

Artificial Intelligence (AI) for water security

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Imagine standing on the bund of Parakrama Samudraya after a period of heavy rain. The vast expanse of water stretches toward the horizon, just as it did centuries ago. Yet hidden behind this familiar landscape, modern technologies such as satellites, sensors, and Artificial Intelligence (AI) are beginning to change the way water is managed.

Ancient hydraulic civilization of Sri Lanka

From a history spanning more than two thousand years, Sri Lanka has played a prominent role in shaping the Sri Lankan society through water management systems. The ancestors of Sri Lankans have created a very practical network of reservoirs, known locally as "wewa". By connecting canals that carried water across the island, each *wewa* has provided water for agriculture. Without the availability of modern technology, ancestors did this by carefully studying the environment, including rainfall, rivers, landscapes, and seasons. The reservoirs of Anuradhapura

and Polonnaruwa still stand today in an active state while providing living proof of their engineering brilliance. These reservoirs enriched agricultural societies and flourishing kingdoms in the past. Ancient masterworks such as *Parakrama Samudraya* reflect the excellent creativity of the ancient Sri Lankan engineers. Reservoirs, streams, waterways, and canals were interconnected to capture, stock, and distribute water across a vast distance. There is a famous quote of King Parakramabahu, which states, *"Not even a single drop of rainwater should flow into the sea without being used for the benefit of the people"*.

The quote itself reflects a deep understanding of sustainability that was far ahead of its time.

With the climate changes that make rainfall less predictable, today Sri Lanka faces a different type of challenge. While some regions experience severe floods, some regions endure long droughts. Urban growth, industrial activity, and pollution are placing increasing demand on our water resources. Even as a water-rich country, the question remains the same across generations in Sri Lanka, viz; "How do we use our water wisely and sustainably?"



Figure 1: Ancient Sri Lankan reservoirs (wewa)

With the availability of new tools, satellites, sensors, computers, and AI, the modern engineers have found new approaches for managing water resources. In many ways, AI can be seen as the next chapter in Sri Lanka's long tradition of water engineering.

Why water security matters more than ever

Water is essential for life. Although about 71% of the earth's surface is covered by water, only a very small fraction includes usable freshwater. Even from this small fraction of usable freshwater, less than 1% is readily accessible in rivers, lakes, reservoirs, and shallow groundwater. Water security is not just about achieving water availability, but about ensuring the availability of quality water with reliable supply.

Heavy rainfalls are becoming more frequent, that can influence severe floods causing negative impact on societies and infrastructure. Droughts threaten livelihoods, agriculture, and drinking water supplies. The rapid changing of climate patterns increases uncertainty of water demand forecasting, population growth, urbanization, industrial activities,

and pollution increase stress on our limited water resources.

In early Sri Lanka, the water management had to mainly rely on experience and observation. At present we are equipped with data from weather stations, river gauges, satellites, and monitoring systems, which bring us a huge advantage to establish a better water management system. Nevertheless, we have a new hurdle to overcome at present, where the challenge has transformed from the lack of information to the information processing. To overcome this challenge, AI serves as a powerful tool.

How AI learns about water

AI is not only about robots, but also a very powerful ally in decision-making *via* data analysis. Students learn from examples and exploring relationships, likewise AI. By exploring a vast amount of data, which includes rainfall records, river flows, reservoir levels, and weather patterns, AI is capable of providing predictions on future weather conditions.

The data collection is the starting process of hydrological intelligence. In this phase, AI

systems gather information from numerous sources such as weather stations, satellites, sensors, drones, and historical records. This raw data is then forwarded for the data preparation. During the data preparation, cleaning, integrating, and normalizing procedures are done to organize and make the data ready for analysis. Within the AI learning phase, the models such as machine learning and deep learning are used to process the labeled input data for identifying complex patterns and relationships within the water systems. These models then generate insights and predictions, providing valuable outputs that include rainfall forecasting, flood predictions, water quality monitoring, assessments of water availability, and drought conditions. At the final stage, the generated insights and predictions lead to Smart Decisions, empowering human decision-makers to take early and wise actions. By doing so, the decisions can be made on a solid data driven platform for managing reservoir operations, allocating water resources, controlling pollution, and preparing for floods or droughts.

We have to understand that AI is not about replacing engineers,



Figure 2: Sri Lanka faces increasing extremes of flooding and drought

hydrologists, or environmental scientists. It acts as a powerful assistant to make the situation better in less amount of time.

AI as a new guardian of water resources

AI enriches water security in numerous ways. Even though the majority of people never see these systems directly, the latter increasingly facilitate scientists, engineers, hydrologists, farmers, and water managers to understand what is happening within the very complex water systems and to behave more efficiently in rapidly changing conditions.

