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ORIGINAL PAPER

A study on the factors that affect the adoption of Smart Water Grid

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Abstract Due to recent climate changes that accompany drastic changes in water recycle process, extreme floods and droughts are occurring frequently throughout the world. In response to these events, Smart Water Management that refers to implement intelligent water information systems by IT convergence is considered as a new paradigm. In this study, we seek to explore the Smart Water Management, especially the adoption of Smart Water Grid Technology. We aim to review previous studies to identify factors that influence the adoption of the Smart Water Grid and to analyze the importance and priority of the factors affecting Smart Water Grid adoption, thereby presenting the successful adoption measures for Smart Water Grid in Korea. This study set a research model with the influencing factors in relation to the adoption of new IT technologies that were identified through the literature reviews of previous studies based on the TOE framework. This study also conducted empirical analysis of the findings and found out that the issue of privacy protection and security due to hacker's attack would be emerged as a significant risk factor.

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1 Introduction

Since 2009, many have discussed the development of a Smart Water Grid that can achieve an efficient and reliable water supply with high quality around the world. In particular, since 'Water Innovation Alliance' in 2009, where the prominent water-related companies around the world participated in the launch of the Smart Water Grid Initiative, the term, Smart Water Grid (SWG) has been used widely.

Although SWG has been considered to be the next-generation intelligent water management system that can simultaneously solve the water problems and achieve economic growth, SWG research is currently in the early phase in the world and few studies have been done on the adoption of SWG technology in Korea.

Therefore, this study of the factors that affect the adoption of the SWG will be the basis for effective adoption and activation of this next-generation water management system.

2 Concept and main components

No clear definition and scope regarding the SWG have been derived so far. In addition, no consensus of the definition regarding this term has been made. However, in summarizing the concept as it has been proposed in the previous literatures, SWG can be defined as "a next-generation water management system that introduces ICT in order to increase

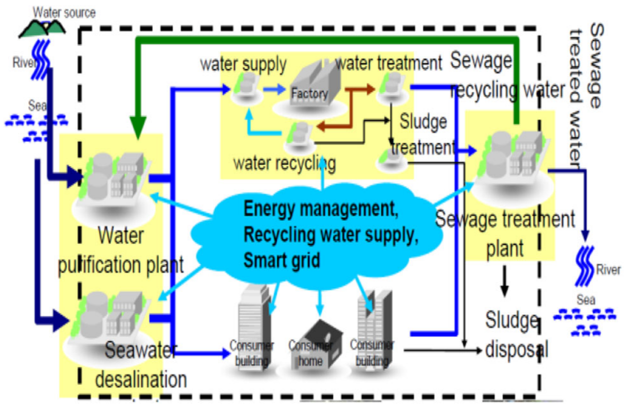

Fig. 1 SWG technologies

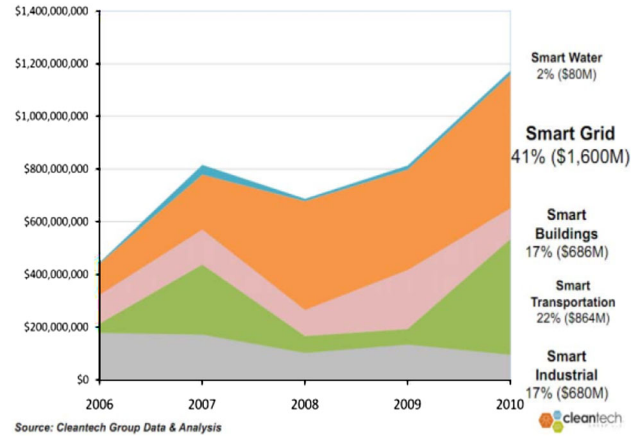

Fig. 2 Breakdown of Smart SOC [3]

the management efficiency for water resources and water supply and drainage" [1] (Fig. 1).

