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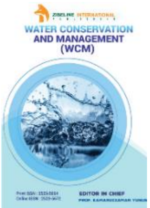

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REVIEW ARTICLE

ENHANCING WATER SUSTAINABILITY INDEX ASSESSMENT THROUGH RISK MANAGEMENT, IOT, AND ARTIFICIAL INTELLIGENCE IN WATER OPERATION: A REVIEW

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ABSTRACT

Water is an important element for all living things. It is very important to have sustainability in drinking water operations. This is because sustainability in drinking water operations means continuous water supply without interruption. Sustainability is very related to risk management. This can be said that a good water supply sustainability index must be assessed using good risk management. However existing water sustainability index has proved inaccuracy, this can be seen from the sustainability index parameter that has the same weight between each other. An additional method such as Artificial intelligence and IoT was needed to enhance the accuracy of the water supply sustainability index. This method (artificial intelligence and IoT) was used as an enhancement for risk management parameters based on its severity, thus impacting sustainability index accuracy. In this paper, we propose to review detailed risk management research and operations management for sustainable drinking water supplies. Various challenges (issues) that exist in the water sustainability index that are inside drinking water operations are presented together with the future direction of sustainability index based on artificial intelligence and IoT that can enhance the framework. A good drinking water operation combined with enhanced risk management (IoT and artificial intelligence) can boost the sustainability index (assessment) accuracy.

KEYWORDS

Risk Management, Water Sustainability, Drinking Water Operation, Artificial intelligence, IoT

1. INTRODUCTION

In this modern age water is an important element for all living things. The general problem of human daily life, it's very highly significant to provide or generate a sustainable water supply from the water reservoir, river, or even from rainwater (Mocek-Plóciniak et al., 2021; Song et al., 2009). In big metropolitan cities, the water supply comes from river water treatment plants (Altansukh et al., 2011). Therefore, it is important to have good water supply operation management in the water treatment plant. The very specific problem is that conventional water delivery systems have poor management and operations, which contributes to erratic water supply or, in certain cases, no service at all (Mohapatra et al., 2022). To solve this problem, and to ensure the security and sustainability of drinking water supplies, it is vital to have a full drinking water system that incorporates water supply, quality, and management.

The sustainability phrase comes from 2 words, which are sustain and ability. Sustain means "caused to continue for an extended period without interruption", while ability is "a skill to do something" [Oxford Dictionary]. We could simply say that sustainability is the skill to be maintained for an extended period without interruption. Those statement would be in line with sustainable development definition from United Nation (UN) in Brundtland Report 1987, which is "growth that satisfies current needs while without jeopardizing the potential of next generations to fulfill their own needs" (Brundtland, 1987). Sustainability is very related to risk management. According to Schulte and Knuts, The adoption of a risk management strategy can be utilized to reveal potential negative effects of sustainability-related decisions (Schulte and Knuts, 2022). Another researcher such as Wong emphasized non-financial risk management's importance for boosting business sustainability (Wong, 2014). From those 2 cases, we may claim that the relation between risk management and sustainability is very deep. A good risk management will produce a good sustainability index and a bad risk management will produce a bad sustainability index.

Risk management was built on risk assessment with the purpose to produce the best management policy (Simonovic, 1997). There are several epistemological approaches to risk, such as risk developed concerning uncertainty and possible undesirable consequences. Risk epistemological approaches have been identified and comprehended variously over time and throughout fields of study (Althaus, 2005; Aven, 2012). The general concept of risk management consists of negative opportunities and threats that have or will occur (Linnerooth-Bayer et al., 2010). Risk management processes need to be controlled to reduce the risk until it is accepted by the users (community, people, etc) (Klinke et al., 2021; Van Asselt et al.,

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2011).

The objective of this paper would be to enhance the water sustainability index using risk management, IoT, and artificial intelligence, The authors would like to highlight the risk management that combines with IoT and artificial intelligence, how it can or may improve the sustainability index, and how it can be used in drinking water operations. We would also like to highlight the potential issues and obstacles that may arise when risk management is combined with IoT and artificial intelligence.

The schematic of the paper is explained as follows: Section I describes the needs of risk management and sustainability index in drinking water. Section II presents risk management. Section III presents sustainability and Section IV presents drinking water operation. Section V presents risk management, its relationship with the sustainability index, and its implementation in drinking water operations. Section VI presents challenges and issues regarding those three topics. Section VII describes future research that is possible to do. Section VIII conclusion of our survey paper result.

2. RISK MANAGEMENT

There are several stages to ensure that all actions taken from within risk management include evaluation, alternative decisions, action plans to address appropriate risks and evaluation of risks that have been carried out (Monis et al., 2017; Hrudey et al., 2006; Pollard et al., 2004; Hrudey, 2001). Pollard et al. define a comprehensive range of many risk types (including those related to drinking water) that affect society as a whole: financial risks, business risks, environmental hazards, health risks, reputational risks for an organization, risks brought on by inadequate regulation. Various risks challenges are incorporated in various regulatory frameworks, necessitating the use of various risk management techniques (Bernero, 2002).

