sankranti, is one of the largest religious gatherings in India. Pilgrims undertake ritual bathing (*Snan*) at the confluence and perform rites such as *Shraddha*, which are believed to confer *moksha* (liberation from the cycle of rebirth). The presence of the Kapil Muni Ashram further enhances the site's spiritual importance. This river–sea confluence represents a unique intersection of hydrological, ecological, and spiritual systems.

Cultural practices across the Lower Ganga are also shaped by local ecological contexts. In the estuarine and mangrove-influenced regions, communities revere nature-associated deities such as Banbibi and Manasa, reflecting adaptation to environmental risks such as wildlife encounters and flooding. Festivals such as Chhath Puja, Ganga Dussehra, Makar Sankranti, and Durga Puja are widely celebrated along the river, reinforcing the river's centrality in cultural life.

The Lower Ganga also supports diverse forms of recreation and tourism. Upstream wetlands and river stretch offer opportunities for birdwatching and dolphin sightings, while downstream regions support pilgrimage tourism (e.g., Gangasagar, Nabadwip), heritage tourism (e.g., Kolkata), and coastal tourism. The Bhagirathi–Hooghly riverfront, with major port cities such as Kolkata and Haldia and iconic structures like the Howrah Bridge, contributes to a dynamic cultural landscape. Additionally, culinary traditions, particularly centred around species such as hilsa, form an important component of cultural identity in downstream regions.

Overall, the Lower Ganga stretch represents a multi-scalar cultural system, where local traditions, regional pilgrimage networks, and globally significant religious gatherings are interconnected with riverine ecology. However, increasing tourism pressure, urbanisation, and pollution are placing stress on these cultural landscapes, leading to issues such as waste accumulation, degradation of water quality, and reduced aesthetic value. The persistence of these cultural services depends on maintaining the ecological integrity of river systems, highlighting the need for integrated management approaches.

Table 5.3. An overview of the ecosystem services and drivers of change along the Ganga River

Ganga River Stretch	Ecosystem Services	Drivers of Change (Natural and Anthropogenic)
Upper Ganga Stretch *Origin of glacial rivers; Himalaya; Himalayan foothills; Terai* *Hydroelectric projects; religious, spiritual and adventure tourism, and related developments such as road construction and urban sprawl* *Rivers: Bhagirathi, Alaknanda, Dhauliganga, Ganga* *Wetlands: Tehri Dam reservoir, Bhimgoda Barrage reservoir, Jhilmil Jheel Conservation Reserve*	**Provisioning Services** ➢ Water for drinking and domestic use: Mountains → sourced from streams, springs, and lakes (e.g., Saat Tal), with seasonal shortages and pipeline damage; Foothills/plains → primarily groundwater (tube wells, handpumps) and canal supply from Bhimgoda Barrage, with higher reliability but increasing extraction pressure. ➢ Water for irrigation: Mountains → stream-fed canals (guls), highly seasonal and climate-sensitive; Foothills/plains → groundwater and canal irrigation supporting intensive agriculture, with concerns of over-extraction. ➢ Agriculture: Mountains → horticulture (apple, cherry), rajma, millets, potato; declining traditional crops and high wildlife depredation; Foothills/plains → rice-wheat systems, sugarcane, vegetables, fodder crops, supported by irrigation and inputs. ➢ Livestock: Mountains → grazing-based systems (Badri cows, sheep, goats), declining pastoralism and long-distance fodder collection; Foothills/plains → stall-fed cattle and buffaloes with cultivated fodder. ➢ Fishing: Mountains → limited due to religious beliefs; species include brown trout; Mid-altitudes → snow trout, mahseer, catfish affected by dams; Foothills/plains → more active subsistence/commercial fishing, impacted by pollution. ➢ Fuelwood and fodder: Mountains → forest-dependent with high labour burden; Foothills/plains → reduced fuelwood use (LPG), fodder cultivated. ➢ Abiotic resources: Mountains—small-scale sand/stone extraction; Mid-altitudes → greater access due to reduced flows; Foothills → larger-scale, sometimes mechanised mining. **Regulation & Maintenance Services** ➢ Soil fertility: Mountains → naturally maintained through sediment deposition; Foothills/plains → maintained through fertilisers and irrigation inputs. ➢ Hydrological regulation: Mountains → natural flow regimes altered by hydropower projects (e.g., Maneri Bhali I & II, Tehri); Foothills/plains → regulated flows with reduced natural variability. ➢ Sediment transport and erosion: Mountains → active geomorphic processes, landslides, erosion; Foothills/plains → altered sediment dynamics due to dams and river regulation. ➢ Flood regulation: Mountains → settlements at higher elevations reduce exposure but flash floods affect agriculture; Foothills/plains → greater floodplain exposure with embankment-based control. ➢ Habitat for biodiversity: Mountains → support cold-water species (snow trout, mahseer), otters, birds; Foothills/plains → habitats modified by agriculture and settlements, with some conservation areas (e.g., Rajaji landscape).	• Geophysical and climatic factors: Geologically fragile and climate-sensitive region, with climate variability affecting rainfall, snowfall, and water availability, influencing hydrology and ecosystem stability. • Hydropower development: Multiple projects including Maneri Bhali I & II, Tehri, Koteshwar, Vishnuprayag, Srinagar, and Chilla, along with barrages in foothill regions, alter river flow regimes, sediment transport, and aquatic habitats, leading to habitat fragmentation and reduced ecological connectivity. • Infrastructure development: Large-scale projects such as the Char Dham road, tunnelling for hydropower, and the Rishikesh–Karnaprayag rail line contribute to landslides, slope instability, and increased sediment load in rivers. • Tourism and urbanisation pressures: Rapid growth in Char Dham Yatra, Kumbh Mela, and Kavad Yatra, along with expansion of towns such as Rishikesh, Haridwar, and Uttarkashi, has led to unplanned urbanisation, infrastructure expansion, increased resource demand, and waste generation. • Waste and pollution: Increasing sewage discharge and solid waste generation from settlements and tourism, along with industrial pollution in downstream areas, contribute to declining water quality and loss of aquatic biodiversity. • Agricultural intensification and land-use change: Expansion of agriculture into river floodplains, use of chemical fertilisers leading to nutrient runoff and eutrophication, and shift toward input-intensive systems in foothills and plains. • Sand mining and resource extraction: Both regulated and illegal sand mining, particularly in foothill areas

	➢ Waste management (sewage): Mountains → low volumes but untreated discharge into streams, especially during tourism peaks; Foothills/plains → higher sewage loads discharged into drains, canals, and river, contributing to pollution. **Cultural Services** ➢ Religious and spiritual value: Mountains → linked to Gangotri pilgrimage and local rituals; Foothills/plains → major centres near Haridwar and Rishikesh with large-scale religious activities. ➢ Cultural practices: Mountains → local festivals, river-based rituals (e.g., *Panchkoshi Yatra*, *Magh Mela*); Foothills/plains → larger congregations and ritual practices at ghats. ➢ Recreation and tourism: Mountains → pilgrimage tourism, trekking, nature-based livelihoods; Foothills/plains → mass tourism (*Kumbh Mela*, *Kavad Yatra*), rafting, urban tourism hubs. ➢ Livelihood linkages: Mountains → small-scale, seasonal tourism economies; Foothills/plains → more commercialised tourism with higher economic returns but greater ecological pressure.	with high sediment deposition, altering river morphology and ecological processes. • Biodiversity and fisheries decline: Loss of fish populations due to altered flows, habitat fragmentation, and water pollution from domestic and industrial sources. • Protected Areas (PAs): PAs support biodiversity conservation and tourism potential, but also restrict access to forest resources, affecting local livelihoods. • Socio-economic transitions: Shift from traditional livelihoods (agriculture, pastoralism, fishing) to tourism and migratory labour, accompanied by decline in traditional ecological knowledge (TEK) and changing cultural practices.
Middle Ganga Stretch *Gangetic plains; confluences with Ramganga, East Kali, Yamuna, Gomti, Solani* *Barrages; extensive and intensive agricultural cultivation; religious and tourism centres; large cities; urban sprawl* *Rivers: Ganga, Solani, East Kali* *Wetlands: Haiderpur wetland, Upper Ganga River*	**Provisioning Services** ➢ Water for drinking and domestic use: Groundwater is the dominant source, accessed through handpumps, submersible pumps, and piped supply schemes; depth of extraction varies spatially (shallow in floodplains and near wetlands, deeper in inland areas with declining water tables). In some villages, government water tanks supplement supply. Surface water is rarely used directly for drinking due to pollution, but is used for bathing and washing. Groundwater quality is increasingly threatened by seepage of sewage and agrochemicals. ➢ Water for irrigation: Irrigation is supported through a combination of canal systems (Upper, Lower, and Madhya Ganga canals), pump canals, and direct abstraction from the river upstream of barrages. However, unreliable canal supply has led to high dependence on private tube wells. Groundwater irrigation dominates, especially in downstream and inland areas, increasing energy costs (diesel/electric pumps). Riverbank farmers directly pump river water where accessible, while barrage-induced flow reduction constrains availability downstream. ➢ Agriculture: Highly intensive agriculture with multi-season cropping (Rabi, Kharif, Zaid), dominated by water-intensive crops such as sugarcane and paddy, alongside wheat and pulses. Riverbed (Diara) farming supports seasonal cultivation of cucurbits (watermelon, muskmelon, gourds). Soil fertility is high in Khadar (flood-replenished) areas but moderate to low in Bangar regions, necessitating heavy fertiliser use. Increasing mechanisation, input dependency, and market linkages characterise the agricultural system. ➢ Livestock: Livestock (cows, buffaloes, goats, sheep, poultry) form an important livelihood component. Water is sourced from rivers, ponds, canals, and groundwater. Riverbanks, wetlands, and forest edges serve as grazing areas, though access is increasingly restricted due to protected area regulations. Stall-feeding is common where grazing land is limited. Livestock also rely on agricultural residues and cultivated fodder (e.g., jowar, bajra).	• Hydrological alterations: Construction of barrages, canals, and pump canals has significantly altered natural flow regimes, reducing downstream discharge, impairing dilution of pollutants, and limiting water availability for downstream irrigation. These interventions have also led to upstream inundation and wetland formation (e.g., Haiderpur), and increased flow fragmentation. • Groundwater depletion: Extensive extraction of groundwater through private tube wells has led to a significant decline in water tables, resulting in seasonal water scarcity, especially during dry periods. Increasing dependence on groundwater is driven by unreliable canal irrigation, despite localized recharge in floodplain and wetland areas. • Agricultural intensification and land use change: Expansion of irrigation-intensive crops (e.g., sugarcane, paddy) and riverbed (Diara) farming has increased pressure on land and water resources. Riverbank and riverbed cultivation encroach upon critical habitats of aquatic fauna, including breeding and basking sites of gharials, turtles, and waterbirds. Intensive agriculture has also contributed to declining soil fertility in some areas.

	➢ Fishing: Fishing is practiced both for subsistence and commercial purposes, with some stretches having leased fishing rights. However, fishing is restricted in protected areas (e.g., near wetlands and sanctuaries) and in religious towns. Fish diversity includes major carps and other freshwater species, but overall fish catch has declined due to pollution, reduced flows, and habitat fragmentation. Accidental capture of aquatic megafauna occurs due to fine-mesh nets. ➢ Fuelwood and fodder: Riverine grasses (*kans*, *munj*, *narkat*, *khus*) are widely used for fodder, thatching, and handicrafts. Limited forest patches and plantations (eucalyptus, poplar) provide fuelwood, supplemented by cow dung. Wetlands and floodplains also provide fodder resources. However, access to forest and wetland resources is increasingly regulated, reducing availability for local communities. ➢ Abiotic resources: Sand and gravel are extracted from riverbeds and banks for construction. Both artisanal/small-scale extraction by local communities and mechanised mining operations are present. These activities provide income but also alter river morphology, reduce bank stability, and affect groundwater recharge. **Regulation & Maintenance Services** ➢ Soil fertility: Flood-driven deposition of nutrient-rich sediments maintains high soil fertility in floodplain (Khadar) regions, supporting year-round cropping. However, sediment trapping upstream of barrages reduces nutrient replenishment downstream, increasing dependence on chemical fertilisers. Continuous cultivation and input use are contributing to declining soil health in some areas. ➢ Hydrological regulation: Floodplains, wetlands (e.g., Haiderpur), and river channels regulate water flow by storing excess water during monsoon and releasing it gradually, thereby supporting base flows and groundwater recharge. However, barrages, canals, and embankments have significantly altered natural flow regimes, leading to reduced downstream discharge, artificial flow control, and altered seasonal hydrology. ➢ Sediment transport and erosion: Natural sediment transport maintains channel morphology, floodplain formation, and Diara lands. Barrages interrupt sediment flow, causing upstream deposition and downstream sediment starvation. This alters erosion–deposition dynamics, leading to riverbank erosion in some areas and reduced soil fertility in others. Riverbank farming and sand mining further exacerbate erosion. ➢ Flood regulation: Natural floodplains and wetlands attenuate flood peaks and reduce flood risk. However, structural interventions such as embankments and barrages modify flood regimes, reducing flooding in some areas while increasing vulnerability in others (e.g., waterlogging upstream, erosion downstream). Seasonal flooding continues to affect agricultural lands, especially in low-lying areas. ➢ Habitat for biodiversity: The river system supports diverse aquatic and riparian biodiversity, including Gangetic dolphin, gharial, mugger crocodile, turtles, otters, fish, and migratory birds. Wetlands, oxbow lakes, and conservation reserves (e.g., Haiderpur, Jhilmil Jheel) provide critical habitats for species such as barasingha. However, habitat quality is declining due to pollution, flow alteration, and human disturbances.	• Agrochemical pollution: Heavy use of fertilisers and pesticides leads to agricultural runoff, particularly during the monsoon, resulting in river pollution, groundwater contamination, and reduced soil health and nutritional security. • Water pollution (domestic and industrial): Discharge of untreated or inadequately treated sewage from villages and urban centres, along with industrial effluents from major cities (e.g., Kanpur, Varanasi), has severely degraded water quality. Village ponds and local streams are also used as sewage disposal sites, further polluting freshwater systems. • Solid waste and tourism-related pollution: Improper disposal of solid waste, including religious offerings, contributes to river pollution, eutrophication, and proliferation of invasive species such as water hyacinth. • Biodiversity degradation: Habitat loss and fragmentation due to altered flows, riverbed farming, and sand mining have led to declining populations of aquatic and riparian species. Fisheries have declined due to pollution, reduced flows, and habitat degradation. • Unsustainable fishing practices: Year-round fishing and the use of fine-mesh nylon nets (e.g., seine and mosquito nets) contribute to overexploitation of fish stocks and accidental mortality of non-target species such as dolphins, turtles, and gharials. • Sand mining and river morphology changes: Unsustainable and mechanised sand mining causes habitat degradation, alters river morphology, lowers groundwater tables, reduces land availability for riverbank farming, and negatively impacts cultural and ecological services. • Geomorphological processes: Natural processes such as fluvial avulsion and channel migration contribute to the formation of extensive floodplains

	➢ Waste management (sewage): Rivers, ponds, and local streams act as sinks for domestic sewage, agricultural runoff, and, in some areas, industrial effluents. While natural processes provide limited assimilation capacity, this function is severely degraded due to high pollution loads, leading to poor water quality, eutrophication, and proliferation of invasive species such as water hyacinth. **Cultural Services** ➢ Religious and spiritual value: The Ganga and Yamuna rivers are revered as sacred entities in Hinduism. Ritual bathing, daily river aarti, and offerings are integral practices. Sacred sites such as Varanasi, Prayagraj (Triveni Sangam), and Shukratal hold immense spiritual significance and attract pilgrims year-round. ➢ Cultural practices: Traditional practices include cremation at river ghats (e.g., Manikarnika Ghat in Varanasi), religious congregations, and ritual ceremonies. Large-scale festivals such as Kumbh Mela (every six years at Prayagraj), Magh Mela (annual), Kartik Purnima, and Ganga Dussehra attract massive gatherings. The riverscape is deeply embedded in cultural narratives linked to epics such as the Mahabharata and Ramayana. ➢ Recreation and tourism: Religious tourism dominates, supported by activities such as boating, pilgrimage visits, and participation in rituals. Wetlands and barrages provide additional recreational opportunities including birdwatching and eco-tourism. Scenic landscapes, temples, and ghats contribute to aesthetic value. However, tourism pressure leads to waste accumulation and environmental degradation. ➢ Livelihood linkages: A wide range of livelihoods are linked to river-based cultural and natural resources, including priesthood, boat services, guiding, handicrafts, hospitality (ashrams, dharmshalas, hotels), agriculture, fishing, livestock rearing, and resource extraction (sand, NTFPs). Increasing restrictions, environmental degradation, and economic transitions are influencing a shift towards wage labour and migration.	and meandering channels, influencing land use patterns and settlement dynamics. • Flood and erosion dynamics: Altered hydrology and infrastructure interventions modify natural flood regimes, leading to localized flooding, riverbank erosion, and waterlogging in certain areas. • Protected Area restrictions: Designation of protected areas (e.g., wetlands, wildlife sanctuaries) restricts community access to natural resources such as fisheries, fodder, fuelwood, riverine vegetation, and sand. • Human-wildlife conflict: Crop depredation by species such as nilgai and wild boar, and occasional livestock predation, has increased due to habitat changes and proximity to protected areas. • Urbanisation and infrastructure development: Expansion of urban and industrial areas, along with associated infrastructure, has intensified pressure on land, water resources, and ecosystems. • Socio-economic transitions: Rising costs of agriculture (diesel, irrigation, inputs) and declining productivity have contributed to a shift from traditional livelihoods (agriculture, livestock rearing, fishing) to wage labour and migration to urban centres and other agricultural regions. • Decline in cultural ecosystem services: Deteriorating water quality and pollution have reduced the use of rivers for cultural and religious practices such as bathing and rituals. Increasing tourism pressure has also led to environmental degradation of culturally significant sites.
Lower Ganga Stretch *Gangetic plains; confluences with Ghaghra, Son, Gandak, Kosi, Mahananda, Ajay, Damodar and Rupnarayan;*	**Provisioning Services** ➢ Water for drinking and domestic use: Upstream areas rely primarily on groundwater (40-350 ft), supplemented by direct river abstraction, ponds, and wetlands, with concerns of iron contamination and localized sewage pollution. In downstream stretches, domestic water is sourced from both groundwater and regulated freshwater flows through the Farakka feeder canal (Bhagirathi–Hooghly system), often treated through filtration plants. However, salinity intrusion in tidal and coastal zones increasingly affects water quality and potability, particularly in estuarine regions.	• Hydrological alteration: Barrages (notably Farakka) and canal systems regulate flows—upstream retains more natural variability, while downstream experiences controlled discharge, reduced freshwater flow, and altered hydrology, including tidal influence.

Sundarbans delta; mouth of the Ganga River *Transboundary water sharing; barrage; braided channels; lowland region interspersed with ox bow lakes and natural depression wetlands; large cities; urban sprawl; industrial centres; international and river ports; tidal dynamics (ingress, etc.)* *Rivers: Ganga, Budhi Gandak, Nagi* *Wetlands Baraila Lake (Salim Ali-Jubba Sahni Bird Sanctuary), Kanwar Jheel (or Kabartal Wetland), Nagi Bird Sanctuary, Udhwa Lake Bird Sanctuary, Purbasthali Wetland, the East Calcutta Wetlands*	➢ Water for irrigation: Upstream irrigation is supported by a combination of direct river pumping, wetlands, canal systems (e.g., pump canals), and groundwater, enabling multi-season cultivation. In downstream areas, irrigation depends on regulated river flows, lift irrigation systems, and groundwater, but is increasingly constrained by salinity ingress and unreliable freshwater availability in lower tidal zones. ➢ Agriculture: Upstream regions support intensive floodplain and Diara farming, facilitated by fertile alluvial soils and sediment deposition, with crops including rice, maize, jute, wheat, mustard, and vegetables such as onion, potato, cauliflower, tomato, brinjal, cucumber, and pointed gourd. Downstream agriculture remains diversified, with cropping patterns including rice, maize, jute, jowar, bajra (Kharif); mustard, lentil, potato, peas, onion, garlic, cauliflower, tomato (Rabi); and cucurbits (Zaid), along with horticulture (mango, guava, litchi, coconut, banana, palm) and betel nut plantations in coastal areas. However, reduced sediment load and salinity intrusion have led to declining soil fertility and cropping intensity in lower reaches. ➢ Livestock: Upstream livestock systems depend on floodplain grazing, riverbank pastures, crop residues, and seasonal use of river shoals (chars). In downstream areas, reduced grazing commons and land-use changes (e.g., aquaculture and urban expansion) have increased reliance on stall feeding, wetland vegetation, and agricultural residues, with livestock largely dependent on surface water sources. ➢ Fishing: Upstream fisheries are predominantly riverine and wetland-based, with species such as rohu (*Labeo rohita*), catla (*Catla catla*), tengra (*Mystus* spp.), *Wallago attu*, and *Clupisoma garua*. Downstream fisheries are more diversified and commercially significant, including freshwater, brackish, and estuarine systems, with species such as hilsa (*Tenualosa ilisha*), bhetki (*Lates calcarifer*), shrimp (*Penaeus* spp., *Litopenaeus vannamei*), and cultured species like silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), and tilapia (*Oreochromis mossambicus*). The Farakka Barrage disrupts Hilsa migration, leading to reduced upstream populations and greater concentration downstream. ➢ Fuelwood and fodder: Upstream communities depend on riverine grasses (kans, munj), crop residues, and scattered trees for fodder and fuelwood. Downstream, dependence shifts towards wetland vegetation *(kans*, *jharua*, *dhuna*), plantation species, and market sources, with reduced access to common grazing lands and increasing reliance on agricultural by-products. ➢ Abiotic resources: Upstream areas, characterised by active sediment deposition, support sand and gravel extraction from river shoals and banks for local use. In contrast, downstream stretches experience reduced sediment load due to upstream barraging, limiting deposition and making sand mining relatively less prevalent. Additionally, the downstream Bhagirathi–Hooghly system supports inland navigation (National Waterway-1), facilitating transport of bulk goods and passengers, and contributing significantly to regional economies. **Regulation & Maintenance Services**	• Sediment dynamics: High sediment load upstream supports floodplain fertility but causes channel instability and erosion; downstream sediment deficit due to upstream trapping reduces soil fertility and contributes to riverbank and coastal erosion. • Fluvial processes: Active avulsion, meandering, and braided channels upstream create dynamic floodplains and Diara lands, whereas downstream channels are more regulated but increasingly sinuous, with siltation and geomorphic changes. • Flood regime: Seasonal flooding upstream enhances soil fertility but causes land loss and displacement; downstream flooding is prolonged due to backwater effects, tidal influence, and low elevation, increasing waterlogging and disaster risk. • Groundwater stress: Over-extraction and contamination (e.g., arsenic) affect both regions, but water scarcity is more acute upstream in dry seasons, while downstream quality is further impacted by salinity intrusion. • Agricultural intensification: Intensive farming and agrochemical use in both regions drive runoff pollution and soil degradation; however, downstream agriculture is additionally constrained by salinity and reduced sediment inputs. • Pollution: Upstream pollution is dominated by agricultural runoff and urban sewage (e.g., Patna, Bhagalpur), while downstream experiences cumulative impacts from industrial effluents, ports, and urban centres (e.g., Kolkata, Haldia), along with poor waste management at ghats. • Wetland degradation: Wetlands upstream (e.g., Kanwar, Udhwa) are affected by eutrophication and invasive species, while downstream systems (e.g., East Calcutta Wetlands) face urban encroachment, industrial contamination, and reduced treatment capacity.

	➢ Soil fertility: Upstream floodplains benefit from regular sediment deposition, maintaining high soil fertility and supporting intensive agriculture. In contrast, downstream regions experience reduced sediment supply due to the Farakka Barrage and upstream dams, leading to declining soil fertility, particularly in deltaic and tidal areas. While sediments from tributaries (e.g., Ajay, Damodar, Rupnarayan) contribute locally, overall sediment load in the Bhagirathi–Hooghly system remains lower, affecting long-term soil productivity. ➢ Hydrological regulation: Upstream hydrology is characterised by dynamic flow regimes, wetlands, and active groundwater recharge zones, supporting natural regulation of water availability. Downstream systems are highly regulated, with freshwater flows controlled through the Farakka Barrage and distributed via the feeder canal, which also helps flush saline water and reduce tidal ingress in the Hooghly estuary. However, tidal influences still play a significant role in lower reaches. Groundwater recharge remains relatively high in parts of the Hooghly riverscape due to soil moisture retention, enabling multiple cropping seasons. ➢ Sediment transport and erosion: Upstream regions exhibit active fluvial processes such as meandering, avulsion, and braided channel formation, resulting in both erosion and deposition, shaping dynamic floodplains and Diara lands. Downstream, sediment trapping upstream and altered flow regimes reduce sediment availability, leading to channel instability, localized siltation, and increased coastal and riverbank erosion, particularly in deltaic zones. ➢ Flood regulation: Upstream flooding is seasonal and sediment-driven, contributing to soil fertility but also causing land loss, erosion, and displacement. Downstream, backwater effects of the Farakka Barrage, tidal dynamics, and low-lying topography result in prolonged flooding and waterlogging. In deltaic and coastal regions (e.g., Gangasagar), vulnerability is further exacerbated by cyclones, storm surges, and embankment breaches, while excess floodwaters are redistributed through distributary channels and drainage networks. ➢ Habitat for biodiversity: Upstream habitats support rich freshwater biodiversity, including Gangetic dolphin (*Platanista gangetica*), turtles, and migratory birds, particularly in wetlands and river islands. Downstream ecosystems transition into estuarine and coastal habitats, supporting brackish water species and mangrove-associated biodiversity, along with high avifaunal diversity in wetlands such as Purbasthali and East Calcutta Wetlands. However, these ecosystems face increasing stress from salinity intrusion, reduced freshwater inflows, and habitat modification. ➢ Waste management (sewage): Upstream rivers and wetlands provide limited natural assimilation capacity but are increasingly impacted by agricultural runoff and untreated domestic sewage. In downstream areas, systems such as the East Calcutta Wetlands function as large-scale nature-based wastewater treatment systems, where wastewater is naturally treated and reused for pisciculture and agriculture. However, their effectiveness is under pressure from urban expansion, industrial discharge, and increasing pollutant loads. **Cultural Services**	• Fisheries and biodiversity: The Farakka Barrage disrupts hilsa migration, reducing upstream populations while concentrating them downstream; overfishing, destructive gear, and navigation pressure affect aquatic biodiversity (e.g., Gangetic dolphins, turtles) across both regions. • Sand mining: More prevalent upstream due to active sediment deposition; reduced downstream sediment availability limits extraction but increases erosion vulnerability. • Climate change impacts: Downstream and deltaic regions are more vulnerable to sea-level rise, salinity intrusion, cyclones, and coastal erosion (e.g., Gangasagar), while upstream impacts are comparatively less severe. • Mangrove and coastal ecosystem loss: Primarily a downstream issue, where reduced freshwater inflow and rising salinity degrade mangroves, weakening coastal protection and affecting livelihoods. • Socio-economic transitions: Upstream regions face declining viability of traditional livelihoods and migration, while downstream areas show diversification into aquaculture, navigation, tourism, and industrial economies. • Tourism and cultural pressure: Localised upstream impacts contrast with large-scale downstream pressures, especially from pilgrimage tourism (e.g., Gangasagar Mela), leading to waste generation and infrastructure stress.

	➢ Religious and spiritual value: Upstream cultural practices are centred around local ghats, riverbank rituals, and confluences, with festivals such as Chhath Puja and Ganga Dussehra reflecting strong community-level engagement with the river. In addition, in the Rajmahal hills region (Jharkhand), the Rajkiya Maghi Purnima Mela is an important cultural and religious event celebrated by tribal communities, particularly the Santhals, reflecting indigenous spiritual connections with the river and surrounding landscapes. Downstream, the Bhagirathi–Hooghly is revered as the Ganga, and its confluences with tributaries such as Ajay, Damodar, Rupnarayan, and Jalangi are important religious sites. Major pilgrimage centres such as Nabadwip and Mayapur attract large numbers of devotees. Cultural significance culminates at Gangasagar (Sagar Island), where the river meets the Bay of Bengal; ritual bathing and rites such as Snan and Shraddha are believed to confer spiritual merit and moksha (liberation). ➢ Cultural practices: Upstream practices are largely localized and linked to seasonal river cycles, including large riverine fairs associated with confluences. Notably, the Sonepur cattle fair at the Ganga–Gandak confluence (Bihar)—widely regarded as Asia's largest cattle fair—and the Dadri Mela in Ballia district (Uttar Pradesh), considered one of India's largest cattle fairs, reflect long-standing traditions of trade, pilgrimage, and cultural exchange in upstream floodplain regions. Downstream, cultural practices are more large-scale and institutionalized, with major gatherings such as the Gangasagar Mela during Makar Sankranti, where pilgrims perform ritual bathing at the river–sea confluence and visit the Kapil Muni Ashram. In the Hooghly estuarine region, cultural identity is also shaped by aquatic resources, with species such as hilsa (*Tenualosa ilisha*) holding strong cultural and culinary significance, especially during festive periods. Local belief systems further include reverence for nature-associated deities such as Banbibi and Manasa, reflecting adaptation to ecological risks. ➢ Recreation and tourism: Upstream regions provide localized eco-cultural services, including birdwatching in wetlands and dolphin sightings. Downstream, tourism is more diversified and large-scale, encompassing pilgrimage tourism (Gangasagar, Nabadwip), heritage tourism (Kolkata, Mayapur), and coastal tourism. Wetlands such as Purbasthali and East Calcutta Wetlands offer opportunities for eco-tourism, while estuarine zones contribute to culinary tourism centred on fish (particularly Hilsa), shrimp, and other coastal resources. The Hooghly riverfront, with port cities such as Kolkata and Haldia and iconic structures like the Howrah Bridge, further enhances the cultural riverscape. ➢ Livelihood linkages: Upstream livelihoods are primarily subsistence-oriented, with strong linkages to agriculture, livestock, fishing, and periodic fairs such as Sonepur and Dadri that support trade-based incomes. In contrast, downstream areas exhibit diversified and market-linked livelihood systems, including aquaculture, fisheries (notably Hilsa-based), navigation (NW-1), port-based trade, tourism, and service sectors. Religious tourism and coastal economies provide additional livelihood opportunities, reflecting deeper integration with regional and global markets.	

Note: Ecosystem services in the Upper Ganga stretch are analysed across mountain, and foothills/Terai zones, while in the Lower Ganga stretch they are examined upstream and downstream of the Farakka Barrage

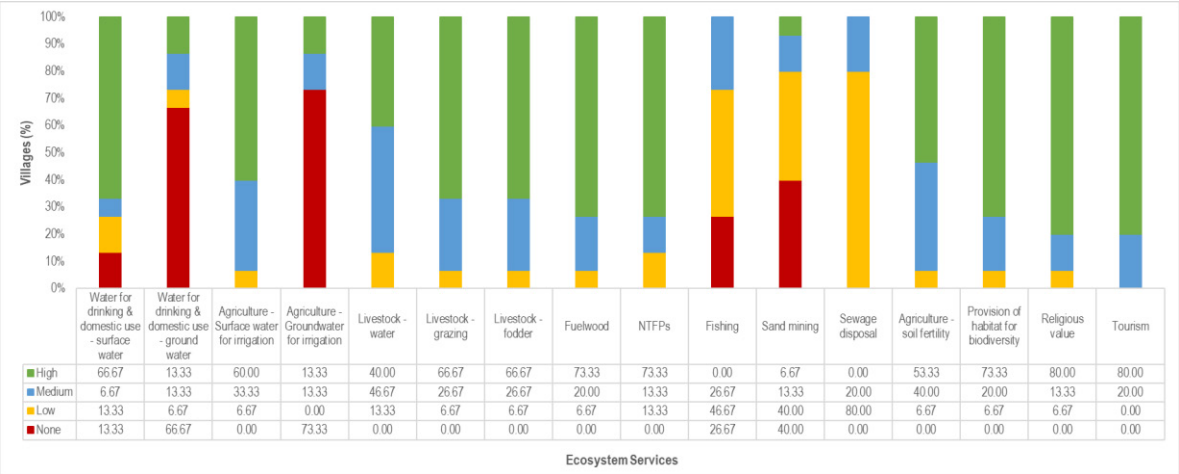
5.4.3. Perceived extent and trend of ecosystem services availed by the riverside communities

5.4.3.1. Extent

Upper Ganga Stretch: The perceived extent of provisioning ecosystem services in the Upper Ganga stretch indicates that several services are available at high levels across many villages (Figure 5.3). Surface water for drinking and domestic use was perceived to be high by 66.7% of villages, while 60% of villages reported high use of surface water for irrigation. Livestock-related services were also important, with 66.7% of villages reporting high use of grazing and fodder resources, and 40% reporting high use of water for livestock. Forest-based resources such as fuelwood and non-timber forest products (NTFPs) were perceived as high by 73.3% of villages. Fishing was perceived mostly at low (46.7%) and medium (26.7%) levels, indicating moderate reliance on riverine fisheries. In contrast, groundwater for irrigation (13.3% high) and sand mining (6.7% high) were perceived to have limited extent. These patterns reflect local hydrological conditions, where villages in mountainous areas rely primarily on streams for drinking, domestic use, and irrigation, while communities in the plains depend more on groundwater.

Regulation and maintenance services were generally perceived at moderate to high levels. Agricultural soil fertility was reported as medium by 40% and high by 53.3% of villages, highlighting the importance of riverine processes and fertile alluvial soils for agriculture. Similarly, the provision of habitat for biodiversity was perceived as medium by 20% and high by 73.3% of villages, indicating that the river and associated ecosystems continue to support ecological functions and biodiversity. In contrast, the regulating service related to sewage disposal was perceived to have limited extent, with none of the villages reporting it at high levels.

Cultural ecosystem services were perceived to be highly significant in the Upper Ganga stretch. Religious value and tourism were perceived as high by 80% of villages, reflecting the strong spiritual, cultural, and recreational importance of the river. These perceptions highlight the continued role of the Upper Ganga in supporting pilgrimage activities, cultural traditions, and nature-based tourism.



