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AI-Enabled Environmental Communication for River Rejuvenation: A Review of Technological Advances and Strategic Gaps in the Namami Gange Programme

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Abstract:

Environmental communication has been at the heart of large-scale river rejuvenation programmes, However, the role of artificial intelligence (AI) in empowering environmental communication is not well documented in the water governance literature. The study, in this review, critically synthesizes research around the field of Environmental Communication through AI and explores the extent to which these developments have been incorporated into India's flagship initiative to start the rejuvenation of the river Ganga – the Namami Gange Programme. After an informed narrative synthesis of literature on both academic databases and institutional grey literature from 2015 to 2026, the review presents the development of environmental communication theory, the mapping of the AI technologies that are transforming the public engagement with environmental issues (such as generative AI and natural language processing, computer vision, digital twins, remote sensing and citizen-science platforms), and an evaluation of their use in international river restoration contexts, including the Cheonggyecheon (Seoul), the Rhine, the Thames and the digitally twinned Yangtze. The review then puts the Namami Gange Programme in the global context and demonstrates that the programme has invested significantly in the physical infrastructure, effluent monitoring, and geospatial planning, but has not yet had an effective communication architecture, which is still largely one-way, campaign-oriented, and less AI-integrated. There are four dimensions of strategic gaps – technological adoption, institutional coordination, communication design, and policy-data governance. Based on these results, the review suggests an AI-Enabled River Communication Framework (AERCF) to connect AI-enabled monitoring to knowledge generation, strategic communication, citizen engagement, behavioral change, and policy feedback. The review concludes that river rejuvenation programmes in the Global South need not only the use of AI tools but their intentional incorporation in a communication architecture that can turn environmental data into public trust and participation and sustain behavioural change. Implications for researchers, communicators, and policy makers involved in river governance are discussed, and a future research agenda that is focused on generative AI, Digital Twins, and Responsible AI governance is presented.

Keywords: Artificial Intelligence; Environmental Communication; River Rejuvenation; Namami Gange; Water Governance; Digital Twins; Citizen Science; Behavioural Change

1. Introduction

Freshwater resources are facing unprecedented pressures in the world. Older, long-established rivers are now faced with industrial pollution, raw sewage, uncontrolled pumping, encroachment, and added stresses from climate change. In this context, river rejuvenation and restoration has become a governance challenge, as well as an ecological need, one that demands both engineering solutions, including sewage treatment facilities and e-flow management, and

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sustained public engagement that turns the words and actions of science and administration into behavioural and civic change. Environmental communication is therefore an essential yet under-theorized facet of river restoration governance—one that is deliberately used to inform environmental understanding and action. In the last ten years, AI has revolutionized the communications environment for river rejuvenation programmes. At the same time, machine learning and natural language processing, computer vision, and generative AI and digital twin technologies enable environmental communicators to shift from one-to-many to one-to-one and many-to-one strategies to more adaptive, data-driven, and participatory types of engagement. Generative AI is transforming how scientific, journalistic, non-governmental, and citizen audiences create and consume environmental information (Schäfer et al., 2026). Recent ScienceDirect scholarship on AI-driven participatory environmental management (2025) highlights parallel advancements of AI-driven participatory environmental management tools for adaptive strategies, disaster response, and community engagement in environmental governance more generally. The Namami Gange Programme of the Government of India, which was conceived as an integrated mission for the conservation of the river Ganga in 2014, is a particularly instructive example to illustrate this intersection. The programme includes sewage-treatment infrastructure, monitoring of sewage effluents on industrial premises, afforestation, development of riverfronts, and campaigns to raise awareness among the general public, which is being coordinated by the National Mission for Clean Ganga (NMCG) (National Mission for Clean Ganga, n.d.). It has been stimulating significant investment – around Rs. 15,000 crores were allocated initially. 20,000 crore (tenth one of ten 'World Restoration Flagship' initiatives by the United Nations Environment Programme in 2022, Namami Gange Programme, n.d.). The programme has also started to explore geospatial and AI-enabled solutions, such as high-resolution digital elevation modelling of the Ganga basin in partnership with the Survey of India and the National Remote Sensing Centre (Geospatial World, 2018), and, more recently, using AI in youth engagement and behavioural outreach through River Youth Clubs (Indian Community Editorial Team, 2025).