One of the major challenges in water management is recognizing how much water will be required in the future. The water demand continuously increases with the population growth, expansion of cities, development of industries, and increased farming activities.

The weather conditions also play a significant role. Prior preparation is essential for managing sudden unexpected changes in the global climate such as dry spells or heavy rain. By analyzing historical data with real-time data, AI can recognize climate changes accurately since it provides a solid foundation for decision-making in advance. It is not an easy task for a manual analytical approach, as the data sets are more complex than ever before, with various inputs, which are available from satellite to water level sensors. With help of AI, this complex analysis can become realistic and generate more accurate forecasting in water management.

Continuous monitoring and analysis is another area where AI plays a leading role, for the purpose of identifying anomalies to make water management a proactive approach. Small water leakage may not be visible without continuous

monitoring and analysis. Data generated from the sensors that continuously measure the pressure and flow rates can be analyzed by AI to identify unusual patterns that may indicate a leak. Identifying even a small leakage can lead to preventing a major water wastage in the future. The story of the "Kala Wewa" reminds us of how the identification of a small water leak in the water dam prevented a disaster.

The quality of water is another important fact in the discussion of water security. The water demand can be fulfilled not only by the quantity. It is an approach of both quantity and quality. With the help of modern technology, the characteristics of water, such as temperature, acidity, turbidity, and dissolved oxygen level, are visible for AI to analyze. With such analyses, AI can identify water pollution more efficiently. Early identification of water pollution

creates space for authorities to respond more rapidly and reduce potential impacts on people and ecosystems.

Nevertheless, agriculture also benefited from intelligent water management. Farmers have always depended on their own experiences, and local knowledge to decide at what time crops need water. Today, AI-integrated real-time water management systems can provide extra support by analyzing weather forecasts, soil moisture conditions, satellite images, and crop information. As a replacement for releasing

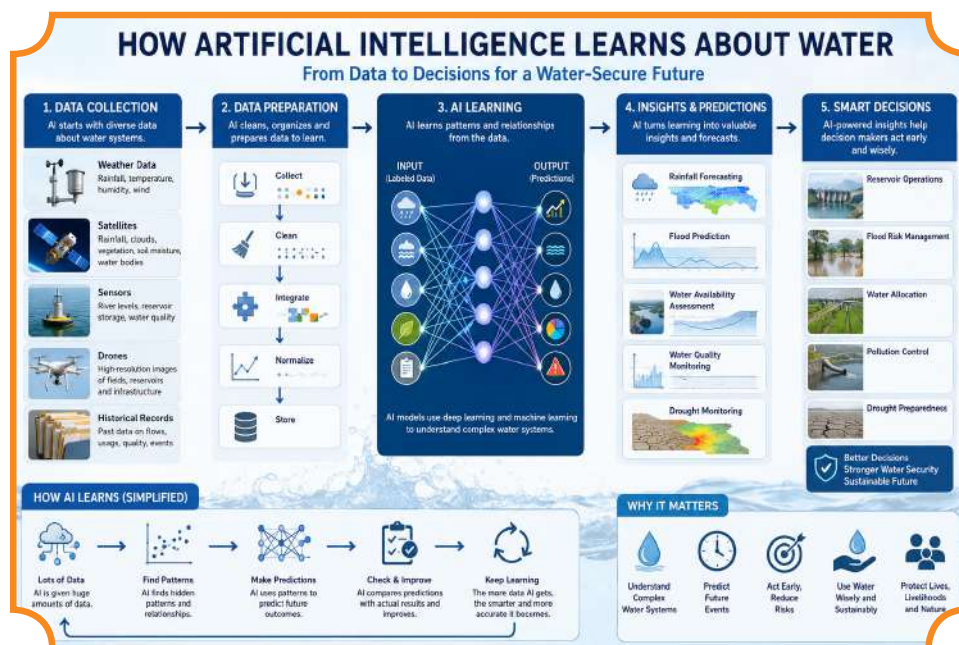


Figure 3: Process of AI learning from data



Figure 4: Application of AI for water security

water according to predefined fixed schedules, irrigation can be adjusted according to real field conditions. This helps save water while confirming that crops receive adequate water for healthy growth on time.

To reduce the risk from floods and droughts, early identification is a key factor. For this purpose, we need to generate a data set, which includes critical data such as rainfall readings, river flow, soil moisture, reservoir levels, and land use, in the form of real-time and historical data. AI can be used to analyze data for the purpose of generating more accurate forecasting. With such forecasting mechanisms, one can create early warnings to take preventive actions. Even with AI, hoping for a perfect prediction is still not realistic. But with more accurate forecasting, even a pre-warning within a few hours before the hazard, we are

can still save life, protect property, and help authorities respond more effectively.