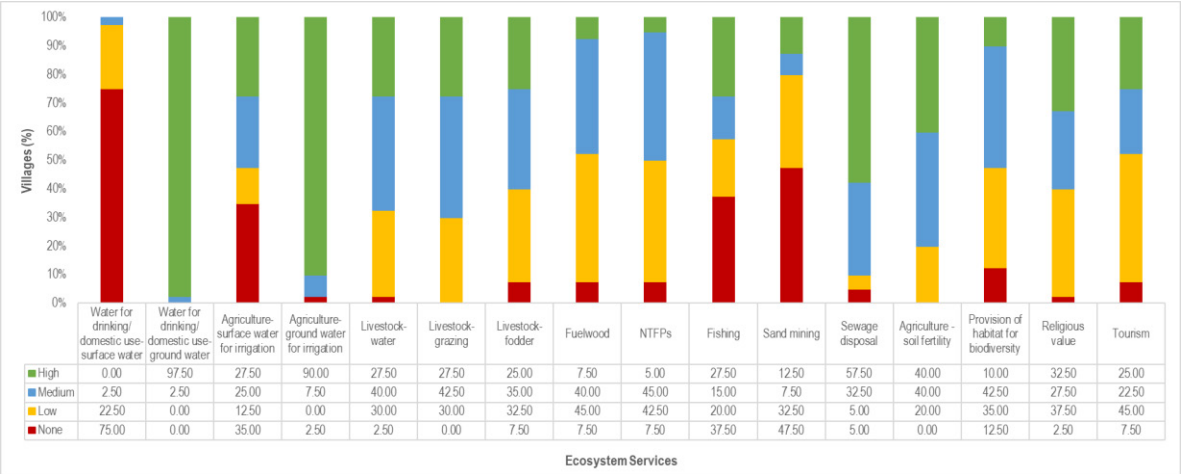
	Water for drinking & domestic use - surface water	Water for drinking & domestic use - ground water	Agriculture - Surface water for irrigation	Agriculture - Groundwater for irrigation	Livestock - water	Livestock - grazing	Livestock - fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
High	66.67	13.33	60.00	13.33	40.00	66.67	66.67	73.33	73.33	0.00	6.67	0.00	53.33	73.33	80.00	80.00
Medium	6.67	13.33	33.33	13.33	46.67	26.67	26.67	20.00	13.33	26.67	13.33	20.00	40.00	20.00	13.33	20.00
Low	13.33	6.67	6.67	0.00	13.33	6.67	6.67	6.67	13.33	46.67	40.00	80.00	6.67	6.67	6.67	0.00
None	13.33	66.67	0.00	73.33	0.00	0.00	0.00	0.00	0.00	26.67	40.00	0.00	0.00	0.00	0.00	0.00

Figure 5.3. Perceived extent of the ecosystem services at the grassroots along the Upper Ganga Stretch

Middle Ganga Stretch: In the Middle Ganga stretch, groundwater-related services were perceived to be used to the greatest extent among provisioning ecosystem services (Figure 5.4). Groundwater for drinking and domestic use was reported at high extent by 97.5% of villages, while 90% reported high extent of groundwater use for irrigation. Surface water for irrigation was perceived at moderate to high extent (25–27.5%), reflecting the strong dependence of agriculture on river water and irrigation systems. Livestock-related services were largely perceived at moderate levels of use, including livestock water (40% medium), grazing (42.5% medium), and fodder (35% medium). In contrast, forest-based resources such as fuelwood (45% low) and NTFPs (42.5% low) were perceived to be used to a relatively limited extent compared to the upper stretch. Fishing was perceived mostly at low (20%) and medium (15%) extent, while sand mining showed variable levels of use across villages.

Regulation and maintenance services were generally perceived to be used at moderate extent. Agricultural soil fertility and the provision of habitat for biodiversity were both reported as medium by about 40–42.5% of villages, indicating the continued role of the river in supporting agricultural productivity and ecological functions. Sewage disposal was perceived to occur at high extent in 57.5% of villages.

Cultural ecosystem services were perceived to be primarily low (45%) for tourism, and nearly evenly distributed for religious value (37.5% low, 27.5% medium and 32.5% high) in the Middle Ganga stretch, highlighting, indicating mixed cultural and recreational use of river-related ecosystem services by the riverside communities in the Middle Ganga stretch.



	Water for drinking/ domestic use- surface water	Water for drinking/ domestic use- ground water	Agriculture- surface water for irrigation	Agriculture- ground water for irrigation	Livestock- water	Livestock- grazing	Livestock- fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
High	0.00	97.50	27.50	90.00	27.50	27.50	25.00	7.50	5.00	27.50	12.50	57.50	40.00	10.00	32.50	25.00
Medium	2.50	2.50	25.00	7.50	40.00	42.50	35.00	40.00	45.00	15.00	7.50	32.50	40.00	42.50	27.50	22.50
Low	22.50	0.00	12.50	0.00	30.00	30.00	32.50	45.00	42.50	20.00	32.50	5.00	20.00	35.00	37.50	45.00
None	75.00	0.00	35.00	2.50	2.50	0.00	7.50	7.50	7.50	37.50	47.50	5.00	0.00	12.50	2.50	7.50

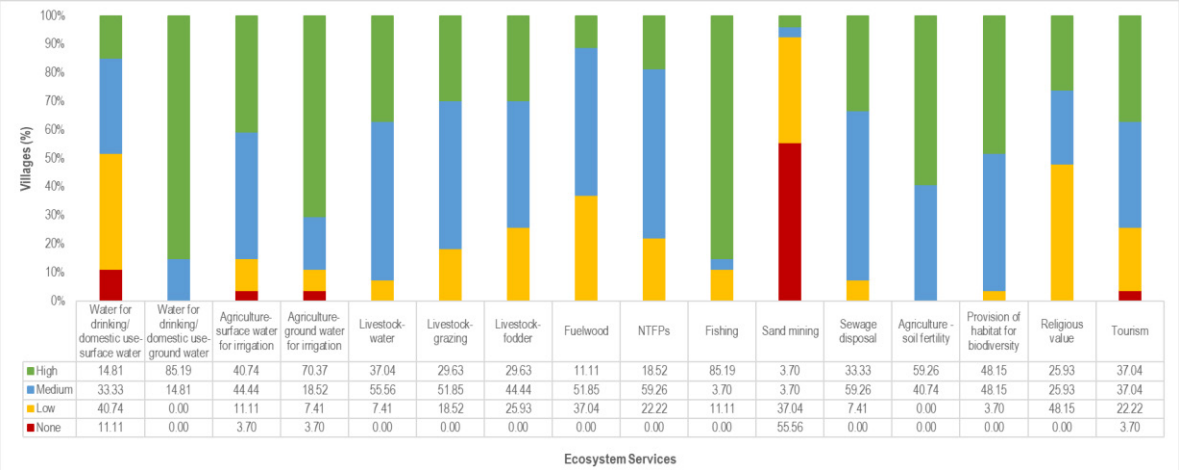
Figure 5.4. Perceived extent of the ecosystem services at the grassroots along the Middle Ganga Stretch

Lower Ganga Stretch: In the Lower Ganga stretch, the provisioning ecosystem services were primarily perceived to be used at moderate to high extent (Figure 5.5). Groundwater for drinking and domestic use was reported at high extent by 85.2% of villages, while 70.4% reported high extent of groundwater use for irrigation, indicating strong reliance on groundwater resources in this region. Fishing was also perceived at high extent by 85.2% of villages, reflecting the importance of riverine and floodplain fisheries. Surface water irrigation was reported at medium extent by 44.4% of villages and high by 40.7%. Livestock-related services were generally perceived at moderate levels, including livestock water (55.6% medium), grazing (51.9% medium), and fodder (44.4% medium). In contrast, fuelwood was perceived to

be used to a limited extent (37% low), while NTFPs were mostly reported at medium extent (59.3%). Sand mining showed relatively limited use across villages.

Regulation and maintenance services were perceived mostly at moderate levels of use. Agricultural soil fertility was reported at medium to high extent by about 59.3% of villages, highlighting the continued role of riverine and alluvial processes in supporting agricultural productivity. Provision of habitat for biodiversity was also perceived at moderate to high extent across several villages, indicating the ecological importance of the river and associated habitats. Sewage disposal showed variable levels of use.

Cultural ecosystem services were generally perceived to be used at low to moderate extent. Religious value was reported as low by 48.1% of villages, while tourism was perceived as medium to high by 37% of villages, indicating relatively moderate cultural and recreational use of river-related ecosystem services in the Lower Ganga stretch.



	Water for drinking/ domestic use-surface water	Water for drinking/ domestic use-ground water	Agriculture-surface water for irrigation	Agriculture-ground water for irrigation	Livestock-water	Livestock-grazing	Livestock-fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
High	14.81	85.19	40.74	70.37	37.04	29.63	29.63	11.11	18.52	85.19	3.70	33.33	59.26	48.15	25.93	37.04
Medium	33.33	14.81	44.44	18.52	55.56	51.85	44.44	51.85	59.26	3.70	3.70	59.26	40.74	48.15	25.93	37.04
Low	40.74	0.00	11.11	7.41	7.41	18.52	25.93	37.04	22.22	11.11	37.04	7.41	0.00	3.70	48.15	22.22
None	11.11	0.00	3.70	3.70	0.00	0.00	0.00	0.00	0.00	0.00	55.56	0.00	0.00	0.00	0.00	3.70

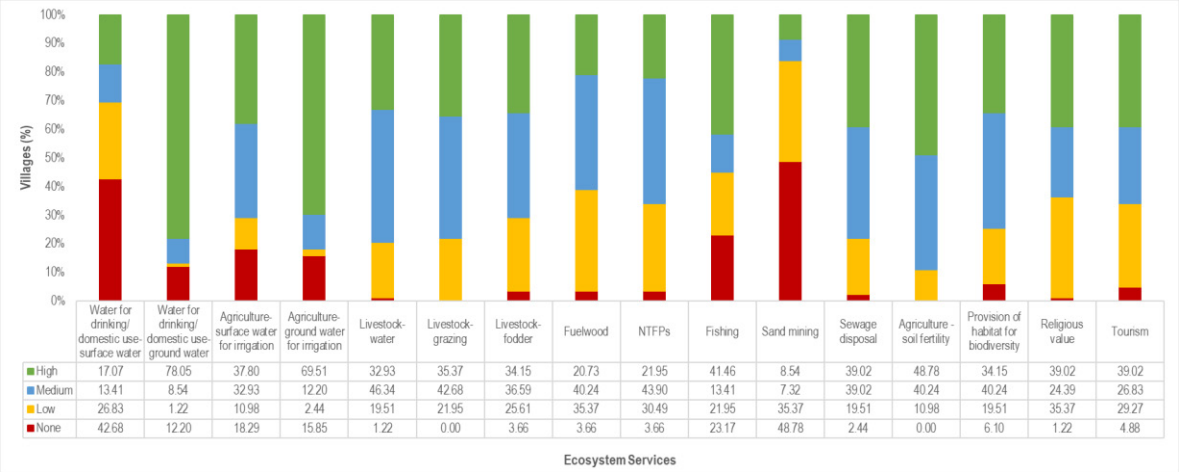
Figure 5.5. Perceived extent of the ecosystem services at the grassroots along the Lower Ganga Stretch

Ganga River: Across the entire Ganga River, provisioning ecosystem services showed considerable variation among villages and stretches (Figure 5.6). Groundwater for drinking and domestic use was perceived at high extent by 78% of villages, while 69.5% reported high extent of groundwater use for irrigation, indicating strong dependence on groundwater resources. Surface water for irrigation was perceived at medium extent by 32.9% and high by 37.8% of villages. Livestock-related services were largely perceived at moderate levels, including livestock water (46.3% medium) and grazing (42.7% medium). Fishing was reported at high extent by 41.5% of villages, although 23.2% reported no fishing activity, suggesting spatial variability in fisheries dependence. Fuelwood (35.4% low) and NTFPs (30.5% low) were perceived to be used to a relatively limited extent in many villages, while sand mining was mostly reported at low extent (35.4%).

Regulation and maintenance services were generally perceived at moderate to high extent along the river. Agricultural soil fertility was widely recognized as an important service supporting farming systems, while provision of habitat for biodiversity was perceived at high extent by 34.1% of villages, reflecting the ecological importance of the river and its associated habitats. Sewage disposal services were perceived

at medium to high extent in about 39% of villages, suggesting increasing anthropogenic pressures on the river system.

Cultural ecosystem services were widely perceived along the Ganga River. Religious value and tourism were reported at high extent by about 39% of villages, highlighting the strong spiritual, cultural, and recreational significance of the river across its stretches. These services underscore the central role of the Ganga in sustaining cultural traditions, pilgrimage activities, and river-based tourism.



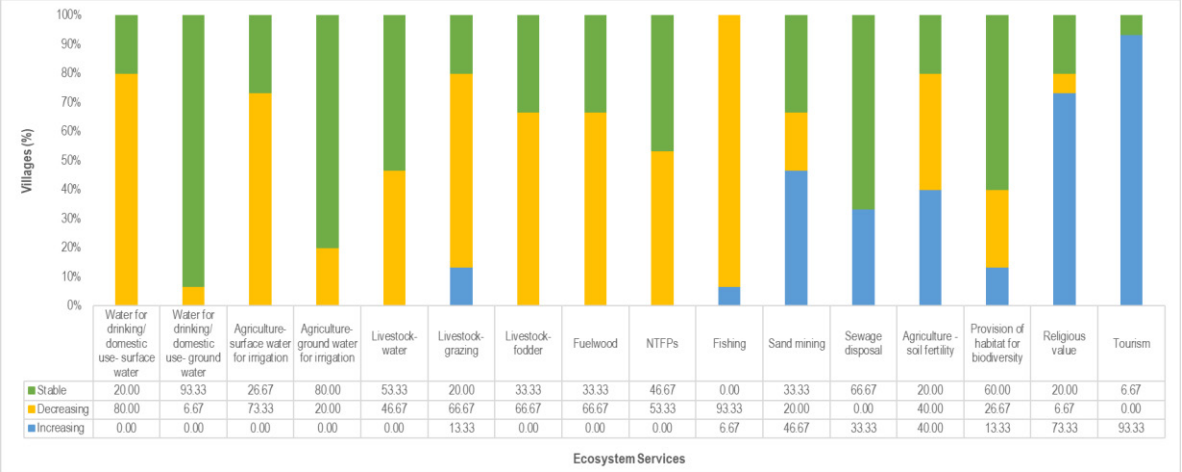
	Water for drinking/ domestic use- surface water	Water for drinking/ domestic use- ground water	Agriculture- surface water for irrigation	Agriculture- ground water for irrigation	Livestock- water	Livestock- grazing	Livestock- fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
High	17.07	78.05	37.80	69.51	32.93	35.37	34.15	20.73	21.95	41.46	8.54	39.02	48.78	34.15	39.02	39.02
Medium	13.41	8.54	32.93	12.20	46.34	42.68	36.59	40.24	43.90	13.41	7.32	39.02	40.24	40.24	24.39	26.83
Low	26.83	1.22	10.98	2.44	19.51	21.95	25.61	35.37	30.49	21.95	35.37	19.51	10.98	19.51	35.37	29.27
None	42.68	12.20	18.29	15.85	1.22	0.00	3.66	3.66	3.66	23.17	48.78	2.44	0.00	6.10	1.22	4.88

Figure 5.6. Perceived extent of the ecosystem services at the grassroots along the Ganga River

5.4.3.2 Trend

Upper Ganga Stretch: Trends in provisioning ecosystem services in the Upper Ganga stretch, as perceived by rural communities, indicate declining patterns for several services (Figure 5.7). Surface water for drinking and domestic use was perceived as decreasing by 80% of villages, while 73.3% reported declines in surface water used for irrigation. Livestock-related services also showed negative trends, with 66.7% of villages reporting declines in grazing and fodder resources. Forest-based provisioning services were similarly perceived to be declining, with 66.7% reporting decreases in fuelwood and 53.3% in NTFPs. Fishing showed the strongest decline, with 93.3% of villages reporting decreasing trends. In contrast, groundwater-related services were largely perceived as stable, with 93.3% of villages reporting stable groundwater for drinking and domestic use and 80% reporting stable groundwater for irrigation. This value must be treated cautiously since the communities in the mountains primarily rely on streams and springs for meeting their drinking, domestic use and irrigation requirements, which were perceived to have declined significantly; hence, the stability is indicative of non-use of groundwater resources in the mountains. Sand mining was one of the few provisioning services perceived to be increasing, reported by 46.7% of villages.

Regulation and maintenance services showed mixed trends. Agricultural soil fertility and provision of habitat for biodiversity were perceived as stable in many villages but declining in others, suggesting localized ecological changes. In contrast, sewage disposal was perceived to be increasing in 33.3% of villages. Cultural ecosystem services showed increasing trends as perceived by rural communities. Religious value was reported to be increasing in 73.3% of villages, while tourism was perceived to be increasing in 93.3% of villages, highlighting the expanding importance of pilgrimage activities and tourism in the Upper Ganga stretch.



	Water for drinking/ domestic use- surface water	Water for drinking/ domestic use- ground water	Agriculture- surface water for irrigation	Agriculture- ground water for irrigation	Livestock- water	Livestock- grazing	Livestock- fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
Stable	20.00	93.33	26.67	80.00	53.33	20.00	33.33	33.33	46.67	0.00	33.33	66.67	20.00	60.00	20.00	6.67
Decreasing	80.00	6.67	73.33	20.00	46.67	66.67	66.67	66.67	53.33	93.33	20.00	0.00	40.00	26.67	6.67	0.00
Increasing	0.00	0.00	0.00	0.00	0.00	13.33	0.00	0.00	0.00	6.67	46.67	33.33	40.00	13.33	73.33	93.33

Figure 5.7. Perceived trend in the ecosystem services at the grassroots along the Upper Ganga Stretch

Middle Ganga Stretch: In the Middle Ganga stretch, rural communities perceived declining trends in most provisioning ecosystem services (Figure 5.8). Surface water for drinking and domestic use was reported as decreasing by 92.5% of villages, while 100% reported declining groundwater for drinking and domestic use. Similarly, surface water for irrigation declined in 85% of villages and groundwater for irrigation in 97.5%. Livestock-related services also showed negative trends, with 77.5% of villages reporting declining grazing resources and 75% reporting declines in fodder availability. Forest-based resources were perceived to be decreasing, with 87.5% reporting declines in fuelwood and 85% in NTFPs. Fishing was reported as declining in 77.5% of villages, while sand mining declined in 65%, indicating widespread perceptions of reduced provisioning benefits from river ecosystems.

Regulation and maintenance services were also perceived to be declining in many villages. Agricultural soil fertility and the provision of habitat for biodiversity were reported to be decreasing by a considerable proportion of communities, suggesting concerns about ecological degradation and declining agricultural productivity. In contrast, sewage disposal was perceived to be increasing in 77.5% of villages.

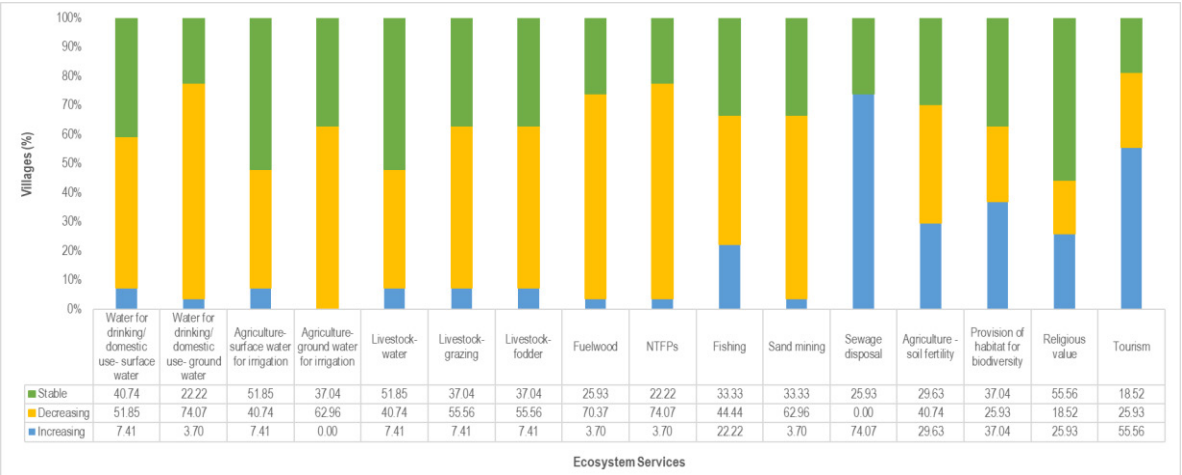
Cultural ecosystem services were generally perceived to be relatively stable in the Middle Ganga stretch. Religious value was reported as stable by 50% of villages, while tourism was perceived as stable by 42.5%, though some villages reported moderate increases. These perceptions highlight the continued cultural importance of the river despite declining trends in many provisioning and regulating ecosystem services.

Lower Ganga Stretch: In the Lower Ganga stretch, rural communities perceived declining trends in several provisioning ecosystem services (Figure 5.9). Groundwater for drinking and domestic use declined in 74.1% of villages, while groundwater irrigation declined in 63%. Livestock-related services also showed decreases, with 55.6% of villages reporting declines in grazing and fodder resources, although livestock water remained stable in 51.9% of villages. Forest-based resources showed notable declines, with 70.4% of villages reporting decreases in fuelwood and 74.1% in NTFPs. Fishing, an important livelihood in the region, was perceived to be declining in 44.4% of villages. In contrast, surface water irrigation was perceived as stable by 51.9% of villages, indicating relatively stable irrigation use in some areas. Regulation and maintenance services showed mixed trends. Agricultural soil fertility and habitat provision for biodiversity were perceived as stable in several villages, though some communities

reported declines, suggesting localized ecological pressures. In contrast, sewage disposal was perceived to be increasing in 74.1% of villages. Cultural ecosystem services were generally perceived to be stable or increasing. Religious value was reported as stable by 55.6% of villages, while tourism was perceived to be increasing in 55.6%, reflecting the continuing cultural and recreational significance of the river in the lower stretch.

	Water for drinking/ domestic use- surface water	Water for drinking/ domestic use- ground water	Agriculture- surface water for irrigation	Agriculture- ground water for irrigation	Livestock- water	Livestock- grazing	Livestock- fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
Stable	7.50	0.00	12.50	2.50	25.00	17.50	20.00	10.00	12.50	17.50	17.50	17.50	35.00	30.00	50.00	42.50
Decreasing	92.50	100.00	85.00	97.50	67.50	77.50	75.00	87.50	85.00	77.50	65.00	5.00	52.50	55.00	15.00	25.00
Increasing	0.00	0.00	2.50	0.00	7.50	5.00	5.00	2.50	2.50	5.00	17.50	77.50	12.50	15.00	35.00	32.50

Figure 5.8. Perceived trend in the ecosystem services at the grassroots along the Middle Ganga Stretch



	Water for drinking/ domestic use- surface water	Water for drinking/ domestic use- ground water	Agriculture- surface water for irrigation	Agriculture- ground water for irrigation	Livestock- water	Livestock- grazing	Livestock- fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
Stable	40.74	22.22	51.85	37.04	51.85	37.04	37.04	25.93	22.22	33.33	33.33	25.93	29.63	37.04	55.56	18.52
Decreasing	51.85	74.07	40.74	62.96	40.74	55.56	55.56	70.37	74.07	44.44	62.96	0.00	40.74	25.93	18.52	25.93
Increasing	7.41	3.70	7.41	0.00	7.41	7.41	7.41	3.70	3.70	22.22	3.70	74.07	29.63	37.04	25.93	55.56

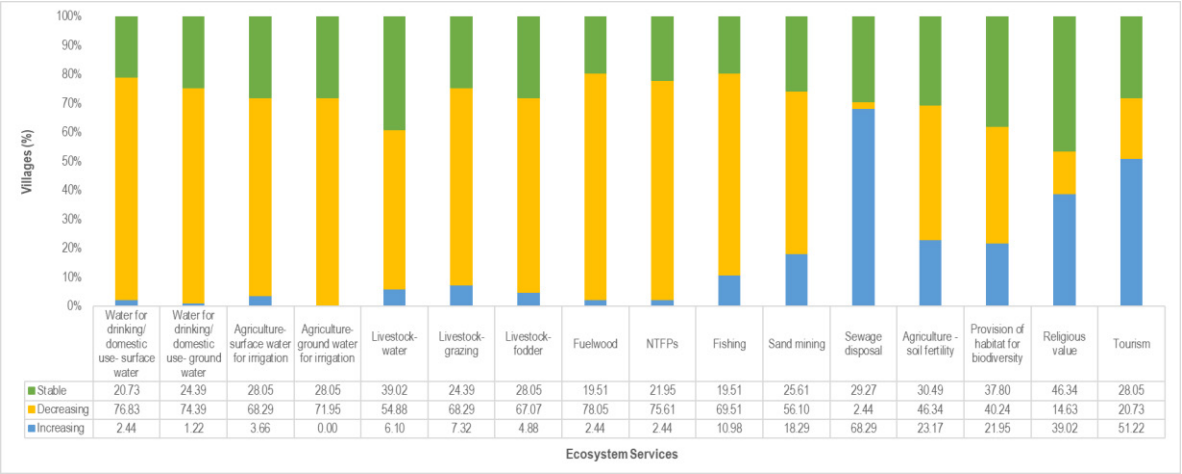
Figure 5.9. Perceived trend in the ecosystem services at the grassroots along the Lower Ganga Stretch

Ganga River: Across the Ganga River, rural communities perceived declining trends in most provisioning ecosystem services (Figure 5.10). Surface water for drinking and domestic use declined in 76.8% of villages, while groundwater for drinking declined in 74.4%. Similarly, surface water irrigation declined in 68.3% and groundwater irrigation in 72.0% of villages. Livestock-related services also showed negative trends, with 68.3% of villages reporting declining grazing resources and 67.1% reporting declines in fodder availability. Forest-based resources were widely perceived to be decreasing, with 78% reporting

declines in fuelwood and 75.6% in NTFPs. Fishing declined in 69.5% of villages, indicating reduced reliance or availability of fisheries. Sand mining was also perceived as declining in 56.1% of villages.

Regulation and maintenance services showed mixed trends along the river. While some villages reported stable conditions for agricultural soil fertility and habitat provision for biodiversity, others perceived declines, suggesting localized ecological pressures. In contrast, sewage disposal was perceived to be increasing in 68.3% of villages, highlighting growing anthropogenic pressure on the Ganga River system through waste discharge.

Cultural ecosystem services were generally perceived to be stable or increasing. Religious value was reported as increasing in 39.0% of villages, while tourism increased in 51.2%, reflecting the continued cultural, spiritual, and recreational importance of the Ganga. Overall, community perceptions suggest that although the river continues to support diverse ecosystem services, many provisioning and regulating services are under increasing pressure, while cultural services remain resilient or expanding.



	Water for drinking/ domestic use- surface water	Water for drinking/ domestic use- ground water	Agriculture- surface water for irrigation	Agriculture- ground water for irrigation	Livestock- water	Livestock- grazing	Livestock- fodder	Fuelwood	NTFPs	Fishing	Sand mining	Sewage disposal	Agriculture - soil fertility	Provision of habitat for biodiversity	Religious value	Tourism
Stable	20.73	24.39	28.05	28.05	39.02	24.39	28.05	19.51	21.95	19.51	25.61	29.27	30.49	37.80	46.34	28.05
Decreasing	76.83	74.39	68.29	71.95	54.88	68.29	67.07	78.05	75.61	69.51	56.10	2.44	46.34	40.24	14.63	20.73
Increasing	2.44	1.22	3.66	0.00	6.10	7.32	4.88	2.44	2.44	10.98	18.29	68.29	23.17	21.95	39.02	51.22

Figure 5.10. Perceived trend in the ecosystem services at the grassroots along the Ganga River

5.5. Conclusion

Ganga River provides vital ecosystem services to riverside communities across the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal. Twenty-four key ecosystem services were identified — 13 provisioning services, seven regulation and maintenance services, and four cultural services — through an extensive review, field surveys, participatory mapping, and key informant interviews. The extent of provisioning services was high in the middle and lower stretches and low to medium in the upper stretch, while regulation and maintenance services such as habitat provision and microclimate regulation were high across all stretches. Cultural services were consistently high throughout the Ganga riverscape. Keeping riverside communities at the centre, 16 key ecosystem services were assessed across the upper, middle, and lower stretches. The participatory mapping reveals complex interlinkages between community dependence, ecological processes, and anthropogenic pressures.

Groundwater has emerged as the dominant and most extensively used source for drinking and irrigation along the river, with a high proportion of villages reporting strong dependence, although its availability is widely perceived to be declining. Surface water from streams and the main river channel remains

important in the upper stretch, but its use is increasingly constrained downstream due to reduced flows and pollution. Over-extraction, declining recharge, and contamination from sewage and industrial discharge pose growing risks to long-term water security.

Agriculture remains the principal livelihood supported by the Ganga, benefiting from fertile alluvial soils and seasonal sediment deposition, particularly in the middle and lower stretches. However, agricultural productivity is under increasing pressure from declining water availability, altered sediment regimes, soil degradation, and intensive agrochemical use. Livestock systems continue to support rural livelihoods, though grazing areas and access to natural fodder are declining, leading to a shift toward stall-fed and input-dependent systems.

Fishing, fuelwood, fodder, and other biotic resources continue to contribute to household subsistence and income, particularly in the middle and lower stretches. However, fisheries are widely perceived to be declining due to pollution, flow regulation, habitat fragmentation, and unsustainable fishing practices. Sand mining occurs along the river, transitioning from small-scale extraction upstream to mechanised operations in the plains, contributing to habitat degradation, riverbank erosion, and ecological instability.

Ganga River system sustains globally significant aquatic biodiversity, including species such as the Gangetic dolphin, gharial, freshwater turtles, otters, and numerous fish and migratory bird species. However, habitat degradation driven by hydrological alterations, pollution, sand mining, and land-use change is increasingly threatening ecological integrity and species survival.

A critical regulating service provided by the river system is waste assimilation, wherein rivers, wetlands, and floodplains naturally process and dilute pollutants. In the absence of adequate sewage and industrial effluent treatment infrastructure, this service has become increasingly important but is now severely overburdened, leading to declining water quality, eutrophication, and ecosystem degradation.

Cultural services remain central to the Ganga River, with deep religious, spiritual, and historical significance across its course, from the Char Dham pilgrimage in the upper reaches to major confluences such as Prayagraj and globally significant centres like Varanasi, and further to Gangasagar at the mouth of the river. These cultural landscapes support substantial livelihoods through pilgrimage, tourism, and associated services. However, increasing tourist pressure, waste generation, and environmental degradation are affecting the quality and sustainability of these services.

Planning for the conservation and sustainable management of the Ganga River must adopt an integrated, multi-scalar, participatory, and ecosystem-based approach that focuses on: (i) safeguarding environmental flows, restoring hydrological connectivity, and ensuring equitable water access; (ii) strengthening water security through sustainable and ecologically sensitive supply- and demand-side management (e.g., enhancing groundwater recharge, incentivising water-efficient irrigation practices and regulating extraction); (iii) scaling-up nature-based solutions, promoting sustainable agriculture and soil health management; (iv) conserving biodiversity and restoring critical habitats such as wetlands and floodplains; (v) strengthening wastewater treatment and reducing pollution loads; (vi) regulating sand mining and other extractive activities, and promoting sustainable fishing practices; (vii) promoting culturally sensitive and ecologically responsible tourism; and (viii) integrating local knowledge and community participation into river basin governance to address trade-offs between conservation and development.


शिव बाबा
गंगा-प्रहरी बरैला झील जीव रक्षा सह शोध संस्थान

Chapter 06

VILLAGE-LEVEL MICROPLAN DEVELOPMENT TO MAINSTREAM BIODIVERSITY CONSERVATION

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Summary

The chapter on village-level microplan development presents a structured, community-centric framework to integrate biodiversity conservation with local development planning in the area along mainstem Ganga River. The approach is embedded within a broader socio-ecological paradigm that recognizes riverine communities as active co-managers rather than passive beneficiaries of conservation interventions. Microplanning is conceptualized as a decentralised governance tool aimed at reconciling local socio-economic aspirations with ecological sustainability. It builds upon prior components of stakeholder identification, institutional strengthening, livelihood interventions, and assessment of social-ecological linkages.

The process is designed to ensure that conservation actions are context-specific, participatory, and aligned with local ecological conditions and cultural practices. A key foundation of the microplanning process is the systematic understanding of community dependence on riverine resources. This was achieved through questionnaire-based surveys, participatory mapping of ecosystem services, and representative sampling of villages based on spatial, demographic, and socio-economic criteria. At least 10% of households in selected villages were surveyed, supplemented by secondary data from government sources, enabling robust characterization of human–river interdependencies. Institutionally, microplanning emphasizes strengthening local governance structures and promoting decentralization to ensure long-term sustainability of conservation outcomes. It integrates multiple stakeholders including local communities, government departments, and line agencies through coordinated planning processes. The approach also leverages the Ganga Prahari cadre as a critical institutional mechanism to facilitate community mobilisation, awareness generation, and implementation of conservation actions at the grassroots level. Livelihood integration constitutes a central pillar of the microplans. Recognizing that economic constraints limit participation in conservation, the framework incorporates need-based livelihood interventions aligned with local ecological and cultural contexts. These include capacity building, skill development, and linkages with government schemes (e.g., NRLM, PMKVY, RSETI) and market systems to ensure sustainability. By creating economic incentives, the approach seeks to transform conservation into a rational and viable choice for marginalized and resource-dependent communities.

