Digital Transformation for the Management of Water Resources in Malaysia

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Abstract. Water professionals play a critical role in the digital transformation of the water sector through a fair, sustainable, equitable, and integrated manner. Artificial intelligence (AI) and Machine Learning (ML) and Internet of Things (IoT) can aid in the management of water resources by using algorithms, regression models, and data analytics. The 2030 Agenda for Sustainable Development of the United Nations requires decision-makers to recognize, quantify, and communicate the value of water in order to achieve the Sustainable Development Goals (SDGs). Despite the acceleration of Malaysia's digital water journey over the past two decades, we still need to address significant water concerns such as rising urbanization, flood mitigation, water shortages, climate change, and ageing infrastructure to accelerate this progress comprehensively. This paper is aim to explores how AI, ML, and IoT technologies can transform water management by enhancing monitoring, optimizing treatment, reducing waste, and ensuring sustainable supply. It reviews innovative applications, addressing urbanization challenges and supporting the UN's Sustainable Development Goals (SDGs). By integrating water according to usage with digital control, we can enable data-driven models that can help integrate and optimize smart pumps, valves, sensors, and actuators, thereby offering diversity and adaptability through digitalization.. The three elements energy, food, and water are essential at our current pace of consumption and expansion, a shortage of water might halt the supply of food and energy and halt economic growth. Using a digital strategy that is both actionable and adhered to must be put in place that emphasis on business needs and convey the advantages and quick payback to establish a connection between the strategies supporting outcomes and the digital technology investment.

Keywords: Aritificial Intelligence (AI), Machine Learning (ML), Sustainable Development Goal (SDG), Internet of Things, Data Security, Sensors.

1 INTRODUCTION

Global water crisis may be resolved in large part by implementing digital water infrastructure, which encourages optimal water use and reduces excess. Water professionals play a critical role in the digital transformation of the water sector through a fair, sustainable, equitable, and integrated manner. As technology develops, our capacity to utilize Artificial Intelligence (AI) , Machine Learning (ML) and Internet of Things (IoT) to interpret a structured data set that is becoming more and more unstructured based on text or sensor data, or to collect information from distant devices and relate the information from various systems to enable almost real-time

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management. Artificial intelligence (AI) can be defined as the replication of human intelligence through the use of machines or computer expert systems that possess a variety of capabilities, including the ability to learn on its own, process natural language, process images, visualize them, investigate and recognize dialogue, make decisions, and carry them out. Machine learning is a subfield of artificial intelligence, which is broadly defined as the capability of a machine to imitate intelligent human behaviour. The Internet of Things, or IoT, is the collective term for the network of interconnected gadgets as well as the technology that enables communication between devices and the cloud. The ability to extract value from those data and carry out or automate the optimal course of action that follows from the analysis of predictive and prescriptive data will be enhanced by reasoning analysis. Numerous innovative applications have been created and put into use by utilizing large-scale and widely dispersed data collection, cloud computing with ever-more-advanced forecasting capabilities using AI, and worldwide connectivity using the IoT

As nations work to strike a balance between economic growth, environmental conservation, and social well-being, sustainable development has gained importance on a global scale. The 2030 Agenda for Sustainable Development of the United Nations requires decision-makers to recognize, quantify, and communicate the value of water in order to achieve the Sustainable Development Goals (SDGs). The swift progress in AI and ML presents unparalleled prospects for tackling intricate sustainability predicaments. The simulated human intellect in computers, known as artificial intelligence (AI), enables them to do tasks like learning, problem-solving, and decision-making that otherwise need human intelligence. Machine Learning (ML) is a division of artificial intelligence that focuses on techniques that help computers learn from data and improve over time without explicit programming.

Now-a-days, IoT technology is a basic requirements of water infrastructure management. It facilitates the continuous monitoring of turbidity, pH levels, and chemical contents [1] In the water management structure, the IoT technology provides water flow data, pressure and leak detection, smart meter for water consumption in real-time and also remote monitoring of water distribution network. Hence, it is possible for effective repose during emergencies, also for proper preventive maintenance [2].AI with machine learning algorithms can examine historical data to detect patterns and predict future water quality, and thus the water treatment processes can be optimized. Adaptive learning algorithms facilitates the continuous improvement to the performance of water treatment plants [3]. AI with machine learning provides a capacity to amend the maintenance approaches of water management and able to replace equipment's that are expected to fail [4, 5]

AI-enabled IoT-enabled water treatment systems can optimise the use of treatment plants, reduce water waste, and meet the flexible demand for water consumption [6]. AI maximises the supply of water while lowering operational costs, improving capital allocation, and mitigating negative social and environmental impacts [7]. AI uses analytics, models, and algorithms to enhance the effectiveness of water resource management. These tools ensure water quality assessment, expedite facility construction, and enhance network design [8]. We suggested using the latest SCADA system that integrates IoT for real-time water quality monitoring. It can detect contamination and pipeline breaks, as well as measure temperature, flow, and color automatically and in real time with an Arduino and a GSM module [9].