Risk management in drinking water has contributed to the assessment based on water quality risk, safe drinking water, consisting of political issues for public health protection from pathogens, toxic concentrations of chemicals, microbial pathogens issues, as well as environmental quality instance of plastic and microplastic pollution and antibiotics (Jayaratne, 2008; Vieira, 2007; Sorlini et al., 2017; Hasan et al., 2021; Al-Sulaiman et al., 2012; Kouzminov et al., 2007; Wee et al., 2017; World Health Organization (WHO) , 2019; Ferraz et al., 2020; Barroso Pena et al., 2019; Shi, 2022). Therefore, this the legal aspects for water availability issues (Yastrebova et al., 2021; Otazo-Sánchez et al., 2020; Weintraub et al., 2017; Hassanzadeh et al., 2016; Cai et al., 2021; Pérez-Blanco et al., 2014; Tzanakakis et al., 2020; Singh et al., 2020). It is clear from previous studies that risk management in drinking water includes considerations for the welfare of people, the environment, and the legal, and political. The Risk assessment benefits drinking water companies by improving water adequacy, increasing operational effectiveness, eliminating consumer complaints, saving production costs, and eliminating potentially harmful accidents (Tsitsifli et al., 2021).

Even though risk assessment has benefits for operation management, it is not without fault. The fundamentals of risk evaluation and management remain have uncertainty regarding some problems, in that sense both practice and scientific work depends on views potentially seriously mislead decision-makers (Aven, 2016; Aven, 2012). Furthermore, weak basic knowledge among others results in complicated assign the effect and opportunity and also in an assignment of the occurrence itself (Flage and Aven, 2015).

3. SUSTAINABILITY

Many associate sustainable developments of the “Triple Bottom Line” perspective with issues involving the economy, society, and the environment (Mihelcic et al., 2003; Singh et al., 2012; Singh et al., 2009; Ekins et al., 2003). Elkington first mentioned three aspects of decision making: financial, social, and environmental (Elkington, 1997). The construction of TBL "Triple Bottom Line" is built on consistency since the build is specifically predicated regarding the fusion of the three lines. Furthermore, TBL provides similar importance on all three lines, which adds equilibrium and coherence to the framework (Epstein et al., 2017; Reference et al., 2022; Hourneaux et al., 2018).

Therefore, Rosen et al revealed that two sustainability models based on a triple bottom line with a “Venn Diagram” model of Intersection circles (left), implying that the three sustainability areas are all equally crucial and the “Bull’s eye” model (right), which holds that the environment is the first and most important area without wherein humans cannot exist as can be seen in Figure 1. There is a social realm within the environmental realm, which includes an economic realm. According to this point of view, the environmental realm is the most significant and the economic realm is the least significant for long-term development (Rosén et al., 2015).

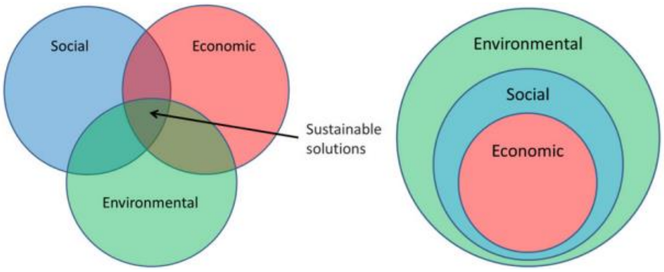

Figure 1: Two sustainability models, the “Venn diagram” model (left) and the “Bull’s eye” model

A variety of standards and frameworks have been created to evaluate an organization's sustainability. based on the concepts of sustainability, such as the Global Reporting Initiative (GRI), Principles for Responsible Investment, and International Integrated Reporting Council (Pryor, 2016). Even though frameworks such as GRI were becoming important for sustainability effect that caused by managing water utilities (Marques et al., 2015). However, water planners rarely use the guidelines due to a lack of practicability and data presence (Rathnayaka et al., 2016). Therefore, there are several case-specific frameworks that cannot be applied for a thorough sustainability assessment of sustainable long-term water use planning.

The GRI framework has offered a new perspective for sustainability measurement and is the most popular framework for sustainability reporting worldwide (King et al., 2015). GRI is a sustainable reporting framework used to increase transparency and exchange of information related to economic, social, environmental and organizational governance that is communicated sustainably by reflecting positive and negative impacts (Fig.2) (Mohapatra et al., 2015).