Altogether, these applications show that AI is rapidly becoming worthier than a computer technology. It is gradually growing into a powerful tool that helps society to understand, protect, and manage one of the world's most precious resources. By transforming large amounts of information into valuable knowledge, AI allows better decisions that support water security for societies, agriculture, industry, and the environment.

A future scenario for Sri Lanka

Let us think of a scenario in the near future viz., the AI-assisted predicting systems forecast heavy rainfall over the Central Province of Sri Lanka. The weather stations have been reporting the increase

of rainfall, while satellites have shown dense cloud formation over the Province. The sensors located in the Mahaweli River have been detecting rising water levels. An AI platform is processing these data in real time to compare it with the past flood events. Within seconds, the system will be identifying a high risk of downstream flooding in the next 24 hours.

The reservoir managers are receiving recommendations on controlled water releases. Moreover, disaster management authorities are receiving early warnings. Farmers in the danger zone have been alerted through mobile apps. Also, communities in vulnerable areas will receive timely evacuation or safety notices.

Simultaneously, the AI system estimates future reservoir storage and advises on managing flood control and hydropower needs. Human decision makers remain in control. Hence, they now have a reliable data and information foundation for the decisions they are going to make.

In the near future, this will no longer be a science fiction. Advances in sensors, communication networks, cloud computing, and AI are increasing the practicality and reliability of such a water management system.

The Mahaweli system, where AI would make a real difference

When people think of using AI for water management in Sri Lanka, one project that stands

out immediately is, the Mahaweli Development Programme. As the country's biggest multipurpose river basin development project, the Mahaweli system supports irrigation, drinking water supply, hydropower generation, and flood management across a large part of the country.

Managing such a complex system is not an easy task. The water managers must make decisions continuously as to how much water should be stored, released for irrigation, or used for electricity generation. These decisions depend on large amount of factors, including rainfall forecasts, reservoir water levels, river flows, water requirements of agricultural practices, electricity demand, and environmental conditions. Making the right decision at the right time is often challenging due to weather conditions, which can rapidly change and many other factors that need to be considered simultaneously.

AI can scan thousands of data points simultaneously and identify patterns that would be difficult for humans to separately identify. By analyzing real time data from relevant different data sources and historical records, the AI systems can provide real-time actual conditions across the entire Mahaweli basin instead of analyzing each source of data separately. This is where AI could play a major role.

Another important application is the automating reservoir operation. AI can forecast weather and predict

how much water is likely to receive by reservoirs in the coming days or weeks or months. Based on this information the AI system can automatically control as to whether water should be stored, released, or transferred to other parts of the Mahaweli system.

Currently, reservoirs within the Mahaweli project play a vital role in electricity generation. With the integration of AI for forecasting inflows, electricity demand etc., it is

soil moisture information, satellite imagery, and crop data to estimate irrigation requirements more accurately, the release of water can be scheduled to comply with real demand instead of following a fixed schedule. This kind of approach leads to reduce wastage of water while supporting agricultural productivity.

Flood mitigation is another important area, which can be addressed with the integration of



Figure 5: AI can add value to the Mahaweli system

possible to make recommendations on the best operating strategies that increase power generation while confirming that a sufficient amount of water remains available for domestic use and agriculture.

Agriculture is one of the leading beneficiaries of efficient water management. With the ability of AI to combine weather forecasts,

AI. The AI systems can analyze data to identify areas at high risk of flooding. During heavy rain seasons, the automated reservoir operators can receive recommendations on water releases prior to critical situations, while disaster management authorities can issue prior warnings to relevant communities. Therefore, reliable early warning systems can

significantly improve community safety while decreasing the damage.

During drought conditions, AI can identify evolving shortages before they develop severely. Authorities will then be able to implement conservation actions, adjust water distributions, and develop contingency plans well in advance.

More than half a century ago, the Mahaweli Development Programme transformed Sri Lanka's approach to water resource management. In the near future, AI possesses the potential to become the next major step in the said journey, serving the country to manage its most valuable resource with better efficiency, resilience, and sustainability.

The next chapter of Sri Lanka's water heritage

Although the development of water management systems in Sri Lanka continues from the ancient Wewa era, at present, the approach

involves science, engineering, and technological innovation. The ancient engineers observed the environment to make decisions, the

engineers today are equipped with new technologies such as satellites, sensors, computer models, and digital dashboards. Ensuring the

