AI-Driven Water Pollution Detection and Cleanup Decision Support System

Internship Project Report

Submitted in partial fulfillment of the requirements for
IBM SkillsBuild / 1M1B – AI for Sustainability Virtual Internship

Submitted by

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Academic Year

2024 – 2025

1.Project Overview

This project focuses on the development of an AI-driven decision support system for detecting water pollution and assisting authorities in planning effective cleanup actions. The system aims to address the growing issue of polluted water bodies such as lakes, ponds, and tanks, particularly in urban and semi-urban areas.

The proposed solution uses Artificial Intelligence to analyze visual data of water bodies and identify visible signs of pollution, including garbage accumulation and abnormal water appearance. Based on the detected pollution severity, the system assigns priority levels and generates recommendations to support cleanup and preventive actions.

Rather than replacing human decision-making, the system is designed to support authorities with data-driven insights, helping them identify highly polluted water bodies, prioritize cleanup efforts, and use resources more efficiently. By reducing reliance on manual surveys and enabling early detection of pollution, the project contributes to cleaner water bodies, improved public health, and sustainable water resource management.

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2. Project Title

AI-Driven Water Pollution Detection and Cleanup Decision Support System

This project uses AI to identify pollution in water bodies and help authorities decide suitable actions for cleanup and better water management.

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3. SDG Alignment

Primary SDG:

SDG 6 – Clean Water and Sanitation

This project supports clean and safe water by detecting pollution in water bodies and helping plan timely cleanup actions.

Secondary SDGs:

SDG 14 – Life Below Water:

Reducing water pollution helps protect aquatic ecosystems and marine life.

SDG 11 – Sustainable Cities and Communities:

Cleaner water bodies improve environmental quality and public health in communities.

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4. Problem Statement

Water bodies such as lakes, ponds, and tanks in and around urban and semi-urban areas are increasingly polluted due to improper waste disposal, untreated wastewater, and lack of regular monitoring. In many locations, these water bodies are filled with garbage, and visible changes in water colour indicate pollution caused by waste, bacteria, or other contaminants. Polluted water poses serious risks to human health, aquatic life, and the surrounding environment, as it can lead to the spread of diseases and ecological imbalance.

Although government authorities and organizations conduct water body rejuvenation activities through surveys and cleaning processes, these efforts are often manual, periodic, and reactive in nature. Due to limited monitoring capacity and lack of continuous data, authorities may not always be aware of which water bodies are most polluted at a given time. As a result, highly polluted lakes may remain unattended, while other water bodies with lower pollution levels are cleaned repeatedly.

This lack of a unified, data-driven decision-making system leads to inefficient use of resources, increased costs, and poor prioritization of cleanup efforts. There is currently no integrated approach that helps authorities assess pollution severity, compare multiple water bodies, and plan cleanup actions in a timely and efficient manner.

Therefore, there is a need for a system that can support continuous monitoring, identify pollution levels, prioritize water bodies based on severity, and assist authorities in planning cleanup actions more effectively. An AI-based decision support system can help address these gaps by providing pollution detection, priority alerts, and planning support, enabling proactive and efficient water body management for improved public health and environmental sustainability.

5. Target Users

The primary users of this project are government authorities and local bodies responsible for managing and maintaining water bodies. The system can help them identify polluted water bodies, prioritize cleanup activities, and plan actions more effectively.

Secondary users include environmental agencies, water management departments, and cleanup teams who can use the system's outputs to support monitoring, field operations, and decision-making.

Local communities and residents living near lakes, ponds, and tanks are indirect beneficiaries of the project, as improved water quality contributes to better public health, environmental conditions, and quality of life.

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6. AI Solution Overview

This project proposes an AI-based decision support system for monitoring and managing water pollution in lakes, ponds, and other water bodies. The system allows images of water bodies to be collected from two main sources: photographs uploaded by members of the public and images or videos captured through local monitoring cameras installed near water bodies.

The collected visual data is analyzed using AI models trained on pollution-related data to identify visible signs of pollution such as garbage accumulation and changes in water appearance. Based on this analysis, the system assesses the level of pollution and assigns a priority level to each water body.

Using the assessed pollution severity, the system provides decision support outputs such as recommended cleanup priority, possible cleanup methods, and preventive measures to reduce further pollution. These insights can help authorities and cleanup teams plan actions more effectively and focus resources on highly polluted water bodies.

By combining community participation, automated visual monitoring, and AI-based analysis, the system supports timely detection, better prioritization, and improved management of polluted water bodies.

