

Knowledge Governance for Water Pollution Prevention: From Routine Regulation to Crisis Response in Jamaica

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Abstract

Jamaica's environmental governance system, anchored in the Natural Resources Conservation Authority (NRCA) Act, establishes regulatory mechanisms to oversee development and protect water resources. Through its Permit and Licence System, developments are categorised according to environmental risk to ensure compliance and protection. Nevertheless, Jamaica has experienced an increase in water pollution incidents in recent years, posing significant risks for water resources. Given that water constitutes a critical resource for the island, persistent contamination risks point to gaps that extend beyond regulatory design into the realm of knowledge governance, the processes through which information is generated, shared, interpreted, and applied across institutions.

This study examines the knowledge governance mechanisms embedded within Jamaica's environmental regulatory system and evaluates their effectiveness under routine, crisis, and disaster conditions.

Using a mixed-methods approach, the research maps formal and informal governance structures. It assesses knowledge flows during standard monitoring and enforcement processes. The research also analyses knowledge generation, coordination, and application during water pollution-related crisis events. Hurricane Melissa is used as a stress test of institutional resilience.

The study identifies barriers and enablers affecting knowledge retention, inter-agency coordination, and adaptive learning, to develop an evidence-based Knowledge Governance Framework for water pollution prevention with applicability to Jamaica and transferability to other Small Island Developing States (SIDS).

Keywords: Knowledge governance, water pollution prevention, water protection, environmental regulation, crisis response, Small Island Developing States (SIDS), Jamaica.

INTRODUCTION

Water is among Jamaica's most vital natural resources, underpinning public health, economic activity, and ecosystem stability. However, persistent incidents of water pollution threaten the quality of the island's freshwater sources (NEPA, 2024) and underscore ongoing weaknesses in the country's environmental governance system. Although Jamaica's framework, anchored in the Natural Resources Conservation Authority (NRCA) Act (1991), has established robust regulatory instruments, such as the Permit and Licence System, environmental degradation continues to pose serious sustainability challenges. These issues suggest that institutional shortcomings extend beyond policy design and enforcement into the domain of knowledge governance, the generation, sharing, interpretation, and application of environmental information across agencies and stakeholders.

This study explores Jamaica's knowledge governance mechanisms in environmental regulation, focusing particularly on how they support or hinder water pollution prevention under both routine operations and crisis situations. Using Hurricane Melissa (2025) as a Case Study, the research examines institutional coordination, adaptive learning, and resilience under environmental stress.

The significance of this research lies in its potential to develop an evidence-based Knowledge Governance Framework for water pollution prevention, applicable to Jamaica and transferable to other *Small Island Developing States (SIDS)*, by integrating governance theory, knowledge management and environmental regulation.

THEORETICAL FRAMEWORK

This study draws on knowledge governance theory, which examines the institutional processes regulating how knowledge is produced, disseminated, and applied within organisations and policy systems. Situated at the intersection of governance theory, knowledge management, and environmental regulation, this framework is particularly useful for understanding how Jamaican institutions manage knowledge related to water pollution, prevention, and resource sustainability. The Knowledge Governance Approach (KGA) posits that organisational structures and formal rules shape how knowledge is created, shared, and mobilised for decision-making (Foss, 2007; Schiuma, 2011). In Jamaica, agencies such as the National Environment and Planning Agency (NEPA) and Water Resources Authority (WRA) operate within institutional frameworks (MEGJC, 2021) that govern water quality monitoring, pollution control, and Integrated Water Resources Management (IWRM) (Government of Jamaica, 2023). Effective knowledge governance ensures that scientific data, monitoring outputs, and local ecological knowledge are integrated into decision-making processes, supporting evidence-based management and improved watershed outcomes (Global Water Partnership-Caribbean [GWP-C], 2023; Lewis, Paliszkievicz, & Roopnarine, 2024).

Complementing this, adaptive governance theory emphasises flexibility, collaboration, and iterative learning in responding to complex environmental challenges (Chaffin, Gosnell, & Cosens, 2014). In Small Island Developing States (SIDS) such as Jamaica, this is critical to address uncertainty arising

from climate change, freshwater scarcity, and watershed degradation. Jamaica's approach to adaptive governance is reflected in its Watershed Area Management Mechanism (WAMM) and IWRM framework, which foster cross-sectoral collaboration and stakeholder engagement for integrative, science-based water management (Government of Jamaica, 2023). Adaptive governance also aligns with efforts across the Caribbean to enhance institutional learning and responsiveness to environmental stress through regional cooperation (Thomas et al., 2024).