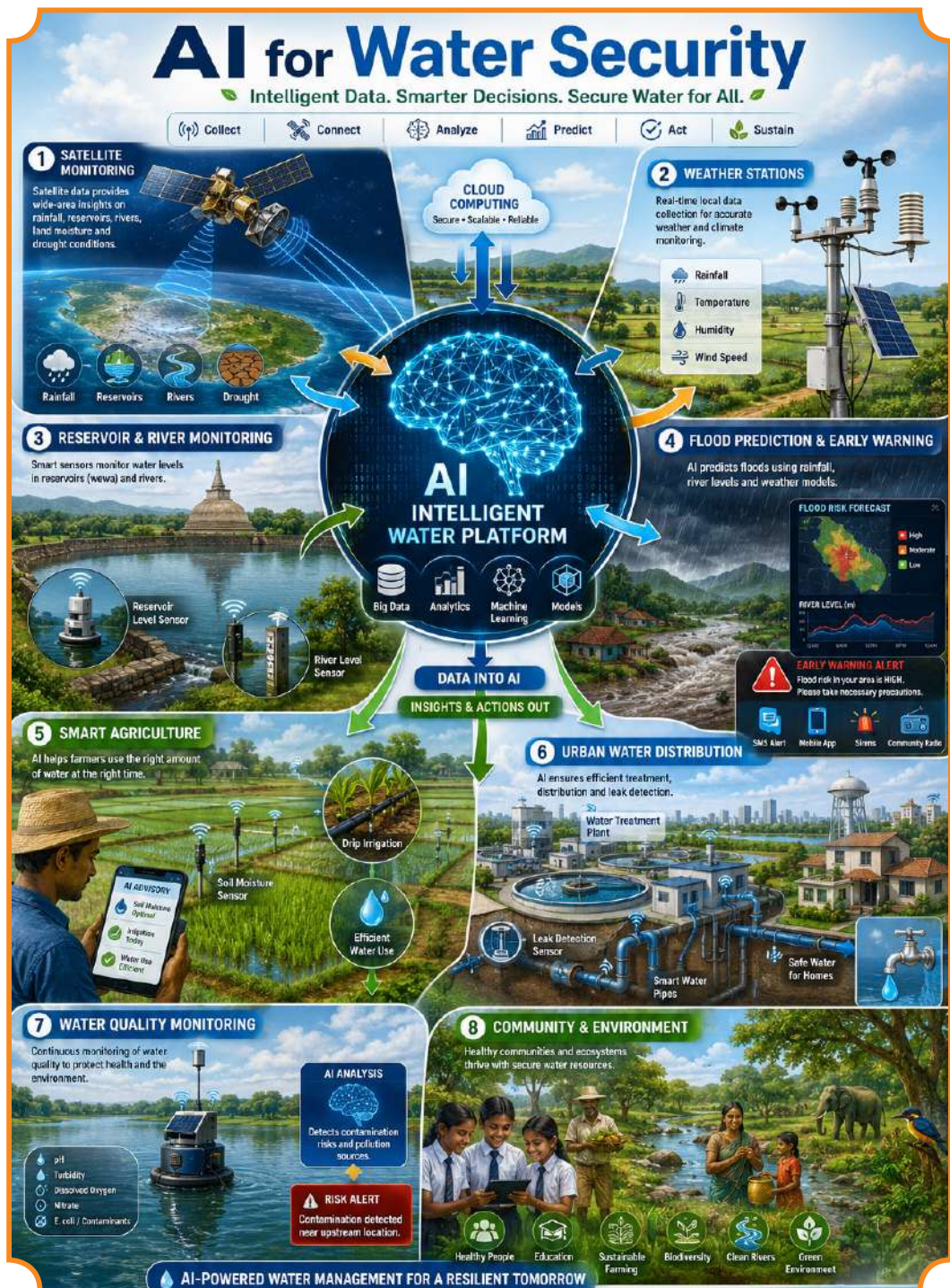


Figure 6: AI for a water management system in the future

availability of quality water when and where it is needed remains the core concept of the water management system.

AI is not about replacing humans with robots. Instead, it is a new tool that complements human expertise. With the combination of Sri Lanka's hydraulic heritage and modern technology, Sri Lanka has the potential to build a more resilient and sustainable water management system in the future.

Conclusion

For any country, the ability to manage water intelligently has been one of the greatest strengths. Water has always molded the prosperity in Sri Lanka, throughout the history. New challenges such as rapid climate changes, population expansion, and modernized agriculture etc., demand novel solutions for water security.

AI stands as a valuable technology that can help us in achieving sustainable water security. Forwarding data collected from satellites, sensors, weather stations, and water management systems, to AI for analysis, can support to make better decisions with a solid platform, improve efficiency, and provide early warnings of potential problems. The better decisions that lead to helping farmers use water more efficiently, protecting communities from floods, monitoring drought conditions, would support the operation of large reservoir networks. Thus, AI offers a new approach to save this precious water resource.

More than a thousand years ago, Sri Lankan engineers built extraordinary water systems without modern knowledge and tools. Today, we have the opportunity to combine that same spirit of innovation with modern

AI technologies. If used wisely, AI can help ensure that future generations continue to benefit from clean, reliable, and sustainable water resources. In doing so, we are not replacing the wisdom of the past, but we are rebuilding upon it.



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