However, the degree of these tech innovations' incorporation into a unified, AI-driven communication strategy (rather than in a narrow application for infrastructure planning and monitoring) has remained under-studied in the academic field. That's what this review is for. It questions the nature of environmental communication in global river restoration initiatives (RQ1), the current role of AI in environmental communication (RQ2), how AI has been applied in the Namami Gange Programme (RQ3), the existing gaps in technology, institutions, communication and policy in the context of river rejuvenation initiatives (RQ4), and the possibility of an integrated framework for enhanced AI-enabled river rejuvenation communication (RQ5). As these questions are addressed, the review provides a synthesis, not just a summary, that goes beyond descriptively summarizing conflicting evidence and existing literature to also offer a new conceptual framework, the AI-Enabled River Communication Framework (AERCF), that will inform future research and practice.

2. Review Methodology

This review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. In the Identification stage, searches were carried out in Scopus, Web of Science, ScienceDirect, SpringerLink, IEEE Xplore, Taylor & Francis Online, and Wiley Online Library, and complemented by searches on Google Scholar search engine and institutional grey literature (government reports, NMCG publications, and documentation from UN agencies) to provide the detail of the programmes which was not available in the peer-reviewed literature. Artificial Intelligence, Environmental communication, River rejuvenation, Namami Gange, Water governance, Machine learning, Digital twin, Citizen science, Remote sensing, IoT, Smart rivers, Behavioural change, were combined to form the search strings, which were limited to publications from 2015 to 2026, except for seminal papers from earlier years that were essential to the theory of environmental communication.

The screening was performed on the records, excluding any duplicates, non-English sources not translated, and sources without clear institutional or scholarly affiliation. The eligibility was also tightened to include the inclusion of sources that provided substantive discussion on AI technologies, environmental communication, or case evidence from river restoration programmes, not just a passing mention. The literature on the impact of AI on communication practice in the context of Namami Gange is limited, and the review draws on authoritative institutional documents from NMCG, the Prime Minister's Office of India, the Central Pollution Control Board, and the Press Information Bureau, which are considered primary programme evidence, rather than peer-reviewed literature.

Quality assessment focused on three elements: recency, methodological transparency, and source authority, with preference given to peer-reviewed journal articles and systematic reviews, as well as conference proceedings and institutional or governmental reports for factual programme description. Data was extracted into five main categories, which were then subject to a thematic synthesis outlined in Sections 3–9: AI technology type, communication function, governance level, geographic context, and reported outcome or limitation. This synthesis is thematic, to provide comparisons across the global and Indian evidence base, as well as to reflect the critical analysis requirements of the review; it is not a study-by-study inventory.