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7. Role of AI:

Artificial Intelligence plays a key role in analyzing pollution data and supporting decision-making in this project. Machine Learning and Deep Learning techniques are used to analyze

images of water bodies and identify visible signs of pollution such as garbage accumulation and changes in water appearance.

Generative AI and Retrieval-Augmented Generation (RAG) are used to support analysis and recommendations by combining learned patterns from trained data with relevant reference information. This helps the system provide meaningful insights rather than simple predictions.

Based on the AI analysis, the system classifies the pollution level, assigns priority rankings to water bodies, and generates recommended cleanup methods and preventive measures. The AI-supported outputs are then used to trigger alerts and provide decision support to authorities and cleanup teams, enabling timely and informed action.

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8. Design Thinking Approach

Empathize

The idea for this project originated from earlier work on a sustainability poster related to **SDG – Life Below Water**, which created awareness about water pollution and its impact on aquatic life, human health, and the environment. Through this work and observation of nearby lakes, ponds, and tanks, it was noticed that many water bodies are polluted with garbage and show visible changes in water color. These conditions negatively affect ecosystems and the quality of life of surrounding communities.

Define

The key problem identified is that water pollution monitoring and prevention are currently handled through manual surveys and inspections. Authorities and organizations visit water bodies to assess pollution levels, which consumes significant time and effort. This process is slow, periodic, and reactive, often leading to delays in cleanup and prevention. As a result, highly polluted water bodies may not receive immediate attention, and preventive actions are delayed.

Ideate

To overcome these limitations, the idea evolved toward reducing manual effort and improving efficiency through technology. The use of AI was explored as a way to analyze images of water bodies to detect visible pollution such as garbage and abnormal water appearance. The concept focused on using AI to assess pollution severity, assign priority levels, support cleanup planning, and help prevent further pollution in the future.

Prototype

A conceptual prototype was designed as a workflow where images of water bodies are collected through public uploads and local monitoring cameras. These images are analyzed using AI to identify visible pollution and estimate severity levels. Based on this analysis, the system assigns priority rankings and generates recommendations to support cleanup and prevention decisions. The prototype demonstrates how AI can act as a decision-support tool for authorities rather than replacing human judgment.

Test and Refine

The system can be further refined in the future by integrating a low-cost monitoring unit placed near water bodies. This unit can include a basic pH sensor and a camera to continuously observe water conditions. The camera can help detect visible garbage and surface-level pollution, while the pH sensor can provide basic water quality readings. Data from these components can be analyzed by the AI system to trigger alerts and priority notifications when pollution levels exceed defined thresholds. This approach can reduce the need for frequent manual surveys, save time and resources, and enable faster response to pollution issues. Future improvements may include better sensor accuracy, improved AI models trained on larger datasets, and feedback from authorities to enhance system effectiveness.

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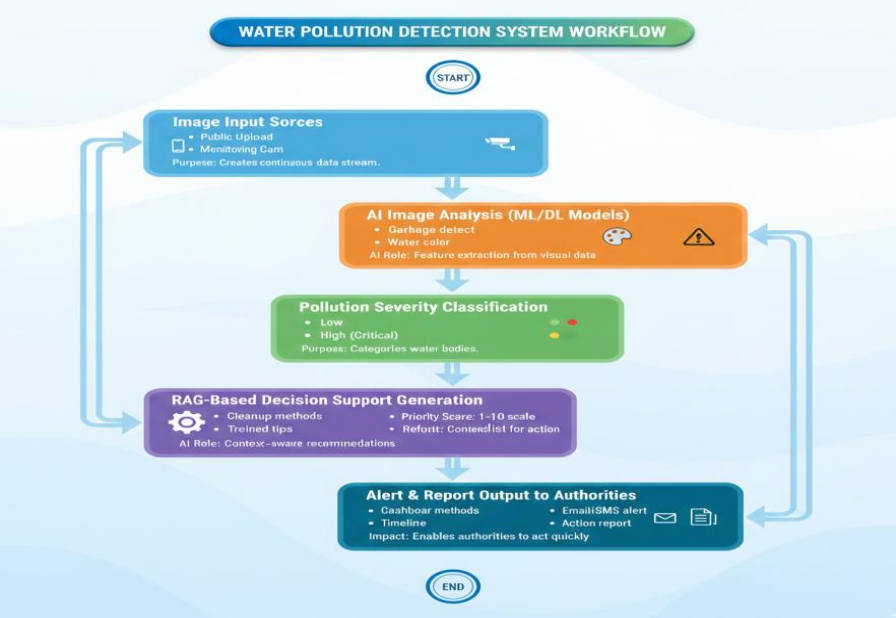
9. Prototype

9.1 Conceptual Prototype Overview

This prototype presents a conceptual AI-based workflow designed to support water pollution detection and cleanup decision-making. The prototype focuses on demonstrating how visual data from water bodies can be transformed into actionable insights for authorities, rather than representing a fully implemented or deployed system.