A total of 10 site-specific microplans were developed for the villages located along mainstem Ganga River. For HBZ II of the Ganga River, microplans of two villages namely Daranagar in Bijnor and Niwadi Khadar, in district of Bulandshahr, have been prepared. For HBZ III, microplans of three villages, namely Chittupur and Molnapur in Varanasi and Sonbarsha in Chandauli district have been prepared. For Zone IV, microplans for Khawaspur in district Bhagalpur and Rasalpur in district Samastipur of Bihar state, for Zone V microplan for village Saidpur, district Sahibganj of Jharkhand and Zone VI one village Nayachar, district Nadia, West Bengal. Microplan for village Deer Forest, district Mursidabad, West Bengal located upstream Zone VI was also prepared. Key issues and challenges were identified for each site. Across Zones II to VI, a consistent pattern emerges of intensive riverbank and riverbed agriculture, characterized by heavy use of chemical fertilizers and pesticides, leading to habitat degradation, water pollution, and loss of aquatic biodiversity. Riverbed cultivation and expansion into active channels disturb breeding grounds and ecological balance, particularly noted in Zones II and III. A major cross-cutting issue is poor sanitation and waste management, including open defecation, dumping of household and market waste, and discharge of untreated wastewater, all contributing to declining water quality. Degradation of riparian vegetation due to agriculture, grazing, and fuelwood extraction is also widespread. Livelihood

dependence on river resources such as fishing, agriculture, and related activities are high across all zones, but alternative livelihood options remain limited, resulting in overexploitation of natural resources. In Zones V and VI, unsustainable fishing practices, including fine-mesh nets and harmful methods (chemicals/electric current), further threaten aquatic species such as fish, turtles, and the Ganges River Dolphin. To address these issues, microplans across Zones II–VI follows a common framework integrating awareness, institutional strengthening, livelihood development, sanitation, sustainable agriculture, and biodiversity conservation. However, priorities vary by local conditions, such as pilgrimage, agriculture, or fishing dependence, ensuring targeted interventions. This zone-specific approach enhances ecological sustainability and livelihood resilience, making conservation efforts more context-relevant and effective in the Ganga basin.

Institutional and social constraints are also evident, including low awareness of biodiversity conservation, weak community institutions, poor enforcement mechanisms, and limited knowledge of environmental policies. Additional localized pressures include tourism (Zone III), illegal activities like poaching and sand mining (Zone IV), and religious practices contributing to pollution (Zones II and IV). The microplans are designed as adaptive, site-specific instruments that operationalize the linkage between river health and village development. They aim to mainstream biodiversity conservation into routine planning processes by embedding ecological considerations within local development priorities, fostering inter-departmental convergence, and enabling long-term community stewardship of river ecosystems. The chapter demonstrates that village-level microplanning serves as a critical interface between policy and practice, translating basin-scale conservation goals into actionable, locally grounded strategies that enhance both ecological resilience and community well-being.

6.1. Introduction

Village-level microplanning has emerged as a critical participatory planning instrument for integrating biodiversity conservation with local socio-economic development. The approach is grounded in principles of decentralized governance, participatory decision-making, and community-based natural resource management, where local communities play a central role in planning, implementing, and monitoring conservation actions. By aligning ecological priorities with local livelihood needs, microplanning provides an operational framework to achieve both conservation outcomes and sustainable rural development.

Village microplanning is fundamentally participatory, enabling local communities to identify ecological resources, threats, and development priorities within their landscapes. This bottom-up approach strengthens local ownership of conservation initiatives, which is widely recognized as essential for long-term environmental sustainability. In contrast to centralized resource management systems that are often detached from local realities, decentralized community-based frameworks empower communities to regulate and manage natural resources according to locally appropriate norms and institutions. Such localized governance structures have been shown to enhance compliance, reduce resource conflicts, and improve conservation outcomes (Gruber, 2010; Milupi et al., 2017). Microplanning processes typically involve participatory resource mapping, household consultations, and stakeholder discussions, allowing communities to collectively define management strategies and conservation priorities. These processes enhance transparency and accountability, while ensuring that ecological interventions are socially acceptable and culturally relevant. Another key strength of village-level microplanning lies in its ability to integrate traditional ecological knowledge with scientific conservation planning. Rural

communities possess extensive knowledge of local ecosystems, species behaviour, seasonal resource availability, and landscape dynamics. Incorporating such knowledge into formal planning frameworks improves the accuracy and contextual relevance of conservation strategies.

Village microplanning explicitly recognizes the interdependence between biodiversity conservation and rural livelihoods. In many biodiversity-rich landscapes, local populations depend heavily on forests, wetlands, rivers, and agricultural ecosystems for subsistence and income. Consequently, conservation strategies that ignore livelihood needs often fail due to resource conflicts and economic pressures. Microplanning addresses this challenge by identifying sustainable livelihood alternatives such as eco-tourism, agroforestry, sustainable agriculture, or non-timber forest product enterprises, while simultaneously promoting ecosystem restoration and resource protection. Such integrated approaches are consistent with the broader framework of Integrated Conservation and Development Projects, which aim to achieve biodiversity conservation through socio-economic incentives and community participation.

Despite its ecological significance, the river ecosystem faces multiple anthropogenic pressures including habitat degradation, water abstraction, pollution, unsustainable fishing practices, sand mining, and riverbank modification (Dudgeon et al., 2006; Sinha & Kannan, 2014). Many of these threats originate from localized socio-economic activities occurring along riverbanks and floodplain settlements. Consequently, effective conservation and rejuvenation of the Ganga requires decentralized planning approaches that incorporate community participation and address site-specific ecological challenges. Village-level microplanning provides a mechanism to operationalize such decentralized conservation strategies by translating basin-level policies into locally relevant management actions.

6.2. Aim

Develop site-specific plans to address the challenges of aquatic biodiversity conservation in different high-biodiversity stretches of the Ganga River**.**

6.2.1. Objectives

1) To facilitate active participation of local communities in river conservation and biodiversity protection initiatives.
2) To identify and address village-level environmental pressures and livelihood dependencies affecting river ecosystems.
3) To promote the adoption of sustainable resource-use practices that support the conservation of riverine biodiversity.
4) To strengthen community stewardship and enable local stakeholders to take ownership of conservation and restoration actions.

6.3. Approach

Representative microplans (n= 10) were prepared for five High Biodiversity Zones (HBZ) of the Ganga to assess grassroots-level conservation challenges and identify feasible community-driven solutions. The villages were strategically selected based on the following criteria: (1) proximity to the river and associated floodplain habitats, (2) ecological importance of the stretch in terms of aquatic biodiversity, (3) presence or potential habitat of priority species such as dolphins, turtles, and migratory fishes, (4) willingness and proactive participation of local communities in conservation initiatives. The preparation of village-level microplans followed a systematic and participatory approach to ensure that local ecological concerns and community needs were adequately reflected in conservation planning for the Ganga River. The process involved several sequential steps, combining field assessments with community engagement and institutional coordination (Figure 6.1).

6.3.1. Awareness and sensitisation meetings

The microplanning process began with awareness and sensitisation programmes conducted within the selected villages. These meetings were organised to inform local communities about the importance of aquatic biodiversity, the ecological significance of the Ganga River, and the threats posed by activities such as pollution, habitat degradation, and illegal fishing practices. The programmes also highlighted the link between healthy river ecosystems and local livelihoods, including fisheries, agriculture, and ecosystem services.

6.3.2. Data collection and baseline assessment

Following the initial awareness activities, detailed baseline information was collected to understand the ecological and socio-economic conditions of the villages. This included surveys, field observations, consultative meetings and ecological assessments. Data were gathered on livelihood patterns, dependence on river resources, sanitation and waste management practices, and the presence of important habitats and aquatic species.

6.3.3. Stakeholder consultations

Consultations were organised with various stakeholders to obtain a comprehensive understanding of local issues and priorities. These consultations involved representatives of Panchayati Raj Institutions (PRIs), self-help groups, youth groups, women's groups, fisher communities, and other local stakeholders. The discussions helped identify key environmental concerns, livelihood challenges, and possible conservation measures, while also encouraging community participation in the planning process.

6.3.4. Development of the microplan

Based on the information collected through surveys and consultations, a detailed village-level microplan was prepared. The microplan identified key environmental issues and prioritised actions required to address them. Proposed interventions typically included habitat restoration, improvement of solid waste management systems, promotion of sustainable fishing practices, afforestation and riparian vegetation restoration, and the development of alternative livelihood opportunities to reduce pressure on natural resources.

6.3.5. Institutionalisation and letter of consent

To ensure community ownership, the draft microplan was presented to the village community for feedback and validation. The Gram Panchayat formally endorsed the microplan through a Letter of Consent, indicating its commitment to support implementation of the proposed activities. Institutional support from local governance bodies is essential for long-term sustainability and integration of conservation actions within village development planning.

6.3.6. Finalisation of microplans

The microplan was finalised after incorporating feedback from community members and local institutions. The final document integrates scientific assessments with local knowledge and community priorities, thereby ensuring that proposed interventions are ecologically relevant and socially acceptable.

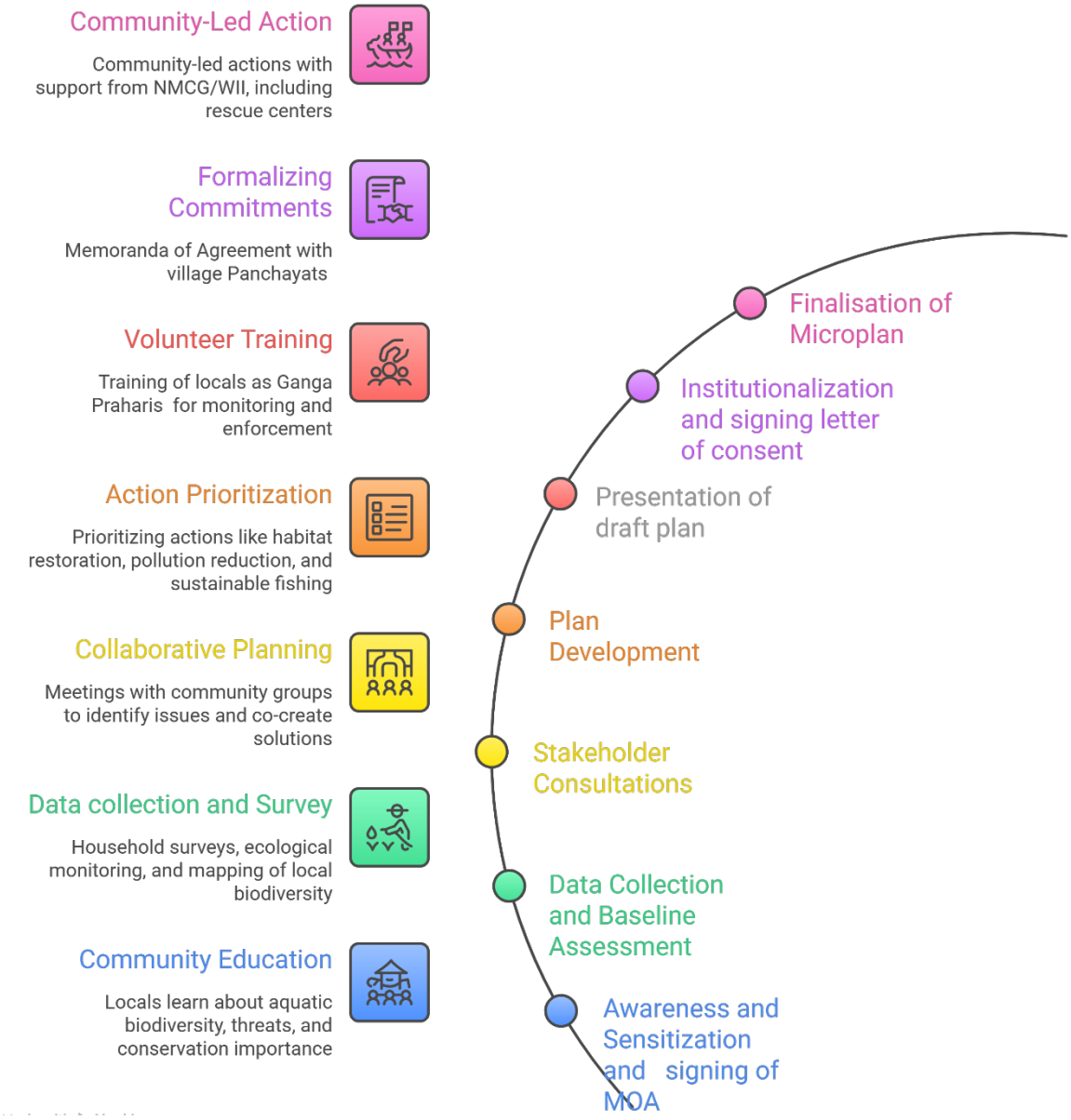

Figure 6.1. Process followed to develop microplans for villages located along Ganga River

To prepare the microplan, multiple field visits have been undertaken to the selected villages to build rapport with the community and to gain a comprehensive understanding of local socio-ecological conditions. During these visits, meetings have been conducted with a wide range of stakeholders, including village leaders, women's groups, farmers, fishers, youth representatives, and other resource-dependent households. These interactions are complemented by village-level mapping exercises and various Participatory Rural Appraisal (PRA) tools such as resource mapping, seasonal calendars, transect walks, and problem-ranking exercises.

The meetings provided a platform to openly discuss existing problems and emerging threats to river biodiversity, including issues related to habitat degradation, overexploitation of resources, pollution, and changing livelihood patterns. Stakeholders actively shared their observations, traditional practices, and long-standing ecological knowledge about the river system and its biodiversity.

Based on these discussions, locally appropriate and practical solutions have been jointly explored. Emphasis was placed on integrating traditional wisdom with scientific understanding to develop feasible conservation measures that align with community needs and livelihood priorities. This participatory and consultative process ensured that the microplan reflected ground realities, fostered community ownership, and promoted sustainable and inclusive biodiversity conservation strategies.

6.4. Results

6.4.1. Microplans developed

A total of 10 site-specific microplans were developed for the villages located along mainstem Ganga River. For HBZ II of the Ganga River, microplans of two villages namely Daranagar in Bijnor and Niwadi Khadar, in district of Bulandshahr, have been prepared. For HBZ III, microplans of three villages, namely Chittupur and Molnapur in Varanasi and Sonbarsha in Chandauli district have been prepared. For Zone IV, microplans for Khawaspur in district Bhagalpur and Rasalpur in district Samastipur of Bihar state, for Zone V microplan for village Saidpur, district Sahibganj of Jharkhand and Zone VI one village Nayachar, district Nadia, West Bengal. Microplan for village Deer Forest, district Mursidabad, West Bengal that is located upstream Zone VI was also prepared (Table 6.1).

Table 6.1. Villages selected for microplan development along the Ganga River

Sl. No.	Village	Block	District	State
High Biodiversity Zone II				
1	Niwari Khadar	Dibai	Bulandshahr	Uttar Pradesh
2	Daranagar	Haldaur	Bijnor	Uttar Pradesh
High Biodiversity Zone III				
3	Chhitupur	Kashi Vidhya Peeth	Varanasi	Uttar Pradesh
4	Molnapur	Cholapur	Varanasi	Uttar Pradesh
5	Sonbarsha	Chahaniya	Chandauli	Uttar Pradesh
High Biodiversity Zone IV				
6	Khawaspur	Peerpanti	Bhagalpur	Bihar
7	Rasalpur	Mohanpur	Samastipur	Bihar

High Biodiversity Zone V				
8	Saidpur	Rajmahal	Sahibganj	Jharkhand
High Biodiversity Zone VI				
9	Deer forest	Farrakka	Mursidabad	West Bengal
10	Nayachar	Kaliganj	Nadia	West Bengal

6.4.2. Issues identified in high biodiversity zones of Ganga River through microplanning

The microplanning exercise across different zones of the Ganga highlights that livelihood dependence, unsustainable fishing practices, intensive agriculture, riparian vegetation extraction, sanitation gaps, and poor waste management are the major factors contributing to ecological stress in the river system.

6.4.2.1. High Biodiversity Zone II

High biodiversity zone II of the Ganga River expands from Mukdumpur to Narora in Uttar Pradesh. Microplan for village Daranagar in Bijnor district and Niwadi Khadar in Bulandshahr district have been prepared for this stretch (Figure 6.2). The issues identified in this stretch are explained below (Table 6.2):

(1) Limited awareness regarding river biodiversity

There is less understanding among local communities about the ecological importance of river biodiversity, including its role in maintaining ecosystem balance, supporting fisheries, improving water quality, and sustaining livelihoods. This lack of awareness often results in unintentional practices that negatively impact aquatic and riparian ecosystems. In the villages of Daranagar and Niwadi Khadar, community members show limited awareness and appreciation of the biodiversity present in their surrounding riverine ecosystem. Due to inadequate knowledge about the ecological importance of local species and habitats, there is a lack of interest and active participation in conservation initiatives.

(2) Indiscriminate use of chemical fertilizers and pesticides

In both Daranagar and Niwadi Khadar, agriculture is the primary source of livelihood for most households. To protect crops from pests and to enhance productivity, farmers commonly use chemical fertilizers and pesticides. While these inputs help in increasing agricultural output, their excessive or unregulated use poses risks to soil health, groundwater, and the adjacent river ecosystem through runoff. In Niwadi Khadar, riverbed agriculture is practiced by more than 100 families during the lean season. Cultivation on exposed riverbeds provides additional income, but it also increases pressure on sensitive riverine habitats and may contribute to habitat disturbance and chemical contamination of the river system.

(3) Habitat degradation due to riverbed farming and overuse of riparian vegetation

Expansion of cultivation activities on the riverbed and excessive extraction of riverside vegetation for fodder, fuelwood, and other domestic uses in and around these villages has led to habitat loss and fragmentation. This is disturbing the breeding grounds of aquatic species and weakening the natural buffer zones that protect riverbanks from erosion.

(4) Inadequate liquid and solid waste management systems

The absence or poor functioning of waste collection, segregation, and disposal systems has led to the dumping of household and market waste along the riverbanks and, in some cases, directly into the Ganga

River. In Niwadi Khadar, proper waste management facilities are largely lacking, resulting in open dumping and unmanaged waste accumulation. In contrast, in Daranagar, waste management infrastructure is available; however, limited awareness and low community participation have resulted in underutilization of these facilities. Additionally, the discharge of untreated wastewater and greywater into open drains that ultimately connect to the river further deteriorates water quality. This continuous inflow of pollutants not only degrades the aquatic environment but also poses serious threats to riverine biodiversity and public health. Additionally, many households in the Gram Panchayat either lack toilets or do not use existing ones, highlighting the urgent need for community awareness regarding toilet construction and usage. Large quantities of cloth, plastic, and other waste materials are also left along the riverbanks by devotees, which eventually enter the river and aggravate pollution levels.

(5) Immersion of idols and religious waste

In the village Niwadi Khadar there is a famous Gandhi ghat with regular tourist inflow. The site is religiously significant and hosts large monthly fairs, attracting a heavy influx of pilgrims. Due to deep religious faith in the Ganga River, devotees take ritual baths and immerse pooja materials such as idols, pictures, calendars, incense sticks, cloth, and polythene into the river, adversely affecting its ecological system. Despite being a major pilgrimage centre, there is no proper sanitation facility for visitors. The absence of public toilets leads pilgrims and temporary shopkeepers during fairs to defecate along the riverbanks, resulting in unhygienic conditions and water pollution. Traditional practices such as immersion of idols made from non-biodegradable materials, along with disposal of flowers, plastics, and other religious offerings into the river, in both the villages contribute to chemical and physical pollution, affecting aquatic life and water quality.

(6) High Dependence on river-based livelihoods with limited alternatives

A significant proportion of the community in these villages relies directly on the river for fishing, sand mining, agriculture, and other activities. The lack of diversified and sustainable alternative livelihood options increases pressure on river resources and makes conservation efforts challenging.

(7) Overexploitation of river resources

Due to limited employment opportunities in the area, nearly 60 families in Gram Panchayat Daranagar are engaged in the extensive harvesting of reeds and grasses (such as kans, khamla, sarkanda, and patera) that naturally grow along the riverbanks. This practice is also prevalent in other nearby villages. This over-extraction is causing degradation of riparian habitats and damaging the natural shelter and breeding grounds of several aquatic and semi-aquatic species. The collected grasses are sold to farmers engaged in vegetable cultivation and are also used locally for making baskets and thatching the roofs of temporary or kutcha houses. While this activity provides supplementary income to economically vulnerable households, unsustainable harvesting practices are contributing to habitat loss and ecological imbalance along the riverine ecosystem.

(8) Open defecation along riverbanks

Many households in the Gram Panchayat Niwadi Khadar either lack toilets or do not use the existing ones, highlighting the urgent need for community awareness regarding toilet construction and usage. Ghats in and around these villages lack proper sanitation facilities, waste bins, drainage systems, and regular cleaning mechanisms. This leads to littering, wastewater discharge, and overall degradation of riverfront areas.

(9) Weak enforcement and monitoring mechanisms

Although environmental regulations and conservation guidelines exist, their implementation and monitoring at the local level remain inadequate. Limited coordination among line departments and insufficient manpower further reduces the effectiveness of enforcement.

(10) Weak community institutions and limited collective action

Local institutions such as self-help groups, village committees, and conservation groups lack awareness and capacity, resources, and organizational strength. Weak institutional structures limit coordinated action, accountability, and long-term sustainability of conservation efforts.

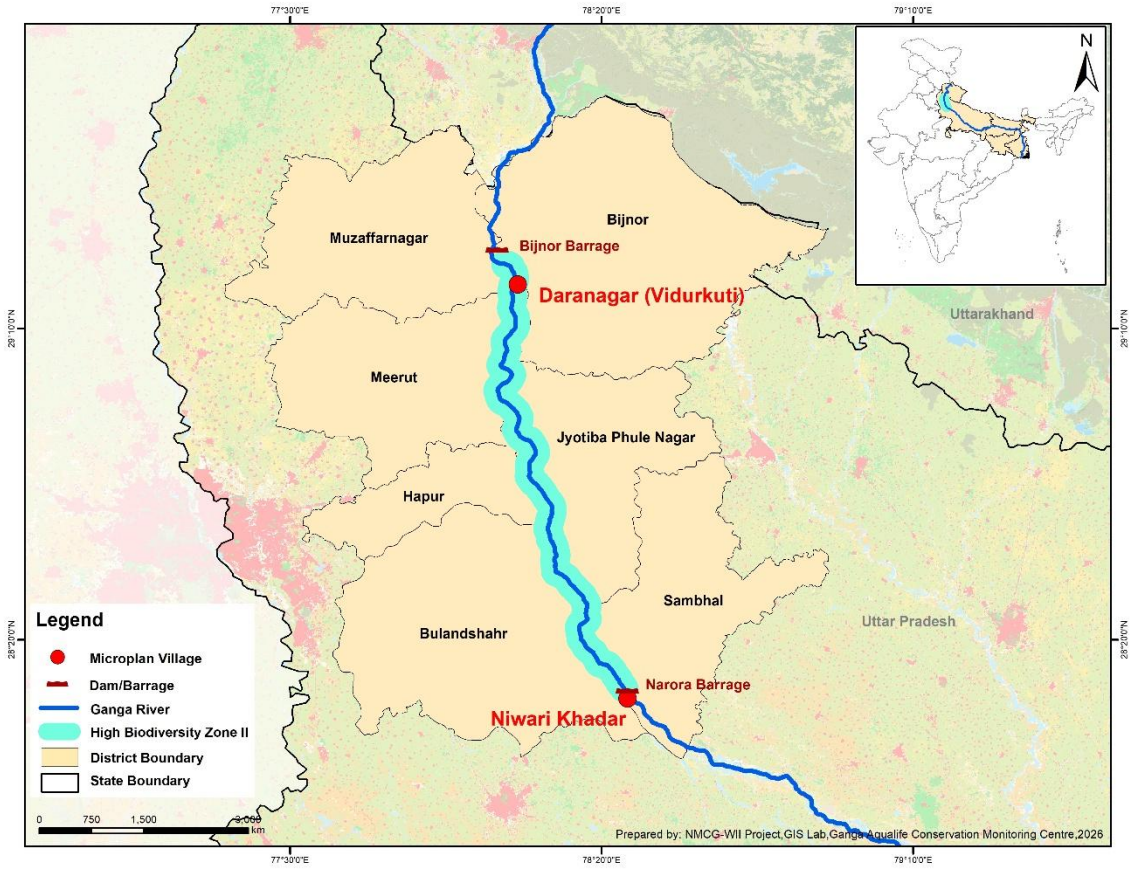

Figure 6.2. Microplanning villages in High Biodiversity Zone II

6.4.2.2. High Biodiversity Zone III

Microplans have been prepared for the villages of Chittupur, Molnapur, and Sonbarsa located within the HBZ III (Figure 6.3). Key issues affecting the river ecosystem and local biodiversity (Table 6.2) in this zone have been identified as follows:

(1) Agricultural runoff and chemical pollution

Like in other areas along the rivers, In the microplan villages located in Zone III, most families depend on agriculture as their primary source of income. Since farming is the main occupation, farmers try to increase crop production to ensure stable earnings and food security. To achieve higher yields, many of them use large quantities of chemical fertilizers and pesticides. Farmers in village Chittupur, Sonbarsa

and Molnapur use chemical fertilizers and pesticides to increase crop productivity. During rainfall, these agro-chemicals wash into the Ganga River, leading to water pollution and negatively affecting aquatic biodiversity.

(2) Habitat degradation due to riverbed farming and other anthropogenic activities

In the villages of this zone, riverbed farming is commonly practiced during the lean season, when the water level of the river goes down and parts of the riverbed become dry. Farmers use this exposed land to grow seasonal crops as an additional source of income. Seasonal cultivation along the riverbanks is practiced by several households in village Sonbarsa and Molnapur. Continuous farming near the river disturbs natural habitats and breeding sites of aquatic species, including turtles.

(3) Habitat Disturbance due to Livestock Grazing and Fodder Collection

Riparian vegetation is frequently harvested for fodder, fuelwood, and construction material. Over extraction reduces the natural buffer capacity of riverbanks, accelerates erosion, and destroys habitat for birds, reptiles, and other wildlife. In Chittupur, about 176 households practice livestock rearing and animals are often grazed along the riverbanks. In Molnapur, grass and fodder are collected from riverbanks for livestock and thatching. These activities disturb aquatic habitats and breeding areas of riverine fauna.

(4) Accidental Entanglement of Aquatic Species in Fishing Nets

Around 100 households from the Mallah community depend on fishing in village Sonbarsa. Aquatic species such as river dolphins and turtles have been reported to occasionally become entangled in fishing nets, posing a serious risk of injury or mortality. Fishers currently lack awareness about safe rescue and release practices.

(5) Waste Disposal along Riverbanks

Village Chittupur is located on the opposite site of the prime ghats of Varanasi. Due to the village's proximity to Varanasi, large religious gatherings during festivals such as Magh Mela, Dev Deepawali, Deepawali, and Chhath Puja attract visitors. Devotees immerse idols, cloth, plastic, and ritual materials into the river, contributing to pollution and ecological stress. Lack of proper waste management systems in village Sonbarsa and Molnapur results in household waste being dumped along riverbanks. This waste is eventually carried into the river by rainwater or wind, contributing to pollution. In these villages, untreated wastewater from settlements and drains flows directly into the Ganga due to the absence of proper drainage and treatment systems.

(6) Open Defecation along Riverbanks

In Chittupur, only about 50% of households have toilets, and in Sonbarsa some households do not regularly use existing toilets. As a result, open defecation occurs along riverbanks, contributing to river water pollution.

(7) High Tourist Inflow and Increased Anthropogenic Pressure

Village Chittupur is located near the main ghats of Varanasi city. This area experiences continuous inflow of people from surrounding regions. Increased human movement and settlement are putting additional

pressure on the resources of the Ganga River. Pilgrimage tourism and recreational activities along the Ganga ghats significantly increase waste generation, noise, and physical disturbance to riparian zones. Unregulated tourism infrastructure and crowd management during peak seasons intensify pressure on fragile riverbank ecosystems. Further, these activities disturb the breeding and nesting grounds of turtles, even though the area falls within the boundaries of the turtle sanctuary, which is proposed to be de-notified by the government.

(8) Limited Alternative Livelihood Opportunities

Communities residing along the Ganga depend on fishing, agriculture, boating, sand mining, and other river-related occupations. Limited access to diversified and sustainable livelihood options increases extraction pressure on natural resources and complicates conservation efforts. Lack of skill development and alternative employment opportunities in all three villages **(**Chittupur, Sonbarsa, Molnapur**)** keeps communities dependent on agriculture, fishing, and riverbank resources, increasing pressure on the river ecosystem.

(9) Limited Awareness of the Ecological Significance of the Ganga

Like zone two villages, there is insufficient understanding among local communities regarding the ecological importance of the biodiversity of Ganga. Many people are unaware of the role of aquatic species in maintaining ecological balance, supporting fisheries, and providing ecosystem services such as water purification. This knowledge gap reduces community however, the riverbed is a natural part of the river system and plays an important role in maintaining its health. Activities such as seasonal farming, sand extraction, small constructions, and other human uses in the active river area disturb the natural structure and flow of the river. These activities can change the way water moves, spreads, and recharges the surrounding areas.

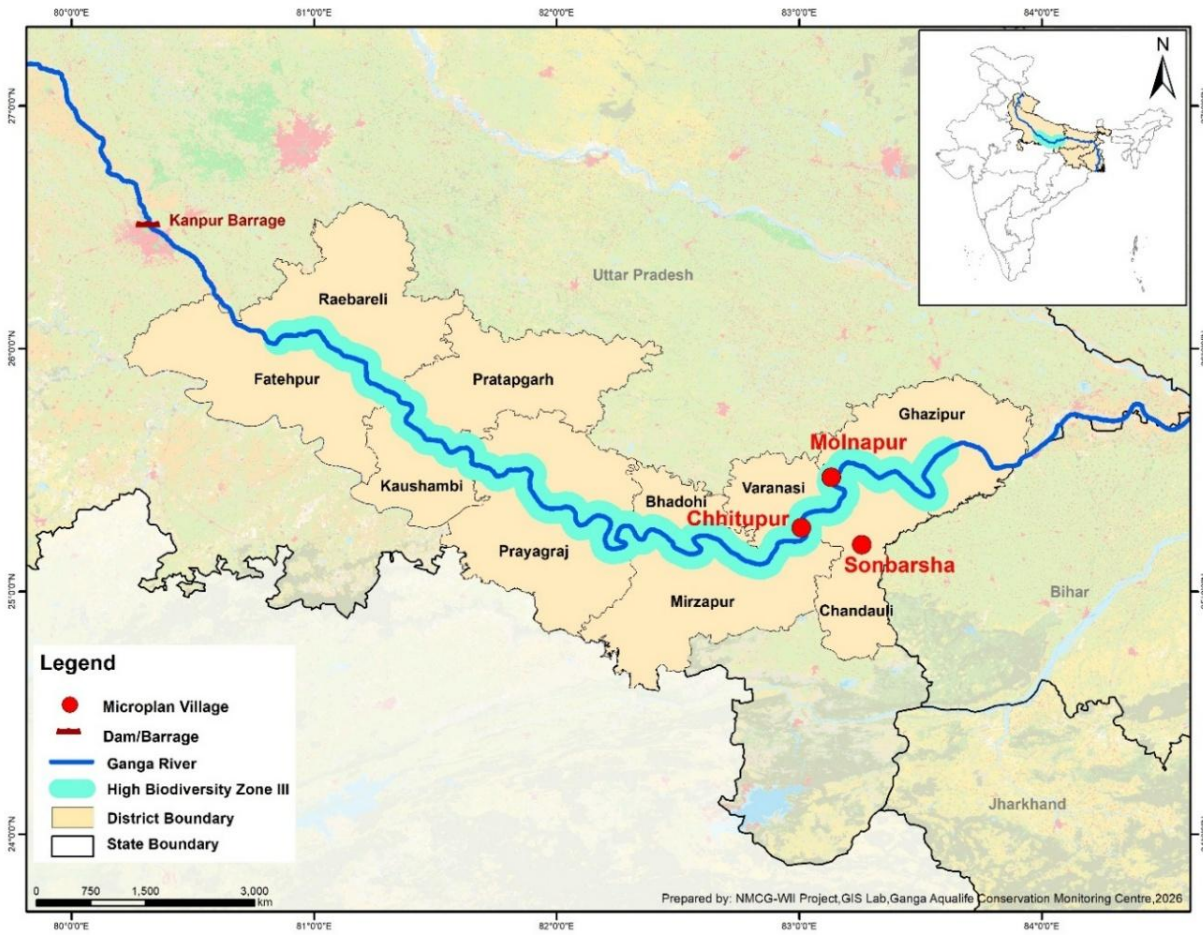

Figure 6.3. Microplanning villages in High Biodiversity Zone III

6.4.2.3. High Biodiversity Zone IV

Microplans have been prepared for two villages located along the Ganga stretch — Khwaspur in Bhagalpur district and Rasalpur in Samastipur district (Figure 6.4). The key issues identified through village-level microplanning are summarized below (Table 6.2):

(1) Inadequate sanitation facilities

In Khwaspur village, located along the Ganga, more than 2000 families do not have access to toilet facilities. Similarly, in Rasalpur village, nearly 20% of households lack toilets. Due to the absence of proper sanitation infrastructure, open defecation is widely practiced, which leads to contamination of water sources and increases the risk of disease transmission.

(2) Use of inorganic fertilizers in agriculture

The economy of Bihar is largely agrarian, and farmers often rely on chemical fertilizers and pesticides to enhance crop productivity. In Khwaspur, approximately 438 hectares of land, including riverbed areas, is used for agricultural activities. In Rasalpur, about 567 hectares of agricultural land and 226 hectares of riverbed land is cultivated. The extensive use of agro-chemicals in these areas results in runoff during rainfall, which eventually enters the river and adversely affects water quality and aquatic biodiversity.

(3) Habitat loss due to riverbed farming

Large-scale cultivation on riverbeds in villages located along the river is causing the loss and alteration of natural habitats. Such practices disturb the ecological conditions required by aquatic and riparian species, leading to habitat degradation.

(4) Over-extraction of water for irrigation and domestic use

Excessive extraction of groundwater for irrigation and domestic consumption has become a major concern in these villages. In Rasalpur, there are 9 tube wells and approximately 1,000 hand pumps are used for domestic purposes, along with 60 tube wells dedicated to irrigation. Similarly, Khwaspur has about 3,054 hand pumps for domestic use and more than 100 bore wells for irrigation, in addition to direct water extraction from the river. Such large-scale withdrawal of groundwater has resulted in a declining water table, particularly during the summer months. Furthermore, deforestation and the loss of riverine vegetation are increasing surface runoff during rainfall, thereby reducing the natural recharge of groundwater.

(5) Lack of solid and liquid waste management facilities

Both microplan villages lack adequate infrastructure for the management of solid and liquid waste**.** In Rasalpur, although a solid waste management system has been established, it is currently non-functional. Whereas Khwaspur totally lacks the waste management facilities. Consequently, household waste is often dumped in open areas, with a significant portion eventually reaching the river. In addition, religious offerings and other waste materials are frequently disposed of directly into the river. Such unregulated disposal of household, religious, and other waste contributes significantly to river pollution and poses risks to both environmental and public health.