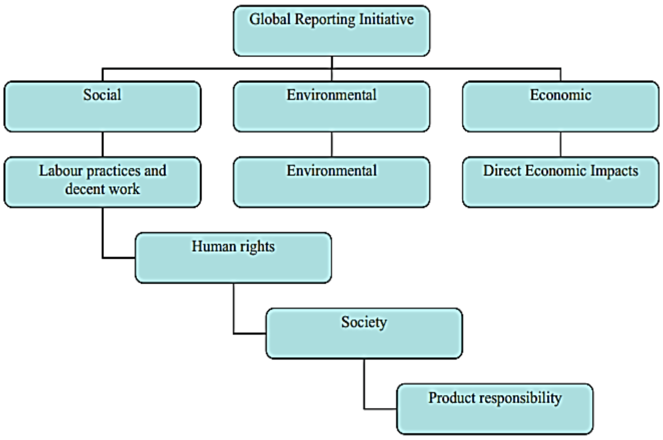

Figure 2: The organizational hierarchy of the global reporting initiative (GRI) framework adopted.

4. DRINKING WATER OPERATION

The production and distribution of drinking water supply consists of a network of interconnected institutional, physical, and organizational variables and processes. Water is a fundamental asset that can be obtained through surface water (a lake or river) or groundwater (the water held underground in an aquifer). Water was supplied from water sources to water treatment facilities and from water treatment facilities to end customers via an underground pipeline infrastructure (Plummer et al., 2010).

The basic water treatment for drinking water, referred as conventional treatment, includes of disinfection, coagulation, flocculation, sedimentation, filtration, and disinfection within detailed process are (Gerba et al., 2020):

i. Chlorination is a single treatment technique that disinfects chlorine compounds (Figure 3.A).

ii. The filtration treatment train consists of filtering after chlorination using sand or coal, which eliminates particulate particles from the water and decreases turbidity (Figure 3.B).

iii. Before filtering at the next phase of treatment, a coagulant is used during in-line filtering. (Figure 3.C).

iv. *Coagulation* changes the physical and chemical states of suspended and dissolved particles, making filtering easier. More conservative water treatment facilities include a flocculation (stirring) phase before filtration, which increases particle agglomeration and removal effectiveness in a treatment process train known as *direct filtration* (Figure 3.D).

v. The most typical drinking water treatment process train, referred as *conventional treatment*, consists of, filtering, coagulation, sedimentation, flocculation, and disinfection (Figure 3.E)

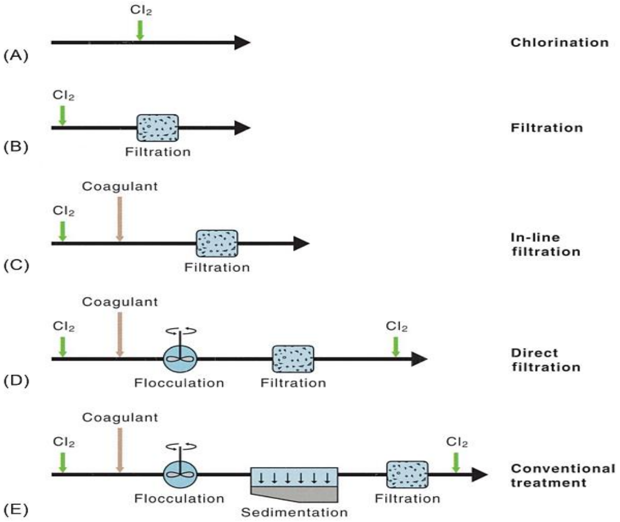

Figure 3: Typical technique for treating drinking water

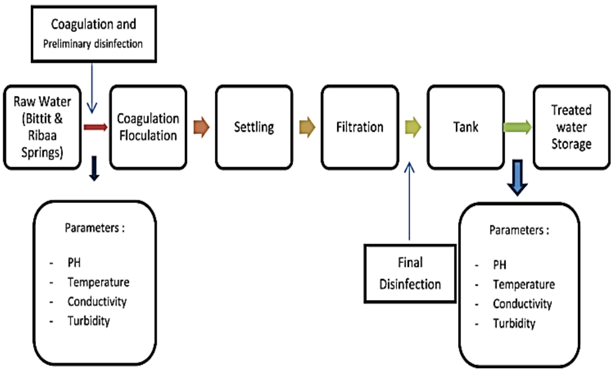

Figure 4: A general overview of the water treatment plant (Farhaoui et al., 2016)

5. SUSTAINABILITY IN DRINKING WATER OPERATIONAL EVALUATION USING RISK MANAGEMENT

Maintaining the provision and long-term clean water and sanitation is also a critical element of the UN Sustainable Development Goals 2030 (UN General Assembly Resolution 70/1). The management of Sustainable water is critical since it guarantees that social, economic, and environmental concerns are taken into account at all levels of water management. Long-term water sustainability can be achieved with the application of water sustainability indices (Juwana et al., 2010). To determine the sustainability of different management of water supply and demand policy alternatives, a thorough assesment methodology that can evaluate a variety of these options is essential (social, economic, environmental, functional performance, and risk-based). The literature conducted from year 2000 until 2016 does not have a framework for evaluating policies that is so comprehensive, general, and detailed.

