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An investigation of smart water meter adoption factors at universities

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Abstract

The study investigates the factors affecting the adoption of smart water meters in universities. The study used a systematic literature review to explore factors affecting the adoption of smart water meters using secondary data. The Technology, Organisation, Environment (TOE) Framework was used as a theoretical lens to identify themes that affect the adoption of smart water meters. The study adopts the quantitative content analysis to identify adoption factors from published literature on smart water meters. The collected was analyzed quantitatively to reveal factors affecting the adoption of smart water meter technologies. The study results suggest that technological factors are the most popular adoption factors affecting the adoption of smart meter technology. Environmental factors are the second important factor affecting the adoption of smart meter technology. The organizational factors were the least important factors affecting the adoption of smart meter technology in organizations. The research contributes to the body of knowledge on factors affecting smart water adoption in universities. In addition, the study stimulates further research in the area using empirical and other research methods.

Keywords: Smart water, Adoption, big data, IOT, TOE, Smart Meter.

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1. Introduction

Population growth and economic development are driving demand for freshwater globally. Climate change along with urbanization will create growth in the demand for freshwater supplies, and in doing so raise the profile of water awareness [1]. Organizations such as universities need to promote the security of water, as it is a key resource in safeguarding sustainability. Smart water initiatives are as important to universities, as they are to the communities they serve. Continuous smart water innovation can better equip the universities to manage their water resources, whilst acting as an example for other organizations [2]. Smart water meters reduce costs and decrease the overall consumption of water within organizations or individual homes. Farah et al., [2] explains that smart water meters automate the process of meter reading, allowing easy exchanges of reading data. Universities are struggle to successfully implement smart water meters as part of wider smart water university innovations programme within their local campus buildings, due to the inability of these innovations to receive buy-in from their respective users. One reason for a lack of buy-in may stem from social-cultural issues. Watson [3] explains that the inability of an organization to receive buy-in from the water users will result in a failed programme, limiting the stated objectives of such a programme both financially and socially. The failure of smart water initiatives leads to no change in the consumption of water or the efficient management of the water resources [3]. This study explores factors affecting the adoption of smart water meters in universities. The rest of the structure of the rest of the paper is as follows: Section 2 literature review, Section 3 research methodology, Section 4 study results, Section 5 conclusion.

2. Literature Review

Technology is dramatically changing the way organizations operate and leverage resources. Digitization affects all aspects of an organization and thus creates opportunities for the use of new technologies [4]. In the context of a city, the use of a combination of technologies such as big data, cloud, and the internet of things gives rise to the idea of a smart city. LiMao et al. [5] explains that smart cities refer to modern cities, which utilize information system trends such as IoT, big data, and cloud computing, to improve efficiencies within operations and promote better behavior in people. There are common elements between a city and university to the implementation of the smart university concept on a smaller scale [6]. The vision of a smart university can be considerably easier to realize than that of a smart city.

The use of smart sensors has allowed many universities to experiment with dynamic monitoring interfaces as a quick and easy way to demonstrate environmental consciousness [7]. The concept of a smart university is an evolving and fast-growing area, which characterizes a creative integration of smart technologies, smart features, smart software and hardware systems, smart pedagogy, smart curricula, smart learning and academic analytics, and various branches of computer science and computer engineering [8]. It is now quite feasible to monitor campus-scale water and energy distribution systems using off-the-shelf, low-cost sensors, electronics, communication links, and cloud software stacks [7]. The lower cost of technology coupled with an awareness of sustainability and social responsibility has motivated universities to implement various smart-university approaches.

2.2 Smart water meters

A water smart-meter is an electronic device designed to record water consumption for the utility company and the user [9]. Where traditional water meters read manually in monthly or yearly intervals, smart meters record consumption in real-time or near real-time, and communicate this information to the utility and consumer. Organizations such as universities with consume large amounts of water, and thus have a large impact on the environment [10]. The demand for water is increasing at a rate that exceeds the rate of increase in available water resources [9]. O'Brien, et al. [10] states that because of dwindling water supplies and forecasted increases in demand for water, the management of water resources has become a major concern for consumers, industry, and all levels of government. The understanding that water scarcity is a growing concern on a global scale, emphasizing the need for all organizations to adopt smart water programmes or initiatives, which can negate the effects of increased demand for water and the effects of climate change.