(6) Poaching and sand mining

Incidents of poaching of turtles and migratory birds have been reported in both villages. Sand mining activities, particularly in Khwaspur, have caused soil erosion and destruction of natural habitats, disturbing the ecological balance of the river system.

(7) Dependence on river resources and lack of alternative livelihoods

Communities in these villages depend heavily on river-based resources such as fishing, sand extraction, and riverbed farming. Although the availability of these resources has declined over time, limited alternative livelihood opportunities and lack of employable skills force people to continue exploiting the river. This dependence increases pressure on the ecosystem.

(8) Lack of awareness about policies and conservation laws

There is limited awareness among community members about biodiversity conservation and the laws protecting riverine species. Due to this lack of information, harmful practices such as using mosquito nets for fishing, accidental killing of aquatic and migratory species, habitat destruction, and over-extraction of resources continue unchecked.

(9) Religious and cultural practices

Several religious festivals are celebrated along the riverbanks, especially Chhath Puja. During these events, large gatherings take place and religious offerings are immersed in the river. The disposal of organic and non-biodegradable materials into the water contributes to pollution and negatively affects aquatic species and overall river health.

Overall, the issues identified through microplanning highlight the close connection between livelihoods and river health, emphasizing the need for integrated conservation and community-based management approaches in these Ganga villages.

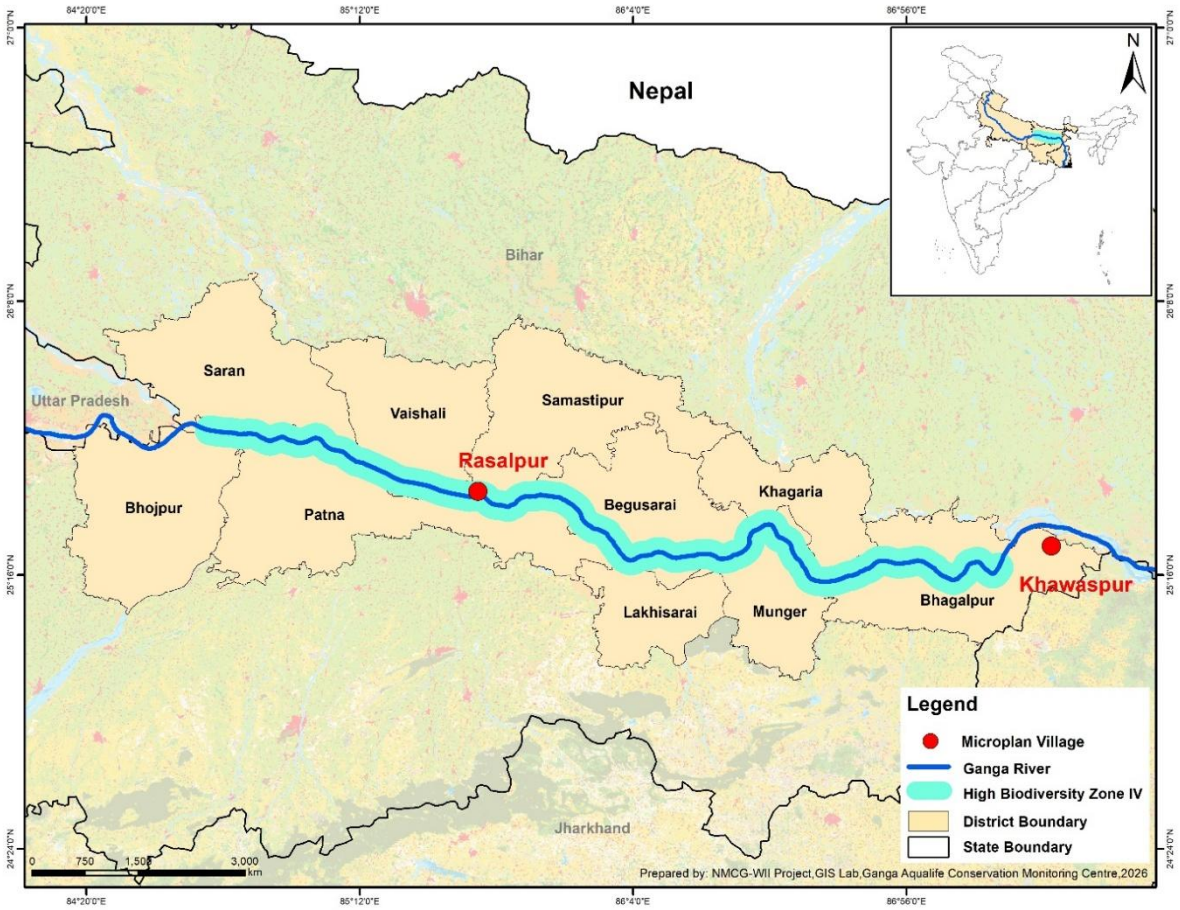

Figure 6.4. Microplanning villages in High Biodiversity Zone IV

6.4.2.4. High Biodiversity Zone V

The microplan of village Saidpur highlights the issues in HBZ V of the Ganga River stretch (Figure 6.5). It reflects a range of ecological and socio-environmental concerns that are affecting biodiversity conservation and overall ecosystem health in the Ganga River basin of Jharkhand. These challenges arise mainly from heavy livelihood dependence on river resources, changing land-use patterns, and weak waste and resource management systems, all of which are putting pressure on the river's ecological integrity (Table 6.2).

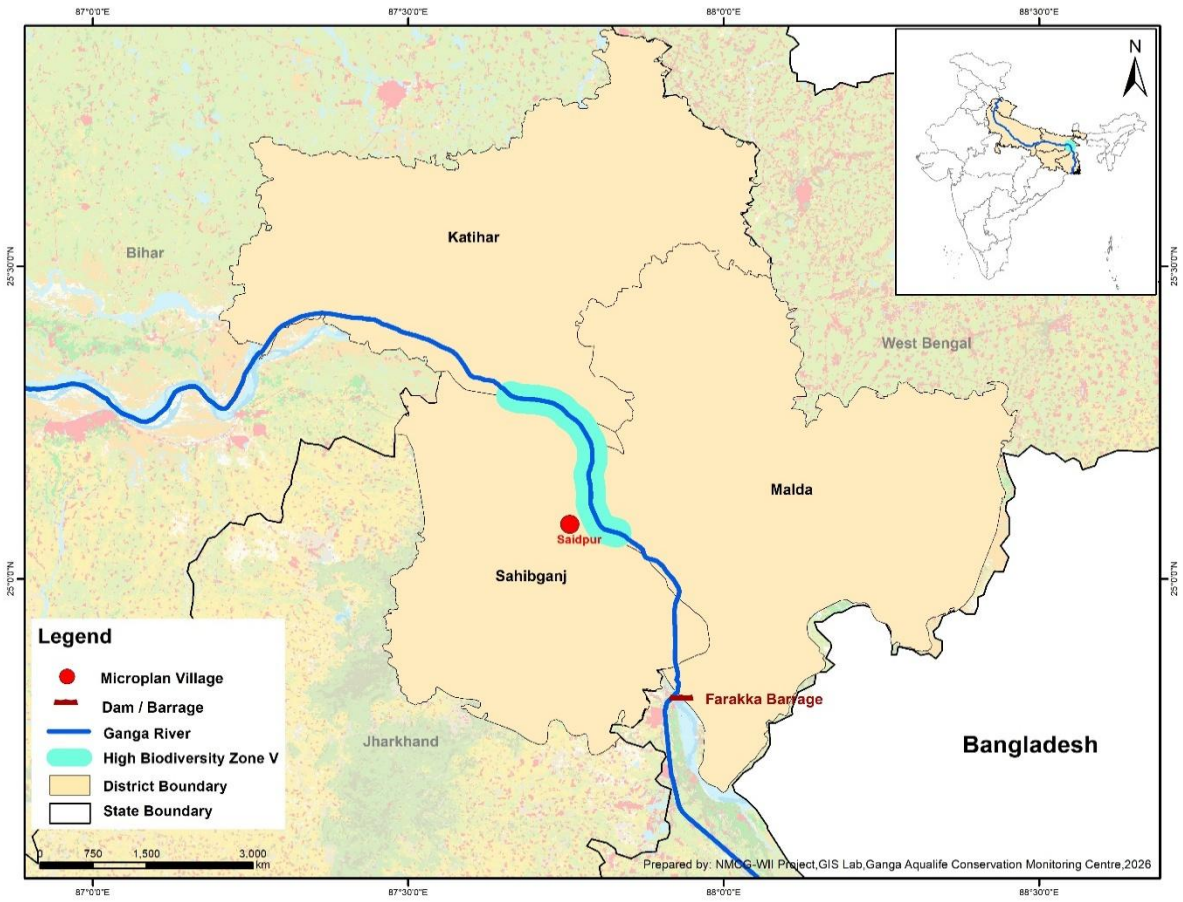

Figure 6.5. Microplanning village in High Biodiversity Zone V

(1) Unsustainable fishing practices

Fishing is an important source of income for many village families. Around 100 households in Village Saidpur depend on fishing and boating activities for their livelihoods, increasing pressure on local fish resources. Continuous and intensive fishing activities have resulted in a noticeable reduction in fish populations in the river stretch near Village Saidpur. The growing use of fine-mesh nets and drag nets has increased pressure on aquatic species. These nets often catch juvenile fish and non-target species, disturbing breeding cycles and reducing fish populations over time. In the absence of proper regulation and awareness about sustainable fishing methods, such practices threaten long-term aquatic biodiversity as well as the livelihood security of fishing communities.

(2) Improper solid waste management

There is no well-organized system for waste collection and disposal in the village. As a result, household waste, including plastic and organic matter, is frequently dumped in open spaces and near river channels. This leads to degradation of riverbanks, declining water quality, and increased health risks due to disease-carrying vectors. The situation calls for decentralised waste segregation, regular collection systems, and stronger community participation in waste management.

(3) Water pollution and sanitation issues

Although sanitation coverage has improved under national schemes, incomplete toilet usage and continued open defecation near riverbanks remain concerns. A large number of households (about 609)

do not have toilet facilities, resulting in open defecation, which contributes to river water pollution and impacts aquatic ecosystems.

(4) Agricultural runoff and chemical inputs

A large proportion of the village population depends on agriculture and livestock rearing for their livelihoods. Intensive farming practices involving chemical fertilizers and pesticides result in nutrient leaching and runoff into nearby water bodies. Farming along the riverbanks leads to increased chemical runoff and also disturbs breeding and habitat areas of aquatic organisms.

(5) Degradation of riparian habitats

Expansion of agriculture, grazing, and settlements along riverbanks has led to the clearing of natural vegetation. This has fragmented habitats and reduced the natural buffering capacity of floodplains. Loss of vegetation increases soil erosion, weakens habitat connectivity, and limits breeding and nesting spaces for birds, reptiles, and small mammals. Restoration of riparian vegetation is therefore critical for improving ecological stability.

(6) Limited institutional coordination and awareness

Awareness about the importance of biodiversity conservation remains limited among local communities. As a result, accidental entanglement and mortality of aquatic fauna occur during fishing operations. In addition, coordination among Panchayats, Forest Departments, and other local institutions is weak, reducing the effectiveness of conservation and restoration efforts. Strengthening institutional collaboration, improving biodiversity monitoring, and promoting community stewardship are essential to achieve sustainable conservation outcomes in the region.

6.4.2.5. High Biodiversity Zone VI

Microplans have been prepared for the villages of Deer Forest and Nayachar located along the Ganga River in the state of West Bengal. Village Nayachar falls within the High Biodiversity Zone VI of the Ganga River, while Deer Forest is situated upstream of this zone (Figure 6.6). The main issues observed in these villages are as below (Table 6.2):

(1) Intensive riverbank agriculture and disturbance to turtle nesting habitats

Agriculture is the primary livelihood in both villages, where most households cultivate crops along the riverbanks. Farmers grow cash crops and rely heavily on chemical fertilizers and pesticides to increase productivity. Runoff from these chemicals enters the Ganga River, degrading water quality and negatively affecting aquatic biodiversity. Agricultural expansion, human disturbance, and riverbank activities are affecting natural sandbanks that serve as nesting and breeding habitats for freshwater turtles and other riverine species. Mining and other disturbances along the riverbanks further damage these critical habitats.

(2) High dependence on fishing

Fishing is a major livelihood activity for communities living within 6–10 km of the river. In Deer Forest village, around 98 households are involved in fishing either for commercial purposes or for household consumption. In Nayachar, about 75 families depend on fishing as a primary income source, while others

fish for subsistence. Over the past 14–15 years, excessive fishing pressure has resulted in a significant decline in fish populations, reducing the number of families dependent on fishing from more than 150 to around 75. At present, approximately 200 kg of fish are caught daily and sold in nearby markets such as Katwa.

(3) Unsustainable and indiscriminate fishing practices

Fishers commonly use permanent fishing gear such as door nets and fine-mesh mosquito nets that capture juvenile fish and non-target species. In some cases, destructive methods such as bleaching powder, explosives, and electric current are also used to catch fish. These practices kill both adult and juvenile fish, disrupt breeding cycles, and disturb the natural balance of aquatic ecosystems. Certain fish species, such as Banded Gourami and mullet have reportedly declined in this river stretch.

(4) Accidental capture and illegal hunting of aquatic wildlife

During fishing operations, aquatic wildlife such as the Ganges River Dolphin and freshwater turtles sometimes become entangled in fishing nets. This has been reported particularly in the Nayachar village area. Local communities lack awareness and training on rescue methods. In addition, incidents of illegal hunting of turtles have been reported in the area.

(5) Degradation of riparian vegetation

Local communities collect riverbank vegetation and cut trees for fuelwood and livestock fodder. Excessive extraction of these resources has led to the degradation of riparian habitats that are essential for maintaining riverbank stability and supporting wildlife. Due to limited alternative livelihood options, villagers rely heavily on natural resources such as fish, riverbank vegetation, and forest products. This increasing dependence has placed additional pressure on riverine ecosystems and biodiversity. Over extraction of riverbank resources and large-scale tree cutting have resulted in habitat loss for many wildlife species. As a consequence, a noticeable decline in animals such as wild cats and foxes has been reported in the region.

(6) Improper waste disposal and lack of waste management

Neither village has an effective waste management system. Household waste is often dumped in open areas or along the riverbanks, and eventually enters the river. Religious waste such as offerings, idols, and ritual materials are also immersed in the river, leading to the accumulation of solid waste and deterioration of water quality.

(7) Sanitation gaps and open defecation

Of the total 510 households in Nayachar village, around 110 do not have toilets, mainly due to poor economic conditions. Some houses in Deer Forest also lack toilet facilities. As a result, open defecation along riverbanks continues, contributing to water pollution and negatively impacting aquatic ecosystems. The microplans reveal that heavy dependence on riverine resources, unsustainable fishing practices, intensive agriculture, inadequate sanitation, and weak waste management systems are the key drivers affecting biodiversity and ecological health in the Ganga river stretch near Deer Forest and Nayachar.

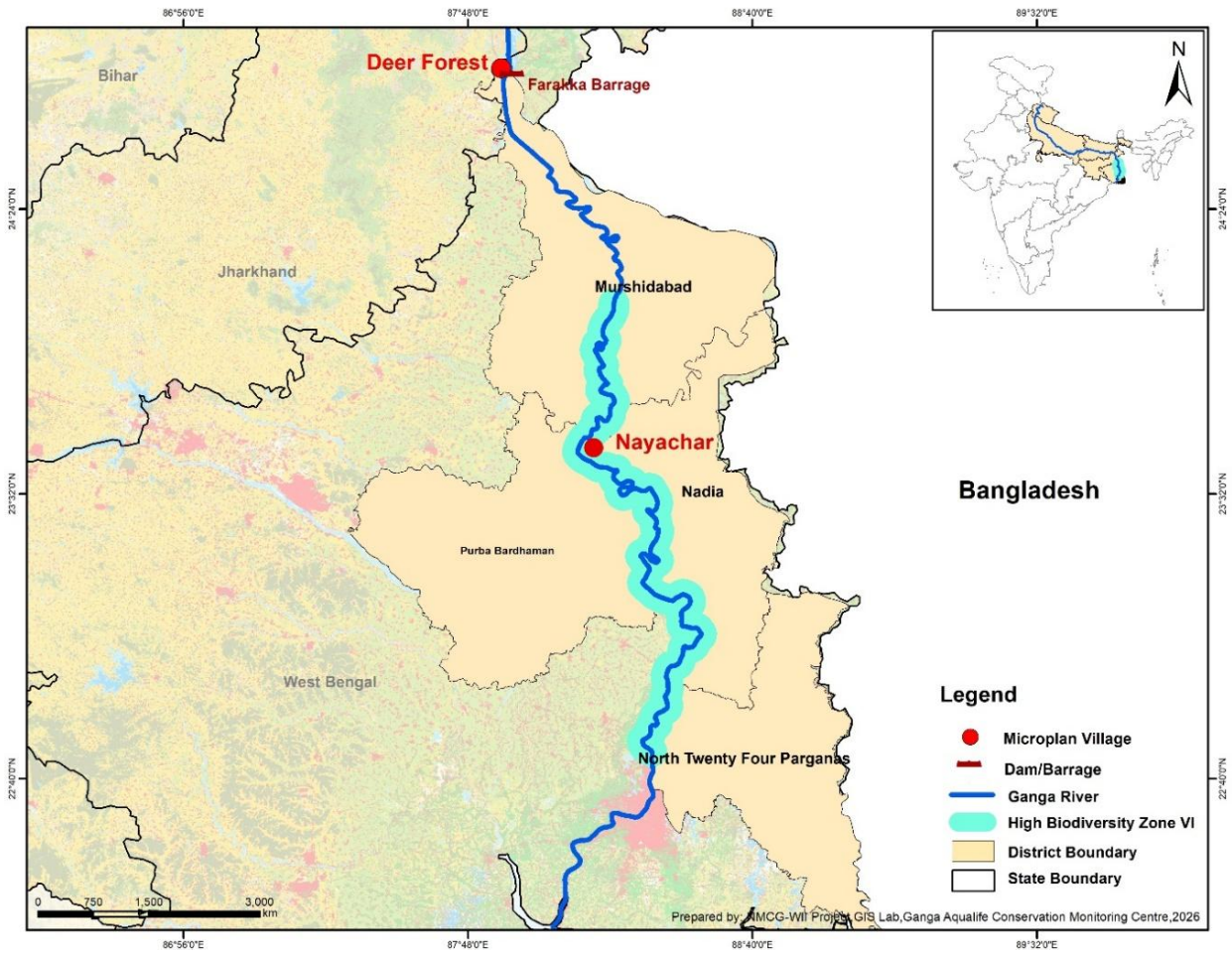

Figure 6.6. Microplanning villages in High Biodiversity Zone VI

Table 6.2. Conservation and development challenges and issues identified in High Biodiversity Zones through microplanning approach

Zone	Villages Covered	Key issues identified
Zone II	Daranagar and Niwadi Khadar (Uttar Pradesh)	Limited awareness among local communities about biodiversity and conservation initiatives; intensive agriculture along riverbanks with extensive use of chemical fertilizers and pesticides; riverbed agriculture practiced by more than 100 families in Niwadi Khadar; absence of proper waste management facilities in Niwadi Khadar and poor utilization of existing facilities in Daranagar; dumping of household and market waste near or into the river; discharge of untreated wastewater and greywater degrading water quality and affecting aquatic biodiversity, Overuse of Riparian Vegetation, Immersion of Idols and Religious Waste, High Dependence on River-Based Livelihoods with Limited Alternatives, Overexploitation of River Resources, Open Defecation Along Riverbanks, Weak Enforcement and Monitoring Mechanisms, Weak Community Institutions and Limited Collective Action.
Zone III	Molnapur, Chittupur and Sonbarsa (Uttar Pradesh)	Intensive agricultural activities along the river banks; Habitat Degradation due to Riverbed Farming and Other Anthropogenic Activities, excessive use of chemical fertilizers and pesticides to increase crop productivity; riverbed cultivation during the lean season; expansion of farming into the active riverbed leading to disturbance of aquatic habitats and breeding grounds of riverine species, Accidental Entanglement of Aquatic Species in Fishing Nets, Waste Disposal along Riverbanks, Open Defecation along Riverbanks, High Tourist Inflow and Increased Anthropogenic Pressure, Limited Alternative Livelihood Opportunities, Limited Awareness of the Ecological Significance of the Ganga.
Zone IV	Khawaspur and Rasalpur (Bihar)	Lack of adequate sanitation facilities, Use of chemicals in farming, Habitat loss due to riverbed farming, Over extraction of water for irrigation and domestic use, Lack of solid and liquid waste management facilities, Illegal poaching and sand mining, Dependence on river resources and lack of alternative livelihoods, Lack of awareness about policies and conservation laws, Religious and cultural practices contributing to pollution.
Zone V	Saidpur and nearby villages (Jharkhand)	Unsustainable fishing practices including the use of fine-mesh and drag nets resulting in capture of juvenile fish; lack of organized waste management systems leading to dumping of household waste near river channels; partial toilet usage and open defecation near riverbanks contributing to water contamination; agricultural runoff

		carrying fertilizers and pesticides into the river; degradation of riparian vegetation due to agriculture and grazing; weak institutional coordination and limited awareness regarding biodiversity conservation.
Zone VI	Nayachar and Deer Forest (West Bengal)	High dependence on fishing as a primary livelihood; use of fine-mesh mosquito nets and harmful fishing methods such as chemicals and electric current; excessive fishing pressure and decline in certain fish species; accidental entanglement of aquatic fauna such as the Ganges River Dolphin and turtles; intensive riverbank agriculture with heavy chemical use affecting biodiversity and turtle nesting habitats; extraction of riparian vegetation for fuelwood and fodder; lack of proper waste disposal systems and dumping of household waste along riverbanks; open defecation due to lack of toilets; sand mining and other disturbances affecting turtle habitats; overexploitation of natural resources due to limited livelihood alternatives.

6.4.3. Suggested strategies and activities to address the identified issues

The success of river conservation initiatives depends largely on the participation and cooperation of local communities living along the river. Communities in the microplan villages depend on the river and surrounding natural resources for agriculture, fishing, livestock rearing, and other livelihood activities. However, unsustainable practices, lack of awareness, and inadequate infrastructure often lead to ecological degradation and pressure on biodiversity.

To address these challenges, the proposed activities focus on community awareness, strengthening local institutions, livelihood diversification, sanitation improvement, sustainable agriculture, and biodiversity and habitat conservation. These interventions are designed to reduce pressure on natural resources while simultaneously improving the socio-economic conditions of local communities. The microplans are structured around the following nine thematic areas: (1) community awareness, (2) cleanliness and sanitation, (3) strengthening of local institutions, (4) livelihood and skill development, (5) agricultural development, (6) animal husbandry and livestock management, (7) promotion of renewable energy, (8) fisheries development and awareness, (9) habitat and biodiversity conservation. Under each of these thematic areas, a set of targeted activities has been proposed to address local environmental and socio-economic issues. These activities aim to support ecological restoration, biodiversity conservation, improved livelihoods, and enhanced community well-being, while ensuring the long-term sustainability of riverine ecosystems.

(1) Community awareness and capacity building

Community awareness is essential for ensuring active participation of local communities in river conservation and biodiversity protection. In many villages along the river stretch, awareness regarding aquatic biodiversity, sustainable resource use, and sanitation practices remains limited. Therefore, a series of awareness and capacity-building activities will be undertaken. Key activities include:

- Organizing community meetings, workshops, and group discussions on river ecology, biodiversity conservation, and sustainable livelihoods.

- Discussing the impacts of daily human activities—such as fishing practices, waste disposal, and agriculture—on river ecosystems.
- Conducting awareness campaigns through rallies, community gatherings, and school programmes.
- Using communication materials such as signboards, wall paintings, banners, and posters to disseminate conservation messages.
- Creating awareness on the harmful effects of single-use plastic and improper waste disposal.
- Conducting awareness programmes on sustainable fishing practices and the importance of observing closed fishing seasons.
- Promoting awareness on the benefits of organic farming and environmentally sustainable practices.
- Organizing awareness sessions with fishing and boating communities regarding appropriate fishing gear and conservation measures.

(2) Strengthening community-based institutions

Community-based institutions play a vital role in ensuring the long-term sustainability of conservation initiatives. Existing local groups such as Self-Help Groups (SHGs), youth groups, and other village institutions will be strengthened and involved in biodiversity conservation efforts. Key activities include:

- Conducting meetings with existing Self-Help Groups to increase awareness about river biodiversity and conservation initiatives.
- Identifying and nominating community volunteers as Ganga Praharis.
- Providing training to Ganga Praharis on river conservation, biodiversity monitoring, and awareness activities.
- Forming village-level committees of Ganga Praharis to support continuous conservation activities.
- Encouraging community groups to participate in plantation drives, cleanliness campaigns, and awareness programmes.

(3) Livelihood diversification and skill development

In many villages, households depend heavily on river resources for their livelihoods, including fishing, riverbank farming, and wage labour. Excessive dependence on natural resources can place pressure on aquatic ecosystems. Therefore, livelihood diversification and skill development activities will be promoted to reduce this dependency. Key activities include:

- Providing information on government livelihood and development schemes through meetings and workshops.
- Organizing skill development training programmes for youth and women.
- Promoting livelihood activities such as incense stick production, basket and mat making, fruit processing, and other small enterprises.

- Conducting training on crop diversification including millet cultivation, coconut farming, dragon fruit cultivation, and medicinal plant cultivation where feasible.
- Providing digital literacy and computer training for youth.
- Exploring opportunities for eco-tourism, bird guiding, and tourism-related livelihoods where suitable.
- Facilitating market linkages for locally produced products.

(4) Sanitation and waste management

Sanitation and waste management remain major concerns in many villages along the river, particularly during religious gatherings and community events at river ghats. Lack of proper waste management systems and open defecation contribute to river pollution. Key activities include:

- Conducting awareness campaigns on sanitation, waste management, and environmental health.
- Promoting the segregation of biodegradable and non-biodegradable waste at the household level.
- Encouraging the reduction of plastic use, particularly single-use plastic.
- Organizing community cleanliness drives along riverbanks and ghats.
- Encouraging households without toilets to construct them through government sanitation schemes.
- Creating awareness to prevent the immersion of idols and other religious materials in the river.

(5) Promotion of alternative energy

Although many households have access to modern energy sources, traditional fuels such as firewood continue to be used in several villages. This leads to pressure on nearby vegetation and natural resources. To address this issue, the following measures will be promoted:

- Creating awareness about the environmental and health impacts of traditional fuel use.
- Encouraging households to use clean energy sources such as LPG.
- Promoting the adoption of renewable energy technologies such as solar cookers and biogas plants.
- Demonstrating alternative energy solutions in selected households.

(6) Agriculture development

Agriculture is the primary livelihood activity in most villages along the river stretch. However, the extensive use of chemical fertilizers and pesticides can negatively affect soil health, water quality, and aquatic biodiversity. Riverbank cultivation may also disturb aquatic habitats and breeding areas. Agriculture development activities will therefore focus on sustainable practices, including:

- Creating awareness about the negative impacts of chemical fertilizers and pesticides.
- Promoting organic and natural farming practices.
- Providing training on the preparation and use of organic fertilizers and compost.

- Demonstrating organic farming practices through pilot plots.
- Establishing coordination with the Agriculture Department for access to government schemes and technical support.
- Promoting cultivation of traditional and climate-resilient crops such as millets.

(7) Livestock development

Livestock rearing serves as an important supplementary livelihood source in several villages. Improving livestock productivity can help strengthen household incomes while reducing pressure on natural resources. Key activities include:

- Providing training on improved livestock management practices.
- Promoting fodder cultivation and improved livestock nutrition.
- Facilitating access to veterinary services and vaccination programmes through coordination with relevant departments.
- Encouraging youth to engage in dairy-related enterprises and livestock-based livelihoods.

(8) Fisheries awareness and sustainable practices

Fishing is an important livelihood activity in many villages located along the river. However, unsustainable fishing practices and the use of destructive fishing nets can negatively affect fish populations and aquatic biodiversity. Key activities include:

- Conducting awareness programmes on sustainable fishing practices.
- Encouraging fishing communities to avoid fishing during breeding seasons.
- Promoting the use of appropriate fishing nets that reduce harm to juvenile fish and other aquatic species.
- Encouraging fish farmers to explore alternative fish farming opportunities where feasible.
- Linking fishing communities with government fisheries development schemes.

(9) Biodiversity conservation and habitat restoration

Conservation of river biodiversity is essential for maintaining ecological balance and ecosystem services. Community participation will be encouraged to support biodiversity conservation and habitat restoration efforts. Key activities include:

- Raising awareness about river ecosystems and aquatic biodiversity.
- Training Ganga Praharis and community volunteers in biodiversity monitoring and conservation.
- Establishing coordination with the Forest Department for wildlife rescue and conservation activities.
- Organizing school-based awareness programmes involving students and teachers.
- Promoting tree plantation along riverbanks and community lands to improve habitat quality.
- Monitoring and reporting cases of injured or stranded aquatic animals.

6.4.4. Tailored activities suggested to be conducted in high biodiversity zones

The zone-wise activity matrix shows that the proposed interventions across Zones II to VI follow a broadly similar thematic structure, focusing on community awareness, strengthening local institutions, livelihood development, sanitation and waste management, promotion of alternative energy, sustainable agriculture, livestock development, fisheries management, and biodiversity conservation. These themes form the core framework of the microplan and aim to address both ecological concerns and community livelihood needs. However, the emphasis of specific activities varies across zones depending on local socio-economic conditions, livelihood patterns, and geographical characteristics (Table 6.3).

In Zone II, the presence of important religious sites and ghats result in frequent pilgrim inflow and public gatherings. Therefore, greater emphasis is placed on awareness campaigns during festivals, improved sanitation facilities at ghats, waste management, and community participation in cleanliness drives. Livelihood activities in this zone also include small enterprises linked to tourism and religious fairs, such as handicrafts and eco-friendly products (Table 6.3).

Zone III villages are closely connected with pilgrimage, agriculture, fishing, and river-based livelihoods. As a result, the activities focus more on awareness about the impacts of chemical fertilizers and pesticides, promotion of organic farming practices, awareness about water born disease, sanitation and waste management, monitoring and rescue trainings etc. In addition, institutional strengthening is emphasized through the involvement of Self-Help Groups, Anganwadi workers, and village-level committees to support conservation initiatives (Table 6.3).

Zone IV shows a stronger focus on institutional strengthening and biodiversity conservation. Activities include the formation and strengthening of Biodiversity Management Committees, training of Ganga Praharis, and community-based monitoring of aquatic wildlife, organic farming, plantation and alternative livelihoods. Awareness programmes also highlight the importance of aquatic species such as the Ganges River Dolphin and the need to protect river habitats through plantation and pollution control measures along with reducing use of single use plastic (Table 6.3).

In Zone V, livelihood dependence on fishing and riverbank farming is more prominent. Consequently, the microplan emphasizes livelihood diversification, sanitation improvement, and sustainable fishing practices. Awareness campaigns are also directed towards reducing open defecation, improving waste management at ghats, and encouraging community participation in conservation through Ganga Praharis, monitoring of illegal poaching and mining activities through coordination between Ganga Praharis and concerned departments (Table 6.3).

In Zone VI special attention is given to strengthening local institutions through the identification and training of Ganga Praharis, engaging Self-Help Groups, and promoting community participation in conservation and monitoring activities (Table 6.3).

The microplan also includes livelihood diversification and skill development programmes such as training on millet cultivation, bamboo products, food processing, and other small enterprises to reduce pressure on river resources. Additionally, sanitation drives, waste management awareness, promotion of clean energy, and sustainable agriculture practices are proposed to reduce pollution and ecological stress on the river. Biodiversity conservation efforts in the zone further include training for rescue and rehabilitation of aquatic species, plantation along riverbanks, and collaboration with relevant government departments for long-term habitat protection and monitoring (Table 6.3).

Overall, while the core activities remain consistent across all zones, the specific priorities and implementation strategies vary depending on local environmental pressures, livelihood dependence, and infrastructure conditions. This zone-specific approach ensures that conservation interventions are locally relevant and more effective in addressing the socio-ecological challenges of the Ganga River basin.