The third theoretical strand, resilience and disaster governance, derives from Holling's (1973) and Folke et al. (2005) conceptualisation of resilience as a system's ability to absorb disturbances and reorganise while maintaining essential functions. For Jamaica's water governance institutions, resilience implies the capacity to sustain knowledge continuity, uphold water quality monitoring, and preserve institutional learning amid recurrent crises such as hurricanes, floods, and droughts (GWP-C, 2023; Lewis et al., 2024). Effective resilience governance ensures adaptive responses through data-driven decision-making and learning from environmental shocks, thereby reinforcing sustainability and preparedness.

Water Pollution in Jamaica

In response to the need for more dependable coastal water quality data, the National Environment and Planning Agency (NEPA) launched the Coastal Water Quality Monitoring Programme (CWQMP) in March 2008. The initiative aimed to create a consistent and scientifically sound system for monitoring Jamaica's coastal environments.

Over the past 18 years, the programme's scope has grown, evolving into the Ambient Water Quality Monitoring Programme (AWQMP). The AWQMP now includes the routine monitoring of both coastal and inland surface waters, enabling NEPA to track long-term water pollution trends and assess environmental conditions across the island through annual reports.

The programme serves as a cornerstone of NEPA's environmental protection mandate. Through systematic sampling and laboratory analysis, it generates detailed data on the physical, chemical, and microbiological characteristics of Jamaica's water bodies within designated Watershed Management Units (WMUs). These data underpin NEPA's regulatory functions, including environmental permitting, licensing, and compliance monitoring, and guide the formulation of policies and programmes to safeguard water resources and guide the formulation of policies and programmes to safeguard water resources (NEPA, 2025). Complementing the monitoring efforts is NEPA's Pollution Incident Response Protocol (2018), which mandates investigation and assessment of pollution events and the application of sanctions when necessary. According to the 2024 Pollution Incident Report, Jamaica recorded 57 pollution incidents, a 21% increase over 2023.

Complementing NEPA's work, the Planning Institute of Jamaica (PIOJ) in its *Economic and Social Survey Jamaica* (2023), emphasises that water pollution remains a key developmental challenge with implications for public health, fisheries, and tourism. The PIOJ identifies nutrient enrichment from agriculture, untreated sewage, industrial waste, and solid waste mismanagement as principal sources of contamination in rivers and coastal ecosystems. Additionally, it notes that climate variability—manifesting through increased flooding and drought—exacerbates pollutant mobilisation, thereby increasing the vulnerability of water resources.

The Office of Disaster Preparedness and Emergency Management (ODPEM) also underscores the interconnection between environmental degradation and disaster risk. ODPEM's *National Disaster Risk Management Framework* (2022) recognises that water pollution can intensify hazard exposure and recovery burdens, particularly following extreme weather events that overwhelm wastewater and drainage systems. The agency advocates for the integration of disaster-resilient planning into watershed and coastal management to mitigate pollutant runoff and protect critical water infrastructure. By integrating the Knowledge Governance Approach, Adaptive Governance, and Resilience and Disaster Governance, this study establishes a robust theoretical basis for analysing how Jamaica's institutions manage environmental knowledge under variable and uncertain conditions. Collectively, these frameworks highlight that effective knowledge governance promotes informed decision-making for water pollution prevention and water quality management; adaptive governance enables collaborative and flexible approaches to watershed management and IWRM; and resilience governance strengthens institutional learning and continuity during crises. Together, they provide a holistic lens for evaluating the Caribbean's capacity, particularly in Jamaica, to achieve sustainable and resilient water governance through informed, networked, and adaptive institutional practices.

RESEARCH GOALS AND RESEARCH QUESTIONS

The overall goal is to assess efficacy of Jamaica's current knowledge governance system in relation to water pollution prevention and crisis response. Specifically, the study aims to:

1. Map the formal and informal knowledge governance structures within Jamaica's environmental regulatory system.
2. Examine knowledge flows during routine monitoring, enforcement, and crisis response activities.
3. Identify barriers and enablers affecting inter-agency coordination, information sharing, and learning.
4. Develop a Knowledge Governance Framework that integrates resilience principles to enhance water pollution prevention and regulatory performance.