Water-consuming organizations such as universities are increasingly utilizing smart water meters to reduce water consumption [11]. One key way in which smart meters promote water savings, is by using the data recorded and transmitted by smart meters to provide frequent feedback to consumers about their water consumption [9]. Smart water meters can also assist in the detection of leaks and rapid water consumption. Stewart et al. [12] suggest that the use of smart water meters reduce the hourly loss of water leaks by 89%. Britton et al. [13] add that smart water data help to forecast and predict future leaks based on characteristics of past leaks thereby reducing costs and improve water management planning. Smart metering is an established technology that is now cost-effective and can provide benefits to both consumers and water authorities for monitoring and controlling water consumption [13, 12]. The significant benefits for consumers include, recording of water consumption, remote reading of water usage, being able to control water consumption and water costs.

2.3 Theoretical framework

Several theoretical frameworks and models such diffusion of innovation theory (DOI), Technology Acceptance Model (TAM) and Technology Organization Environment Framework (TOE) are used to investigate technology adoption issues. The TOE Framework (TOE) is the popular adoption framework for the adoption of ICT within the context of organizations [14]. The framework illustrates that technological, organizational, and environmental contexts are exogenous variables that affect an organization's buy-in of innovative technology, with each variable affecting an organization's intent to adopt the technology [14]. The TOE framework was found suitable for the study, which is based on three constructs: technology, organisation and environment [15].

2. 4.1 Technological factors

The Technological adoption factors of the TOE framework consist of internal and external variables that influence organization in accepting innovation [15, 6]. Internal technologies relate to practices and technologies within the organization, whilst external technologies refer to the group of technologies available on the open market [6]. In the case of smart universities and smart water innovations, external technologies include smart meters and smartphone technologies, which form a smart water grid [14]. Previous studies on IT adoption found that technological characteristics, such as perceived benefits, perceived cost, and perceived risk, had a significant influence on the adoption of technologies [14]. The TOE framework suggests that factors such as perceived risk, perceived cost, and perceived benefit of the innovations will play a large role in adoption of technology [14]. Other important factors to consider about smart water meters include perceived ease of use and compatibility with existing infrastructure [16].

Many perceived risks are associated with the use of smart water meters and the data they gather. The perceived benefits of smart meter technology are a significant factor in the adoption of the technology, for both users and organizations [17]. From the perspective of the smart university, the effective management of water resources to save money and water is a substantial benefit and a factor to consider when adopting smart water meters. The perceived cost is a significant barrier to smart water meter adoption. The infrastructure costs for organizations can negatively affect the adoption of smart water where financial resources are less. The inability to quantify the return on investment is a critical risk factor in the adoption of smart water meters [14]. Perceived ease of use in the context of smart water meters is another significant factor in the adoption of smart water meter technologies [16]. Previous studies suggest that ease of use is a significant factor in the adoption of smart water meters [16, 17].

2.4.2 Organizational Context

The organizational context within the TOE framework refers to the characteristics and resources available to an organization for successful adoption and operationalization of the new technology [15, 6]. Support for new technology is a critical factor in the adoption of smart water meters. The benefits of technology are lost if there is no direct support from the organization in efforts to adopt innovatively [6]. Ignoring the need for supporting information could lead to the benefits of smart water meters not being realized. The support of management within an organization is key to the success of any smart programme. Top Management can influence policy and determine strategies, the key to smart water initiatives [14]. The adoption of smart water meters in an organization depends on how mature an organization is in its capabilities and operations. The importance of organizational size and scale realizing a meaningful return on investment from networked smart water meters [14, 10]. Larger organizations are more likely to perform frequent maintenance of water infrastructure and upgrade existing infrastructure more efficiently than smaller organizations.

2.4.3 The Environmental Context

The environmental Context of the TOE framework represents the landscape in which an organization conducts its business. This may include factors external to an organization that present prospects and limitations for technological innovations [6]. The environmental smart meters adoption factors may relate to relationship with suppliers (industry standards), the macro environment (environmental concerns) and the legal framework (Government Policy) among others [14]. Organisations are accepting climate change as one of the most significant problems facing the world, and thus are willing to invest resources into smart technologies to protect the environment [6].