Table 6.3. Activities proposed to be conducted in High Biodiversity Zones

Sl. No.	Theme	Proposed activities in High Biodiversity Zones				
		Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
1	**Community Awareness & Capacity Building**	Awareness during religious festivals, ghats, pilgrim management, plastic reduction, rallies, school programmes	Awareness on river conservation, aquatic biodiversity, chemical pollution, fishing practices	Awareness on aquatic species, community meetings, school programmes, ward meetings	Village meetings, rallies, campaigns, plastic reduction, sanitation awareness	Awareness on aquatic biodiversity, Natural farming, Sustainable fishing practices and signage, sustainable plastic pollution
2	**Strengthening Community Institutions**	Strengthening SHGs, forming new SHGs, training Ganga Praharis	Strengthening SHGs, Strengthening Anganwadi/ASHA workers, forming BMCs	Strengthening SHGs, BMCs, Ganga Prahari networks	Strengthening SHGs and youth forums	SHG awareness, Ganga Prahari identification, training and forming and strengthening of GP committees
3	**Livelihood & Skill Development**	Sewing, handicrafts, incense sticks, herbal products, eco-friendly products, tourism skills	Sewing, embroidery, mobile repair, plumbing, electrical work, small enterprises	Organic farming, bamboo products, LED assembly, food processing, herbal juice, backyard poultry, marketing platforms	Incense stick making, basket/mat weaving, fruit processing, bird/tourist guide	Millet cultivation, coconut, dragon fruit farming, medicinal plants, small enterprises development, linkages
4	**Sanitation & Waste Management**	Community toilets, awareness on use of toilets, dustbins at ghats, waste segregation, clean-up drives	Awareness on solid waste management, waste segregation, waste reduction	Awareness and Coordination for toilet construction, household sanitation, solid waste management	Cleanliness drives at ghats, toilet construction awareness and linkages	Cleanliness drives, waste segregation, plastic waste awareness

5	**Promotion of Alternative Energy**	LPG, solar cookers, biogas, Ujjwala scheme awareness	LPG, biogas, smokeless chulhas, solar energy promotion	LPG, solar energy, biogas, solar irrigation pumps awareness	Promotion of LPG, solar cookers and biogas awareness	LPG, solar cookers, biogas awareness
6	**Agriculture Development**	Organic farming promotion, agroforestry, horticulture promotion, cash crops, millet cultivation, compost	Organic farming training, compost preparation, nurseries, medicinal plants cultivation	Awareness on improved technologies and tools, organic Kisan pathshala, organic farming training, soil testing, climate-resilient crops	Promotion of natural farming, training and development of demonstration plots	Organic farming awareness, compost training, millet cultivation
7	**Livestock Development**	Dairy promotion, awareness on improved breeds, fodder cultivation	Veterinary camps, awareness on improved breeds, fodder cultivation, poultry farming	Vaccination camps, dairy development, poultry keeping, fodder cultivation, awareness on livestock schemes	Livestock management training, awareness on improved breeds	Fodder cultivation awareness, dairy promotion for livelihood
8	**Fisheries Development / Awareness**	Integrated fish farming, training information on fisheries schemes	Fish farming promotion, sustainable fishing awareness	Scientific fish farming training, fisheries schemes awareness	Sustainable fishing awareness, breed season protection, coordination with departments	Awareness on sustainable fishing practices
9	**Biodiversity Conservation & Habitat Restoration**	Biodiversity awareness, monitoring illegal fishing and poaching, training, nursery raising, plantation, awareness, livelihood training	Aquatic biodiversity awareness, monitoring, rescue training and coordination, waste management	Community monitoring like protection of aquatic biodiversity, plantation, awareness on impact of deforestation, rescue training, plantation	Ganga Praharis monitoring ghats, awareness, waste management awareness and facilities, monitoring illegal poaching and mining.	Biodiversity awareness, monitoring, plantation, rescue training, coordination and linkages

6.5. Conclusion

The village-level microplanning exercise undertaken across different stretches of the Ganga River provides a detailed understanding of the complex interactions between human livelihoods and riverine ecosystems. The analysis of microplans prepared for villages across multiple zones reveals that ecological pressures on the river vary significantly along its course, reflecting differences in socio-economic conditions, livelihood strategies, and patterns of resource use. In the upper and middle stretches of the river, agriculture emerges as one of the dominant livelihood activities influencing the river ecosystem. Intensive cultivation along riverbanks, riverbed farming during lean seasons, and the extensive use of chemical fertilizers and pesticides contribute to nutrient runoff and sedimentation, which adversely affect water quality and aquatic biodiversity. These practices also lead to encroachment into natural river habitats, disturbing breeding and nesting sites of several aquatic and semi-aquatic species. In the middle floodplain areas, the microplans highlight the increasing dependence of local communities on riparian vegetation and other natural resources. The extraction of reeds and grasses from the riverbanks for purposes such as basket making, roofing, and sale to farmers illustrates how traditional livelihood practices, when intensified due to limited economic opportunities, can gradually lead to degradation of riparian habitats. Such vegetation plays a critical ecological role in stabilizing riverbanks, preventing soil erosion, and providing habitat for a variety of wildlife species. The removal of these resources therefore has broader implications for the ecological integrity of the riverine landscape.

Further downstream, particularly in the lower stretches of the river, the pressures on the ecosystem become more diverse and complex. High dependence on fisheries, the use of destructive fishing practices such as fine-mesh nets and chemicals, and excessive fishing pressure have resulted in declining fish populations and disruption of aquatic food webs. In some areas, the accidental entanglement of aquatic fauna, including species such as the Ganges River Dolphin and freshwater turtles, highlights the growing conflict between livelihood activities and biodiversity conservation. Habitat disturbances caused by agricultural expansion, sand mining, and human activities along the riverbanks further threaten important breeding and nesting habitats of riverine species. The microplans also bring attention to critical environmental management challenges such as inadequate waste disposal systems, sanitation gaps, and limited awareness regarding biodiversity conservation. In several villages, the absence of organized waste management facilities and improper disposal of household and religious waste contribute to the accumulation of solid waste along the riverbanks and in the river channel. Similarly, open defecation and discharge of untreated wastewater in some locations lead to further deterioration of water quality. These issues demonstrate that river conservation is closely linked with improvements in basic infrastructure, public health, and community awareness.

Overall, the findings from the microplanning process clearly demonstrate the value of localized, participatory assessments in understanding the drivers of ecological degradation in large river systems. Unlike broad basin-level analyses, village-level microplans capture site-specific realities and provide insights into how local livelihood practices interact with river ecosystems. By identifying the key environmental pressures, socio-economic drivers, and knowledge gaps within each village, microplans serve as an important planning and management tool for designing targeted conservation interventions. They help bridge the gap between national river conservation programmes and local community actions by translating broader ecological objectives into practical, context-specific strategies. Therefore, village-level microplanning not only highlights the diversity of challenges faced across different stretches of the Ganga but also underscores the importance of community participation in river conservation efforts. The

process encourages local stewardship, strengthens awareness about sustainable resource use, and supports the development of interventions that balance biodiversity conservation with livelihood security. In this way, microplans contribute significantly to the long-term goal of restoring and maintaining the ecological health, biodiversity, and ecosystem services of the Ganga River system while ensuring the well-being of the communities that depend upon it.


Golden mahseer
Tor putitora
Gharial
Gavialis gangeticus
Beautiful stream frog
Amolops formosus
Hilsa
Tenualosa ilisha
Irrawaddy dolphin
Orcaella brevirostris
Red-crowned
roofed turtle
Batagur kachuga

Chapter 07

FROM AWARENESS TO ACTION: INTEGRATED ENVIRONMENTAL EDUCATION AND OUTREACH STRATEGIES FOR GANGA RIVER CONSERVATION

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Summary

The chapter, “From Awareness to Action: Integrated Environmental Education and Outreach Strategies for Ganga River Conservation”, presents a comprehensive framework for strengthening participatory conservation of the Ganga River through environmental education, awareness generation, and community outreach. It establishes environmental education (EE) as a critical mechanism for addressing environmental challenges such as biodiversity loss, pollution, and unsustainable practices by improving environmental literacy, promoting behavioural change, and encouraging active public participation in conservation. The chapter highlights that although environmental education has long been recognized globally and in India, its implementation often remains overly theoretical. Therefore, the programme emphasized experiential and activity-based learning approaches, including workshops, interpretation centres, games, exhibitions, and community engagement activities, to make ecological concepts more understandable and relatable. The primary aim of the programme was to design, implement, and evaluate interventions that enhance awareness, build capacity, and promote participatory conservation of the Ganga River and its biodiversity. Two key objectives guided the initiative: establishment of Ganga Knowledge Corners as information dissemination platforms and development of outreach and conservation education programmes to garner support for aquatic biodiversity conservation. A dual strategy of localized and mass awareness was adopted. Localized interventions included school workshops, low-cost interpretation corners, interpretation centres, and educational publications, while mass outreach consisted of radio talks, social media campaigns, puppet shows, street plays, exhibitions, and public awareness campaigns.

Government schools, located within 5–8 km of the river, were prioritized because many students belonged to river-dependent communities and had limited access to environmental education resources. Interactive learning modules focusing on river biodiversity, culture, heritage, and conservation were developed using oral presentations, visual tools, discussions, and game-based learning methods. Activities such as the “Web of Life,” biodiversity-themed Snake and Ladder, puzzles, quizzes, origami, and biodiversity games simplified ecological concepts and encouraged student participation. Among these, the Snake and Ladder game emerged as the most effective tool due to its familiarity and its ability to integrate conservation messages into gameplay. Pre- and post-questionnaire surveys were conducted to evaluate programme effectiveness.

The results demonstrated significant educational impact. A total of 185 awareness workshops were conducted across Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal, reaching 14,240 participants. Analysis of data from 60 schools involving 3,077 students showed a 27.85% increase in knowledge about riverine biodiversity, a 39.93% increase in understanding of culture and heritage, and a 19.04% increase in conservation values. Statistical analysis using the Wilcoxon Signed-rank test confirmed that these improvements were significant ($p < 0.05$). Teacher training programmes formed another major component of the initiative. A total of 489 pre-service teachers, 34 DIET lecturers, and 825 in-service teachers were trained through interactive and experiential workshops. Training included presentations on river biodiversity, educational games, discussions, and use of the instructional manual

"Discovering Ganga." Schools were also provided with "Gyan Kosh" resource kits containing manuals, activity books, educational games, puppets, biodiversity factsheets, videos, and water testing kits to support continued environmental learning. The programme established 106 low-cost interpretation corners called "Jalmala Samvaad" across 58 districts in five Ganga basin states. These centres functioned as localized biodiversity galleries and educational spaces, collectively sensitizing 81,900 students and 1,820 teachers. Additionally, five major interpretation centres were established at Haridwar, Kanpur, Varanasi, Rudrapur, and Ramnagar to promote awareness regarding the ecological and cultural significance of the Ganga River. These centres recorded steadily increasing visitor numbers and served as major public engagement platforms. Mass outreach initiatives greatly expanded programme reach. Approximately one crore people were sensitized through campaigns such as Ganga Utsav, Nadi Utsav, Mission LiFE, Swachhta Hi Sewa, and Mahakumbh 2025. Outreach methods included radio talks, mobile and static exhibitions, social media campaigns, village walks, publications, puppet shows, and nukkad nataks. Social media platforms and digital content engaged over 15.65 lakh participants globally, while publications and exhibitions further strengthened awareness dissemination.

The chapter concludes that integrated environmental education and outreach interventions can successfully bridge the gap between scientific knowledge and societal action. By combining formal education, interpretation centres, teacher capacity building, community participation, and mass communication strategies, the programme created a scalable and participatory model for river conservation and governance in the Ganga basin.

7.1. Introduction

Environmental Education (EE) has emerged as a critical instrument for addressing contemporary environmental challenges, including climate change, pollution, and biodiversity loss (Alvarado, 2025; Husin et al., 2025). Its fundamental purpose is to transform human attitudes, enhance environmental literacy, and translate ecological awareness into informed, pro-environmental actions (Husin et al., 2025). As defined by IUCN (1970), EE facilitates the development of knowledge, skills, and values necessary to understand environmental issues and recognize the interdependence between humans and nature. By equipping individuals with cognitive skills and confidence, EE acts as a catalyst for community engagement, citizen science, and participatory governance, enabling local populations to actively contribute to conservation (Alvarado, 2025; Chen et al., 2025). Globally, EE has been integrated into academic systems (Neal and Palmer, 2003), and in India, environmental values have long been embedded within educational traditions (Ravindranath, 2007). However, despite its widespread recognition, EE in India continues to face challenges, particularly its over-reliance on theoretical instruction, which limits practical application and behavioral change (Bhatia, 2020). Research demonstrates that experiential learning approaches such as field visits, hands-on activities, and interactive classroom sessions, are significantly more effective in fostering environmental awareness, positive attitudes, and conservation-oriented behavior (Ramadoss and Poyyamoli, 2011; Leeming et al.,

1993; Rickinson, 2001). Increasingly, EE is also leveraging digital tools such as simulations and augmented reality to enhance engagement and comprehension of complex ecological processes (Ahmadov et al., 2025).

The importance of environmental education and awareness in achieving sustainable development has been globally recognized. Agenda 21 of the Rio Earth Summit emphasizes that education and public awareness are indispensable for enabling individuals and societies to address environmental challenges and adopt sustainable practices (UNCED, 1992). Empirical evidence further suggests that well-designed outreach programmes can significantly influence attitudes and behaviours, translating knowledge into conservation action (Montana & Mlambo, 2018). Despite the ecological, cultural, and economic significance of the Ganga River, a substantial gap persists in public awareness regarding its biodiversity and the impacts of unsustainable practices. The river, spanning approximately 2,525 km across multiple states, supports millions of livelihoods and diverse ecosystems, yet communities often lack a comprehensive understanding of its ecological complexity. This disconnect contributes to practices that degrade water quality and biodiversity. Given the scale and complexity of the Ganga basin, conservation efforts must adopt an interdisciplinary and participatory approach, engaging stakeholders who are directly or indirectly dependent on the river. EE and outreach programmes are therefore essential to bridge this gap by translating scientific knowledge into accessible and locally relevant information, promoting informed decision-making, and fostering collective responsibility (Alvarado, 2025; Chen et al., 2025). When integrated with local governance systems, such initiatives can transform individual awareness into sustained collective action, thereby strengthening conservation outcomes.

A key mechanism for delivering such education is through nature interpretation and awareness initiatives. Interpretation centres serve as focal points for disseminating knowledge about natural and cultural heritage, enhancing public understanding, and fostering emotional connections with ecosystems (Orams, 1996; Bramwell and Lane, 1993). These centres and associated programmes play a critical role in influencing behaviour by making ecological concepts relatable and meaningful. Research indicates that interpretive programmes are effective in enhancing knowledge, shaping attitudes, and encouraging responsible environmental behaviour (Powell and Ham, 2008; Sharp et al., 2012). School-based environmental awareness programmes further contribute to long-term conservation by instilling ecological values at an early age. Such programmes improve understanding of biodiversity, correct misconceptions, and promote sustainable practices among students (Morgan & Gramann, 1989; Kumar, 2023). Importantly, they also facilitate intergenerational learning, where students influence household behaviours and community practices (Kendall et al., 2022). Structured workshops complement formal education by translating theoretical concepts into practical applications through interactive and experiential learning environments (Zainudin & Rosini, 2010). Teachers play a pivotal role in this process, acting as key agents of educational transformation. Effective teacher training programmes are therefore essential to equip educators with the knowledge, pedagogical skills, and tools required to deliver impactful environmental education (Darling-Hammond, 2020). Such training must extend beyond basic environmental knowledge to incorporate the broader framework of Education for Sustainable

Development (ESD), integrating environmental, social, and economic dimensions (Eliyawati et al., 2023). Evidence suggests that sustained and continuous training, rather than one-time interventions, is necessary to achieve meaningful changes in teaching practices and environmental behaviour (Özyurt et al., 2025). Despite existing challenges, including limited infrastructure, insufficient professional development opportunities, and gaps in ICT integration, teacher training remains a highly scalable strategy for conservation outreach, with the potential to influence large student populations and communities (Kumar and Azad, 2016; Kendall et al., 2022). In addition to formal education systems, community engagement and public participation are central to effective conservation. Public support influences policy decisions and determines the success of conservation initiatives (Doley and Barman, 2025). Conservation efforts that actively involve local communities are more likely to succeed, as they align ecological objectives with local needs and socio-economic realities (Infield & Tolisano, 2019; Dhliwayo et al., 2023). Communication strategies that promote awareness, participation, and shared responsibility are therefore essential for driving behavioural change and fostering stewardship (De Lange et al., 2022). Community-based conservation education initiatives, including workshops, awareness campaigns, and participatory activities play a crucial role in promoting environmental stewardship. These programmes facilitate knowledge exchange, integrate traditional ecological knowledge, and encourage collective action (Stern et al., 2017). Evidence indicates that communities exposed to sustained awareness efforts exhibit more positive conservation behaviours compared to those with limited exposure (Montana & Mlambo, 2018).

In this context, the establishment of Ganga Knowledge Corners and the implementation of outreach and conservation education programmes represent strategic interventions to strengthen environmental awareness and public engagement. Knowledge Corners function as localized hubs for information dissemination, interpretation, and community interaction, while outreach initiatives, including mass awareness programmes, workshops, and teacher training, aim to build ecological understanding and promote conservation-oriented behaviour. Mass awareness programmes conducted across Ganga basin states are particularly important for reaching diverse stakeholder groups, including local communities, students, and youth. These programmes focus on enhancing understanding of riverine biodiversity, pollution challenges, and sustainable practices, thereby fostering a sense of ownership and collective responsibility for river conservation. By engaging communities and aligning conservation efforts with local contexts, such initiatives contribute to the development of a participatory and sustainable model of river governance. Overall, conservation education serves as a bridge between scientific knowledge and societal action. It transforms conservation from a regulatory obligation into a shared societal commitment, empowering individuals and communities to actively participate in safeguarding the Ganga River and its biodiversity.

7.2. Aim

To design, implement, and evaluate environmental education and outreach interventions that enhance awareness, build capacity, and promote participatory conservation of the Ganga River and its biodiversity.

7.2.1. Objectives

1. Establishment of Ganga Knowledge Corners in select sites as a platform for dissemination of information towards Ganga River conservation and cleanliness.
2. Garner support for aquatic biodiversity and Ganga conservation through outreach and conservation education programmes.

7.3. Approach

A comprehensive framework for "Awareness and Sensitization Programmes" divided into two main categories: (a) localized Awareness and (b) mass Awareness (Figure 7.1). Localized Awareness includes targeted initiatives like School Awareness Workshops, low-cost interpretation corners, Interpretation Centers, and publications tailored for school students, focusing on engaging smaller, specific groups. In contrast, Mass Awareness encompasses broader outreach methods such as Radio Talks, Puppet Shows, Nukkad Natak (street plays), Social Media campaigns, Publications, and both Static and Mobile Exhibitions, designed to reach a wider audience and maximize public engagement. Together, these strategies aim to educate and sensitize diverse populations through a mix of localized, community-focused efforts and large-scale outreach methods.

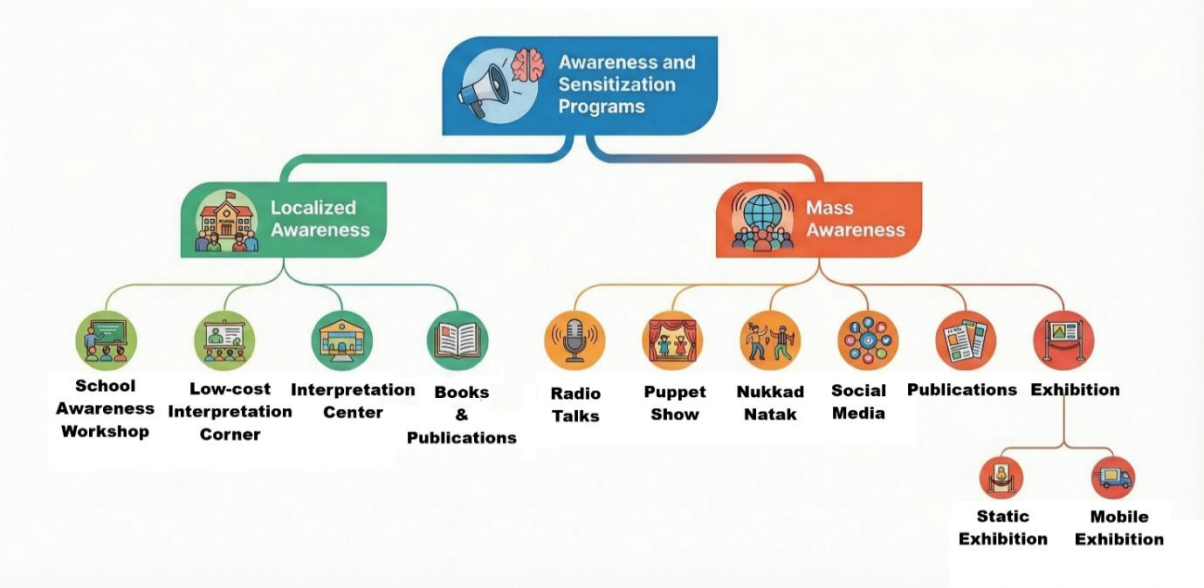


Figure 7.1. Approach adopted for conducting awareness and sensitization programmes

7.3.1. Creating awareness among students and teachers to encourage critical thinking and responsible behaviour

A reconnaissance survey was conducted along the Ganga River to identify suitable government schools within a 5–8 km radius of the river for programme implementation. Government schools were prioritized as they often have limited access to environmental education resources and infrastructure, making them important entry points for targeted educational interventions. Additionally, many of these schools cater to students from river-dependent communities whose livelihoods and daily lives are closely linked to the river ecosystem, thereby making them key stakeholders in conservation efforts. Engaging students from such backgrounds provides an opportunity to build early awareness and foster long-term behavioural change within communities. Priority was given to schools with strong administrative support, accessibility, and adequate student strength. An interactive and experiential learning module on river biodiversity and conservation was developed. The learning modules were site and issue specific tailored for individual sites and were delivered through interactive awareness workshops with the school students. Activities included oral/visual presentation, game-based learning methods and interactive discussions sessions. To evaluate the programme's impact, a structured pre- and post-questionnaire survey was administered, to understand changes in students' knowledge, attitudes, and intentions towards environment, with the post-survey conducted three months after the intervention to assess knowledge retention. Low-cost interpretation corners "Jalmala Samvaad" were also set up in schools as permanent learning spaces, where classrooms and galleries were utilized to showcase river biodiversity.

7.3.2. Training teachers through interactive awareness programmes and environmental education tools

The teacher training programme is conducted with both pre-service and in-service teachers. The selection of in-service and pre-service teachers for the training programme was guided by their availability and willingness to participate. For pre-service teachers, participants were chosen from the District Institutes of Education and Training (DIETs). In the case of in-service teachers, the focus was on those working in schools where student awareness workshops had already been conducted, allowing for continuity and reinforcement of conservation education. All selected institutions and schools were located within the Ganga River states, primarily in close proximity to the river, to ensure contextual relevance and enhance the connection between local environmental issues and educational content. Training programme follows an interactive, activity-based approach aimed at enhancing educators' understanding of riverine ecosystems and conservation. It begins with a presentation on the followed by a series of hands-on activities designed to engage participants in experiential learning.

7.3.3. Establishment of interpretation centers

The approach for establishing interpretation centers along the Ganga River focused on strategic location, thematic relevance, and long-term sustainability. The central theme across all centers is the Ganga River—highlighting its biodiversity, journey from origin to destination, and the challenges posed by pollution. Each center was developed with context-specific content, interactive displays, and educational materials to engage diverse audiences, including students, local communities, and tourists. The planning process included site selection based on accessibility and ecological relevance, design of interpretive content tailored to local culture and river ecology, and collaboration with government stakeholders for long-term stewardship.

7.3.4. Outreach and conservation education programmes

To promote biodiversity and environmental awareness along the Ganga River, a multi-pronged outreach approach was adopted, targeting a wide range of stakeholders.

7.3.4.1. Stakeholder identification

Key stakeholders were identified, including school and college students, teachers (both in-service and pre-service), forest department officials and community members.

7.3.4.2. Audio-visual material

A variety of interactive and culturally relevant activities were planned and designed to suit different audience groups. These included interactive sessions and workshops, edutainment/Performative Communication Tools like Puppet shows, and nukkad nataks (street plays), exhibitions (both mobile and static), social media and publications. The Figure 1.2 categorizes audio-visual material into three main types: Audio, Visual, and Audio-Visual. Audio content includes Interactive Sessions, Radio Talks, and Publications, focusing on sound-based engagement. Visual content encompasses exhibitions and social media, emphasizing visual presentation and interaction. Audio-Visual material consists of Puppet Shows and Nukkad Natak (street plays), blending both audio and visual elements to create a more immersive experience. This classification highlights the diverse formats through which audio-visual content can be delivered, catering to different audience preferences and engagement styles.

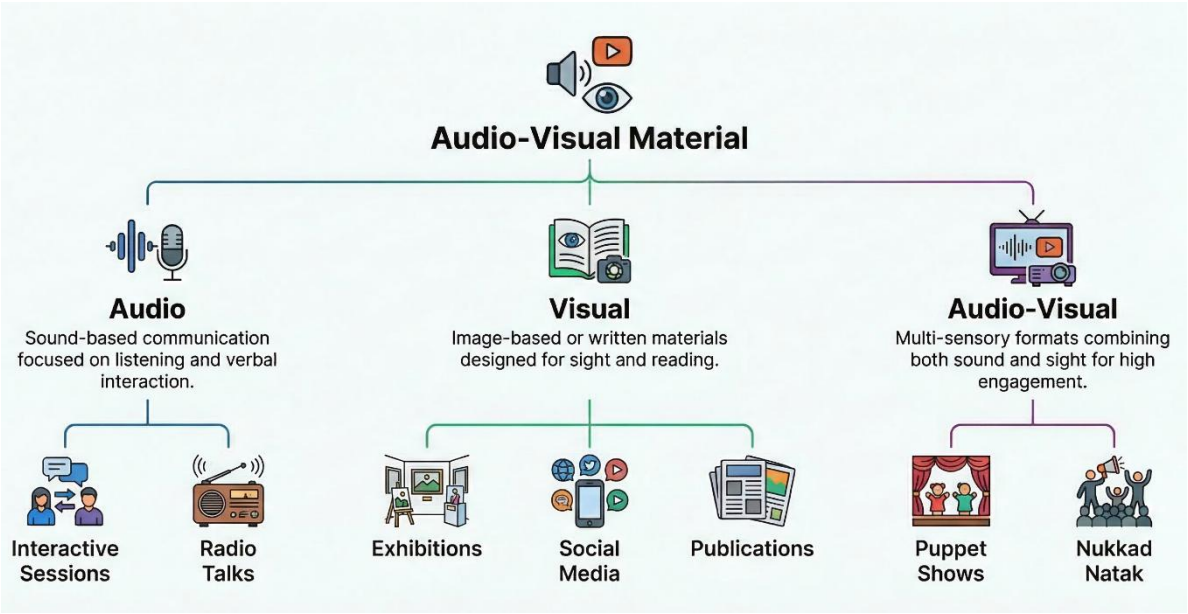


Figure 7.2. Audio-visual materials being utilized to conduct mass awareness and outreach programmes

7.4. Results

7.4.1. Assessing awareness level of teachers and students, activities conducted and impact of activities

7.4.1.1. Pre-questionnaire survey

A pre-workshop questionnaire survey was conducted among school students to assess their baseline knowledge, perceptions, and awareness levels related to riverine biodiversity, culture and heritage, and conservation values. The survey was administered prior to the intervention to establish a reference point for evaluating learning outcomes. A total of 60 schools (n = 3077) across the Ganga River states were included, ensuring a diverse representation of students from different geographical and socio-cultural contexts.

7.4.1.2. School awareness programmes

We conducted school awareness and sensitization workshops across five Ganga River states to create awareness about riverine biodiversity and related concerns. Site and issues specific awareness programmes were organized. A total of 185 awareness and sensitization workshops have been so far conducted along the Ganga River in the five states of Uttar Pradesh, Uttarakhand, Bihar, Jharkhand and West Bengal (Table 7.1). As part of the awareness workshops, a range of game-based learning activities were incorporated to enhance engagement and facilitate experiential learning among students. These included activities such as the “Web of Life” to demonstrate food chain interactions, biodiversity-themed Snake and Ladder focusing on Dos and Don’ts, riddle-based quizzes, puzzles, and origami exercises

related to aquatic species. These interactive tools helped simplify complex ecological concepts and encouraged active participation. Among these, the Snake and Ladder game emerged as the most effective and popular activity due to its familiarity among students, ease of understanding, and its ability to seamlessly integrate conservation messages within gameplay. Its structured format, combined with visual cues and reward-based progression, made learning enjoyable while reinforcing positive environmental behaviours and discouraging harmful practices.

Table 7.1. Awareness workshops conducted along the Ganga River

Sl. No.	States	No. of awareness workshops	No. of participants
1	Uttarakhand	36	3231
2	Uttar Pradesh	123	9355
3	Bihar	16	871
4	Jharkhand	5	487
5	West Bengal	5	296
Total		**185**	**14240**

7.4.1.3. Post-questionnaire survey

A post-workshop questionnaire survey was conducted to evaluate knowledge retention and learning outcomes after the intervention. From the analysis of the questionnaire of 60 schools (n = 3077) from the Ganga River states we found out that there was a knowledge gain amongst students across three categories. Comparing the responses, we found a 27.85% increase in their knowledge about riverine biodiversity (Figure 7.3), 39.93% increase in culture and heritage (Figure 7.4) and 19.04% in conservation values (Figure 7.5). We used Wilcoxon Signed-rank test to check if the pre to post changes are statistically significant and it gave a p-value < 0.05 indicating that there is significant change in the learning outcome of the students.

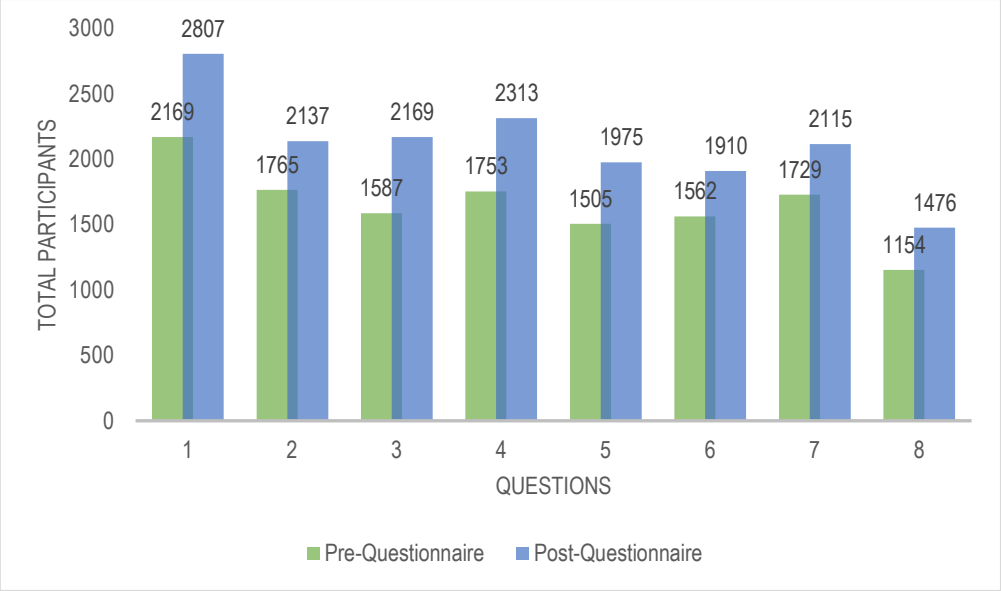


Figure 7.3. Comparison of pre and post score and average percentage increase in knowledge level in the Ganga River states in the category "Riverine Biodiversity"

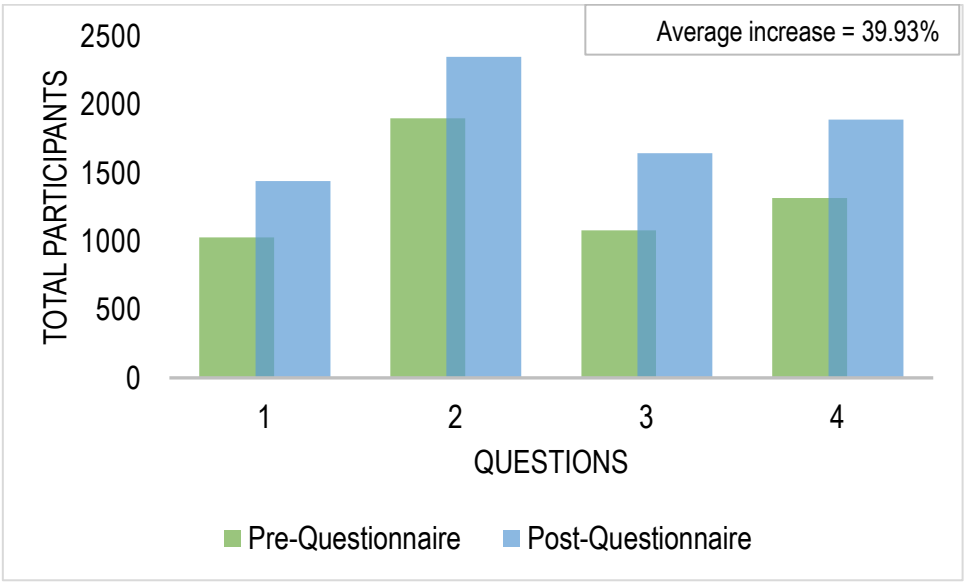


Figure 7.4. Comparison of pre and post score and average percentage increase in knowledge level in the Ganga River states in the category "Culture and Heritage"

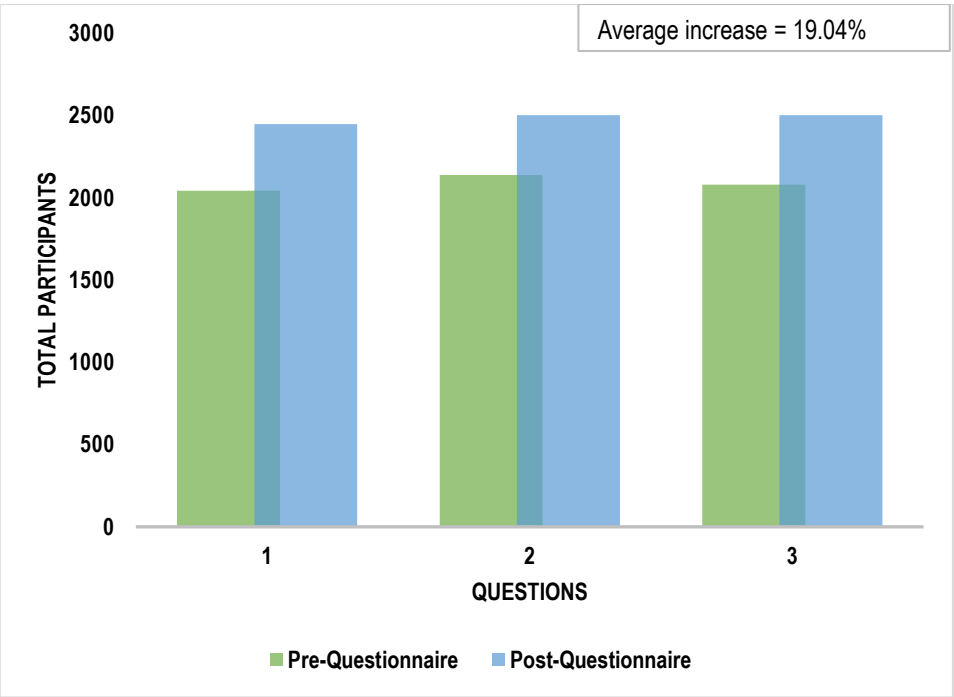


Figure 7.5. Comparison of pre and post score and average percentage increase in knowledge level in the Ganga River states in the category "Conservation Values"

7.4.1.4. Training of in-service and pre-service teachers

A total of 489 pre-service, 34 lecturers (Table 7.2) and 825 in-services teachers (Table 7.3) have been trained through these training workshops. The teacher training programme was successfully implemented using an interactive, activity-based approach to enhance educators' understanding of riverine ecosystems and conservation. Each session began with a presentation on the biodiversity of the Ganga River and its tributaries, highlighting the ecological significance of the river system and the impacts of human activities on its health. This was followed by a series of hands-on, experiential learning activities designed to actively engage participants. Educators participated in group discussions using the instructional manual "Discovering Ganga" and took part in educational games such as snake and ladder, web of life, biodiversity dart, and species puzzle. These activities fostered critical thinking, collaboration, and innovative teaching strategies for integrating river conservation themes into classroom practice.