The SWG has the following main technological components: water resources management technology that collects and stores a variety of water resources into water platforms and also integrates and manages the distribution and transportation of water. It includes an ICT-based integration management system that can support real-time monitoring for securing, transporting and utilizing of water resources. It also supports integration management and decision making regarding water information.

3 Case studies

3.1 Background

Attempts to construct smart social overhead capital (SOC) by combining traditional SOC with information technology (IT) have steadily been made.

"Smart" SOC refers to digitalization of the entire SOC such as transportation, electrical power, education, the medical service and the environment, using built-in sensors which connect information generated from these systems with the other information through wired and wireless networks. In addition, it analyzes and predicts those systems, and responds to them optimally [2]. In other words, smart SOC is designed to provide intelligence to traditional SOC.

When the smart SOC is realized, the efficiency and functions of SOC may be rapidly enhanced. Accordingly, the concept of "smart" is gradually introduced to SOC related to water. However, as shown in the Fig. 2, "smart water" in the uppermost section is still small compared to other areas such as the smart grid in the electrical power area or smart buildings.

The reason why the need for SWG has been intensified is the lack of water resources across the globe. While the world population has increased 3.7 folds during the twentieth century, water resource withdrawals grew 6.7 folds for the same period. Therefore, the amount of water resources with annually stable availability faced limitations across the world.

The global population has grown up to about 7 billion people, due to the rapid population increases and urbanization, and half of the people live in cities. It can be predicted that usable water resources will be reduced, and water-related environmental damages will accelerate over time.

Due to such circumstances, it is essential to build and utilize water infrastructure such as multipurpose dams or tap water facilities. However, current water management systems fail to effectively respond to changes in water demand, occasionally triggering an imbalance between demand and supply and lowering the efficiency of facility operation. Other issues involve loss of water by pipeline water leakage and excessive use of energy spent for water production and transportation. SWG is expected to have diverse effects: improving efficiency of water production and supply with real-time water management through sensor attachments, reducing costs through systematic management of facilities, and resolving the imbalance of water resources between regions.

The crisis of a global water shortage provides us a great opportunity in terms of the water industry. Due to the population increase, the aggravation of the water shortage corresponding with climate change, and water pollution, the water industry has emerged as a blue gold industry to lead the twenty-first century. According to the prediction of a consulting company, Booz Allen Hamilton, investment in water infrastructure from 2005 to 2030 could amount to 22,600,000,000 dollars, which is much higher figure than the amount predicted for electrical power or other infrastructure areas [4]. The global water market which is expected to grow rapidly will provide the domestic water industry with an opportunity for a new challenge.

3.2 United States

SWG is spreading across the world under the leadership of the United States, and the introduction of SWG by countries suffering from water shortages, such as Australia and Singapore, is increasing. The concept of SWG was first introduced through the establishment of the Smart Water Grid Initiative, a private association, in May 2009. At present, the introduction of SWG is being pushed for in two dimensions: the government and the private sector. In the governmental dimension, the direction is toward building efficient water resource supply networks at the national level, and the private dimension concerns the construction of sensor networks for water resource and quality management and the installation of a two-way water information management system.

Currently, IBM in the private sector leads the development of SWG while interest from water-related businesses such as Siemens or Suez grows; IBM is globally heading the "smartization" of the water management area by pushing ahead with development of smart water management solutions [5].

1. IBM is developing data platforms that can monitor, on a real-time basis, the conditions of the Hudson River (500 km. length) of the US, by installing state-of-the art sensor networks covering all sections of the river.
2. In Brazil, IBM is developing geographical and spatial three-dimensional computer simulation systems that can predict the effects of utilization of land and water on the ecological system and can effectively manage the water.
3. In the Netherlands, IBM is working on a project of monitoring the condition of flood inundation, which changes moment by moment, and constructing smart levees that will respond accordingly on a real-time basis.

Regarding the intelligent management of water resources in the American Midwest, Lawrence Laboratory published a report on SWG TM in July 2009, presenting a new type of water resource management measure to transport water from rivers in the middle region, where damages from floods occur, to the Colorado River and the western region undergoing a water shortage. Aimed at flood prevention and drought resolution through pipelines, this plan of water resource transportation at the national level is estimated to produce a net profit of more than 33 billion dollars [6] (Fig. 3).