Numerous studies have been conducted on the implementation of sustainability in water companies. Water supply sustainability must be assessed for the development and administration of a vast water resources system that includes reservoirs, cross-water transfer, and customer and interested parties from various sectors such as drinking, industry, fish farming, agribusiness, and the environment (Abdi-Dehkordi et al., 2021). The study, sustainability requirements for water supply, discusses the importance and challenge of reconsidering techniques for water resource management and planning. Some techniques for measuring and modelling sustainability are described, as well as examples of how these metrics and models could be deployed for assessing designs and operating policies (Anon, 1998).

Climate change and the increasing demand for drinking water risk the global sustainability of drinking water supplies. To address this concern, local drinking water systems must be adapted. Van Engelenburg et al. suggested the following policy development processes for sustainable drinking water supply in the Netherlands: (1) water resource availability, water quality, and the effect of drinking water abstraction; (2) technical system dependability and toughness, as well as influence of energy use on the environment, and (3) water management, availability of drinking water, and water and land use. Sustainability is a conceptual idea, finding it challenging to evaluate (Van Engelenburg et al., 2021). Based on quantitative metrics, a variety of sustainability practices were created. Despite water resource scarcity, climate change, and population growth, long-term sustainability in water distribution systems is a key challenge (Momeni et al., 2021). Sustainability is a fundamental concept to develop when assessing if current water management strategies are sustainable and ensuring sustainability in management decision making (Harmancioglu et al., 2013).

For integrated water risk assessment, seven SDG criteria includes five outcome-based targets were chosen to comprehensively represent varied water concerns (wastewater treatment, water resources management,, drinking water sanitation and hygiene, water stress, water productivity, and transboundary cooperation). Risk management's function is focused on identifying and analyzing the impact of loss on business, environment, and the society. Risk management improves the effectiveness of the business, thus making it more appropriate choices regarding sustainability. It also focuses on preparing by coverage budget and developing strategies to ensure sustainability (Abdel-Basset et al., 2020). This was a challenge for company with the small systems owing restricted resources that serve 10,000 consumers (Jones et al., 2019).

The sustainability index approach can be used to evaluate sustainability. To address various environmental issues, several sustainability indices have been developed. In the current past, five indices refer to drinking water sustainability have been research. They are the Canadian Water Sustainability Index (CWSI) by the Policy Research Initiative, the Watershed Sustainability Index (WSI) by Chaves & Alipaz, Water Poverty Index (WPI), West Java Water Sustainability Index (WJWSI) by Juwana et al, and Water Supply Systems Sustainability Index (WSSI) (Government of Canada, 2007; Chaves et al., 2007; Sullivan, 2002; Odjegba et al., 2020).

Canadian Water Sustainability Index (CWSI) was developed by Water Policy Institute (WPI) and the Policy Research Initiative (PRI) in 2007. CWSI measures the socioeconomic, environmental, and physical characteristics of Canada's water supplies.

The WSI is a comprehensive indicator based on the state of the basin's Hydrology, Environment, Life, and Policy (HELP) and it is appropriate for use in the Langat River reservoir in Malaysia, which has an equivalent area of catchment (up to 2,350 km^2) (Elfithri et al., 2018). Chaves and Alipaz established a watershed sustainability index (WSI) that combines environmental, life, hydrologic, and political interests, as well as current pressures and regulatory actions, into a single combined indicator that applies a pressure-state-response function.

WPI is a systematic tool for managing water developed to assist in more appropriate management of water and water supply evaluation in accordance with the sustainable method of evaluating development progress (Sullivan et al., 2002). It is possible to assess the Water Poverty Index (WPI) locally, regionally, or nationally. The index has found use in policymaking as a useful tool for managing water, notably in processes for allocating resources and setting priorities (Giné Garriga et al., 2013). WPI assists in developing strategies, assessing plan progress, and establishing development priorities. If WPI is calculated on a time-interval basis, it can be effectively utilized to track the development process (El-Gafy, 2018).

The West Java Water Sustainability Index (WJWSI) is founded on input from key stakeholders. It has 11 indicators and a set of four components. The use of the Delphi technique is introduced in the second half to complete decisions the WJWSI framework. This water sustainability index for West Java, Indonesia was proposed by (Juwana et al., 2010).

The Water Supply Systems Sustainability Index (WSSI), a field evaluation tool, was developed to provide a quick assessment of drinking water systems in a few Nigerian areas, both urban and rural. The WSSI categories for the systems were Sustainable, Highly Sustainable, Unsustainable, and Averagely Sustainable. The WSSI is easy and focuses on the property owner's sources of water as well as water users. WSSI is a quick assessment technique it should not be used in place of sanitary risk assessment or water quality assessment techniques, but rather as a field studies assessment instrument for water sources.