3. Environmental Communication in River Rejuvenation

The study of environmental communication is not only a more journalistic and campaign-based discipline, but also a field of communication that has become a theorized approach that combines aspects of risk communication, science communication, behavioural change theory, and participatory governance. The application to river rejuvenation highlights a larger shift in environmental governance – the restoration of rivers is no longer simply an engineering task to be solved by infrastructure, but a socio-ecological system which requires ongoing and continued public cooperation, civic monitoring, and political will. Early river-restoration communication had a more top-down approach with public-awareness campaigns (billboards, television, etc) aimed at educating rather than engaging. This model would be described as a linear "deficit" model that assumes that more information equals more behaviour change. This assumption has been challenged in later theory, with a focus on dialogic, participatory, and risk-communication approaches in which citizens are not merely receivers of expert messages but also co-creators of environmental knowledge. This evolution echoes that of climate change communication more generally, by focusing more on citizen involvement, framing effects, and the importance of trust between scientific institutions and citizens (Schäfer et al., 2026). In this participatory shift in river governance, systematic reviews of river-monitoring citizen-science projects show that water-quality parameters have increasingly been measured in the field using smartphone applications, sensors, and GIS-based participatory platforms, with examples that include Danube river monitoring by volunteers using smartphones to document water quality, that can facilitate rapid dissemination of knowledge in real time between regions (as summarized in the 2025 systematic review published in Frontiers in Environmental Science). This evolution has also practical implications for river rejuvenation programmes: communication is no longer seen as a post-engineering and post-monitoring task, but rather is also viewed as a process that influences both the data collected and its interpretation, as well as the ability of communities to trust and act on the data. River programmes are required to coordinate a number of different kinds of communicative genres: environmental journalism, risk communication in the context of flood and pollution events, as well as behaviour-change campaigns around industrial and household polluters. However, as this review shows, the theoretical development of environmental communication research has outstripped its application to make communication tools accessible to AI in most river rejuvenation schemes, such as the Namami Gange.

4. Artificial Intelligence in Environmental Communication

From generating and personalizing content, analyzing sentiment and discourse, to forecasting outcomes for campaign design, computer vision monitoring and visualization, and conversational interfaces for citizen engagement, AI is transforming environmental communication across multiple interacting effects. Perhaps the most disruptive recent development is generative AI and large language models (LLMs). The comprehensive 2026 review of AI and climate change communication notes a shift in the distribution of generative AI as it now permeates the work of scientists, NGOs, corporations, journalists, influencers and citizens, influencing the production and reception of environmental information, yet also giving rise to concerns about misinformation, bias and the challenge of verifying AI-generated content for non-expert audiences (Schäfer et al., 2026). The same review points out the modest and conditional level of trust in generative AI as an information source, and the possibility of AI systems perpetuating the exclusion of the voices of the Global South and of marginalized groups from environmental discussion, which has particular relevance for programmes like Namami Gange, which are implemented among linguistically and economically diverse populations.

A second major application is predictive analytics, which can help environmental campaigners understand audience behaviour, predict engagement patterns, and better allocate resources and target messaging. AI integration is linked to the effectiveness of campaigns and engagement of stakeholders, and offers real-time monitoring, which facilitates adaptive communication in relation to the new environmental challenges (Journal of Jurivox, 2024). However, complementary case evidence provided by environmental advocacy organizations indicates that the use of generative AI tools is being integrated into campaign efforts to increase their productivity and impact, while also posing emerging questions regarding authenticity and the loss of grassroots voice in environmental campaigns (Artificial Intelligence and New Voices in Environmental Campaigning, 2025).

In addition to content and campaign applications, computer vision, remote sensing, and Internet-of-Things (IoT) sensor networks are increasingly supporting environmental monitoring in support of communication and decisionsupport systems. The digital twin river basin is a case in point of this convergence: a digital twin river basin integrates continually updated real-time data, machine learning forecasting and simulation capabilities, and immersive visualization to facilitate hydrological forecasting, flood and drought forecasting, and most importantly, multi-stakeholder, transparent engagement on water management decision-making (IWMI, 2025). For example, in the Limpopo River Basin, a digital twin platform has been implemented to deliver near-real-time monitoring of more than 1,400 waterbodies and 96 dams, machine-learning-based reservoir forecasts, and an Environmental Framework Assessment tool, which can be used by stakeholders who do not possess technical skills to test water management scenarios (CGIAR, 2024). The Digital Twin Yangtze programme in China is also designed as a basin-scale application of digital twins for dam security, water quality, and flood control measures, but again, critical scholarship warns that these efforts of digitalization also reflect specific governance politics, and that the digitalization might be more about centralized state control than about participatory communication (Xu et al., 2025). Analysis of public perception of climate and environmental issues on a scale, however, is now possible thanks to natural-language-processing tools applied to public discourse, providing empirical knowledge to environmental communicators about how issues are being framed by audiences and their sentiments (Sinergi International Journal of Communication Sciences, 2025).