Urbanization by 2050, projected to include 70% of the population, risks agricultural, environmental, and socio-economic issues. Unchecked urbanization encroaches on agricultural fields and biodiverse areas, contaminating water supplies and aggravating poverty, inequality, pollution, and unemployment. AI technology can resolve these issues [10]. AI applications on water can address intelligent infrastructure solutions, lower energy costs, forecast emergencies faster, offer powerful decision-making intelligence, optimize operations, and provide innovative water system management [11]. Based on this thorough reviews, AI offers solutions in urban management and water systems, enhancing efficiency and forecasting. However, challenges in implementation, equity, and sustainability must be addressed to ensure AI benefits all urban residents equitably.

The integration of AI with various technologies is proving effective in water management. Combining AI, IoT, and deep learning can address water management challenges. According to Malviya et al., AI techniques were implemented to measure Chemical Oxygen Demand (COD), pH levels, Biological Oxygen Demand (BOD), nitrogen, turbidity and sulphur using Genetic Algorithms (GA) [13]. Bhagat et al. stated that multiple AI techniques were used to detect the heavy metal from the water source [14]. Kamali et al., recommended that AI with Membrane Bioreactors (MBR) is one of the proficient ways to mitigate the pollutants within the water source [15].

Integrating AI and IoT technologies with deep learning and machine learning techniques can help overcome the complexities and challenges of water management systems and water supply distribution systems. [16, 17]. Liu et al., designed the IoT system for water management system in agriculture sector using ZigBee wireless module to measure the water quality of agricultural usage in real-time [18]. A hydro informatics integration platform developed in Taiwan using machine learning technique to monitor online flood forecasting and flooding to trigger the alarms of flash floods [19].

The objective of this paper is to explore how integrating Artificial Intelligence (AI), Machine Learning (ML), and Internet of Things (IoT) technologies can revolutionize water management systems. It aims to demonstrate the potential of these technologies to enhance water quality monitoring, optimize treatment processes, reduce waste, and ensure sustainable water supply amidst the challenges posed by rapid urbanization and environmental degradation. The paper reviews various innovative applications and implementations, highlighting their effectiveness in addressing the complexities of water resource management and their role in achieving the United Nations' Sustainable Development Goals (SDGs).

2 TRANSFORMATION OF WATER SECTOR WITH DATA

In Malaysia, poor instrumentation has been the cause of many project failures, which leaves data either lacking or of low quality and hence worthless. Getting the fundamentals right is essential if the sector is to undergo digital transformation. We can make sure that instrumentation is operated and maintained correctly to provide for optimal data and information quality by installing it appropriately and using it for the necessary applications.

This ensures that neither tactical nor strategic viewpoints are compromised and that the data and insights that eventually result from the instrumentation are founded on accurate principles.

"Water Management Crisis" is a bigger issue than "Water Crisis." Accurate, up-to-date data is essential for effectively managing water resources. A curated list of "Water Data" from all organizations and sources that will help further with addressing some common development concerns is what the Digital Water Data Bank is intended to be. In any issue, data makes it easier to create a bigger picture, which in turn helps us to use the best available information and make wise judgments. Data-driven decisions have the potential to meaningfully improve service delivery, maintain water supplies, and foster resilience in the context of creating a water-secure future.

Developments in the field of hydroinformatics and, more significantly, the use of artificial intelligence (AI) are beginning to have an impact on the management of the water sector. But the water industry's digitalization isn't progressing as quickly as other sectors because of a number of obstacles, such as outdated data collecting and management systems, a lack of a convincing economic case for digital applications, cybersecurity concerns, and the "human factor." The use of engineering principles and analytical techniques to failure investigation has advanced significantly in forensic engineering throughout the past 20 years. Despite the fact that Malaysia's digital water journey has accelerated over the past two decades, significant water concerns like rising urbanization, flood mitigation, water shortage, climate change, and aging infrastructure still need to be addressed in order to expedite this progress in a comprehensive way.

3 WATER SECTOR DIGITALIZATION ADVANCEMENTS

3.1 Instantaneous Identification of Pipe Breaks in Water Distribution Systems:

Around the world, leaks are a big problem for water distribution systems. An AI-based system that can identify equipment failures and other system malfunctions in addition to pipe bursts and leaks is demonstrated in this example. In order to estimate the signal values in the near future, the detecting system processes pressure and flow sensor signals automatically in almost real-time (using ANN). These are then contrasted with newly received observations in order to gather various types of proof on the failure event that is occurring. Bayesian networks are used to process the data gathered in this manner in order to determine the probability of the event occurring and sound the appropriate warnings [20] Romano et al 2014.