The previous 5 sustainability indices focus strongly on water management, water infrastructure, and water supply in the relation of poverty. Studies highlight the importance of using water sustainability indices to identify factors influencing the improvement of water supplies, help decision-makers emphasize problems or initiatives designed to improve water supplies and explain the current state of available water resources.

The five existing indices, CWSI, WSI, WPI, WJWSI, and WSSI (shown in Table 1), are composed of a collection of components representing different components of water supply sustainability (Juwana et al., 2012). As shown in Table 1, The CWSI has five components and fifteen indicators; the WSI has four components and twelve indicators; the WPI has five components and seventeen indicators; the WJWSI has four components and twelve indicators; and the WSSI has five components and fifteen indicators. The five indices are based on the development of a literature study for components and indicators as a whole.

Water scientists initially offered water as a utility to eliminate poverty, through WPI presenting an evaluation of water stress and water shortage. The index successfully met its objectives by developing an active association between water accessibility and poverty in different nations and comparing 147 national levels with their global status (Sullivan et al., 2003). Furthermore, the WPI presented a methodology based on the sustainability concept to evaluate water sustainability through poverty eradication. In 2007, the Canadian Policy Research Initiative developed the CWSI framework to evaluate water sustainability in Canada by adopting the WPI methodology. CWSI was able to assess clean water demands for urban people, with a focus on rural, remote, and aboriginal populations, as well as wastewater management challenges. The WSI was constructed in Southern Brazil in ways to construct a comprehensive technique within a framework for assessing the sustainability of reservoir management. This methodology able to meet water sustainability and give appropriate information to decision makers, allowing them to eliminate sewage pollution, enhance forest conservation, and advance water resource policies. The WJWSI was adopted to evaluate the sustainability of West Java Province's water resources in Indonesia. The WSSI was developed for drinking water supply systems and it was simple to implement and communicate, especially in low-income countries, and it contributed to the achievement of the relevant SDG (Carter, 2006).

Table 1: Detail of component and indicator of CWSI, WPI, WSI, WJWSI and WSSI

CWSI Component	**Indicator**	**WSI Component**	**Indicator**	**WPI Component**
Resource	Availability	**Hydrology**	Pressure	**Resources**
	Supply		State	
	Demand		Response	
Ecosystem	Stress	**Environment**	Pressure	**Access**
	Quality		State	
	Fish		Response	
Infrastructure	Demand	**Life**	Pressure	**Capacity**
	Condition		State	
	Treatment		Response	
Human Health	Access	**Policy**	Pressure	
	Reliability		State	**Use**
	Impact		Response	
Capacity	Financial			**Environment**
	Education			
	Training			
WJWSI Component	**Indicator**	**WSSI Component**	**Indicator**	
Conservation	Availability	**Access**	Distance of Water Source	
	Land use changes		Closer proximity	
	Water Quality		Water source is easily accessible	
Water Use	Demand	**Quality**	The water source is polluted	
	Access		Sources of contamination	
	Water Services Provision		Protected and treated source	
	- Coverage	**Reliability**	Variability in quantity	
	- Water Loss		Low quantity consumption, largely, due to access	
Policy and Governance	Information Disclosure		Water source is available on demand	
	Governance Structure	**Cost**	High Cost	
	Public Participation		Consumers cover 10–15% of construction cost	
	- Education		Low consumer costs (time/energy/health)	
	- Poverty	**Management**	Consumer cooperation to management is ONLY Financial	
	- Sanitation		For the system to work, consumer support is needed in addition to financial support.	
	- Health Impact		The owner of the water supply system is the only one who manages (self-supply system)	
	Law enforcement			

Many studies in this field focus on risk management to obtain a sustainable Drinking water company. Risk management is critical for analyzing sustainable water supplies. Innovative approaches to developing appropriate assessment methods are required for sustainability. In this context, using the expected value of risk and the conditional expected value is no longer sufficient.

5.1 IoT and Artificial Intelligence in Sustainability and Drinking Water Operation

A. *Best Practice IoT for Water Operation and Management*

There are a lot of IoT concepts that have been developed to produce good water management (Zeng et al., 2021; Jiang et al., 2011). However, we would like to review SWG (Smart Water Grid) that has been developed by (Koo et al., 2021) (see Figure 5 for SWG Architecture).