Table 1. AI Technologies and Their Communication Functions in River Rejuvenation

AI Technology	**Primary Function**	**Communication Relevance**	**Illustrative Source**
Generative AI / Large Language Models	Automated content generation, translation, and dialogue	Personalized, scalable public messaging; conversational engagement	Schäfer et al. (2026)
Natural Language Processing	Sentiment and discourse analysis	Understanding public perception and framing of river issues	Sinergi Int'l J. of Communication Sciences (2025)
Predictive Analytics / Machine Learning	Audience and outcome forecasting	Targeted, adaptive campaign design	Journal of Jurivox (2024)
Computer Vision	Image-based pollution/debris detection	Visual evidence for public reporting and awareness	Water Care (Sinha et al., 2021)
Remote Sensing / GIS	Basin-scale terrain and land-use mapping	Evidence base for planning	Geospatial World (2018)

		communication and public dashboards	
IoT Sensor Networks	Real-time effluent and flow monitoring	Continuous data feed for public-facing alerts	National Mission for Clean Ganga (n.d.)
Digital Twins	Basin-scale simulation and forecasting	Multi-stakeholder visualization and scenario communication	IWMI (2025); CGIAR (2024)
Citizen-Science Mobile Apps	Crowd-sourced water-quality data collection	Two-way participatory engagement and trust-building	Citizen Science: Theory and Practice (2025)

5. AI Applications in Global River Restoration

There are instructive, although not consistently well-documented, precedents in international river restoration programmes for using AI to communicate. One of the most often referenced cases of urban river restoration worldwide, the Cheonggyecheon stream restoration project in Seoul was completed in 2005 when an elevated high way was removed from the site, Although the project predates widespread AI use, it established strong citizen governance mechanisms, that a dedicated Restoration Centre and a Citizens' Committee were set up to collect and report back on public opinion and to provide structured information sessions on the goals of the restoration project (Green, SWITCH Case Study Brief). The project continues to serve as a global case study for the integration of physical restoration with structured citizen communication, and it has influenced restoration processes today using digital technologies in other parts of the world (Webuild Value, 2025).

Newer programs have more recent levels of AI integration. As mentioned in the introduction, digital twin basin approaches like the Digital Twin Yangtze project that unify monitoring, forecasting, and governance functions demonstrate how the digital twin approach can be top-down but also illustrate a recurring theme in the literature between technological sophistication and participatory communication (Xu et al., 2025). The application of water-quality prediction models in European and Asian rivers also reveals a trend toward the growing adoption of machine-learning approaches for predicting water-quality indices from sensor data, such as recurrent neural networks and support vector machines (as found in studies of the Qiantang River in China and more broadly in comparative studies of water-quality-index modelling (Winter Simulation Conference proceedings on river digital twins, cited via Leong et al., 2021; Li et al., 2019)). A three-dimensional digital-twin platform is developed for urban rivers in Nanyang City, China, involving the use of long short-term memory (LSTM) prediction models, spatial interpolation, and pollutantdiffusion simulation to provide a visualized and public-interpreted assessment of the urban water quality — an explicit attempt to connect the technical prediction with public interpretation by visualization (MDPI Water, 2024).