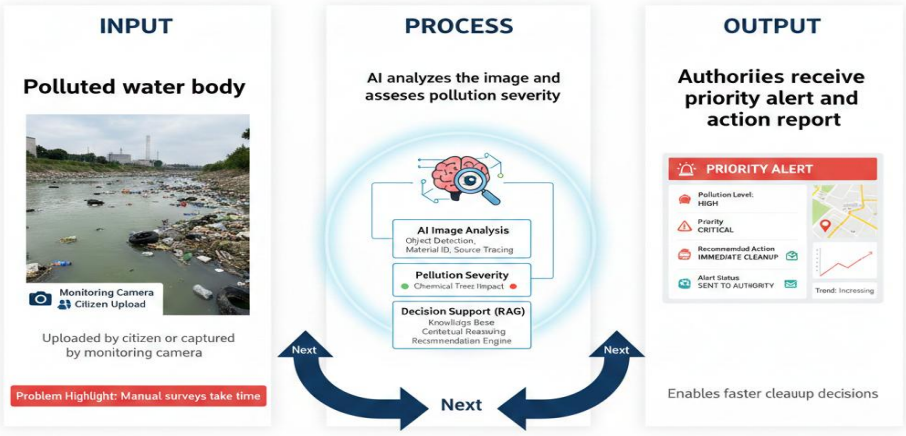
Images of water bodies are collected through citizen uploads and monitoring cameras placed near lakes, ponds, and tanks. These images act as the primary input to the system and help reduce dependence on time-consuming manual surveys.

9.2 Prototype Workflow (Flowchart Representation)



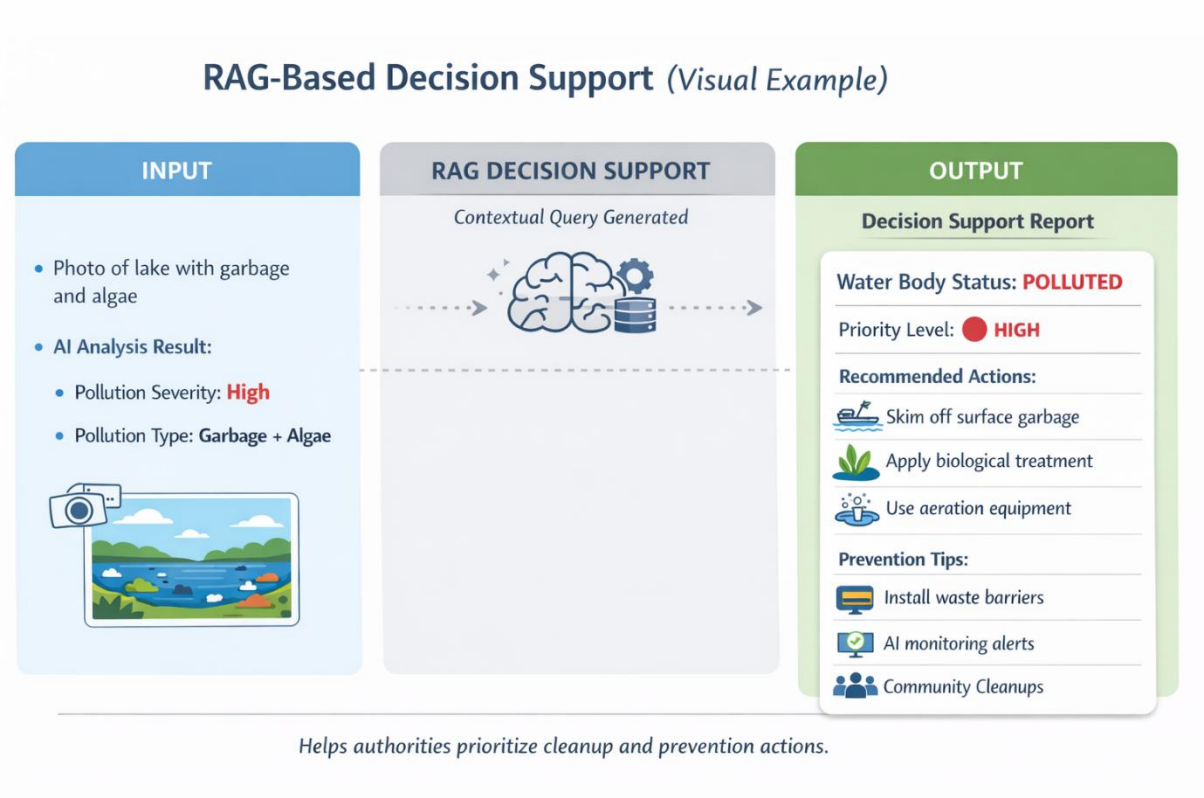
The flowchart illustrates the end-to-end workflow of the prototype. It shows how images of water bodies are taken as input, analyzed using AI to detect visible pollution, classified based on pollution severity, and passed to a decision-support module. The final output consists of priority alerts and cleanup recommendations sent to authorities to support faster and more effective action.