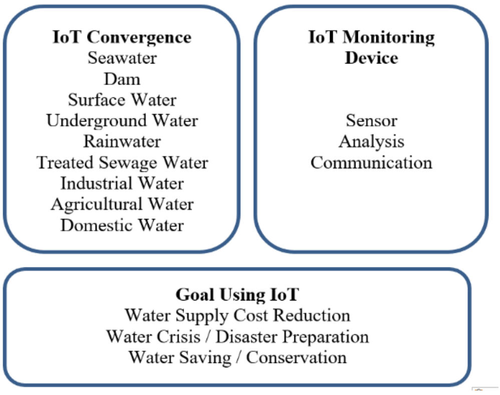

Figure 5: Best Practices SWG Architecture.

Intelligent system for managing and distributing water sources was started from the water source using IoT technologies. In the water source, a real-time intelligent system for regulating and administering sources of water was deployed using an array of flow meters and image-based water level measurement sensor. This sensor was installed for monitoring water resource availability and to evaluate supply capacity based on its availability. In water treatment, sensors were installed for 5 water quality indicators such as Temperature, PH, Alkalinity, Turbidity, and Electrical Conductivity. That parameter isn't absolute many different paper present different parameter such as dissolved oxygen (DO), ammonia-nitrogen (NH3-H), and chemical oxygen demand (CODMn) (Qi et al., 2020). There are also others stated that 11 water quality parameter was needed such as chlorophyll-a (chl-a), total suspended sediments (TSS), total phosphorus (TP), coloured dissolved organic matters (CDOM), water temperature (WT), sea surface salinity (SSS), Secchi disk depth (SDD), biochemical oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), and turbidity (Gholizadeh et al., 2016). Koo et al sensor monitors the 5-water quality parameter of incoming water and processes it to the selective water intake. Pump status (pump working and pump failure) was also monitored by the IoT system. This IoT system can be including a SCADA system as proposed by Salomons et al. Using this system, it's possible to achieve a selective water intake system. Using intelligent water source management and distribution system, Koo et al claimed that it can achieve water supply processes efficiency for 5% in regular and emergencies based on energy costs and water resource independence.

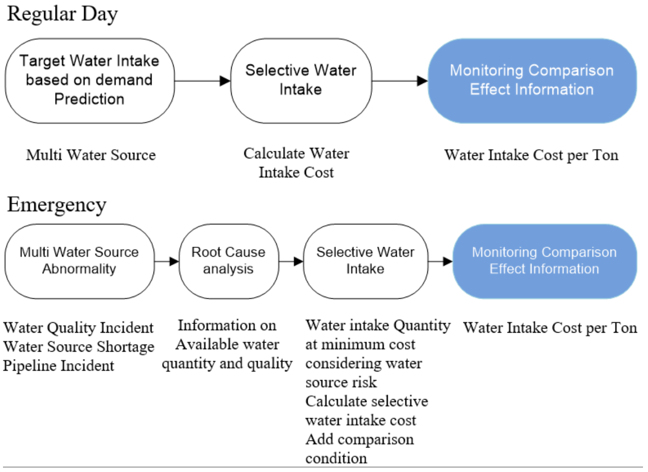

Figure 6: Intelligent water source management and distribution system for regular and emergency water supply

Smart WDN (Water Distribution Network) Planning / Control / Operation establish to supervise and manage water supply operation. When real-time water measurement using IoT devices such as AMI (advanced metering infrastructure) exists, a water supply plan then will be executed such as water withdrawal from the water source, distribution of water supply, leak management, and pump scheduling (Wang et al., 2021; Nimbargi et al., 2017; Saluja, 2020). a water filtration plant and water intake plant receive water from a water source. Using forecasting costumer demand, the ideal water capacity supply from the distributing water source can be calculated. Using IoT management of water intake is also possible using production volume data based on end-user demand. With this system, it can reduce power, and chemical treatment costs, and conserve water (Al-Mulla et al., 2021).

IoT technology such as water quality sensors and AMI devices form the main basis of water information service and analysis (Manjakkal et al., 2021). AMI device composes of SMD (Smart Meter Device), ED (End Device) that collect water consumption, OHD (Outdoor Home Display) for outdoor checking, Each Smart Meter Device is managed by the EDM (End Device Manager), and the NC (Network Coordinator) uses a mobile communication network to send the data to the server. By using IoT such as AMI devices, it was possible to forecast water consumption by using end-user water consumption data that has been stored in a database (Bali et al., 2021).

Although not in a very precise location, IoT can also be used to pinpoint the pipeline where the leak occurs (Gautam et al., 2020). This needed to be done for the engineer to carry out prompt pipeline leak repair work to minimize non-revenue water. However, some of the underground pipelines are hidden and challenging to reach. Therefore, abnormalities can only be sensed by vibrations or ultrasonic waves, or an analysis from water pipelines network (Xu et al., 2019). The two main categories of such analysis are pressure-driven and demand-driven techniques (Laucelli et al., 2012). Recent attention has been focused on a pressure-driven water pipeline network study since water demand can be predicted as a function of pressure circumstances (Adedeji et al., 2019). Due to many uncertainties, it is still thought to be challenging to anticipate pipeline irregularities using either model. The maximum amount of water per person in accordance with the population has typically been applied to a demand-driven water pipeline network study to determine the suitable pressure for the design of a city. IoT can also be used to visualize a hydraulic pipeline network. With intelligent sensors, this network can show a real-time event (Abdelhafidh et al., 2018). This network can be interfaced and visualized using GIS technologies (Wang et al., 2008). A series of end-user nodes, pipes, distributing reservoirs, valves, and pumps, all can be visualized using GIS technologies (Safwani et al., 2020; Firdausi et al., 2021).