Table 7.2. Details of teacher training programme conducted in District Institution of Education and Trainings

Sl. No.	Institution	Total no. of pre-service teachers	Total No. of D.I.E.T. Lecturers
1	D.I.E.T. Uttarkashi	33	4
2	D.I.E.T. Agra	120	4

3	D.I.E.T. Sarnath	81	5
4	D.I.E.T. Kanpur	103	6
5	D.I.E.T. Prayagraj	85	9
6	D.I.E.T. Dehradun	67	6
Total No. of Teachers Trained		**489**	**34**

Table 7.3. Teacher training programme conducted with in-service School Teachers

Sl. No.	State	Total no. of in-service teachers
1	Uttarakhand	251
2	Uttar Pradesh	502
3	Bihar	49
4	Jharkhand	23
Total no. of teachers trained		**825**

7.4.1.5. Making information on aquatic biodiversity accessible through interactive literature

Following the training, each school received a resource kit called "Gyan Kosh." This kit includes a teacher training manual, activity books, a factsheet on river biodiversity, a booklet addressing plastic pollution, educational games, puppets, origami materials, a pen drive containing relevant videos, and a water testing kit. These resources aim to empower teachers with the necessary knowledge and tools to integrate engaging and informative environmental education into their classrooms.

7.4.2. Establishment of low-cost interpretation corners

We have established low-cost Interpretation Corners in accessible locations along the Ganga River. They are strategically located to maximize access and engagement, especially in areas with large student populations near the riverbanks. Jalmala Samvaads have been established in government schools across 58 districts across five states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. In total, 106 low-cost interpretation corners have been established making significant impact in education outreach (Table 7.4, Figure 7.6). These smaller-scale interpretation corners act as specialized libraries or galleries, equipped with models, panels, publications, and artwork focused on Ganga biodiversity. Strategically placed in government schools in the Ganga River states, these centers actively involve students during special events like Wildlife Day, World Environment Day, International Day of Biological Diversity etc. inviting participation from nearby schools, colleges and other academic institutions.

Table 7.4. Low-cost interpretation corners 'Jalmala Samvaad' established along Ganga River

Sl. No.	State	No. of Jalmala Samvaads established	No. of students sensitized	No. of teachers sensitized
1.	Uttarakhand	23	8463	365

2.	Uttar Pradesh	53	54090	961
3.	Bihar	19	9145	213
4.	Jharkhand	6	4274	136
5.	West Bengal	5	5928	145
	Total	**106**	**81900**	**1820**

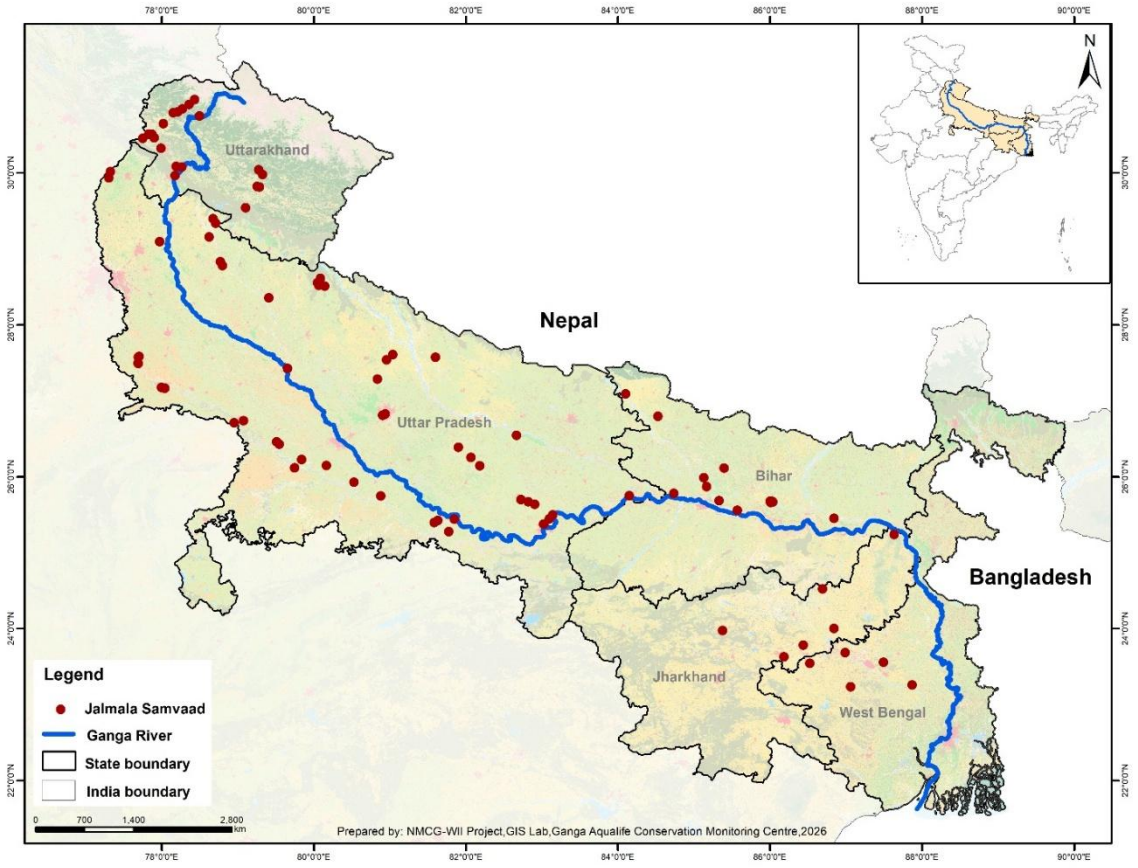


Figure 7.6. Jalmala Samvaad established in the five states along the Ganga River

7.4.3. Establishment of interpretation centres for masses

A total of five interpretation centers were developed, with three located in major urban centers of Uttarakhand (Haridwar) and Uttar Pradesh (Kanpur and Varanasi), ensuring high footfall and visibility (Table 7.5). Two additional centers were designed as open-air interpretation spaces and have been handed over to the Forest Department for continued management and community engagement, in Sanjay Van Rudrapur and City Forest Ramnagar, Uttarakhand. These interpretation centers assist in promoting an understanding and appreciation of the biodiversity and cultural significance of our National River – the Ganges. Interpretation center located at Haridwar is named, “Ganga Avlokan”, and interpretation centres located at Varanasi and Kanpur are named “Ganga Darpan” and “Anubhuti”, respectively.

Table 7.5. Details of participants of educational tours and workshops, and visitors at Interpretation Centres

Sl. No.	Interpretation Center	Visitors/Educational Tours/Workshop participants
1	Ganga Avlokan, Haridwar, Uttarakhand	150432
2	Anubhuti, Kanpur, Uttar Pradesh	169672
3	Ganga Darpan, Varanasi, Uttar Pradesh	50989

7.4.3.1. Ganga Avlokan, Haridwar, Uttarakhand

Located at Chandi Ghat, Haridwar, Uttara khand, the Center is designed to engage and educate visitors about the river Ganga and its biodiversity. These centers feature displays, dioramas, and exhibits, and panels that showcase the journey of the river Ganga - from origin to destination, livelihood that it provides and biodiversity that thrives in and around it. Visitor numbers increased at an average annual rate of approximately 56%, with particularly sharp growth observed in 2025. (Figure 7.7).

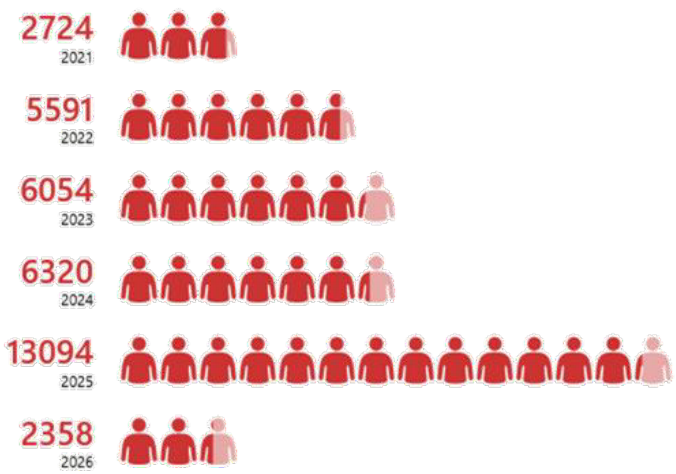


Figure 7.7. Total number of visitors at Ganga Avlokan since the year of inception

7.4.3.2. Ganga Darpan, Varanasi, Uttar Pradesh

“Ganga Darpan” an interpretation center has been developed at the Turtle Rescue and Rehabilitation Center, Sarnath, Varanasi. The center showcases Ganga as an integral part of our lives since ancient time. Visitor numbers showed an average annual increase of ~63%, though trends indicate significant fluctuations with sharp growth in recent years. (Figure 4.2).

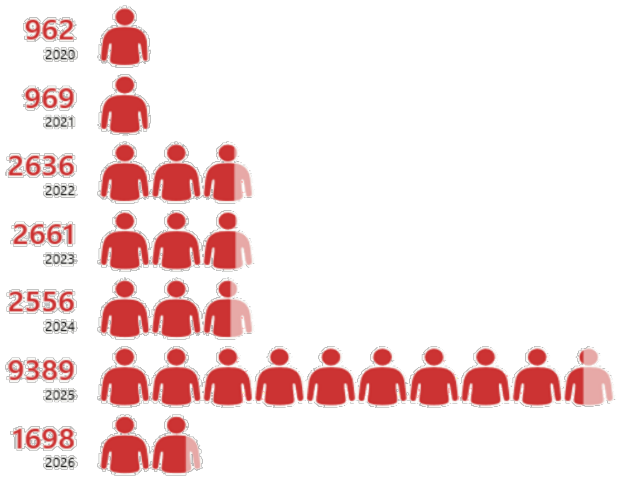


Figure 7.8. Total number of visitors at Ganga Darpan since the year of inception

7.4.3.3. Anubhuti, Kanpur, Uttar Pradesh

"Anubhuti" has been developed at the heritage building of Allen Forest situated at Kanpur Zoological Park. Nestled on the banks of river Ganga, Kanpur stands as one of the North India's major industrial centers with its own historical, religious and commercial importance. Visitor numbers showed an average annual increase of approximately 48%, despite a slight decline observed between 2020 and 2021 (Figure 4.3).

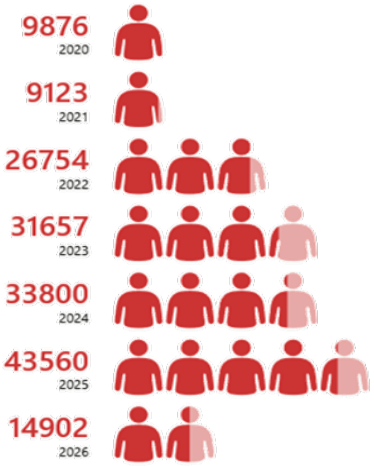


Figure 7.9. Total number of visitors at Anubhuti since the year of inception

7.4.3.4. Sanjay Van, Rudrapur, Uttarakhand

An Open-air Interpretation centers have been established in Sanjay Van Rudrapur, Uttarakhand. Sanjay Van is a green area that is the part of Tanda range forest in Pantnagar town of Udham Singh Nagar

District. The center was developed with the support of the Forest Department and has been handed over to their management.

7.4.3.5. City Forest, Ramnagar, Uttarakhand

This is also an open-air Interpretation center. City forest is part of the Jim Corbett National Park at Ramnagar in Nanital. The center was developed using 3D species model and informative panels with the support of the Forest Department and has been handed over to their management.

7.4.4. Interactive programme – awareness and sensitization workshop

Various interactive workshops were conducted on several events to create awareness about the river and its biodiversity in various states and districts along the Ganga River across five states. Approx 1 crore participants were sensitized through the awareness and sensitization programmes conducted under various initiatives as listed in Table 7.6.

Table 7.6. Details of various awareness and sensitization programmes conducted during various events

Sl. No.	Activity	No of people reached out (Approx.)
1.	Ganga Utsav	10,000
2.	Nadi Utsav	8,00,000
3.	Har Ghar Tiranga	1,50,000
4.	Catch the Rain	25,000
5.	Swachhta Hi Sewa	2,00,000
6.	Maha Kumbh	50,00,000
7.	Ek Ped Ma Ke Naam	10,000
8.	Special Day Celebration	5,00,000
9.	Amrit Dhara	25,000
10.	Vriksharopan	50,000
11.	Mission LiFE	2,50,000
12.	Azadi Ka Amrit Mahotsav	7,00,000
13.	Rashtriya Jal Khata Abhiyan	3000

7.4.4.1. Mahakumbh mela

The environmental awareness and conservation activities conducted by the team, and the Ganga Praharis during Mahakumbh 2025 served as a powerful platform to advocate for river conservation and sustainable practices. At the Mahakumbh, in collaboration with its volunteers - Ganga Praharis, we conducted impactful environmental awareness activities at the NMCG Pavilion, Sangam, Arail Ghat, and the Kalash Awareness Stall. Through awareness programmes, cleanliness drives, street plays (Nukkad Nataks), and plastic waste management sessions, they educated diverse stakeholders about the

importance of conserving rivers and aquatic biodiversity for ecological balance. A total of 50,00,000 people were sensitized through our activities and awareness including local community members, pilgrims, educational institutions, government officials, local vendors, and foreign visitors. The Ganga Prahari group played a pivotal role in mobilizing devotees through street plays and interactive discussions. These sessions highlighted the dangers faced by aquatic species like the Gangetic Dolphin, Gharials, Otters, and Mahseer fish, emphasizing the threats posed by pollution, habitat destruction, and climate change.

7.4.4.2. Radio talks

Radio talks are highly effective for creating mass awareness about riverine biodiversity due to their wide reach and accessibility. They deliver engaging, informative content to diverse audiences, including rural and urban communities, in local languages, making complex ecological issues relatable. By featuring experts, conservationists, or local voices, radio talks educate listeners about the importance of river ecosystems, threats like pollution, and conservation actions.

We conducted Radio talks on Radio Rishikesh and Aakashwadi Dehradun on various topics. The radio talk shows organized focused on raising mass awareness about environmental conservation, youth empowerment, and career opportunities, effectively engaging diverse audiences. Radio Rishikesh aired a total of 14 episodes on topics for riverine conservation, the role of women in Himalayan conservation (celebrated on Himalaya Day), and the significance of street plays for conservation awareness. Waste management, particularly plastic waste and composting, was highlighted during Swachhta Pakhwada. Youth-centric discussions on environment, development, and their role in nation-building, were featured on International Youth Day and Independence Day. Career-oriented talks covered opportunities in forestry, biotechnology, wildlife, environmental science, commerce, science, GIS, and remote sensing, with specific emphasis on GIS applications. Additionally, wildlife photography was explored on World Photography Day. A radio show series of 8 and 6 episodes titled, “Ganga ki Baat” was also conducted through Aakashwadi Dehradun. By aligning with significant days and addressing pressing ecological and social issues, these radio talks developed public understanding and inspired action toward conserving riverine biodiversity and beyond.

7.4.4.3. Mobile exhibition

As part of the Wildlife Week celebration under the aegis of the 75th Azadi Ka Amrit Mahotsav, a Yatra was organized to raise awareness about the significance of water and biodiversity and their impact on our lives. The journey traced the Ganga, Yamuna, and Gomti Rivers, addressing various audiences, including school students, village community members, pedestrians, the Forest department, and teachers (Table 7.7, Figure 7.10).

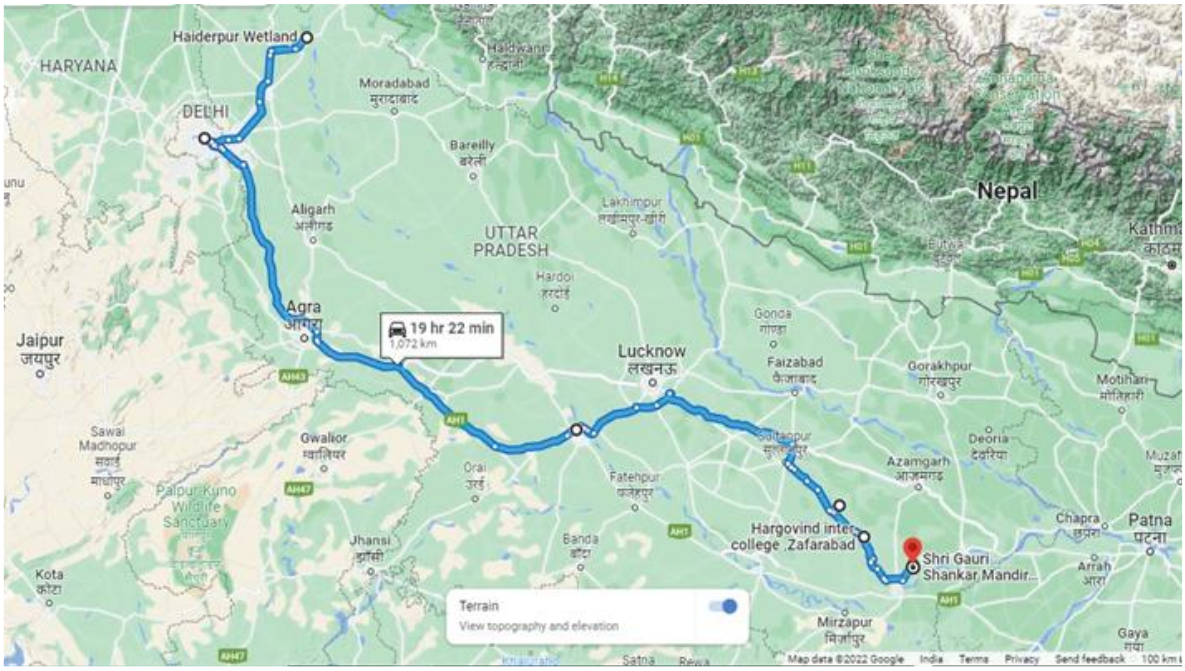


Figure 7.10. Distance covered by Mobile Exhibition vehicle in Ganga River Basin

Table 7.7. Details of places visited, activities conducted and participation from masses during mobile exhibitions conducted along the Ganga River

Sl. No.	Activity	Place	No. of Participants
1	Flag off, Selfie point	Haiderpur Wetland, Bijnor	1500
2	Workshop with underprivileged Children along the Yamuna River	Delhi	5330
3	Educational activities with school students	Kanpur	8040
4	Painting competition	Kanpur zoo	7820
5	Awareness workshop with students	Zafarabad, Jaunpur	6720
6	Awareness workshop with students	Ghanshyampur, Sultanpur	5130
7	Community workshop with villagers	Dhakua, Kaithi, Varanasi	8300
8	Awareness workshop with students and locals	Rajbari, Varanasi	7270
Total			**50,110**

7.4.4.4. Static exhibition

Exhibitions are valuable for raising awareness about riverine biodiversity due to their ability to visually engage and educate diverse audiences. These display posters, models, and informational panels,

provide clear, accessible information about river ecosystems, species, and threats like pollution. Set up in public spaces like schools, ghats etc. they attract broad attention and encourage self-paced learning. Their cost-effective, reusable nature allows for repeated use across locations, ensuring consistent messaging. To sensitize community about biodiversity conservation of Ganga River various exhibitions were exhibited during various occasions. Table 7.8 provides a list of total number of participants who participated in the event.

Table 7.8. Exhibitions conducted along the Ganga River

Sl. No.	Event	Location	No. of Participants
1	Exhibition at Shiv Ghat	Haridwar	200
2	Exhibition at Soor Sarovar wetland	Agra	210
3	Exhibition at USAC	Dehradun	162
4	Vigyan Sarvatra Pujyate' organized by Ministry of Culture, Government of India.	Nehru Stadium, Dehradun	4030
5	Vigyan Sarvatra Pujyate' book fair under Science and Technology Education Theme	UCOST, Dehradun	560
6	Biodiversity Exhibition in association with Azim Premji Foundation	Govt Upper Primary School, Selaqui	500
7	Exhibition on Clean Ganga Mission	Varanasi	100000
Total			**1,05,662**

7.4.4.5. Social media

As we are living in a digital world, we started to focus more on digital content and social media platforms to disseminate knowledge about river and its biodiversity. Also, as print media can only reach to limited audience and stakeholders, these platforms assist in reaching the masses in a convenient manner. Social media helps in creating awareness about riverine biodiversity by reaching vast, diverse audiences instantly with engaging content and stories. It leads to interaction, enabling users to share, comment, and participate in conservation campaigns, amplifying impact. Platforms also connect communities with experts and organizations, driving collective action and sustained interest in protecting river ecosystems. We have created Facebook and Instagram accounts named “Ganga Darpan” and “Glimpses of Ganga” and these pages are constantly updated with educational content to create awareness. So far through our social media pages on Instagram, Facebook and YouTube we have engaged over 15, 65,854 participants from all across the country and world. We also created an Environmental Blog named “Ganga Darpan” with an aim to provide a platform for sharing knowledge, experiences, best practices and stories

in the field of river conservation, with a focus on education and outreach as well. So far we have published 92 blogs and stories, with a visitor engagement of around 3700, and 6000 views.

7.4.4.6. Publications

Publications play a crucial role in enhancing awareness, whether they communicate existing knowledge or introduce new information to the public. In the context of promoting awareness about the Ganga and its biodiversity, specific publications have been meticulously designed, developed, and disseminated among diverse audiences, including the general public, school students, and teachers (Box 7I and 7II). These include both print media as well as digital media publications. We develop publications targeted for school students and teacher as well as for mass awareness. Through our publications we have reached to almost 15, 00,000 participants.

7.4.4.7. Village walk

In Siror Village, Uttarkashi, a transformative initiative was undertaken to promote environmental awareness and celebrate the region's natural heritage. A thoughtfully designed village walk was established along the scenic banks of the Bhagirathi River. This trail was developed not only as a recreational pathway but also as an educational experience for both locals and visitors. Informative signages were strategically placed along the route, offering insights into the diverse flora and fauna that inhabit the region, as well as the ecological importance of the Bhagirathi River. These signboards were designed in simple, accessible language to engage people of all age groups, especially students and community members. The walk serves as a platform to connect people more deeply with their environment, fostering a sense of pride and responsibility towards biodiversity conservation.

7.4.4.8. Puppet shows and nukkad natak

Puppet shows and nukkad nataks play a vital role in addressing social issues and conveying moral messages to the audience. Through their creative performances and symbolic storytelling, they serve as a medium to address issue related to biodiversity conservation attracting masses. Various awareness activities, were conducted along many locations along the Ganga River mainly nukkad natak (Table 7.9) and puppet shows (Table 7.10), were conducted across various locations along the Ganges River to educate communities.

Table 7.9. Nukkad Nataks conducted along the Ganga River in Uttar Pradesh

Sl. No.	Location	Plays conducted	No. of participants
1	Narora	1	25000
		2	25000
2	Kashipur, Sambal	1	4200
3	Kanpur	1	10000

		2	15000
4	Mirzapur	1	5600
5	Varanasi	1	25000
		2	12200
		3	8518
	Total	**9**	**1,30,518**

Table 7.10. Puppet Show conducted along the Ganga River in Uttar Pradesh

Sl. No.	Location	Shows conducted	No. of participants
1	Varanasi	1	50,500
2		2	50,000
3	Mirzapur	1	50,000
	Total	**3**	**1,50,500**

7.5. Conclusion

The chapter demonstrates that environmental education, when designed as an integrated, multi-scalar intervention combining localized engagement and mass outreach, can serve as a highly effective mechanism for advancing participatory river conservation. The framework operationalized in this study successfully bridges the gap between scientific knowledge and societal action by embedding environmental learning within formal education systems, community engagement processes, and public communication platforms.

The implementation of structured awareness programmes across schools, combined with experiential learning approaches, has yielded measurable improvements in environmental literacy among students. The statistically significant increase in knowledge across riverine biodiversity (27.85%), culture and heritage (39.93%), and conservation values (19.04%), validated through pre–post assessment and Wilcoxon signed-rank testing ($p < 0.05$), provides strong empirical evidence of the effectiveness of the intervention design. These findings reinforce the role of activity-based and context-specific pedagogies in translating abstract ecological concepts into meaningful understanding and behavioural intent.

The scale and reach of the interventions further highlight the robustness of the approach. The implementation of 185 school awareness programmes across five states, engagement with over 14,000 students, and training of more than 1,300 teachers (pre-service and in-service) demonstrate the capacity of education-based interventions to generate cascading impacts across institutional and community levels. Teacher training emerges as a critical multiplier, enabling the integration of conservation themes into classroom practices and ensuring continuity beyond one-time interventions. The provision of resource kits such as “Gyan Kosh” further strengthens this continuity by equipping educators with tools for sustained engagement.

The establishment of 106 low-cost interpretation corners (Jalmala Samvaad) across 58 districts represents an important innovation in decentralizing knowledge dissemination. These spaces function as permanent, accessible learning hubs embedded within schools, thereby institutionalizing environmental

education at the grassroots level. In parallel, the development of interpretation centres in high-footfall urban locations has expanded outreach to broader audiences, as reflected in substantial visitor numbers and consistent growth trends. These centres play a dual role in enhancing ecological awareness and fostering emotional connections with the river, which are essential precursors to long-term stewardship.

The multi-pronged outreach strategy, encompassing radio talks, exhibitions, social media engagement, publications, and community-based activities such as puppet shows, nukkad nataks, and village walks, has enabled the programme to reach diverse stakeholder groups at scale. The cumulative outreach of approximately one crore individuals underscores the effectiveness of combining traditional communication methods with digital platforms. Notably, culturally embedded approaches such as street theatre and participatory events have proven particularly effective in engaging local communities and translating conservation messages into socially relevant narratives.

The integration of stakeholder-specific strategies, ranging from school-based interventions to mass awareness campaigns during large public events such as Mahakumbh, demonstrates the adaptability of the framework to different socio-cultural contexts. The active involvement of community members, volunteers, and institutions such as DIETs and the Forest Department further strengthens the participatory nature of the initiative. This alignment between educational interventions and community engagement processes is critical for fostering collective responsibility and ensuring the sustainability of conservation outcomes.

Overall, the chapter establishes that environmental education, when implemented through a structured, evidence-based, and participatory framework, can move beyond awareness generation to influence attitudes, build capacity, and catalyse behavioural change. The convergence of localized learning platforms, institutional capacity building, and large-scale outreach creates a comprehensive model for river conservation that is both scalable and contextually relevant. By embedding conservation within education systems and community practices, the approach contributes to the development of a sustained, participatory model of river governance for the Ganga basin. The findings of this chapter indicate the need for a more structured, long-term, and scalable approach to environmental education and outreach for river conservation. Strengthening monitoring and evaluation frameworks is essential to move beyond short-term knowledge assessments and systematically track behavioural change and conservation outcomes over time, including longitudinal engagement with students and communities. To ensure continuity and institutionalization, environmental education modules should be formally integrated into school curricula, particularly in river basin regions, supported by periodic and advanced teacher training programmes aligned with the principles of Education for Sustainable Development. Expanding the network of low-cost interpretation corners in underserved and remote areas will further democratize access to environmental knowledge, while the integration of digital tools and interactive technologies can enhance engagement and extend outreach to wider and younger audiences. At the same time, the development of localized and multilingual communication materials is necessary to ensure inclusivity and contextual relevance across diverse socio-cultural settings. Strengthening partnerships with government agencies, educational institutions, and community organizations will be critical for ensuring long-term

sustainability and institutional ownership of interventions. There is also a need to deepen community engagement through citizen science and participatory approaches, enabling local stakeholders to move from passive recipients of information to active contributors in conservation processes. Strategic use of large public events and culturally embedded communication platforms can further amplify outreach and behavioural messaging at scale. Finally, integrating livelihood-linked perspectives into outreach programmes will help align conservation objectives with the socio-economic realities of river-dependent communities, thereby enhancing both the effectiveness and sustainability of conservation efforts

Box. 7(I)

I.1. Games & Activities

Activities in school workshops for students are game-based, with the underlying concept of "education with recreation." The session began with a talk on River Biodiversity, outlining threats and conservation status. Subsequently, students were engaged in various games designed to convey conservation concepts through play. These games include "Web of Life," "Biodiversity Dart," "Save Our Rivers - Snake and Ladder," "Species Puzzle," "Origami," "Wildlife Sudoku (Quiz)," and "Animal Stapoo (Identify the pug marks)." These interactive games play a crucial role in biodiversity awareness workshops, making them engaging and interactive. The details are given here -

I.1.1. Web of Life

Web of Life is a fun game that teaches kids about the food chain. Each child gets a card with a component of biodiversity. We use a thread to show how everything is connected in the food chain – like the sun helping plants, bees pollinating, birds eating bees, and so on. If we make one thing extinct, it affects the whole chain. This game helps kids see how nature works and why every part is important.

I.1.2. Biodiversity Dart Game

The Biodiversity Dart Game is a fun way for kids to learn about nature. Using a dartboard, children throw darts at sections divided into good deeds and bad deeds related to nature, earning plus or minus points. Good deeds include actions that protect nature, while bad deeds involve things that harm it. Kids form teams and compete, aiming to understand how their daily actions impact nature. Through this friendly competition, we hope to inspire children to consider how they can contribute to conserving their surroundings in their everyday lives.

I.1.3. Save our rivers (Snake and Ladders)

Snake and Ladders gets a green twist in our version. We replaced snakes with harmful deeds towards nature and ladders with good actions to protect it. The life-sized game lets children become the pawns, making it even more exciting. Our goal is to impart knowledge about their role in protecting the environment. This hands-on activity teaches kids that small actions by everyone can make a big difference in conservation efforts

I.1.4. Biodiversity Jigsaw

The Biodiversity Jigsaw is an engaging puzzle game featuring pictures of the local area's biodiversity. Tailored to our workshop's location, the game includes information about each species and its role in nature. By piecing together, the puzzle, children not only learn about the diverse wildlife in their surroundings but also understand the vital role these animals play in maintaining the area's biodiversity.

I.1.5. Origami

Wildlife Origami is a creative and educational activity where children learn the art of origami while exploring the world of wildlife. With specially designed origami sheets, kids can fold and create paper animals, birds, and insects, discovering the diversity of wildlife. Each origami model is accompanied by interesting facts about the species, helping children connect art with knowledge about nature.

I.1.6. Wildlife Scrabble

This is an interactive game that combines fun and learning. Children are grouped into teams and challenged with questions about wildlife and conservation. Armed with alphabet tiles, they creatively form answers, putting their knowledge and retention skills to the test. This engaging activity not only reinforces facts discussed in the workshop but also serves as a dynamic assessment of the workshop's impact on the children's understanding of wildlife and conservation.

I.1.7. Animal Stapoo

This is an exciting life-sized game that brings the world of wildlife tracking to kids. Teams of children gather around a sheet featuring footprints of various animals. In this instant game, we call out the name of an animal, and the teams race to identify the corresponding footprint or pugmark. Through this activity, children not only have fun but also develop skills in recognizing and understanding the identifying factors of animal footprints, providing them with a hands-on introduction to the fascinating field of wildlife tracking.

I.1.8. Riddle Game

The Riddle Game is a playful activity featuring 15 cards, each with a riddle on one side and its answer on the other. Kids engage in the game by guessing the answers, providing a fun and simple way to assess their factual knowledge about nature. Through this entertaining process, we can gauge their understanding of the roles played by various elements in their daily lives, fostering both enjoyment and learning.

I.1.9. Thumb print

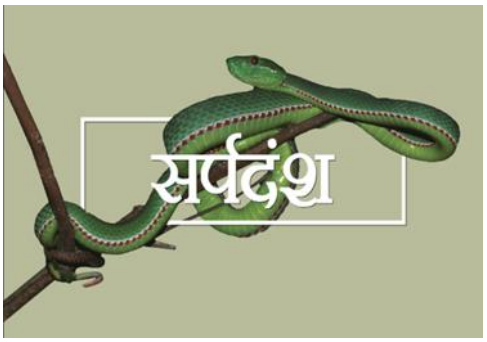
Thumbprint is an inclusive activity designed for both children and adults. By incorporating diverse colour elements, participants learn how to transform a simple thumbprint into a variety of animals. Throughout the activity, we not only engage them creatively but also educate about the characteristics and details of each animal they paint. Thumbprint thus combines artistic expression with an informative exploration of the animal kingdom.

Box. 7(II)

II.1. Print Media

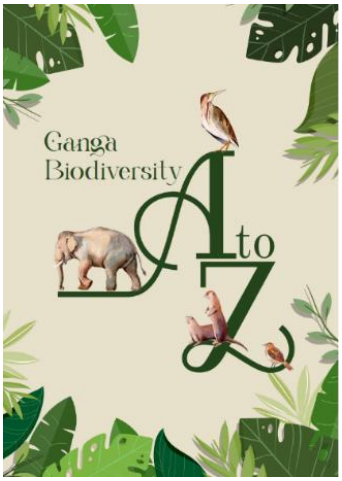
II.1.1. Sarpdansh

A small booklet on snake bite named **"*Sarpdansh*"** has been modified, re-developed and distributed amongst the locals living along the Ganga River basin. *Sarpdansh* is a collection of myths about snakes that local people generally believe in and the facts about them. It also contains first aid and prevention methods that can be followed to avoid such situations.



II.1.2. Ganga Biodiversity - A to Z

This is a bilingual coloring book specially crafted for school students. Each alphabet is paired with information about a specific animal or plant species, with one page dedicated to details about the species and the facing page featuring a coloring activity. This innovative approach merges education with creativity, providing an engaging step towards conservation awareness among students through the exploration of diverse flora and fauna in the Ganga region.



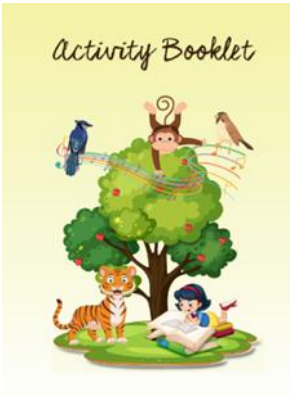
II.1.3. Be Water Wise

This is a compact bilingual booklet emphasizing the significance of water conservation. Packed with engaging games and activities, teachers can lead students through various aspects of water awareness,

including pollution, wastage, and recycling. The activities are thoughtfully designed to make learning about water conservation enjoyable, encouraging students to modify their daily habits and contribute to water-saving efforts in both their homes and surroundings.