There is a third strand of global citizen-science practice: the communication-focused platforms. On the Canadian platform Water Rangers, citizen scientists can use a mobile app to collect temperature, pH, and turbidity data, and link users to local experts and organizations, making it clear that the data collection process is not just a technical task, but also a community engagement and awareness-building effort (Krakensense, 2025). The CrowdWater application, which has been tested in river communities in Latin America, is another illustrative example of usability challenges and opportunities for the practice of participatory digital monitoring: workshop assessments revealed that the categories and questions were not being used meaningfully by community members, and that the categories and questions were not designed with community members, so they might not reflect locally relevant concerns (Citizen Science: Theory and Practice 2025). Assessments of ‘smartphone-based water-quality applications in southern Africa' also warn that the technical promise of these tools does not translate to their usefulness in the field, and that several that were cited as successes were not viable in the typical citizen-monitoring context and/or forfeited technical support over time (CGIAR, Pattinson et al., 2024) — a warning directly applicable to any smartphone-based citizen engagement tool that is proposed for Namami Gange. Altogether, these experiences show that effective AI-driven river communication is not just about the technical monitoring component but requires a conscious investment in governance, usability, and community co-design, aspects that were not adequately captured in the evidence gathered in the Namami Gange cases (Section 5).

6. The Namami Gange Programme: Digital and AI-Enabled Communication

Namami Gange was initiated in 2014 as a comprehensive initiative to conserve the Ganga, involving projects at a basic level, medium, and long term, covering all aspects of sewage-treatment projects, industrial effluent control, riverfront development, conservation of biodiversity, and public awareness raising (Prime Minister's Office). The programme is coordinated at the institutional level by the National Mission for Clean Ganga, Ministry of Jal Shakti, and their implementation is supported by the Central Pollution Control Board, Central Water Commission, state governments, and a consortium of seven Indian institutes of technology for preparing the Ganga River Basin Plan (National Mission for Clean Ganga, n.d.). It has so far achieved a cumulative sewage-treatment capacity of 3,977 million litres per day, drawn up minimum environmental-flow norms, and established seven biodiversity parks and several priority wetlands for conservation of biodiversity (Press Information Bureau, 2026).

In terms of monitoring and data, the programme has progressed a long way towards digital and AI-connected infrastructure. Most of the industrial units responsible for gross pollution have been linked to CPB servers through the Continuous Effluent Monitoring Stations (CEMS) that allow for real-time monitoring of effluents (National Mission for Clean Ganga, n.d.). Manual water quality testing by the CPB takes place at 112 points in the five major-stem Ganga states, and biomonitoring at 50 sites throughout the Ganga and its rivers (Press Information Bureau, 2026). The NMCG has also been collaborating with Indian Space Research Organization's (ISRO) Survey of India and a high-resolution digital elevation model (DEM) of the Ganga basin has been developed by the Survey of India under the project, which has been specifically cited as a remedy for the "biggest challenge in the water sector", namely the absence of reliable data for monitoring, planning and feedback on Ganga River health and management (Geospatial World, 2018). More recent progress has been in relation to AI-specific tools, such as Namami Gange's River Youth Clubs to promote behavioural change on water use and increase outreach to younger audiences by the Indian Institute of Public Administration (Indian Community Editorial Team, 2025).

This is supported by the results of the adjacent research, which showed the technical feasibility of further integration of AI. Prototype autonomous systems (such as the unmanned surface vessel, Ro-Boat designed to detect, collect and remove floating debris and chemical sewage, Water Care: Water Surface Cleaning Bot and Water Body Surveillance System, 2021) demonstrate the potential for robotics and computer vision to contribute to the programme's monitoring and cleaning mission in principle, but as of this writing, they do not represent an installed programme infrastructure, nor are they integrated with public communication. A similar takeaway from the experience of continuous monitoring of the Namami Gange is the recommendation for smart, data-driven river management with the implementation of real-time monitoring systems, AI tools, and sensor networks that are applicable to tributary rivers within the wider Ganga basin (Scientific Reports, 2025).

Despite these developments, the evidence shows that AI is still limited to monitoring, planning, and infrastructure aspects of Namami Gange, and not in the communication architecture itself. While the cases described in Section 4 may be achieving greater personalization, predictive audience targeting, conversational interfaces, and participatory visualization of digital-twin environments, public-facing engagement continues to be mostly based on traditional outreach (awareness-building activities, riverfront events, sanitation initiatives, and, more recently, youth club activities). This asymmetry, where environmental monitoring has been digitalized to a much greater degree than environmental communication, is the main empirical finding that drives the strategic-gap analysis that follows.