Sustainability and environmental leadership have moved to the forefront of the public consciousness, and many universities have followed industry is working to develop or implement formal environmental policies, programs [6]. The benefits of the smart water meter are to the notion of preserving the natural environment, creating a powerful macro adoption influence for an environmentally aware smart university. Smart water meters influence consumer behaviour in a way that reduces inefficacy and expensive peak demands [10]. Government laws play a very important role in the adoption of smart water meters. Government policy is also able to dictate water efficiency programs and regulations, which directly influence the adoption of smart water meters [14]. The implementation and maintenance of smart water meter networks require specialized skills. The non-availability of external technical skills required in smart water meter infrastructure can ultimately undermine the adoption of the technology by organizations such as universities.

3. Research Methodology

The study objective was to investigate factors affecting smart water adoption in universities using a systematic literature. The study conducted in used published articles on factors affecting smart water adoption in universities. The study conducted in 2018 used published articles between 2009 and 2018. The study adopted a systematic literature to investigate factors affecting smart water adoption in universities from articles published 2009 – 2018. The theoretical framework for the study was based on the TOE framework. The study used content analysis research design to review published articles relating to the benefits and adoption factors of smart water meters in organizations between 2009 and 2018. Content analysis allows qualitative data collected in research to be analyzed systematically and reliably so that generalizations can be made from them about the categories of interest to the researcher [18]. The unit of analysis for the study is the organization. Thus, the unit of analysis allow for reliable inferences in the published article.

The convenience (opportunity) sampling was used to select articles from which data for the study was collected. The convenience sampling is a non-probability sampling method that relies convenient availability of a participant member population on data collection in the study [19]. The process of convenience sampling for the study involved searching for keywords in a library database. The keywords used in the screening process included text terms such as 'smart water', 'Adoption Factors', and 'TOE'. The literature search revealed 53 articles that met the study criteria. The selected articles were peer-reviewed and published between 2009 and 2018.

The collected data was analysed by observing of themes in the published articles. A set method of coding based on literature matrix was used to convert the qualitative data from the published articles to quantitative data. The K ALPHA inter-coder reliability test was used to enhance the reliability of findings, as manual coding is a subjective process [18]. The study used quantitative statistical methods to the quantitative data using SPSS to generate descriptive and inference statistical results based coded themes from TOE adoption factors.

4. Research Results

This section present the results of data analysis of the study. The first sub-section 4.1 present the frequency of the demographic data variables year article published and region of the article. The second sub-section 4.2 present the frequencies of the benefits of smart meters. The third sub-section 4.3 present the frequencies of the variables, which are part of the TOE framework constructs drawn from literature.

4.1 Demographic data

This section present the demographic of the published articles on factors affecting smart water adoption in universities from articles published in ten-year period 2009 – 2018. Figure 1 presents the frequency of the published year of the articles that were analysed for the study. The results indicate that there was increase of articles published on smart water meter from 2009- 2018. The study results show 79% of the articles were published between 2014 and 2017 compared to 21% between 2009 and 2013. The highest frequency of published year of article was during 2017.