Research Questions

1. What are the key formal and informal knowledge governance mechanisms embedded within Jamaica's environmental regulation system?
2. How do these mechanisms function under routine, crisis, and disaster conditions?
3. How do water quality parameters change between routine monitoring conditions and disaster events, and what spatial and environmental factors are associated with pollution levels?
4. What barriers limit effective knowledge sharing, retention, and application across institutions?
5. What institutional, technological, and procedural changes do stakeholders identify as necessary to strengthen knowledge governance for water pollution prevention?

Research propositions

It is expected that stronger knowledge governance arrangements will be associated with more effective inter-agency coordination, institutional learning, and resilience in both routine and crisis conditions.

METHODOLOGY

A mixed-methods approach is used in the research design, integrating qualitative and quantitative methods to capture the complexity of environmental knowledge processes. These have been adopted to ensure both depth and breadth in analysing Jamaica's environmental knowledge governance landscape.

Data Collection

- **Literature Review and Document Analysis:** A review of key policy instruments, including the NRCA Act, the Permit and Licence System guidelines, and environmental monitoring reports, will be conducted.
- **Semi-Structured Interviews:** Conducted with representatives from the National Environment and Planning Agency (NEPA), the Water Resources Authority (WRA), local Municipal Corporations, and selected community organisations.
- **Case Study Analysis:** The 2025 Hurricane Melissa event serves as a crisis case to evaluate knowledge flows, coordination effectiveness, and learning outcomes under environmental stress mainly through administration of surveys and the analysis of water quality data .
- **Surveys:** Distributed among environmental officers and local stakeholders such as non-government organizations, churches and community association to assess perceptions of knowledge accessibility and inter-agency cooperation.
- **Collection to include sampling, analysis and incorporation of relevant water quality data for both ambient marine and freshwater based on established protocol at the NEPA (NEPA, 2025) from other sources.**

Data Analysis

- **Qualitative Analysis:** Thematic coding of interviews and policy documents to identify key patterns, gaps, and best practices in knowledge governance. (Miles, Huberman, & Saldaña, 2020).
- **Network Mapping:** Visualization of knowledge flow between agencies to highlight bottlenecks or weak links in communication.
- **Comparative Analysis:** Contrasting findings from routine monitoring periods against crisis management during Hurricane Melissa.
- **Statistical methods to determine differences in water quality during routine and crisis monitoring include the Paired t-test, Chi-square test, Pearson or Spearman Correlation, and visual interpretation, including maps.**

Water samples will be collected from designated monitoring stations and submitted to the NEPA laboratory for analysis. Parameters including biochemical oxygen demand (BOD), faecal coliforms, total suspended solids (TSS), nutrients, and chemical oxygen demand (COD) will be analysed following the protocols established in the *Standard Methods for the Examination of Water and Wastewater* (24th ed.).

Combining these techniques will facilitate the capture of scale, drivers, and persistence of Hurricane Melissa related water pollution. The statistical narration will reveal not only how pollution levels change but why, linking storm intensity, human settlement patterns, and watershed vulnerability.

Ethical Considerations

This research will ensure that ethical standards are adhered to throughout the process. The following ethical guidelines will be followed:

- **Ethics approval:** This research will seek ethical approval from the institution prior to data collection, and all activities involving human participants will be conducted in accordance with the approved protocol.
- **Informed Consent:** All participants will be informed of the research purpose, procedures, benefits, potential impact, and that participation is voluntary. They will be asked to provide their consent before participating in the study.
- **Confidentiality:** Participants' anonymity will be respected, and all data will be kept confidential. It will be clarified who will have access to the data and how it will be used.

Expected Results

The study is currently at the proposal stage, and the expected results will primarily focus on identifying key themes and gaps from information that has already been obtained through water quality data, the literature review offering insights into the integration of knowledge governance with adaptive governance, resilience, and disaster governance as it relates to pollution monitoring and prevention in Jamaica. The following are the anticipated outcomes of this research:

- Mapping water quality data during routine monitoring as well as during a disaster situation, using Hurricane Melissa. Similarly, the formal and informal knowledge governance structures within Jamaica's environmental regulatory system will be mapped. The study aims to document changes in water quality during routine and disaster situations, the correlation between pollution levels and industrial locations, the impact of pollution on groundwater, and weak feedback and learning loops, as articulated by WRA (2025). While reports are often generated after a crisis, few are systematically archived or integrated into policy revision. Further, the results will aim to demonstrate that, although Jamaica's environmental governance system is institutionally robust, it struggles with fragmented knowledge management and weak inter-agency learning mechanisms, both of which exacerbate water pollution.
- Knowledge flow during routine monitoring and crisis response activities: The study expects to outline that during Hurricane Melissa, formal communication channels proved insufficient, while informal professional networks enabled rapid information sharing and decision support. Highlighting both the value and risk of informality, while trust-based ties can fill institutional voids, reliance on personal relationships may undermine transparency and institutional memory. Therefore, effective adaptive governance requires balancing formal coordination mechanisms with relational trust and best practices (UWI, 2023) that drive rapid collaboration during crises and facilitate decision-making to reduce the impact of water pollution.
- Barriers and enhancers to Knowledge Integration: It is anticipated that the findings will suggest that resource constraints and technological limitations remain major barriers to knowledge governance. Investments in digital infrastructure, interoperable databases, and open-access platforms could enable more transparent and efficient information flows. Capacity building, particularly in data analytics,

environmental monitoring, and crisis communication, would strengthen the system's absorptive capacity and facilitate adaptive responses to future shocks and is therefore seen as an enhancer.

- **Strategic Recommendations:** Recommendations will be presented, inclusive of processes for the implementation of the evidence-based Knowledge Governance Framework for water pollution prevention for policy makers in Jamaica, which will be transferable to other SIDS as well as emergent best practices to facilitate cross-agency collaboration projects with academia, non-governmental organisations (NGOs), and community participation.

Discussion

The discussion will be centred on interpreting the expected results of implementing the framework, which would not only improve Jamaica's water pollution prevention but also enhance its resilience to environmental shocks, offering valuable lessons for other SIDS navigating similar vulnerabilities. The research findings will be analysed in the context of recent studies that demonstrate both challenges and opportunities in pollution prevention, as they relate to knowledge governance, adaptive governance, and the integration of resilience and disaster governance. The urgent need for reform will also be discussed in light of persistent water pollution and the need to protect water resources to meet present and future demand. Based on the findings, the study will propose recommendations for restructuring Jamaica's regulatory system to foster more adaptive and resilient knowledge governance.

Key points to be discussed include:

- **Implications for Policy Reform:** The proposed Enhanced Knowledge Governance Framework directly addresses gaps. Integrated data systems and network-based coordination can minimise fragmentation. Continuous learning and capacity-building measures can institutionalise adaptive feedback. By strengthening Jamaica's environmental knowledge infrastructure, this framework could advance not only water pollution prevention but also broader resilience to climate and environmental challenges.
- **Benefits of Integration:** The aim of integrating all of these knowledge governance principles into the Jamaican environmental regulatory framework is to facilitate better water quality and pollution prevention. Using Hurricane Melissa, it is anticipated that, from a resilience theory perspective, the observed weakness in post-crisis feedback loops and learning processes indicates that the Jamaican regulatory system exhibits limited adaptive capacity, and that this can be reversed. Furthermore, the production of post-event reports without systematic archiving or policy integration suggests that lost opportunities for institutional learning can be re-engaged. True resilience, as Folke et al. (2005) argue, depends not only on bouncing back from shocks but also on "bouncing forward", that is, transforming experience into improved governance practices, which result in improved water quality and the prevention of any possible risk of contamination. It is further anticipated that Jamaica's current system, which remains reactive rather than generative and emphasises compliance over adaptive learning, will be transformed by the integration of both. Thus, by embracing the Enhanced Framework, Jamaica can be effective in closing the loop between water pollution and knowledge governance.

Limitations

Certain limitations may affect the study's scope and generalisability. First, the research focuses exclusively on Jamaica, a Small Island Developing State (SIDS), which may limit applicability to larger,

more diversified economies. Second, data access may be uneven; some post-disaster documentation related to Hurricane Melissa may prove to be incomplete. Third, time constraints may prevent longitudinal analysis of multiple crisis events. Nonetheless, the findings are expected to provide valuable insight into knowledge governance practices relevant across SIDS.

Future Research Directions

Future research directions will be outlined, including longitudinal analysis of institutional learning over multiple crisis events, research to assess the long-term impact of integrated management practices, and comparative studies across different regions.

In conclusion, this proposal aims to contribute to a more sustainable knowledge governance framework. Jamaica's environmental regulatory system demonstrates a commendable commitment to water resources through legislation and formal oversight. However, the persistence of pollution incidents reveals critical gaps in knowledge governance. Effective water pollution prevention depends not only on regulations but also on how knowledge is managed, how data are collected, shared, interpreted, and transformed into coordinated action.

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