7. Strategic Gaps

Four interconnected strategic gaps were identified in AI-enabled rejuvenation communication, particularly in the context of Namami Gange. In total, four interrelated strategic gaps are identified from technological capability to implementation in AI-enabled river rejuvenation communication, specifically Namami Gange.

Firstly, despite the presence of AI tools, there are still gaps in both technology and data governance. Digital-twin scholarship highlights that data quality, modelling resources, and — crucially — data-governance protocols are significant challenges for comprehensive basin-scale digitalization, with the need to aggregate high-quality, well-controlled data remaining as a prerequisite that many basins, including those in developing-country contexts, are lacking (Nature npj Natural Hazards, 2024). The unevenness is clearly reflected in the monitoring structure of Namami Gange, as effluent monitoring is significantly digitized with connected sensor stations, but the core monitoring of water quality at stations (112) is still done manually (Press Information Bureau, 2026), limiting the real-time data collection that AI communication tools demand. Secondly, there are institutional and coordination issues that diminish the translation of monitoring data to communication practice. The Namami Gange is a multi-agency initiative comprising NMCG, Central Pollution Control Board, Central Water Commission, State Governments, and Academic consortia that has developed the technical capacities of the initiative but also added to the number of institutional communications that are required between all of these functions as environmental data becomes available for the public. Digital-twin scholarship on the Yangtze also warns that digitalization by the government may be more about administrative forecasting and control than about actual dialogic public engagement (Xu et al., 2025), a warning that has strong implications for large-scale centrally managed missions, like Namami Gange.

Third, communication-design gaps are apparent when we continue to communicate in a one-way, campaign fashion, instead of communicating in a two-way, participatory, conversational fashion, tailored to everyone's needs through the power of AI. This is not an isolated case, however, as this is also highlighted as a key area of concern in climate communication scholarship, where trust in AI-produced environmental information is conditional, unevenly distributed, and where AI systems are likely to continue to marginalize already underrepresented communities unless designed for equity (Schäfer et al., 2026). The concern is echoed at the implementation level with evaluations of citizen-science and participatory water-monitoring tools that indicate that this can lead to lack of true two-way engagement even if the technology works well, provided it is not co-designed with the local community or involves digital literacy and infrastructure that is unevenly distributed in a population (Citizen Science: Theory and Practice, 2025; CGIAR, Pattinson et al., 2024).

Fourth, gaps in ethics, trust, and transparency span the three prior gaps. Citizen-generated environmental data can reveal information on polluters or the citizens reporting the polluters, potentially triggering governance issues regarding the protection of these data that participatory water-monitoring literature identifies as unresolved even in well-resourced environments (Citizen Science: Theory and Practice, 2025). The literature on river-governance is less specific than the more general literature on AI and the environment regarding the role of explainability and algorithmic transparency, which has been explicitly stated as a necessary condition for trust in AI-based environmental systems in the literature elsewhere (EurekAlert, 2026). Capacity building and interdisciplinary collaboration between hydrology, data science, and communication skills under one umbrella are the missing links that could connect the programme's extensive monitoring effort with its more traditional communication approach, according to Namami Gange.

8. Comparative Analysis

Based on the seven dimensions mentioned above, each of the comparisons between Namami Gange and the international cases studied in Section 4 was synthesized in Table 2. The comparison shows that overall, Namami Gange is broadly similar to or better than some international peers in terms of physical monitoring infrastructure and geospatial data investment but is behind in terms of participatory digital-twin visualization, AI-personalized public communication, and codified data-governance protocols for citizen-generated data. While the Cheonggyecheon case predates the era of contemporary AI tools, it still benefits from a superior system of structured citizen-committee governance – one way to improve environmental communication architecture without the help of AI, but one that AI can complement.