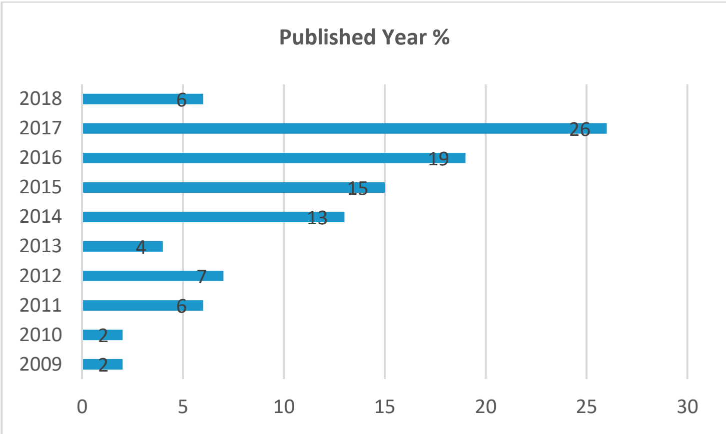

Figure 1: Published year

Figure 2 present the geographical region breakdown of the published articles on factors affecting smart water adoption in universities from articles published in ten-year period 2009 – 2018. The results indicate that 33% of the articles were published in Europe, 25% of the articles were published in America, 24% of the articles were published in Asia, 12% of the articles were published in Africa and only 6% of the articles were published in Oceania. Europe and America contributed 60% of the published articles on factors affecting smart water adoption in universities from articles published in ten-year period 2009 – 2018. Africa and Oceania had the least published articles compared to other regions of published articles on factors affecting smart water adoption in universities from articles published in ten-year period 2009 – 2018.

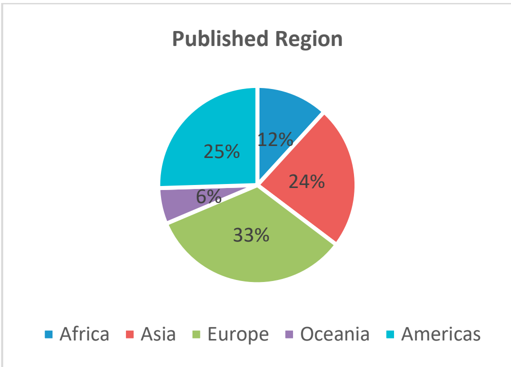

Figure 2: Published Region

4.2 Smart water meter benefits

Figure 3 present results of the four significant benefits of smart water meter from articles published in ten-year period 2009 – 2018. The results from the study show reducing water demand was the most mentioned benefit from published articles (35%), followed by cost savings benefit (29%). The accurate billing and improved maintenance benefits had both 18% of the published articles. The results suggest that the most significant perceived benefits of adopting smart meter technologies was water and cost savings.

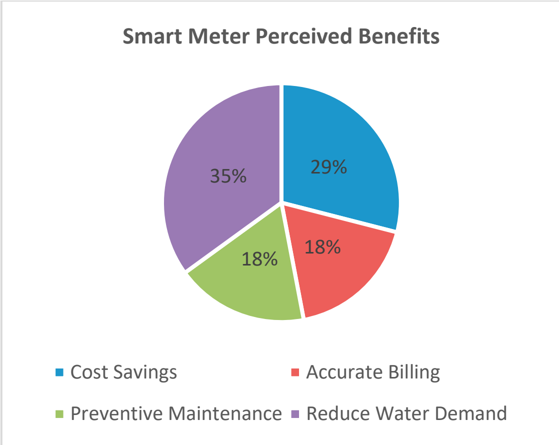

Figure 3: Smart meter perceived benefits

4.3 TOE framework factors

This sub-section present the frequency results of the three TOE framework constructs (technology factors, organizational factors, and environmental factors) variables on factors affecting smart waters adoption in universities from articles published in ten-year period 2009 – 2018.

4.3.1 Technology factors

Figure 4 present results of technology factors which influence the adoption of smart water meters in universities from articles published in ten-year period 2009 – 2018. The perceived benefits of smart water meters are the most mentioned factor (57%), financial costs (43%), perceived risk (34%) and lastly perceived ease of use is the lowest factor mentioned(23%) from articles published in ten-year period 2009 – 2018

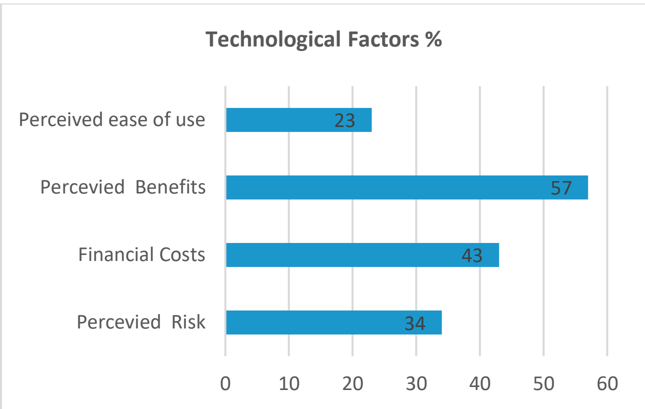

Figure 4: Technological factors

4.3.2 Organisational factors

Figure 5 present results of organisational factors, which influence the adoption of smart water meters in universities from articles, published in ten-year period 2009 – 2018. The management support smart water meters technologies adoption are the most mentioned factor (32%), decision making (21%), organisation readiness (13%) and lastly organisation size is the lowest factor mentioned (23%) organisational factor from articles published in ten-year period 2009 – 2018.