3.2 Predictive Wastewater Treatment Plant Control

In March 2019, PUB Singapore's Integrated Validation Plant at Ulu Pandan Water Reclamation Plant [21] received the Aquasuite® software from Royal Haskoning DHV. It was designed to enhance plant performance and give predictive insights to operators and managers. Aquasuite PURE creates a historical database in addition to gathering real-time data on the plant's flows and qualitative measures, such as those for ammonia, nitrates, oxygen, phosphates, and dry solids. Subsequently, the software employs sophisticated analytics and Machine Learning algorithms to forecast the wastewater flows and loads, oxygen requirements, chemical dosing requirements, and additional demands of the plant. Key treatment procedures are managed by the system, which automatically optimizes them in real time based on forecasts and the plant's past performance.

3.3 Precipitation forecasting

The likelihood of climatic disasters and rainfall damage has increased due to anomalous fluctuations in temperature and precipitation brought on by climate change. Estimating the damage that rainfall causes is still challenging, even with quantitative rainfall projections from weather forecasts. Chu et al. [22] used a variety of techniques, including random forest, eXtreme Gradient Boosting (XGBoost), and support vector machine (SVM), to solve this problem. They discovered that XGBoost performed the best. It is now possible to accurately estimate rainfall caused by flooding and make preparations for vulnerable locations by utilizing XGBoost to compute and validate the threshold rainfall of ungauged watersheds using historical rainfall occurrences and damage instances. As an alternative, Pakdaman et al. suggested a learning strategy based on random forest algorithms and artificial neural networks (ANNs) to give multi-model ensemble forecasting of monthly precipitation in Southeast Asia.

3.4 Temperature forecasting

One essential meteorological variable used for many investigations is temperature. On river basins, variations in precipitation and temperature can have a big effect. A stochastic model for the daily occurrence of precipitation and its impact on maximum and minimum temperatures was created by Hernández-Bedolla et al. [23]. The study used a multisite multivariate autoregressive model (MASCV) to represent the short-term memory of daily temperature and a Markov model to determine the daily occurrence of rainfall. The study focused on the Jucar River Basin in Spain, where a two-state and a lag-one multivariate stochastic model were used to appropriately describe the frequency of rainfall as well as the maximum and minimum temperatures.

3.5 Streamflow forecasting

A probabilistic forecasting model for multi-step-ahead daily streamflow forecasting was proposed by Ghobadi, F and Kang, D [24]. It addresses the subproblem of univariate time series models and quantifies aleatory and epistemic uncertainty by using Bayesian sampling in a long short-term memory (BLSTM) neural network. Three case studies in the USA supported the suggested approach, and three forecasting horizons show that BLSTM performed better overall and in terms of predicting accuracy and reliability than the other models.

3.6 Dam inflow predictions

Using 16 design scenarios, Kim B-J, et al. [25] demonstrated the procedure and methodology for choosing the best deep learning model to estimate dam inflow using hydrologic data collected over the last 20 years. The study concentrated on the South Korean dams of Andong and Imha, which are situated upstream of the Nakdong River. The storage function model (SFM), which is currently employed by both dams, was found to be less accurate in predicting observed inflow than the ideal recurrent neural network-based models. In a variety of typhoon scenarios, the majority of deep learning models produced forecasts that were more accurate than the SFM. For effective dam operation and management, it is imperative to compare the inflow projections of the SFM and deep learning models in order to make an informed decision.

3.7 Rainfall time series generation

Nguyen D.T, and Chen S.T,[26] developed a stochastic rainfall generator to generate continuous rainfall time series at a high temporal resolution of 10 min by utilizing a Monte Carlo simulation, a bivariate copula, and a modified Huff curve approach. After that, the rainfall generator that had been developed was used to replicate rainfall time series for the Yilan River Basin in Taiwan, maintaining statistical indices that were similar to those of the rainfall time series that had been observed. The findings point to the necessity and suitability of the recently developed rainfall type for classification of rainfall types. To sum up, the generated stochastic rainfall generator can accurately replicate continuous rainfall data series with a resolution of 10 minutes.