Table 2. Comparative Analysis of River Rejuvenation Programmes

Dimension	**Namami Gange (India)**	**Digital Twin Yangtze (China)**	**Cheonggyecheon (South Korea)**	**Limpopo Basin Digital Twin (Southern Africa)**
Communication strategy	Campaign-based, youth outreach, largely unidirectional	Administrative forecasting-oriented	Structured citizen-committee dialogue	Stakeholder scenario-testing tools
AI technology	Remote sensing, DEM, and emerging AI pilots	Basin-scale digital twin, four-prediction system	Pre-AI era: physical/social planning	ML-based reservoir forecasting, irrigation mapping
Citizen engagement	Public awareness campaigns, River Youth Clubs	Limited public-facing engagement	Dedicated Citizens' Committee	Community-tested EFA tool
Governance model	Multi-agency central mission (NMCG-led)	Centralized state digitalization	Mayoral initiative with the citizen body	Multi-country, donor-supported consortium

Monitoring infrastructure	OCEMS (885/1072 sites), 112 manual WQ stations	Integrated dam, flood, and water-quality sensing	N/A (pre-digital)	Daily monitoring of 1,424 waterbodies, 96 dams
Policy integration	SDG-aligned national mission	National Water Resources strategy	Municipal urban-regeneration policy	Transboundary basin cooperation
Digital innovation gap	Monitoring digitized faster than communication	Participation is subordinate to control functions	Strong governance, low tech intensity	Strong tech-community bridge via EFA tool

9. Proposed Framework: The AI-Enabled River Communication Framework (AERCF)

Building upon the previous synthesis, this review proposes an AI-Enabled River Communication Framework (AERCF) that is composed of seven interlinked components organized as a feedback loop: AI Technologies, Environmental Monitoring, Knowledge Generation, Strategic Communication, Citizen Participation, Behaviour Change, and Policy Feedback, which in turn returns to River Rejuvenation outcomes and recursively to a more improved deployment of AI technology.

AI Technologies are the basic set of technologies, which include machine learning, computer vision, remote sensing, IoT sensor networks, and generative AI, as per the technology inventory outlined in Section 3. Environmental Monitoring converts these technologies into a stream of data—water quality, load of effluent, flow, and biodiversity, etc.—which has been significantly digitized by Namami Gange so far through environmental monitoring systems and partnering with remote sensing technologies (National Mission for Clean Ganga, n.d.; Geospatial World, 2018). The transition of monitoring to Knowledge Generation is the key transition in the context of Namami Gange, and this is underdeveloped, to use AI tools such as natural-language processing and predictive analytics, to arrive at learning from raw environmental data, forecasts, and risk evaluations in terms of accessible, interpretable information that can be presented to non-specialist audiences, as performed in digital-twin water-quality visualization platforms elsewhere (MDPI Water, 2024).

Strategic Communication brings this knowledge to the operational level through the use of AI-personalized messages, conversation interfaces, and visualization tools that are adapted to different audience groups, such as industrial polluters, riparian communities, youth, and policy makers, based on evidence gathered with predictive analytics that allows for improving the engagement results (Journal of Jurivox, 2024). Citizen Participation routes this communication into a two-way relationship, using co-designed citizen-science applications, yet without losing sight of the fact that participatory tools need to be developed with the community, not just for it; and that, as in similar programmes (Citizen Science: Theory and Practice, 2025; CGIAR, Pattinson et al., 2024), there is potential for usability and relevance failures. Behaviour Change is the anticipated downstream outcome of the implementation of this model—slower household and industrial pollution, continued civic monitoring, and changed norms in the use of water—and Policy Feedback provides a way to circle back—evidence gathered by the citizens, and through the use of AI, is returned to NMCG governance, effluent regulation, and infrastructure prioritization process.

The framework's most important theoretical contribution is to make communication not a 'product' of the campaign at the end of the day, but something 'supplied' in the middle, via the application of AI, that needs to be engineered just as much as its physical counterpart. It is useful in providing a framework for auditing in which AI investments are being made (such as investments in monitoring) versus in which investments in evidence-based indicate they are most effective (such as investments in knowledge generation and participatory communication) to Namami Gange, and other similar Global South River programmes, which is currently the case of disproportionate investment in monitoring.