9.3 Visual Prototype Demonstration (Storyboard Representation)



The storyboard visually demonstrates the prototype in a real-world scenario. It highlights how a polluted water body image is captured as input, processed using AI-based image analysis and RAG-supported decision logic, and converted into priority alerts and recommended actions. This visual representation makes the workflow easy to understand for both technical and non-technical stakeholders.

9.4 RAG-Based Decision Support (Illustrative Example):



Retrieval-Augmented Generation (RAG) is used to provide context-aware decision support by combining AI-based image analysis results with reference knowledge related to water body management.

Input Context:

An image of a water body showing visible garbage and algae growth is analyzed using AI-based image analysis. From this analysis, structured findings such as pollution severity (high) and pollution type are generated. These findings are then used to automatically create a contextual query for the RAG module.

Sample RAG Output (Conceptual):

- **Priority Level:** High
- **Suggested Action:** Immediate cleanup

Recommended Approach:

- Mechanical removal of surface garbage
- Biological treatment to improve water quality
- Aeration support to restore oxygen levels

Prevention Suggestions:

- Installation of waste barriers at entry points
- Periodic AI-based monitoring
- Community awareness initiatives

This example is illustrative and intended only to demonstrate decision-support capabilities, not an actual implementation plan.

9.5 Prototype Scope and Limitations

This prototype is conceptual and intended to demonstrate workflow logic and decision-support capabilities. Human verification and authority involvement are assumed before any real-world action is taken. The prototype avoids direct chemical measurement from images and focuses only on visible pollution indicators to ensure responsible and realistic use of AI.

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10. Responsible AI Considerations

This project is designed with responsible and ethical use of AI in mind. The system is intended to support decision-making and does not replace human judgment. AI outputs such as pollution levels and priority alerts are meant to assist authorities, who can verify information before taking action.

Fairness is considered by ensuring that the system evaluates water bodies based on visible pollution indicators and available data, without bias toward specific locations or communities. Transparency is maintained by clearly explaining how AI-generated results such as pollution severity and priority levels are produced.

The project avoids misleading claims by not attempting to measure chemical properties directly from images. Basic water quality indicators, when used, are treated as separate inputs. Privacy is respected by avoiding the collection of personal or sensitive data from users, and all uploaded images are used only for environmental analysis purposes.

11. Expected Impact

The expected impact of this project is improved cleanliness and management of water bodies such as lakes, ponds, and tanks. By supporting timely detection of pollution and priority-based cleanup planning, the system can help ensure that water bodies are cleaned to a safer and healthier level for humans, animals, and the environment.

The project can also increase public awareness about water pollution and its prevention. By providing information on pollution levels and recommended cleanup and prevention methods, people can better understand how water bodies get polluted and what actions can be taken to reduce pollution in the future.

Additionally, the system can improve transparency and accountability in water body management. Citizens and communities can gain visibility into whether cleanup actions are being planned and addressed by authorities, which can encourage better monitoring and responsible governance.

Overall, the project aims to support sustainable water management, reduce health and environmental risks caused by polluted water, and promote long-term protection of water resources.

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12. Impact Statement

If implemented, this project can support cleaner and safer water bodies by helping authorities identify pollution early and prioritize cleanup actions effectively. It can reduce manual survey effort, improve transparency in water management, and increase public awareness about pollution prevention. Overall, the solution contributes to healthier ecosystems, improved public health, and more sustainable management of water resources.