II.1.4. Activity Book – Kindergarten

The Activity Booklet is a small, bilingual guide that talks about why it's important to take care of nature. It's like a little book of games and activities that teachers can show students. Each game is about different parts of nature, like stopping pollution, not wasting things, and taking care of animals. It's a fun way to help students understand how what they do can affect the environment. The booklet teaches them simple things they can do to keep the Earth safe and happy.



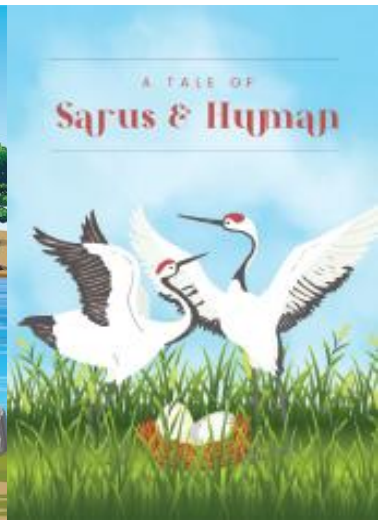
II.1.5. Biodiversity of Uttarkashi

The Biodiversity of Uttarkashi is a bilingual booklet that focuses on the birds, trees, plants, and mammals unique to the Uttarkashi district in Uttarakhand. This compact guide provides comprehensive information about each species, including scientific names, IUCN status, identifying features, basic geographical distribution, and general knowledge about the species. It serves as a small yet significant initiative to encourage the younger generation, living in close proximity to nature, to learn and appreciate the diversity of their surroundings. This booklet aims to foster a sense of curiosity and connection with the natural world among the youth.

II.2. Digital: E-books

II.2.1. Otter story & sarus story

Small story books about smooth-coated otter and Sarus crane with engaging animated images and story line for kids.



Chapter 08

POLICY FRAMEWORK FOR THE GANGA RIVER CONSERVATION

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Summary

The chapter emphasizes that river governance operates within a complex policy landscape where ecological sustainability is inseparable from socio-economic realities, institutional arrangements, and regulatory mechanisms. The analysis highlights that political and institutional coordination across multiple states and agencies is critical, as fragmented governance structures often constrain effective implementation. Economic dimensions underscore the dependence of millions on river-linked livelihoods, necessitating policies that balance conservation with livelihood security. Social factors, including cultural values, community dependence, and traditional knowledge systems, are identified as central to shaping behavioural responses and policy acceptance. Technological aspects relate to interventions such as pollution control, monitoring systems, and sustainable livelihood technologies, which enhance implementation efficiency but require contextual adaptation. Environmental considerations focus on addressing pollution, habitat degradation, and biodiversity loss, while legal dimensions stress the role of regulatory frameworks, compliance mechanisms, and institutional accountability in ensuring long-term conservation outcomes.

The chapter further demonstrates that effective policy analysis must move beyond static evaluation to enable adaptive, evidence-based decision-making. By integrating stakeholder perspectives, socio-ecological linkages, and ground-level realities, the framework supports identification of policy gaps, trade-offs, and synergies across sectors. It underscores that policies lacking alignment with local ecological conditions and community needs risk weak implementation and limited impact. Therefore, the analysis advocates for participatory, multi-level governance approaches where policies are continuously refined through feedback, monitoring, and outcome assessment. This ensures that conservation strategies remain context-specific, inclusive, and responsive to dynamic environmental and socio-economic conditions, ultimately strengthening the effectiveness and sustainability of Ganga River conservation efforts.

8.1. Introduction

The Ganga River basin represents a highly complex socio-ecological system where hydrological processes, biodiversity, cultural values, and livelihood dependencies are deeply intertwined. Effective river conservation planning in such systems necessitates two foundational pillars: rigorous evaluation of policies and schemes and context-specific, informed policy design aligned with ecological and socio-cultural realities. Evidence from peer-reviewed studies on the Ganga basin underscores that neglecting either dimension leads to suboptimal or unsustainable outcomes. Peer-reviewed research highlights that river conservation in the Ganga basin is inherently challenging due to ecological connectivity, spatial heterogeneity, and intense human dependence. Without systematic policy analysis, fragmented sectoral policies (water, agriculture, industry) remain poorly aligned, critical ecological processes such as longitudinal connectivity and environmental flows are neglected and interventions fail to address cumulative impacts across the basin (Jain and Singh, 2021). A policy review of Ganga conservation explicitly identifies “incoherent sectoral policies” and lack of integrated planning as major barriers to effective outcomes. Historical evidence shows that multiple Ganga clean-up programmes have struggled to achieve sustained outcomes, often repeating similar approaches without adequate evaluation. The Ganga basin is characterized by hydrological connectivity, spatial heterogeneity, and competing resource demands, making conservation inherently complex. Peer-reviewed research emphasizes that

interventions such as environmental flow (E-flow) restoration involve trade-offs between irrigation and ecosystem needs, these trade-offs can be optimized only through evidence-based assessment of long-term impacts rather than short-term gains (Kaushal et al., 2019). Thus, policy evaluation must extend beyond immediate outputs to include longitudinal ecological and socio-economic outcomes.

Ganga River sustains millions through agriculture, fisheries, and informal economies. Research indicates that ignoring livelihood dependencies creates resistance and undermines policy effectiveness. E-flow implementation concerns among farmers illustrate perceived trade-offs between conservation and agriculture, integrated approaches demonstrate that efficiency improvements (e.g., irrigation management) can reconcile these conflicts. Therefore, policies must embed livelihood-sensitive design, ensuring conservation does not impose disproportionate socio-economic costs. Effective river conservation requires coordination across scales—from village institutions to national agencies. Literature on river basin management stresses the importance of participatory planning and decentralized governance, integration of local stakeholders into decision-making processes, cross-sectoral coordination (water, agriculture, biodiversity, urban planning), such approaches enhance legitimacy, accountability, and implementation efficiency (Kaushal et al., 2019).

The Ganga basin governance is characterized by multiple institutions and overlapping mandates. Analytical reviews show that integrated river basin management frameworks improve outcomes programmes like Namami Gange Programme attempt to address this through multi-sectoral coordination. However, effectiveness depends on alignment across scales (village–district–basin) and convergence of policies (water, biodiversity, rural development) (Balkrishna et al., 2024). Uniform, basin-wide policy prescriptions are insufficient. Conservation planning must be spatially differentiated, incorporating micro-level ecological variability (e.g., upper Himalayan stretches vs. middle Gangetic plains). Programs such as river rejuvenation and pollution abatement must be informed by stretch-specific ecological indicators, biodiversity-sensitive flow regimes and integrated basin-scale datasets. Incorporating community-based knowledge such as observations from Ganga Praharis and local institutions can Improve biodiversity monitoring, enhance early detection of ecological changes and strengthen adaptive management.

Analysing policies and schemes for their effectiveness and long-term outcomes is not an optional exercise but a foundational requirement for Ganga River conservation. The evidence from peer-reviewed literature consistently demonstrates that fragmented, non-evaluated, and context-insensitive approaches lead to suboptimal or failed outcomes, whereas evidence-based, locally aligned, and integrative policies significantly enhance ecological and socio-economic sustainability. In the Ganga basin where biodiversity conservation, cultural identity, and livelihoods are inseparable, effective river conservation planning must be analytical, adaptive, and deeply contextual, grounded in scientific evidence and responsive to local realities.

8.2. Aim

To evaluate the current national policies and other legislation impacting the Ganga River to determine their efficacy in its conservation

8.3. Approach

Indian policies and other legislation relevant to the use and management of river resources and their impact on its ecology and biodiversity at national and state level were reviewed. Information related to water allocation and use, aquatic biodiversity, management and protection was gathered and their features and gaps were identified in context of river conservation. Policy gaps were manually coded and categorized.

8.3.1. A cross-sectoral assessment of regulatory, permissive, and conservation drivers across ministries and states

A comprehensive cross-sectoral mapping of policies and legislative instruments across multiple ministries and states was done, examining how they influence the ecological integrity of the Ganga River through a matrix of negative and positive drivers. It systematically evaluates the extent to which these instruments prohibit, permit, promote, or remain silent on key anthropogenic pressures such as land use change, resource extraction, transport, tourism, pollution/nutrient load, invasive species, and species trade, across major sectors such as agriculture, urban areas, industries, energy, fisheries, sand mining, and water withdrawal/diversion, while also identifying their contributions toward species and habitat protection.

8.4. Results

India, a country with many large river systems, still lacks an integrated holistic river policy, leading to weak institutional arrangements and inadequate management. Despite a robust policy framework to manage river systems, the policies are spread across various government sectors, which makes the implementation, coordination, and biodiversity-centric orientation of these policies fragmented. Policies and policy instruments were analyzed that are working at national-level and being implemented by various ministries and agencies and how they can influence the conservation of Ganga River. The analysis of the relevant policies reveals both structural strengths and critical gaps (Table 8.1).

Table 8.1. Major concerns and opportunities for policy development

Sl. No.	Major Concerns	Description
1.	**Water Governance Framework**	Lack of a centralized authority for integrated river management at national, state, and local levels.
2.	**Integrated River Basin Management (IRBM)**	IRBM application is still in the early stages; stronger coordination is needed across regions.

3.	**Climate Resilience**	Policies need to address the impacts of climate change, such as erratic rainfall and changing river flows.
4.	**Public Participation**	Limited involvement of local communities in river management and conservation efforts.
5.	**Ecological Flows and Biodiversity**	Many policies do not prioritize maintaining the ecological flows that are crucial for aquatic ecosystems and biodiversity.
6.	**River is seen as water and not as an ecosystem**	Many policies do not consider the aquatic biodiversity as an important parameter for water quality

8.4.1. National level policies related to Ganga River

Initial interventions such as the National Water Quality Monitoring Program (1976) and the Water Act (1974) and Environmental Protection Act (1986) established foundational systems for water quality assessment, pollution control, and institutional regulation through CPCB and SPCBs. These were complemented by policy frameworks like the National Water Policy (1987, revised 2002 and 2012) and programmes such as the National River Conservation Plan (1995), which emphasised integrated water resource management, sewage treatment, and pollution abatement. Subsequent initiatives, including the Central Ground Water Authority Guidelines (1997) and the National Biodiversity Act (2002; 2023), expanded the focus to groundwater regulation and biodiversity conservation, while large-scale interventions like the National River Linking Project (2002) and National Environment Policy (2006) addressed water distribution, environmental governance, and sustainable development. However, these efforts consistently faced limitations related to weak enforcement, fragmented governance, and insufficient stakeholder participation (Table 8.2).

More recent interventions demonstrate a shift toward holistic, basin-scale and community-driven river conservation. Programmes such as the Namami Gange Programme (2014) and the National Mission for Clean Ganga (2016) significantly enhanced sewage treatment capacity, riverfront development, and biodiversity conservation, supported by complementary initiatives like Swachh Bharat Abhiyan (2014), Wetlands Rules (2017), and the National Water Conservation Campaign (2019). Global alignment through SDG 6 (2015) and policies addressing sanitation, flood management, and coastal systems further strengthened the framework. Despite measurable progress in infrastructure, awareness, and ecological restoration, persistent gaps remain, including inadequate monitoring, limited focus on tributaries and rural pollution, insufficient climate integration, and weak community engagement (Table 8.2). The analysis highlights the need for stronger coordination, enforcement, and locally contextualised, ecosystem-based planning to ensure effective and sustainable river conservation outcomes.

8.4.2. State level interventions and initiatives for Ganga River

In Uttarakhand, the State Mission for Clean Ganga (SPMG), established during 2016–2017, operates as a registered society responsible for implementing river conservation interventions including sewage treatment, riverfront development, afforestation, and community engagement across Ganga and its tributaries. Progress includes the awarding of multiple sewage treatment plant (STP) contracts and the

planning of riverfront works alongside community outreach structures. However, improvements are suggested in publishing real-time water quality and STP performance data, strengthening decentralized treatment systems, and ensuring monitoring of post-plantation survival. Similarly, in Uttar Pradesh, the State Mission for Clean Ganga (SMCG-UP), active since 2016, functions as the principal implementing body for sewage infrastructure, riverfront development, solid waste management, and community mobilization. Achievements include the sanctioning and operation of large STPs, ongoing and completed riverfront redevelopment projects, and state-wide awareness campaigns. Suggested improvements include a focus on decentralized faecal sludge and septage management (FS/SM), ecological flow maintenance, fish habitat restoration, and stronger pollution enforcement. Complementing this, the State Ganga Committee (constituted in 2016 under the Environment Protection Act via SO 3187(E)) provides an administrative coordination and oversight platform, linking departments and enabling decision-making; however, transparency through publication of meeting minutes and enhanced interdepartmental field reviews is recommended (Table 8.3).

In Bihar, the Bihar State Ganga River Conservation Authority and associated State Action Plan (circa 2019–2022) aim to address pollution in Ganga stretches through coordinated sewage, sanitation, riverfront, and monitoring interventions. Achievements include finalization of the action plan hosted by the Bihar State Pollution Control Board (BSPCB), sanctioning of STP and ghat projects, and initiation of awareness programs, while recommendations emphasize strengthening decentralized sanitation for smaller towns, publishing city-wise STP data, and expanding community engagement. Jharkhand established its State Ganga River Conservation Authority through gazette notifications between 2016 and 2021 to coordinate basin-level conservation planning, STP proposals, and solid waste management. Key progress includes formal institutional setup, submission of action plans to national bodies (NMCG/NGT), and documentation of initial projects; however, deployment of mobile water quality laboratories, public project tracking systems, and promotion of low-cost treatment solutions in remote areas are identified as priorities. In West Bengal, the State Project Management Group (WBSPMG), operational since around 2016, implements conservation activities under the Namami Gange programme, including STPs, riverfront development, forestry interventions, and river-edge management in the Hooghly/Ganga basin. Achievements include publicly available project plans and forestry initiatives, with recommendations to adopt native salt-tolerant species, improve coordination with coastal and industrial regulators, and publish biodiversity and post-plantation survival data. Additionally, Forestry Interventions for Clean Ganga (FIG) (2019–2024+) focus on riparian afforestation and buffer restoration, with progress in plantation planning and seedling distribution, but requiring improved ecological monitoring, biodiversity integration, and community participation in maintenance (Table 8.3).

Across all states, State Action Plans under the Namami Gange framework (2016–present) provide a coordinated approach aligned with directives from the National Mission for Clean Ganga (NMCG) and the National Green Tribunal (NGT). These plans enable harmonized baseline assessments, town-wise project identification, and phased implementation of interventions such as STPs, ghats, and outreach programs. Suggested improvements include the development of consolidated performance dashboards and incorporation of climate resilience guidelines at the state level, particularly for riverfront infrastructure. Collectively, the table highlights a structured yet evolving governance framework with measurable progress in infrastructure and institutional coordination, while underscoring persistent gaps in transparency, decentralization, ecological integration, and community-based monitoring that require systematic strengthening for long-term river conservation outcomes (Table 8.3).

8.4.3. Suggestions for future policy developments

A comprehensive and multi-dimensional framework is suggested for the conservation and rejuvenation of the River Ganga by integrating pollution abatement, ecological restoration, governance reforms, sustainable livelihoods, and community participation. The proposed plan of action reflects an ecosystem-based river management approach, recognising that river health is intrinsically linked to urban systems, industrial regulation, biodiversity conservation, agricultural practices, and socio-cultural behaviour. Collectively, the recommendations signal a necessary transition from isolated engineering interventions toward integrated river basin governance that combines technological monitoring, ecological restoration, institutional accountability, and citizen engagement.

The first focus area, pollution control, emphasises the urgent need for stricter regulation and monitoring of industrial and municipal pollution sources entering the river. The recommendation for continuous online effluent monitoring systems (OCEMS) reflects the increasing reliance on digital environmental governance for real-time surveillance of industrial discharge compliance. The emphasis on upgrading Sewage Treatment Plants (STPs) and improving their operation and maintenance (O&M) highlights a critical systemic failure: infrastructure often exists but functions inefficiently due to inadequate maintenance, underutilisation, or irregular monitoring. Publishing machine-readable dashboards containing parameters such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), coliform levels, plant throughput, and downtime records constitutes a strong push toward transparency and data-driven decision-making. The explicit prohibition on untreated sewage and solid waste discharge reinforces the principle that pollution prevention at source is fundamental to river rejuvenation. The waste management component focuses on reducing solid waste leakage through decentralised, locally manageable approaches. Decentralised waste segregation and composting systems recognise that urban local bodies often struggle to manage mixed waste streams centrally. Promoting segregation at source and organic waste composting supports circular economy principles while reducing landfill dependency. The strengthening of plastic ban enforcement along ghats and riverbanks directly addresses single-use plastic pollution associated with tourism and religious activities. Floating debris removal mechanisms provide an operational backstop for waste already within the river channel.

The section on faecal sludge and septage management (FSM) addresses a critical gap: many small towns in the Ganga basin lack underground sewerage infrastructure and rely on on-site sanitation systems. Decentralised FSM systems represent a practical, scalable solution for non-sewered settlements. Supporting FSM trucks and co-treatment facilities, alongside nature-based systems such as constructed wetlands and waste stabilisation ponds, demonstrates recognition of low-cost ecological treatment technologies that can simultaneously treat wastewater and provide habitat co-benefits. Afforestation and green belt development are proposed as ecological restoration measures to strengthen riparian ecosystems. Riparian buffers using native species support local biodiversity, stabilise riverbanks, filter pollutants, and enhance ecological resilience. Survival monitoring of plantation drives moves away from the pervasive problem of merely reporting sapling numbers without tracking actual ecological outcomes. Independent third-party ecological audits introduce scientific accountability into restoration programmes, a necessary corrective given the widespread practice of over-reporting in government-run afforestation schemes.

The focus on ecological flow and river connectivity addresses hydrological alterations caused by dams, barrages, and diversions. Legally mandated e-flow norms are critical for maintaining ecological functioning, including sediment transport, habitat maintenance, nutrient cycling, and aquatic biodiversity. Installing fish passes at barrages restores longitudinal connectivity essential for migratory fish species such as mahseer (*Tor tor*) and hilsa (*Tenualosa ilisha*). Coordination of managed water releases with irrigation departments is a crucial inter-sectoral governance requirement that has historically been neglected due to siloed water allocation decisions.

Community engagement forms a central pillar of the strategy. The Ganga Prahari programme is a valuable instrument for grassroots stewardship, but requires strengthened training, resourcing, and integration with official monitoring systems to maximise impact. Community-based monitoring and awareness programmes promote local ownership and participatory governance, bridging the gap between policy and ground-level implementation. Conservation-aligned livelihood development demonstrates an important socio-ecological perspective. Communities are substantially more likely to support conservation when environmental protection is linked with livelihood security and economic incentives. Green livelihood activities, ecotourism, sustainable fisheries, organic farming, riparian nursery management, and ecosystem restoration, align economic interests with conservation objectives.

Urban planning and floodplain protection recommendations reflect growing scientific understanding of the ecological importance of floodplains. Enforcing floodplain zoning and river buffer zones prevents encroachment and habitat degradation. Integrating river-sensitive design into city master plans and ensuring ecological setback distances in riverfront projects is critical, as many urban riverfront developments prioritise aesthetics over ecological functionality. The agricultural runoff control component addresses non-point source pollution from excessive fertiliser and pesticide use, a major but often under-regulated source of nitrogen and phosphorus loading in the Ganga. Integrated nutrient management, vegetative buffer strips, and adoption of water-efficient cultivation technologies such as direct-seeded rice (DSR) reflect a landscape-level approach that extends conservation beyond the river channel.

The biodiversity revival section highlights the ecological dimension of river restoration. Wetland and oxbow lake restoration provides critical habitat, flood buffering, and water purification functions. Establishing fish sanctuaries for keystone species, Gangetic dolphins, Gharials, freshwater turtles, and mahseer, represents targeted conservation for species that serve as ecological health indicators. Biodiversity health assessments using standardised indices (IBI) are necessary to evaluate actual ecosystem recovery against baselines.

Governance and transparency form the institutional backbone. Real-time public water quality dashboards, third-party STP audits, and inter-state coordination mechanisms are all necessary conditions for effective management of a river system spanning eleven states. Without statutory inter-state governance arrangements, basin-scale ecological management will remain fragmented and ineffective. The recommendations concerning cultural and religious activities reflect the necessity of harmonising the profound socio-cultural significance of the Ganga with ecological sustainability. Regulating idol immersion (particularly plaster-of-Paris and chemically painted idols), promoting biodegradable offerings, and developing a Ganga Cultural Conservation Protocol in partnership with religious authorities represent culturally sensitive and ecologically necessary interventions. Public awareness and education emphasise behavioural transformation as a long-term driver of river conservation. Basin-wide multimedia campaigns, integration of Ganga conservation into school curricula,

and digital citizen reporting platforms collectively build an informed and engaged citizenry capable of sustaining conservation momentum beyond project cycles (Table 8.4).

8.4.3.1. Additional policy recommendations: critical gaps identified

Beyond the original framework, the following five priority areas represent critical gaps that must be addressed for the Ganga restoration programme to achieve its long-term ecological and governance objectives. These recommendations are grounded in the best available scientific evidence and international best practices in river basin management.

First, climate resilience and adaptive river management must be integrated into all aspects of Ganga basin governance. The Gangotri glacier, which feeds the Bhagirathi, one of the principal headwater streams, has been retreating at an accelerating rate, with significant implications for long-term dry-season flows. Changes in monsoon intensity and distribution are altering flood regimes, sediment dynamics, and pollutant flushing cycles. Without mainstreaming climate change projections into water resource planning and river management, investments in infrastructure and restoration will face increasing physical risks. Second, the absence of a coherent, independent science-based monitoring programme represents a significant structural weakness in current Ganga restoration efforts. Adaptive management, adjusting interventions based on evidence, requires longitudinal, standardised data on water quality, hydrology, sediment loads, and biodiversity. The proposed Ganga River Science Programme (GRSP) would provide the institutional framework for such monitoring, linking research institutions with management agencies and civil society. Third, while community engagement is mentioned in the original table, the governance architecture for multi-stakeholder participation remains underdeveloped. Meaningful participation of riverine communities, particularly marginalised groups, women, fisherfolk, and small farmers, is not merely a social good but a scientific and governance imperative. Evidence from river restoration programmes worldwide demonstrates that community stewardship programmes significantly improve compliance, early warning of violations, and long-term ecological outcomes. Fourth, the absence of diversified, sustainable financing mechanisms is a structural constraint on Ganga restoration. The Polluter Pays Principle, Payment for Ecosystem Services schemes, green bonds, and performance-based Public-Private Partnerships represent a portfolio of instruments that can mobilise private finance, incentivise pollution prevention, and reward ecological stewardship, reducing exclusive dependence on government budgetary allocations. Fifth, legal and regulatory reform is necessary to provide enduring institutional authority for Ganga conservation. The current legal framework is fragmented, enforcement is inconsistent across riparian states, and NMCG lacks statutory powers adequate for basin-scale enforcement. A dedicated Ganga River Protection Act, informed by the growing international legal movement recognising river rights and legal personhood, could provide the institutional foundation for sustainable, long-term conservation (Table 8.4).

8.4.3.2. Synthesis and key findings

Several overarching patterns emerge from this analysis. First, there is a clear and appropriate emphasis on decentralisation in waste management, sanitation, monitoring, and community engagement. Second, the recommendations increasingly favour nature-based and ecosystem-based solutions over conventional engineering infrastructure, reflecting the global scientific consensus on the cost-

effectiveness and co-benefits of nature-based approaches. Third, transparency and accountability mechanisms, dashboards, OCEMS, third-party audits, form a coherent governance innovation. Fourth, the framework recognises river conservation as a socio-economic and cultural challenge requiring cross-sectoral integration. The suggested framework advocates: climate resilience planning, science-based adaptive management, structured multi-stakeholder governance, diversified financing, and legal reform (Table 8.4).

8.5. Conclusion

The policy analysis underscores that conservation of the Ganga River requires a systemic, multi-dimensional approach that integrates ecological sustainability with socio-economic realities and governance structures. The application of the PESTEL framework demonstrates that river conservation outcomes are shaped by the dynamic interaction of political commitment, economic dependencies, social structures, technological capacities, environmental pressures, and legal-institutional mechanisms. These dimensions are not isolated; rather, they operate as an interconnected policy environment influencing both the effectiveness and long-term sustainability of interventions. The analysis highlights that existing challenges ranging from pollution, flow alteration, and biodiversity loss to livelihood vulnerability and institutional fragmentation, cannot be addressed through sectoral or top-down approaches alone. Instead, effective policy implementation depends on aligning governance mechanisms with ground-level realities, particularly the needs, dependencies, and knowledge systems of riverine communities. The evidence demonstrates that policies lacking stakeholder integration risk limited adoption and weak on-ground outcomes, whereas participatory and adaptive frameworks enhance legitimacy, compliance, and ecological effectiveness.

A central conclusion emerging from the analysis is the critical role of community-based conservation as a policy instrument. Institutional mechanisms such as stakeholder engagement, the Ganga Prahari framework, livelihood-linked interventions, and village-level microplanning collectively operationalize policy intent into actionable, locally relevant strategies. These approaches enable convergence between conservation goals and livelihood security, thereby reducing ecological pressures while strengthening community stewardship. Furthermore, the analysis establishes that policy effectiveness is contingent upon context-specific design and implementation. Spatial heterogeneity across the basin, ecological, socio-economic, and cultural, necessitates differentiated strategies rather than uniform policy prescriptions. The integration of microplanning and localized interventions ensures that biodiversity conservation is embedded within development planning, thereby enhancing both resilience and scalability.

The policy analysis concludes that sustainable conservation of the Ganga River depends on transitioning from fragmented, sector-driven interventions to an integrated, participatory governance model. Embedding stakeholder engagement, aligning livelihoods with ecological objectives, strengthening institutional coordination, and adopting adaptive, evidence-based planning frameworks are essential to bridge the gap between policy formulation and effective implementation, ensuring long-term ecological integrity and socio-economic sustainability of the Ganga basin.

Table 8.2. National-level policies related to river ecosystem in India

Policy/Program/Guidelines/ Acts/Rules/Interventions/Plan/ Project/Order	Year	Description	Achievement	Policy Gaps/Suggestions	Implementing Agency/Ministry
National Water Quality Monitoring Program (NWQMP)	**1976**	Regular monitoring of the water quality of major rivers in India to assess pollution levels and water quality.	1. Established a comprehensive network of monitoring stations across India to assess the quality of surface and groundwater. It laid the foundation for consistent, long-term water quality data collection, helping to identify pollution trends and areas requiring attention. 2. Through systematic monitoring, the program identified critically polluted rivers, lakes, and other water bodies, leading to targeted interventions and policy measures to reduce pollution. This helped in addressing major water pollution issues, such as untreated industrial effluent discharge and sewage contamination. 3. The data generated by the NWQMP served as a critical resource for formulating and enforcing water quality standards and policies. It contributed to the development of national and state-level water management strategies, environmental protection laws, and initiatives like the Ganga Action Plan and the National River Conservation Plan.	1. The program primarily monitors major rivers and urban water sources, focusing little on smaller rivers, rural water bodies, and localised pollution hotspots. 2. Limited participation of local community, industries, and other stakeholders in monitoring, pollution control, and public awareness initiatives undermined the program's impact.	**Central Pollution Control Board (CPCB)**

Environmental Protection Act - 1986 & The Water (Prevention and Control of Pollution) Act - 1974	**1974 (TWA); 1986 (EPA)**	Provides a legal framework for pollution control in rivers by regulating the discharge of pollutants into water bodies and imposing penalties for non-compliance.	1. Both acts established a strong legal framework for the prevention, control, and abatement of environmental pollution, including water, air, and land. The Environmental Protection Act of 1986 empowered the government to take comprehensive actions to safeguard environmental health, while the Water Act focused specifically on controlling water pollution. 2. The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) were established under these acts to monitor pollution levels, enforce standards, and issue guidelines. These bodies play a key role in implementing environmental laws at both the state and national levels. 3. The acts set water quality standards, emission limits, and pollution control measures, guiding industries and municipalities in managing effluents and wastewater. 4. The acts provided legal powers to take action against polluters, including fines and imprisonment for violations. This incentivised industries and local authorities to adopt better pollution control technologies and comply with environmental standards. 5. Laid foundation for environmental regulations, including EIA and CRZ rules.	1. Limited enforcement, especially in rural and informal sectors, where agricultural runoff is a major reason for water pollution. Stronger penalties for violations. 2. Need for greater public awareness and participation, and stringent actions on sewage dumping by the industries and factories along the river banks	**Ministry of Environment, Forest and Climate Change (MoEFCC), Central Pollution Control Board, State Pollution Control Board**

National Water Policy (NWP)	**1987, Revised 2002, 2012**	A comprehensive policy framework for the management and conservation of water resources, including rivers. Emphasises sustainable water management, equitable distribution, interlinking rivers, and river basin management.	1. The policy emphasised the adoption of Integrated Water Resources Management (IWRM) principles, advocating for a holistic approach to water management that integrates economic, social, and environmental considerations. It promoted the coordination of water use across various sectors like agriculture, industry, and domestic consumption. 2. The policy highlighted the need to improve water-use efficiency, particularly in agriculture, which is the largest consumer of water in India. It encouraged the use of water-saving technologies such as drip irrigation and promoted rainwater harvesting to ensure long-term water availability. 3. The National Water Policy aimed for equitable distribution of water resources, ensuring that water reaches all sectors and communities, including marginalised groups. 4. The policy called for the strengthening of institutions at both the state and national levels, including the creation of a National Water Regulatory Authority. It also recommended the establishment of water rights and pricing mechanisms to ensure proper allocation and sustainable use of water resources.	1. Weak implementation and monitoring mechanisms for river basin management at the local levels and remote areas. 2. There is a limited mention of climate change adaptation. Strong ecological assessments are required. 3. Fragmented water governance due to management, regulation, and decision-making related to water resources is divided among multiple agencies, sectors, and jurisdictions, often leading to inefficiencies, conflicts, and a lack of coordination.	**Ministry of Jal Shakti**
National River Conservation Plan (NRCP)	**1995**	Focuses on cleaning and improving the quality of water in	1. It focused on reducing the discharge of untreated sewage and industrial effluents into these rivers, improving water quality in targeted stretches. 2. Establishment of Sewage Treatment Plants	1. Inadequate monitoring of rural pollution due to long gaps in monitoring and maintenance.	**Ministry of Jal Shakti, CPCB, SPCBs**

		major rivers, targeting 38 rivers with a focus on sewage treatment, pollution control, and solid waste management.	(STPs) in cities along the rivers, significantly reducing water pollution. 3. Emphasised community involvement and public awareness programs to sensitise people about the importance of river conservation.	2. Limited community involvement due to a lack of sensitisation and awareness.	
Central Ground Water Authority (CGWA) Guidelines	**1997**	Guidelines to regulate groundwater extraction and prevent over-extraction, impacting river health through hydrological connectivity.	1. Guidelines provided a regulatory framework to control excessive groundwater extraction, particularly in water-stressed regions. 2. Emphasised sustainable groundwater management by introducing measures like rainwater harvesting, artificial recharge, and the promotion of efficient irrigation methods, especially in areas facing over-exploitation. 3. Established a framework for groundwater monitoring and assessment by setting up a system to regularly track water levels and quality across different regions. This helped authorities make informed decisions regarding groundwater regulation and resource management.	1. Lack of strong enforcement and penalties for violations results in ineffective implementation of groundwater conservation measures. 2. Focusing mainly on urban and industrial sectors, neglecting rural areas and agriculture, where excessive groundwater extraction is a major issue. 3. The guidelines do not fully promote integrated water resource management, ignoring the interconnectedness between surface water and groundwater systems. 4. Limited community	**Ministry of Jal Shakti, CGWA**

				involvement and lack of public awareness programs hinder the effective implementation of groundwater conservation initiatives.	
National Biodiversity Act	**2002; 2023**	Provides for conservation of biological diversity, sustainable use, and equitable sharing.	1. People's Biodiversity Registers (PBRs), State Boards Biodiversity (SBB) registers, and Biodiversity Management Committees (BMCs) at the local level. 2. Regulation of access to biological resources and associated knowledge to ensure equitable benefit sharing. 3. Protection of traditional knowledge and prevention of biopiracy. 4. Provision for declaring areas as Biodiversity Heritage Sites.	1. Ensure better representation of river ecosystems in PBRs. 2. Improve implementation through regular Department and public participation.	**National Biodiversity Authority, MoEFCC**
National River Linking Project (NRLP) - 2002	**2002**	Aims to interlink India's major rivers for equitable water distribution, flood and drought mitigation through dams, reservoirs, and canals.	1. Helped in improving water availability for irrigation, drinking, and industrial use in drought-prone and arid regions, also mitigating floods in flood-prone areas by diverting excess water to regions in need. 2. Provide stable irrigation to areas facing inconsistent rainfall, thereby improving agricultural productivity. The project aimed to reduce dependency on monsoon rains and ensure a reliable water supply for crops. 3. Construction of reservoirs and dams, which not only supported irrigation but also contributed to	1. Environmental concerns (ecosystem disruption, biodiversity loss). 2. Financial and technical challenges. 3. Opposition from states due to water-sharing disputes.	**Ministry of Jal Shakti**

			hydroelectric power generation. This enhanced the energy security of the country and provided additional sources of renewable energy.		
National Environment Policy (2006)	**2006**	A comprehensive policy focusing on environmental protection, including river conservation and managing water quality.	1. Emphasised the need for sustainable development by balancing economic growth with environmental conservation. It encouraged the integration of environmental concerns into developmental planning at all levels to ensure long-term ecological sustainability. 2. The policy focused on improving environmental governance by enhancing the effectiveness of regulatory bodies like the Ministry of Environment, Forests, and Climate Change (MoEFCC) and other state-level agencies. It called for better enforcement of environmental laws and the creation of a more transparent, participatory process for decision-making. 3. NEP highlighted the conservation of India's natural resources, such as water, biodiversity, and forests. It promoted initiatives like biodiversity preservation, water management, and reducing the degradation of critical ecosystems	1. The policy does not adequately address the urgent need for climate change mitigation and adaptation strategies. 2. The policy lacks robust enforcement and monitoring frameworks, leading to inconsistent implementation across states and sectors. 3. Limited Public Participation	**Ministry of Environment, Forest and Climate Change (MoEFCC)**
Flood Management and Control (FMC) Program	**2008**	A program to address flood risks in river basins and improve floodplain management,	1. Supported the construction and strengthening of flood protection infrastructure such as embankments, dams, and flood control channels in vulnerable regions. 2. Strengthened flood forecasting and early warning	1. Inadequate addressing of upstream watershed management or river basin-wide solutions. 2. Weak disaster	**Ministry of Jal Shakti, CWC**