10. Future Research Agenda

Based on the above considerations, the following research priorities become apparent in the context of river-rejuvenation communication and AI. First, empirical research is required on generative AI and LLM specifically applied to multilingual, low-literacy river-basin communication contexts, against the backdrop of current climate-communication research which focuses on contexts in the Global North and in English-language settings, to determine the extent to which the effects of persuasive and trust building that have been observed in other contexts can be replicated in programmes such as Namami Gange which operate across multiple regional languages and literacy levels.

Second, comparative research is required to determine if basin-scale digital-twin platforms can be designed for actual, multi-stakeholder communication, as opposed to centrally administered forecasts, in anticipation of the governance critique that can be put forward about the Digital Twin Yangtze (Xu et al., 2025) and tested with the Limpopo digital-twin model's stakeholder accessible scenario tools (CGIAR, 2024).

Third, multimodal AI, by integrating satellite imagery, sensor data, and natural-language generation, should be explored to generate locally relevant, real-time risk and water-quality communication, a concept already tapped to produce multimodal, natural-language output for visualization on urban river water-quality platforms (MDPI Water, 2024). Fourth, studies on autonomous AI agents that interact with citizens, like those designed for reporting pollution or answering questions, are largely missing from river governance research, and are somewhat lacking compared to other related research areas, such as science communication, where the use of conversational AI has already begun to be tracked empirically (Schäfer et al., 2026).

Lastly, continued focus is needed on good and sustainable governance of AI: responsible data practices, algorithm transparency, and reproducibility are all cited as key prerequisites to gaining public trust in environmental systems powered by AI but are largely absent from the reviewed literature on the rejuvenation of rivers. Alongside this, there is a long-term research need for the development of river-basin-specific standardizations for data protection, community co-design, and algorithmic explainability, as well as for the longitudinal assessment of the actual behavioural change that results from an AI-based communication intervention, beyond the mere engagement metrics.

11. Conclusion

This review has critically analyzed the relationship between AI and environmental communication in river rejuvenation governance with the Namami Gange Programme as a detailed case study of a comparative landscape. The evidence shows that the use of AI in river restoration has progressed significantly more quickly in monitoring, forecasting, and infrastructure planning than it has in communicating and engaging citizens, where the expectations for everyday public trust and behaviour change have a greater influence on the success of the restoration. Namami Gange is a good example of this, as significant resources are invested in effluent monitoring, remote sensing, and digital elevation modelling, alongside a rather traditional and campaign Communications approach.

Theoretically, the review introduces the AI-Enabled River Communication Framework (AERCF) that reimagines communication as a cyclical process, moving away from its final role of environmental governance output and towards becoming an AI-mediated process that enables monitoring, knowledge generation, participation, behaviour change, and policy feedback. From a practical point of view, the framework provides programme administrators with a way to assess and understand where they are investing in AI and where they should be based on the international evidence base. Policy recommendations based on the findings include SDG-aligned recommendations that focus on data-governance protocols for citizen-generated environmental data, co-design of participatory digital tools with river-basin communities, and capacity building that incorporates interdisciplinary efforts and combines hydrology, data science, and communication expertise within the institutional framework of NMCG.

The review is limited by a lack of peer-reviewed, empirically tested studies specifically on AI-enabled communication (rather than AI-enabled monitoring) in Namami Gange, which means that to draw programme-level descriptions, reliance on institutional and grey literature was needed, which also forms part of the findings of the review, indicating a research gap. Empirical applications of the AERCF framework, especially with longitudinal and multilingual studies of citizen engagement outcomes, would significantly bolster the evidence base for citizen communication about river rejuvenation with AI in India and similar contexts in the Global South.

Disclosure Statement

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