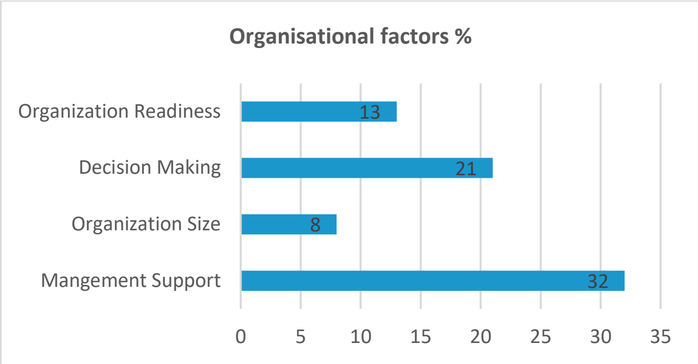

Figure 5: Organisational factors

4.3.3 Environmental factors

Figure 6 present results of technology factors which influence the adoption of smart water meters in universities from articles published in ten-year period 2009 – 2018. The infrastructure issues of smart water meters are the most mentioned factor (43%), government regulations (42%), environmental concerns (33%) and lastly industry standard is the lowest factor mentioned(23%) from articles published in ten-year period 2009 – 2018

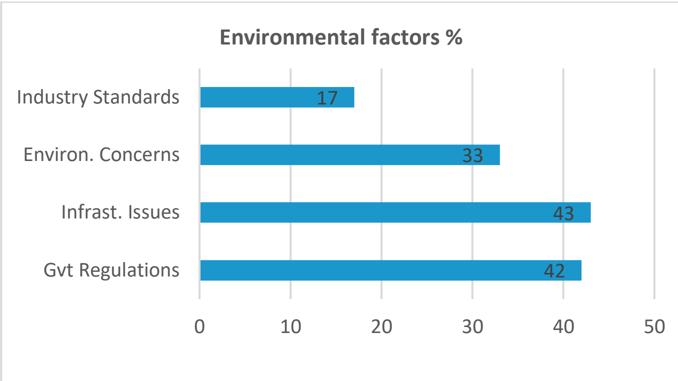

Figure 6: Environmental factors

5. Conclusion

The study adopted a systematic literature to investigate factors affecting smart water adoption in universities from articles published 2009 – 2018. The TOE framework was used as a theoretical lens to investigate factors affecting smart water adoption in universities. The study results suggest that majority of the articles on factors affecting smart water adoption in universities from articles published between 2014 and 2018. The results also show that most of the articles factors affecting smart water adoption in universities were published in Europe and America. The most perceived benefits of adopting smart meter technologies were water and cost savings. The most mentioned technological factors for adopting smart water meter were perceived benefits of smart water meters and financial costs. The most mentioned organisational factors for adopting smart water meter were the management support and decision making during the adoption of smart water meter technologies. The most mentioned environmental factors for adopting smart water meter were infrastructure issues and government regulations.

As a conclusion, the study achieved its objective to investigate factors affecting smart water adoption in universities from articles published 2009 – 2018 using a systematic literature and the TOE framework. The result showed that water and cost savings are main drivers of smart water adoption in universities. The perceived benefits of meters and financial costs are the technological factors affecting smart water adoption in universities. The management support and decision-making are the organisational factors affecting smart water adoption in universities. The infrastructure issues and government regulations are the environmental factors affecting smart water adoption in universities. Despite the study limitation of using secondary data, the research contributes to the body of knowledge on factors affecting smart water adoption in universities. In addition, the study stimulate further research in the area using empirical and other research design.

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