B. Artificial Intelligence for Sustainability in water operation and management

Artificial intelligence in water operations and management was started with an intelligent sensor. Koo et al propose to use an image-based water level gauge sensor for monitoring water level. This can be achieved by using an ordinary camera and SCED algorithm or CNN (Utomo et al., 2021; De Oliveira Fleury et al., 2020). For pump control, Abdullah et al proposed to control the pump using a fuzzy system. Compare with conventional system control pumps using a fuzzy system prove significantly that less water is being used, and watering time has decreased and its result is parallel with Koo et al. (Abdullah et al., 2021). Another case for Artificial intelligence for water pumps was pump fault/health monitoring conditions using CNN as proposed by (Sun et al., 2020).

The water quality monitoring data from the sensor in Koo research can be useful as a dataset from time to time. It can be useful for modelling and forecasting water quality in the face of water pollution. This can be achieved using ANFIS, Feed-forward neural network, and KNN while others propose PSO, NBC, SVM and many others (Al-Adhaileh et al., 2021; Agrawal et al., 2021; Izhar Shah et al., 2021; Karamoutsou et al., 2021). The statistical analysis based on measurement data that has been collected using an AMI device in real-time situations provides end-user water consumption data. This data also can be completed with additional data such as water reception rate, pipe diameter, usage, day of the week, and location. With this thorough and current statistics on water usage data, we can also use statistical and artificial intelligence methods to forecast future water demand. The costumer water usage forecast in real-time events can be built by mixture the statistical seasonal ARIMA (autoregressive integrated moving average) and KNN method (Sampathirao et al., 2014; Oliveira et al., 2017; Antunes et al., 2018). We can see the results on every day, every week, every month basis. We can also do a comparison of the actual water supply demand and the predicted water supply demand. The selective water withdrawal from a combination of multiple water sources could employ the cost function to deliver the lowest supply cost, and the Harmony search algorithm can be used to identify the ideal solution (Yang et al., 2012; Bashiri-Atrabi et al., 2015).

Every operational state is tracked by the Smart WDN operator on a regular basis for integrated water management (Mosleh et al., 2021). However, in an emergency case, the decision-supporting system prompts the support system for decisions regarding the distribution, supply, and shutoff of water (Gwon et al., 2015). This emergency can be varied from a cutoff in the water supply, a surge in pollution from many sources, or even a drought. The decision supports system for water supply can be built using AI techniques such as ANN (Comas et al., 2009; Ponte et al., 2016). In devastating events such as war and others, sometimes it caused water networks or water reservoirs to be collapsed or be destroyed. The decision supports system can also provide an assist from different approaches. This was Ranging from utilizing a deterioration model to determine the technical service life of the water supply network to linear depreciation to determine the economic worth of the water supply network. This decision supports the system to aid in the planning of urban water network restoration that can use MCDM (multi criteria decision making) methods such as ELECTRE, AHP, WSM, TOPSIS, and PROMETHEE (Tscheikner-Gratl et al., 2017).

To optimize the design of a hydraulic pipeline network, an EPANET engine can be used for hydraulic modeling and simulation. The EPANET engine can be used to imitate pipe's and node flow rate, water pressure, water quality behavior, as well as residence time (Ingeduld et al., 2007). Besides simulation, other researchers propose to do calculations to optimize the network. The method to optimize the hydraulic pipeline network based on calculation would be EA (Evolution Algorithm) and its derivative such as GA (Genetics Algorithm) or SCE-UA (shuffled complex evolution-University of Arizona) (Ayad et al., 2018).

The hydraulic pressure distribution can be calculated using demand-driven modeling and the forecasted water demand of each end-use using SWG-DSM (Smart Water Grid). The current WDNs make it challenging to spot the leak, however with SWG-HyNet we are able to quickly identify the areas where the pressure being measured is much lower than the pressure that has been simulated, making it easier to pinpoint the leakage points. It can also provide the functioning of pumps and valves to keep the water pressure in the water pipeline network at ideal level. With the creation of daily, weekly, monthly, and yearly metadata of the input/output data of the integrated operation database, smart DB management enhances the effectiveness of SWG operation and management. There are tools for assessing each user's water use patterns and billing customers using data from remote inspection water consumption. The following features have been developed for the water information mobile app, real-time data retrieval and display for consumer water consumption or over a predetermined time frame (day, week, month, or year), information on the water utility's progressive rate and real-time water rate, assistance programs for socially vulnerable people, such as elderly people living alone or without family or friend, and a community function for two-way communication and sharing of data (Figure 17). Companies that provide water services can poll customers and react swiftly to emergencies like pipeline breakage or freezing/bursting.