4 REQUIREMENTS FOR WATER DIGITAL TRANSFORMATION

Integrating water according to usage with digital control to enable data-driven models that can help integrate and optimize smart pumps, valves, sensors, and actuators, digitalization offers diversity and adaptability. There are six ways that digital water transformation might propel Malaysia's water sector transformation:

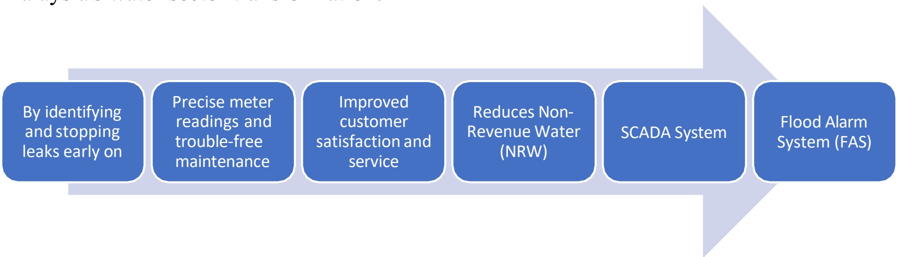

Fig1: Ways Digital Transformation can take place

4.1 By identifying and stopping leaks early on:

Smart water meters give utilities the ability to track usage and identify leaks earlier than usual, which helps with enforcement. For Malaysian utilities, leakage, apparent losses, and rising non-revenue water (NRW) have been serious concerns.

4.2 Precise meter readings and trouble-free maintenance:

Smart water meters are the ideal long-term investment since they are unaffected by trapped air, sand, or particles in the water. This ensures accurate readings from the start of their service life to the end, thereby eliminating unanticipated repair expenditures.

4.3 Improved customer satisfaction and service:

Customers who get accurate and timely billing are less likely to contact their suppliers with billing inquiries or disputes. Utility costs are directly reduced as a result, and customer satisfaction is raised. Because there are no hidden leaks or pipe breaks, the great precision of smart water meters increases accountability for non-revenue water, which contributes to accurate and error-free invoicing.

4.4 Reduces Non-Revenue Water (NRW):

Implementing smart water infrastructure and management would require automation, smart real-time monitoring, and metering at different levels. These measures will collectively guarantee a decrease in system losses and a resurgence of interest in water recycling and reuse, which will boost productivity and lessen water stress.

4.5 SCADA System:

When any of the metrics exceed safe limits, SCADA systems have the ability to generate alert signals in the event of a system failure. Significant issues with the administration and operations of water and wastewater can be mitigated by putting in place a SCADA system. This shortens the response time required for decision-making and aids in the detection of any subsystem inconsistency problem-solving capabilities through real-time data collecting.

4.6 Flood Alarm System (FAS):

It is divided into two parts: 1) forecasting rainfall and 2) evaluating stormwater surge caused by the anticipated rainfall. As a result, a FAS may consist of a collection of digital technologies that have been integrated together, including as computer models, IoT devices, GIS systems, and ICT.

5 CHALLENGES TO WATER DIGITAL TRANSFORMATION

The inconsistency of the true water value, or the undervaluation of water despite its necessity for life, is the primary barrier to the water sector's adoption of digital technologies. In many regions, water is seen as a "right" and as a basic product. Security issues exist for treatment plants and dams because there are more and more threats to vital control systems, particularly those that regulate water flows.

A strong strategic plan and a new ecosystem are required; a technology company alone cannot digitize a resourceful utility company. Let's collaborate to bring about a significant shift in this world as we are on the tip of an amazing transformation.

The key challenges include

- High implementation costs
- People skill gaps
- Lack of adaptability
- Resistance to change
- Challenging system integration

Proposed suggestions need to be considered for successful Digital transformation in Malaysia:

- First, create a digital strategy, then follow through on it with an action plan.
- Secondly, build a technological foundation, making sure you have the fundamentals in place to facilitate expansion in the future.

- ❖ Third, emphasize business imperatives and convey advantages and quick payback to establish a connection between the strategy's supporting outcomes and the digital technology investment.

With the above proposed suggestions, we would be able to promote the digital agenda rather than force it upon people. The water sector has the opportunity to learn from other sectors that are more advanced in terms of automation and digital transformation because of the complexity of managing water systems, their critical nature, the industry's need for a safety culture, and the current state of digitalization.

6 CONCLUSION

Addressing digitization difficulties like fragmentation, lacking a comprehensive vision, or integrating and standardizing technology, the water domain has not yet attained a satisfactory degree of maturity. The three elements energy, food, and water are essential at our current pace of consumption and expansion, a shortage of water might halt the supply of food and energy and halt economic growth. Using a digital strategy that is both actionable and adhered to must be put in place that emphasis on business needs and convey the advantages and quick payback to establish a connection between the strategies supporting outcomes and the digital technology investment. This strategy will make it possible to support the digital transformation agenda. Let's collaborate to bring about a significant shift in this world as we are on the tip of an amazing transformation.

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