		particularly for flood-prone rivers.	systems, improving the ability to predict floods and issue timely alerts. This helped in minimising loss of life and property by allowing communities and authorities to take preventive measures before floods hit.	preparedness and response, leaving communities vulnerable	
National Aquatic Animal Declaration (Gangetic Dolphin)	**2009/2010**	Declared the Gangetic dolphin as the National Aquatic Animal to prioritise its protection. The decision was taken at the first meeting of the National Ganga River Basin Authority (NGRBA) on 5 October 2009; the formal gazette notification was issued on 18 May 2010.	1. Raised awareness and improved dolphin habitat conservation in the Ganga basin.	1. Implement similar initiatives for other keystone aquatic species.	**MoEFCC**
National Green Tribunal (NGT) Orders on River Protection	**2010**	Orders to control pollution in rivers, through judicial directives on pollution control and enforcement.	1. Mandated the treatment of sewage and industrial effluents before they are discharged into rivers, thereby increasing the accountability for municipalities and industries, leading to the establishment of sewage treatment plants and better waste management practices along riverbanks. 2. Issued rulings to preserve and restore river	1. Despite the NGT's orders, there is a lack of effective enforcement mechanisms, leading to delayed or incomplete implementation of river protection measures.	**National Green Tribunal (NGT)**

			ecosystems by preventing encroachments, illegal sand mining, and other activities that damage riverbeds and floodplains.	2. Limited focus on holistic river ecosystem management, like ecological flow maintenance, biodiversity conservation, and integrated river basin management.	
Integrated Coastal Zone Management (ICZM) Plan - 2011	**2011**	Focuses on the management of river estuaries and the river-coast interface, aiming to protect coastal ecosystems.	1. The plan integrated river management with coastal and marine conservation, promoting sustainable management practices to prevent over-exploitation of resources. It encouraged measures like controlling pollution, preventing encroachments, and preserving mangrove and wetland habitats, which help protect rivers that flow into the seas.	1. Coastal erosion aggravated by river modifications. 2. Lack of comprehensive monitoring of river-coast interactions.	**Ministry of Environment, Forest and Climate Change (MoEFCC)**
Integrated River Basin Management (IRBM) Framework	**2012**	A framework to ensure integrated management of river basins, considering ecological, social, and economic aspects.	1. Sustainable river management by integrating environmental, social, and economic considerations, ensuring balanced water resource use. 2. Implement effective conservation and rehabilitation strategies for river ecosystems. 3. Improvements in water quality, riverbank restoration, and ecosystem protection through stricter enforcement of pollution controls and rehabilitation programs.	1. Fragmented governance due to a lack of a centralised, coordinated approach between national, state, and local authorities leads to inconsistent implementation of IRBM principles. 2. Insufficient involvement of local communities, industries, and other	**Ministry of Jal Shakti, CWC**

				stakeholders. 3. Absence of comprehensive data collection and real-time monitoring.	
Water and Sanitation Policy	**2013**	A policy to improve water and sanitation infrastructure, which has a direct impact on river water quality by addressing sewage and waste management.	1. Enhanced river health by promoting pollution control, wastewater treatment, and safe water access, ensuring sustainable use of river resources.	1. Lacks a comprehensive focus on climate resilience, equitable access in rural areas, and efficient wastewater management.	**Ministry of Housing and Urban Affairs**
Swachh Bharat Abhiyan (Clean India Mission)	**2014**	A nationwide cleanliness campaign aimed at reducing pollution, including cleaning river banks and improving sanitation near water bodies.	1. Improved sanitation infrastructure and waste management have significantly reduced open defecation and waste dumping into rivers, leading to cleaner water bodies. 2. Increased public awareness and involvement in river cleanliness drives, promoting long-term behavioural changes for sustainable river conservation.	1. Lacks a robust framework for wastewater treatment and management. 2. Insufficient emphasis on long-term behavioural change regarding waste segregation, disposal, and hygiene practices.	**Ministry of Jal Shakti, MoEFCC**
Namami Gange Programme - 2014	**2014**	Flagship program for the rejuvenation and conservation of the Ganga River,	1. The programme has sanctioned 200 sewerage infrastructure projects with a total cost of ₹31,810 crore, completing 116 projects that are now operational. This effort has significantly increased	1. Slow infrastructure and sewage treatment plant implementation due to a lack of data in the initial	**Ministry of Jal Shakti, NMCG**

		focusing on pollution abatement, riverfront development, afforestation, and sustainable livelihoods.	sewage treatment capacity, reducing pollution levels in the river. 2. Initiatives have been undertaken for the construction, modernisation, and renovation of 267 ghats and crematoria, enhancing the riverfront's aesthetic and cultural value while promoting eco-tourism. 3. To address floating solid waste, river surface cleaning projects have been implemented at 11 locations, improving the visual and environmental quality of the river. 4. The programme has developed and trained volunteers known as 'Ganga Praharis' to support conservation actions. These volunteers, along with 'Ganga Doots,' engage in activities such as tree planting, ghat cleaning, and organising cultural events like Ganga Aarti to raise public awareness about the river's health.	phase. 2. Coordination issues between the central and state governments. 3. Need for more detailed addressing of pollution hotspots. 4. Need of stringent policy regarding waste management and the disposal of hazardous material without affecting the biodiversity	
Sustainable Development Goals (SDG) 6 - Clean Water and Sanitation	**2015**	A global initiative that India aligns with to improve water management, access to clean water, and sanitation systems, benefiting river health.	1. Significant advancements have been made in wastewater treatment and riverfront development, leading to improved water quality and benefiting millions	1. To achieve SDG 6, the government needs to ensure equitable access to clean water and sanitation in remote and underserved rural regions. 2. More emphasis on effective wastewater	**Ministry of Jal Shakti, MoEFCC**

				treatment and pollution control.	
National Mission for Clean Ganga (NMCG) - 2016	**2016**	Implements the Namami Gange program with a focus on wastewater treatment, pollution control, and biodiversity conservation in the Ganga Basin.	1. Out of 492 initiated projects valued at ₹40,121.48 crore, 307 have been completed and made operational, marking substantial progress in river restoration efforts. 2. The NMCG has significantly increased sewage treatment capacity, creating 3,446 million litres per day (MLD), surpassing the pre-2014 capacity by over 30 times. This includes the completion of 127 sewage infrastructure projects, contributing to pollution abatement and improved water quality in the Ganga River. 3. In 2024, the NMCG achieved notable milestones in biodiversity conservation, including the ranching of 4.925 million Indian Major Carps (IMC), 7,370 Mahseer, and 42,117 Hilsa fish. Additionally, afforestation efforts have been undertaken to restore and preserve the ecological balance of riverine environments.	1. Need consistent monitoring of water quality and treatment plants. 2. More focus on tributaries. 3. Stronger community-based governance.	**Ministry of Jal Shakti, NMCG**
Wetlands (Conservation and Management) Rules - 2017	**2017**	Aims to conserve and manage wetlands that regulate river flows, recharge	1. Shifted the responsibility of wetland management from a central authority to state-level bodies, enhancing localised conservation efforts and allowing for more region-specific strategies. 2. India has significantly increased its network of	1. Strong guidelines to enforce conservation strategies and stringent actions on illegal encroachments. 2. Threats from	**Ministry of Environment, Forest and Climate Change (MoEFCC)**

		groundwater, and support biodiversity.	Ramsar sites, with 85 wetlands designated as of December 2024, covering approximately 1.36 million hectares. This expansion underscores the country's commitment to international wetland conservation standards. 3. provided a structured legal framework for the identification, notification, and protection of wetlands, facilitating better management practices and conservation outcomes across various states.	urbanisation and agricultural expansion, for which ground-level conservation strategies that are site-specific need to be developed, keeping the local economy in mind.	
National Water Conservation Campaign	**2019**	Promotes water conservation through rainwater harvesting, efficient use of water, and pollution reduction measures.	1. Completion of over 1.05 crore (10.5 million) water conservation projects, including approximately 34 lakh (3.4 million) related to water conservation and rainwater harvesting, and nearly 18.5 lakh (1.85 million) focused on reuse and recharge structures, directly benefiting river ecosystems. 2. National Water Awards have honoured exemplary efforts in water conservation and management. By 2024, 38 winners across nine categories were recognised for their contributions, including initiatives that have positively impacted river rejuvenation and sustainable water resource management. **Initiatives in 2025:** 1. Catch the Rain – 2025: Initiated by the Ministry of Jal Shakti on World Water Day 2025, this campaign emphasises community-led water conservation across 148 districts, focusing on rainwater harvesting and groundwater recharge to rejuvenate river	1. Need for more comprehensive and sustained public awareness programs 2. Adequate monitoring of water conservation efforts and sufficient enforcement of water-saving measures across sectors.	**Ministry of Jal Shakti**

			ecosystems. 2. Inauguration of 'Water Conservation Campaign 2025' in Dehradun: Launched by Chief Minister Pushkar Singh Dhami, this initiative encourages residents to identify and rejuvenate critical or drying water sources, directly contributing to the health and sustainability of local rivers.		
Jal Jeevan Mission (JJM) - 2019	**2019**	Aims to provide potable water to every rural household, promoting sustainable water management and protection of river systems.	1. promoted rainwater harvesting and groundwater recharge, leading to improved water availability and reduced dependency on river water sources. 2. The mission has trained over 2.4 million women to manage and monitor water supplies, fostering community-led conservation efforts that benefit river ecosystems.	1. Water scarcity and quality challenges in several areas need to be addressed. 2. Over-extraction of groundwater should be checked and penalised. 3. Lack of climate change adaptation strategies to mitigate the loss of drinking water.	**Ministry of Jal Shakti**

Table 8.3. State level Conservation initiatives for Ganga River

State	Policy / Program / Guideline / Act / Rule / Intervention / Plan / Project / Order	Year	Description	Achievements	Suggestion for Improvement	Implementing Agency / Department / Ministry
Uttarakhand	**State Mission for Clean Ganga (SPMG, Uttarakhand)**	**2016–2017 (Establishment)**	Registered society mandated to implement river conservation interventions (sewage treatment, riverfronts, afforestation and community engagement) in Uttarakhand's Ganga & tributary stretches.	1. Multiple STP tenders / awarded contracts 2. Riverfront works planned; community outreach structures established.	1. Publish real-time water quality and STP performance data. 2. strengthen decentralised treatment and post-planting survival monitoring.	**State Mission for Clean Ganga (SPMG, registered society), Dept. of Drinking Water & Sanitation; Forest Dept.**
Uttar Pradesh	**State Mission for Clean Ganga (SMCG-UP)**	**2016 (active)**	State implementing society for Ganga conservation: sewage infrastructure, riverfront work, solid waste management and community mobilisation in UP's Ganga basin.	1. Many large STPs are sanctioned & operational. 2. Several riverfront redevelopments are completed / underway, and statewide awareness campaigns.	1. Focus on decentralised FS/SM. 2. Mandate ecological flow & fish-habitat restoration. 3. Strengthen pollution enforcement.	**State Mission for Clean Ganga-UP; State Ganga Committee; Municipal Bodies; State PCB**
Uttar Pradesh	**State Ganga Committee (Order under EPA)**	**2016**	Administrative body constituted via SO 3187(E) under the Environment (Protection) Act to oversee	A formal decision-making and coordination platform exists, and a committee	1. Publish committee minutes and action notes.	**Environment / Water Resources Department, and**

			implementation, coordination & compliance of Ganga conservation measures at the state level.	structure links departments.	2. Ensure regular cross-department field reviews.	**supported by SMCG-UP**
Bihar	**Bihar State Ganga River Conservation Authority / State Action Plan**	**~2019–2022**	State-level authority and action plan to address polluted Ganga stretches, coordinate sewage & sanitation projects, riverfront upgrades, monitoring and compliance.	1. Action plan finalised and hosted by BSPCB. 2. Some STP and ghat works sanctioned; awareness initiatives started.	1. Strengthen decentralised sanitation for small towns. 2. Publish city-wise STP data. 3. Widen community engagement.	**Bihar State Ganga Authority, Bihar State Pollution Control Board (BSPCB) and Urban Local Bodies**
Jharkhand	**Jharkhand State Ganga River Conservation Authority & Action Coordination**	**2016–2021 (Gazette Notifications)**	State authority constituted to prepare & implement Ganga basin conservation plans, coordinate STP proposals and solid waste management in Jharkhand's stretch.	1. Formal constitution of authority; 2. Action plans submitted to NMCG/NGT. 3. Initial project proposals documented.	1. Deploy mobile water quality labs. 2. Public project tracker; promote low-cost treatment in remote areas.	**Jharkhand State Ganga Authority, Urban Development. & Housing Dept (UDHD), State Pollution Control Board and Municipalities**
West Bengal	**West Bengal State Project Management Group (WBSPMG)**	**~2016–present**	State mission to implement Namami Gange / Ganga conservation: STPs, riverfront works, forest interventions and river edge	1. Project approvals and plans are visible on the state portal; forestry interventions are planned.	1. Use native salt-tolerant species.	**West Bengal State Project Management Group, Water Resources / River**

			development in the Hooghly / Ganga basin.	2. Riverfront project lists are hosted publicly.	2. Coordinate with coastal & industry regulators. 3. Publish post-planting survival & biodiversity data.	**Development, Forest Department and Local Bodies**
West Bengal	**Forestry Interventions for Clean Ganga (FIG)**	**2019–2024+**	State Forest Department's implementation of riparian afforestation and buffer restoration as part of the Namami Gange forestry component.	1. Hectares planned for riverbank afforestation. 2. Seedlings distributed & sites prepared.	1. Monitor survival & ecosystem metrics. 2. Integrate biodiversity surveys. 3. Involve local communities in maintenance.	**West Bengal Forest Department, and coordinated by WBSPMG.**
All States	**State Action Plans under Namami Gange coordination**	**2016–present**	1. Each state prepares action plans and responds to NGT / NMCG directives. 2. Aligns local interventions (STPs, ghats, outreach) with mission objectives.	Harmonised baseline data, town-wise project identification and phased works across states.	1. Publish consolidated performance dashboards. 2. State-level climate resilience guidelines for riverfronts.	**State Missions / Authorities are coordinated by NMCG.**

Table 8.4. Focus area suggested for future policy developments

Sl. No.	Focus Area	Suggested Plan of Action for River Ganga Conservation
1	**Pollution Control**	1. Enforce stricter industrial effluent discharge standards through continuous online effluent monitoring systems (OCEMS) linked to a centralised regulatory dashboard (Central Pollution Control Board, 2022). 2. Upgrade and ensure proper operation and maintenance (O&M) of all Sewage Treatment Plants (STPs). Publish machine-readable O&M and water quality dashboards reporting BOD, COD, coliform levels, STP throughput, and downtime records on a daily basis (National Mission for Clean Ganga, 2023). 3. Strictly prohibit discharge of untreated sewage and solid waste into the river; impose graded penalties with mandatory remediation timelines for violations.
2	**Waste Management**	1. Implement decentralised waste segregation and composting systems in all river-bank towns and urban local bodies (ULBs) along the Ganga basin (Ministry of Housing and Urban Affairs, 2016). 2. Strengthen enforcement of plastic bans along ghats and riverbanks, with geo-tagged inspection records. Establish mechanised floating debris removal mechanisms at strategic river stretches (Pollution Control Board, 2021). 3. Develop Integrated Solid Waste Management (ISWM) plans aligned with the Solid Waste Management Rules 2016 for all Ganga-basin municipalities.
3	**Faecal Sludge & Septage Management (FSM)**	1. Promote decentralised faecal sludge and septage management (FSM) systems in all small towns lacking sewer networks within the Ganga basin (Ministry of Housing and Urban Affairs, 2017). 2. Fund dedicated FSM trucks and co-treatment facilities at existing STPs. Promote nature-based treatment systems, including constructed wetlands and waste stabilisation ponds, for non-sewered settlements (Pollution Control Board, 2021). 3. Mandate regular desludging of on-site sanitation systems and maintain digital registries of service coverage and treatment efficiency.
4	**Afforestation & Riparian Green Belts**	1. Develop riparian buffer zones of a minimum 30-metre width using native and site-adapted species along all Ganga River stretches and tributaries. 2. Conduct plantation drives with mandatory post-planting survival monitoring for at least three years; report survival rates publicly. 3. Commission independent third-party ecological audits annually to assess biodiversity recovery, canopy cover, and ecosystem health rather than relying on sapling-count targets (National Mission for Clean Ganga, 2022). 4. Integrate Miyawaki and other dense-plantation methodologies in degraded riparian zones for rapid ecological recovery.

5	**Ecological Flow & River Connectivity**	1. Implement legally mandated environmental flow (e-flow) norms as per the National Water Policy and notified by the Ministry of Jal Shakti (2018); ensure year-round minimum flows at all major barrage sites. 2. Map all barrages, weirs, and canal offtakes within the basin; install fish passes or fish ladders at structures blocking migratory corridors. 3. Coordinate managed water releases with irrigation departments through an inter-agency Ecological Flow Monitoring Committee to integrate ecological water requirements into seasonal water allocation decisions.
6	**Community Engagement & Ganga Prahari**	1. Organise structured Ganga clean-up drives at quarterly intervals involving local schools, panchayats, urban local bodies, and civil society organisations. 2. Strengthen the Ganga Prahari programme by expanding cadre strength, providing training in water quality testing, and integrating Prahari-reported data into official monitoring systems. 3. Promote community-based environmental monitoring using standardised data collection protocols and citizen science platforms.
7	**Conservation-Aligned Livelihood Development**	1. Develop structured green livelihood programmes — including ecotourism, sustainable inland fisheries, organic farming, riparian nursery management, and community-led conservation monitoring — that provide stable income while reinforcing local stewardship of river ecosystems. 2. Create Ganga Biodiversity Conservation Cooperatives at the gram panchayat level, linking livelihood incentives with verified conservation outcomes. 3. Align all livelihood programmes with the NMCG Arthganga initiative to ensure institutional support and funding continuity.
8	**Urban Planning & Floodplain Protection**	1. Enforce floodplain zoning regulations under the National Disaster Management Authority (NDMA) guidelines; prohibit all permanent construction within the 100-year flood inundation zone. 2. Integrate river-sensitive design standards into all city master plans for Ganga-basin towns, including mandatory ecological setback distances for riverfront projects (Ministry of Jal Shakti, 2016). 3. Demarcate, digitally map, and legally notify river buffer zones in all districts; publish encroachment status annually. 4. Conduct Strategic Environmental Assessments (SEAs) for all major urban infrastructure projects within 500 metres of the river.
9	**Agricultural Runoff Control**	1. Promote integrated nutrient management (INM) and precision agriculture to reduce nitrogen and phosphorus loads entering the river; provide incentives for reduced chemical input farming (Ministry of Agriculture & Farmers Welfare, 2020).

		2. Establish mandatory vegetative buffer strips of at least 10 metres along all agricultural fields adjacent to the river channel and its tributaries. 3. Promote adoption of System of Rice Intensification (SRI) and direct-seeded rice (DSR) in paddy-dominant areas of the basin to reduce agrochemical and water use. 4. Develop a basin-wide non-point source pollution monitoring programme tracking seasonal nutrient loading data.
10	**Reviving Aquatic Biodiversity**	1. Restore degraded wetlands and oxbow lakes along the Ganga corridor; designate critical wetland sites as Ramsar sites or State Wetland Authorities under Wetland (Conservation & Management) Rules, 2017. 2. Establish fish sanctuaries at identified hotspots, particularly for Gangetic dolphin (Platanista gangetica), freshwater turtles (Batagur spp.), Gharial (Gavialis gangeticus), and mahseer (Tor tor). 3. Conduct annual biodiversity health assessments using standardised ecological indices (IBI — Index of Biotic Integrity) to track ecosystem recovery trajectories. 4. Impose seasonal fishing bans during breeding periods and enforce them through joint taskforces involving fisheries departments and community monitors.
11	**Strengthening Governance & Transparency**	1. Develop and maintain publicly accessible real-time water quality dashboards reporting WHO/BIS parameters at all identified monitoring stations along the Ganga. 2. Institutionalise mandatory third-party audits of STPs, afforestation projects, and OCEMS systems at 6-monthly intervals; publish audit results. 3. Strengthen inter-state coordination mechanisms through a formally constituted Ganga River Basin Authority (GRBA) with statutory powers for basin-scale enforcement. 4. Establish a Results Framework for NMCG with SMART indicators, annual performance reviews, and public disclosure of fund utilisation.
12	**Cultural & Religious Activities**	1. Regulate idol immersion through designated, lined immersion ponds with silt traps; prohibit direct immersion of plaster-of-Paris (PoP) and chemically painted idols in the river (Ministry of Environment, Forest and Climate Change, 2020). 2. Promote biodegradable offerings, flower composting, and eco-friendly rituals through collaboration with religious and cultural trusts at major pilgrimage sites (Haridwar, Prayagraj, Varanasi, Patna). 3. Develop a Ganga Cultural Conservation Protocol in consultation with religious leaders, archaeologists, and ecologists to harmonise ritual practices with environmental sustainability.
13	**Public Awareness & Education**	1. Launch basin-wide multimedia awareness campaigns leveraging radio, social media, and local influencers to build understanding of river ecology and conservation responsibilities.

		2. Integrate Ganga conservation into school and university curricula under the National Education Policy 2020 framework; promote river literacy through experiential learning programmes. 3. Use open digital platforms (e.g., the existing Ganga Connect App) for geo-tagged citizen reporting of pollution incidents, enabling rapid institutional response and transparent status tracking.
14	**Climate Resilience & Adaptive River Management**	1. Integrate climate change projections (IPCC AR6 and IMD/IITM regional scenarios) into Ganga basin water resource planning to account for altered monsoon patterns, increased glacial melt from Gangotri, and extreme flood/drought events. 2. Develop an Integrated Ganga Basin Climate Adaptation Plan identifying vulnerable stretches, risk-prone communities, and ecosystem-based adaptation (EbA) measures. 3. Establish a glacier and snowpack monitoring programme in the upper Himalayan catchment (Bhagirathi, Alaknanda sub-basins) to provide early warning signals for downstream flow variability. 4. Mandate inclusion of climate risk assessments in all new water infrastructure (dams, barrages, diversions) proposed within the basin.
15	**Science-Based Monitoring & Adaptive Management**	1. Establish a Ganga River Science Programme (GRSP), an interdisciplinary research consortium comprising IITs, CSIR-NEERI, Wildlife Institute of India (WII), and NMCG, to conduct longitudinal scientific monitoring of hydrology, water quality, sediment dynamics, and biodiversity. 2. Deploy a network of automated multi-parameter water quality sensors at 50-km intervals along the main stem, with data integrated into a publicly accessible open-data portal. 3. Adopt an Adaptive Management Framework (AMF) wherein restoration interventions are periodically evaluated against SMART ecological targets, and management strategies are revised based on evidence. 4. Commission a periodic State of the Ganga River report (every five years) synthesising scientific, socio-economic, and governance data, with peer-reviewed publication.
16	**Multi-Stakeholder Governance & Participatory Platforms**	1. Establish formally constituted River Basin Councils at district and sub-basin levels comprising representatives from agriculture, fisheries, urban local bodies, civil society, youth groups, women self-help groups, and industrial associations, ensuring at least 33% women representation. 2. Develop a structured Ganga Stakeholder Consultation Protocol aligned with UNDRIP and the Aarhus Convention principles, ensuring meaningful participation of marginalised and riverine communities in decision-making. 3. Create a Ganga Conservation Fund with a dedicated window for community-led conservation projects, administered transparently through a participatory governance board.

		4. Institute an annual Ganga Samvaad (River Dialogue), a multi-stakeholder forum, to review progress, surface grievances, and co-develop adaptive management priorities with civil society and scientific experts.
17	**Financing Mechanisms & Economic Instruments**	1. Introduce a Polluter Pays Principle (PPP)-based effluent charge structure for industrial dischargers along the Ganga basin; ring-fence revenues for STP upgrades and ecological restoration. 2. Develop Payment for Ecosystem Services (PES) schemes that compensate upstream communities and farmers for watershed protection, organic farming, and afforestation activities that improve downstream water quality. 3. Issue Ganga Conservation Bonds (green bonds) for financing large-scale infrastructure improvements in STPs, FSM systems, and ecological restoration; align with SEBI Green Bond Framework. 4. Explore Public-Private Partnerships (PPPs) for STP O&M with performance-based contracts benchmarked against effluent quality standards and uptime guarantees.
18	**Legal & Regulatory Reform**	1. Enact a dedicated Ganga River Protection Act granting statutory legal personhood or enforceable rights to the river ecosystem, building upon the Uttarakhand High Court 2017 precedent and subsequent legal developments, to create justiciable ecological obligations. 2. Harmonise the legal status of the National Mission for Clean Ganga (NMCG) by providing statutory authority for enforcement, dispute resolution, and financial penalties independent of state-level administrative bottlenecks. 3. Review and amend the Environment (Protection) Act 1986 and Water (Prevention and Control of Pollution) Act 1974 to strengthen provisions specifically applicable to major river basin systems, including cumulative impact assessment requirements. 4. Develop a comprehensive Ganga Basin Notification under Section 3(2)(v) of the EPA 1986 to establish basin-wide legally enforceable environmental standards across all riparian states.

Chapter 09

CONCLUSION AND RECOMMENDATIONS

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The Ganga River emerges from this assessment as a complex and dynamic socio-ecological system, where ecological processes, cultural values, and economic dependencies are deeply interwoven. It sustains hundreds of millions of people while supporting diverse ecosystems across the Himalayan, alluvial, and deltaic landscapes. The basin's high population density, intensive agriculture, and extensive livelihood dependence including fisheries, tourism, industry, and traditional crafts underscore its critical role in national development, contributing significantly to India's GDP and food security. At the same time, marked spatial heterogeneity exists across states in terms of demographic pressures, economic conditions, and resource dependence, shaping varied patterns of human–river interactions. Ecological integrity, cultural significance, and economic centrality are deeply interlinked in the river basin, yet increasingly threatened by multiple, interacting natural and anthropogenic drivers.

The analysis highlights that livelihood in the states along the mainstem Ganga i.e., Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal, are intricately tied to hydrological regimes, floodplain dynamics, and ecosystem services, yet are increasingly vulnerable to anthropogenic and climatic stressors. Rapid urbanisation, land-use change, and expansion of peri-urban interfaces are transforming floodplains and wetlands, disrupting hydrological processes, degrading water quality, and intensifying ecological risks. Concurrently, multiple pressures including flow regulation by dams and barrages, groundwater depletion, pollution from domestic and industrial sources, unsustainable sand mining, and overexploitation of fisheries are collectively altering riverine habitats and contributing to biodiversity decline, including impacts on flagship species such as the Gangetic dolphin (Figure 9.1).

The basin is further shaped by a combination of natural drivers including monsoon variability, cryospheric processes, sediment dynamics, and floodplain connectivity and human-induced drivers such as infrastructure development, agricultural intensification, and waste mismanagement. These interacting drivers create cumulative and often nonlinear impacts on river health, ecosystem services, and community well-being. Importantly, the evidence demonstrates that ecological degradation is closely linked to socio-economic systems, reinforcing the need for integrated and multi-scalar management approaches.

Within this context, stakeholder diversity and governance complexity emerge as defining features of the Ganga River. The identification of multiple stakeholder groups across states, with varying degrees of power, interest, and legitimacy, highlights the need for differentiated and context-specific engagement strategies. The extensive stakeholder mobilisation efforts, including consultations, capacity building, and participatory interventions, demonstrate that inclusive governance frameworks are essential for translating policy into on-ground outcomes. The scale of engagement with thousands of activities involving over one lakh participants, indicates both the magnitude of effort required and the potential of participatory approaches to strengthen conservation outcomes (Figure 9.1).

The study reinforces that long-term conservation of the Ganga cannot be achieved through regulatory or technological measures alone. Instead, it requires a structured, science-based, and community-centric approach that integrates ecological restoration with livelihood security. The adoption of a PESTEL-informed framework, combined with stakeholder assessment, institutional strengthening through the Ganga Prahari programme, livelihood interventions, and microplanning, provides a comprehensive pathway for aligning conservation objectives with socio-economic realities. By positioning local communities as co-managers and stewards rather than passive beneficiaries, the approach addresses

fundamental barriers to participation and ensures greater ownership and sustainability of conservation actions (Figure 9.1).

Results and responses also suggest an integrated environmental education and outreach framework that can effectively enhance awareness, build capacity, and promote participatory conservation of the Ganga River. Through a combination of school-based interventions, teacher training, interpretation centres, and large-scale outreach programmes, the initiative achieved measurable improvements in environmental knowledge and successfully engaged diverse stakeholder groups at scale. The use of experiential learning and culturally relevant communication tools further strengthened behavioural outcomes. Overall, the approach highlights the potential of combining localized and mass awareness strategies to translate scientific knowledge into sustained community engagement and collective action for river conservation

The findings underscore that the resilience of the Ganga River system depends on the convergence of ecological integrity, inclusive governance, and sustainable livelihoods. The long-term conservation of the Ganga River requires a paradigm shift from fragmented, sectoral interventions to integrated, participatory, and adaptive river basin management. The convergence of ecological science, community stewardship, institutional coordination, and sustainable livelihoods emerges as the central pathway for achieving both biodiversity conservation and human well-being in the Ganga basin (Figure 9.1).

Sustainable conservation of the Ganga at the grassroots level requires embedding biodiversity within livelihood systems, integrating conservation into formal village planning processes, and institutionalising community actors such as Ganga Praharis within governance structures. The evidence clearly indicates that when economic incentives, local knowledge, and institutional support converge, conservation transitions from an external intervention to a self-sustaining community-led process. On the basis of assessment following specific recommendations have been suggested:

1. Embed stakeholder engagement mechanisms within formal governance structures, ensuring sustained participation of local communities, Panchayati Raj Institutions, and civil society in planning and decision-making. Regularly assess outcomes of stakeholder engagement and conservation interventions to enable iterative improvements and context-specific strategies.
2. Expand coverage, enhance capacity-building, and formalize linkages with government schemes to sustain long-term community stewardship.
3. Prioritize participation of Scheduled Tribes, PVTGs, women, and economically weaker groups in conservation programmes to ensure equitable benefit sharing and improved outcomes.
4. Develop and scale livelihood options aligned with local ecological contexts (e.g., sustainable fisheries, eco-tourism, traditional crafts) to reduce pressure on river resources while ensuring economic security.
5. Promote multi-source livelihood models in Ganga villages combining agriculture, fisheries, livestock, and non-farm activities to reduce over-dependence on a single resource.
6. Encourage river-compatible livelihoods such as sustainable fisheries, floodplain agriculture, eco-tourism, and traditional crafts already identified in the basin.
7. Integrate low-input and climate-resilient agriculture (reduced chemical use, crop diversification) in river-adjacent villages to reduce runoff pollution.
8. Facilitate direct market access for products such as fish, horticulture produce, and handicrafts through convergence such as NRLM, PMKVY, and other line agencies, and initiatives e.g., Jalaj initiative.

9. Establish village-level producer groups or cooperatives to enhance bargaining power and income stability.
10. Form village-level producer groups or cooperatives to boost bargaining power and income security. Scale up microplanning approaches to integrate biodiversity conservation with local development planning across all Ganga districts.
11. Embed biodiversity conservation actions into village level development planning, including wetland restoration, plantation, waste management, and sustainable resource use. Ensure that river health indicators are treated as development indicators at village level.
12. Institutionalize participatory mapping of ecosystem services (fisheries, irrigation, grazing, wetlands) to guide planning decisions and prioritise conservation areas. Embed systematic assessment of ecosystem services (e.g., fisheries, irrigation, wetlands, grazing) into Gram Panchayat and district planning processes to ensure that development decisions explicitly account for ecological dependencies and trade-offs. This will strengthen link between community well-being with river ecosystem functions through structured data collection and analysis.
13. Recognize Ganga Praharis as advisory members or technical resource persons in Gram Panchayat committees, District Ganga Committees and district planning forums, particularly in environment, water, and sanitation planning to provide ground-level inputs. Ensure their participation in Gram Sabha meetings during planning and review stages through facilitation of structured communication channels between Ganga Praharis and district administration and other agencies.
14. Build capacity of Panchayats, SHGs, and community groups to co-manage natural resources with technical support from Ganga Praharis and government agencies.
15. Embed the developed environmental education model comprising experiential learning, teacher capacity building, and interpretation-based infrastructure, within formal education systems across the Ganga basin. This includes mainstreaming modules into school curricula, expanding teacher training through continuous professional development, and scaling low-cost interpretation platforms (e.g., Jalmala Samvaad) to ensure sustained and standardized delivery of conservation education.
16. Move beyond short-term knowledge assessments by developing longitudinal monitoring frameworks to evaluate behavioural change, community engagement, and conservation outcomes. This should include periodic follow-ups with students, teachers, and communities, integration of measurable indicators of pro-environmental behaviour, and use of data-driven approaches to refine programme design and policy integration.
17. Enhance the reach and effectiveness of conservation education by integrating community-led approaches, culturally relevant communication tools (e.g., street plays, local campaigns), and digital platforms. Strategic partnerships with government agencies, local institutions, and community groups should be reinforced to ensure co-ownership, while aligning conservation messaging with local livelihoods and socio-cultural contexts to drive sustained public participation.
18. Policy instruments with integration of biodiversity conservation with sustainable livelihood strategies (e.g., fisheries, agriculture, eco-tourism, traditional crafts) should be promoted that can reduce trade-offs between conservation and subsistence by embedding economic incentives and diversification pathways.

19. Policies should be able to recognize the role of cultural values, traditional knowledge, and social structures in shaping environmental behaviour. They should be context-sensitive and tailored to local socio-cultural settings to enhance acceptance and effectiveness.
20. Policies and schemes Recognize and manage trade-offs between development, livelihoods, and conservation by promoting integrated planning approaches that identify synergies across sectors.

Figure 9.1. Socio-ecological system of Ganga River and suggested strategies to strengthen the conservation efforts

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