5.2 Challenges & Issues for Sustainability Through Risk Management in Drinking Water Operation

A. *Optimum Sustainability Index for Optimum Drinking Water operation*

Although there is an increasing trend toward using sustainability index to support plans for long-term, medium-term, and short-term sustainable development, the sustainability index is not infallible on its own. This caused a lot of new sustainability indexes such as swam index, the Canadian Water Sustainability index, and many more (Maiolo et al., 2019). Even though there have been some instances of success with the use of these new and current sustainability indices, they are not entirely relevant in all applications. This was brought on by some of the sustainability indices that were created for usage in particular nations or regions. One could argue that there isn't a universal gauge of water sustainability.

B. *Weighted Parameter for More Accurate Water* Sustainable *Index*

Based on the first issue we have a specific water sustainability index that works on specific applications or specific regions. WSSI, which was created for drinking water systems in Southwest Nigeria, is one example of this. WSSI index contains four categories index, such as Sustainable, Highly Sustainable, Unsustainable, and Averagely Sustainable. However, in the WSSI index, all parameters have the same weight (please see in table 2). This implies that all evaluation components are considered to have equal parameter values, hence will make sustainability measurement inaccurate.

Table 2: WSSI scoring criteria

Sustainability factors	Component	Scores Obtainable
Access	Far distance to water source	0
	Closer proximity	1
	Water source is easily accessible	2
Quality	Water source is polluted	0
	Source is protected close to possible sources of contamination and untreated	1
	Source is protected and treated	2
Reliability	Variability in quantity with respect to yield or season	0
	Low quantity consumption, largely, due to access	1
	Water source is available on demand	2
Cost	High cost	0
	Consumers contribute 10–15% of construction cost	1
	Low consumer costs (time/energy/health)	2
Management	Consumer contribution to management is ONLY financial	0
	Consumer contribution is beyond financial, additional support required for the system to function	1
	Management is solely done by the water supply system owner (self-supply system)	2

All parameters should have different values and different important factors such as primary, secondary, or tertiary in the drinking water industry. This implication means that the value of each parameter is not always equal. A similar problem might arise in risk assessment. To solve this parameter ranking issue in risk assessment, enhance conventional FMEA, using Fuzzy inference IF-THEN rules for each variable for parameter weighting (Sharma et al., 2005; Tay et al., 2006). However, fuzzy is using human experience to enhance the conventional FMEA model, thus is not a very accurate model. Mirror from this FMEA experience we could enhance the fuzzy FMEA model using computational intelligence method such as ANFIS, thus providing more accuracy in sustainability measurement.

5.3 Future Trends for sustainability

The sustainability index (assessment) has been serving users to introduce the continuity of service without interruption. This Sustainability Index, however, is not omnipotent, and as a result, it contains numerous flaws that have led to inaccuracies. And to solve this problem fortunately, today we have computational (artificial) intelligence method. Computational intelligence can solve every problem such as electromagnetic wave, control and other (including to enhanced the sustainability index inaccuracy) (Hakim et al., 2022a; Hakim et al., 2018; Hakim et al., 2022b; Hakim et al., 2022c). To enhance accuracy Halkijevic et al. assess cities' sustainability index using the WSS index combine with the ANFIS method. Other researchers Liang et al, evaluate the sustainability index using interval type-II fuzzy AHP-TOPSIS combine with MEA-MLSSVM (Halkijevic et al., 2017; Liang et al., 2021). Given the tremendous challenges for further sustainable index development, a scientific and accurate evaluation technique is needed through intelligent computational mathematical modelling.

6. CONCLUSION

This study examines many facets of the sustainability system. This article also examines the link between sustainability, risk management, and drinking water operating systems. Detailed research activities concerning drinking water operational combine with IoT and artificial intelligence can enhance risk management can be found in Koo et al research. The study's conclusion is that improved risk management paired with IoT and artificial intelligence can ultimately improve the sustainability index (assessment). The various obstacles (issues) in the water sustainability index used in drinking water operations are addressed in this research. The goal of merging risk management, IoT, and artificial intelligence is to determine the best sustainability index for optimal drinking water operation. The goal of merging risk management, IoT, and artificial intelligence is to determine the optimal sustainability index for optimal drinking water operation, as well as the appropriate weight for each sustainability indicator. The conclusion of the sustainability index's future path is to find computational (artificial) intelligence that can provide accurate mathematical modeling.

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