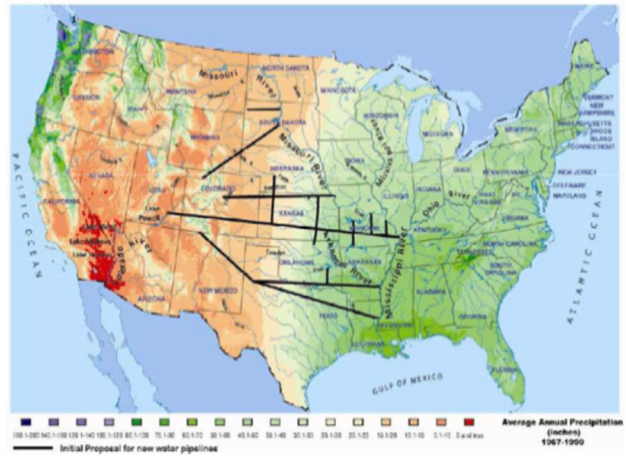

Fig. 3 US National Smart Water Grid

3.3 Australia

Another case of introducing SWG for the resolution of water shortages between regions is that of Queensland in south-eastern (SEQ) Australia. This region suffered from severe drought for 7 years, and an emergency input of 9 billion Australian dollars (0.95 billion won) was made in order to establish a new water resource development plan that secures and supplies an additional 0.35 billion m^3 of water annually. The water resource development plan included construction of new dams and enlargement of existing dams to obtain water resources, turning seawater into fresh water, to reutilize sewage, and to install 535 km of grids in order to connect regions that have extra water with other regions experiencing water shortage. Major items of the SEQ Water Grid project, a long-term project initiated in 2008 to obtain water resources, were completed within 2 years, and as a result, stability of water supply which had greatly declined due to climate change was restored to some extent [7] (Fig. 4).

3.4 Singapore

Singapore has been pursuing for four National Taps, an aggressive measure to secure water resources, in order to overcome water resources shortage within its territory.

Fig. 4 South East Queensland Water Grid

The project consists of four elements—securing water resources by constructing dams, importing raw water from Malaysia, NEWater, and the conversion of seawater into freshwater. Using such national strategies to secure water resources has been the basis for Singapore's development as a hub for the global water industry [8]. Based on the successful, government-led nurturing of the water industry, the nation has established three-step plans to implement SWG research and development (R&D) to find an optimal solution for the management of water resources. By establishing the Singapore SWG Roadmap, Singapore is pursuing R&D to build water and sewage infrastructure and to construct two-way networks of IT-based water resource demand and supply [9].

3.5 Republic of Korea

Korean government has a lot of interest in combining water with ICT, and local governments such as Jeju-do and Jeollabuk-do are considering the applicability of such technologies [10].

Representative stakeholders in relation to the introduction of SWGs are: tap water businesses such as K-water and local governments, relevant businesses that own technologies associated with SWG, citizens who are consumers, and the government and regulatory institutions. Korea's water management is composed of a dual system—the metropolitan cities and local areas centered on a public company, K-water, and on local governments. This composition is divided again into two departments, the Ministry of Land, Infrastructure and Transport and the Ministry of Environment (Fig. 5).

This fragmented structure is a problem in constructing efficient SWG. In particular, the water supply is managed by a system under which K-water and local governments monopolize the operation of tap water facilities, and therefore, this limits the private sector in expanding its participation. Regarding legal and institutional interest, the central government departments in direct charge of domestic water management tasks are the Ministry of Land, Infrastructure and Transport, the Ministry of Environment, the Ministry for Agriculture, Food and Rural Affairs, and the Ministry of Security and Public Administration. There are no uniform laws on water management, and an individual legal system is applied under which major central government departments taking charge of water management enact the necessary laws according to each water-related task. At present, there are no laws on SWG in Korea.

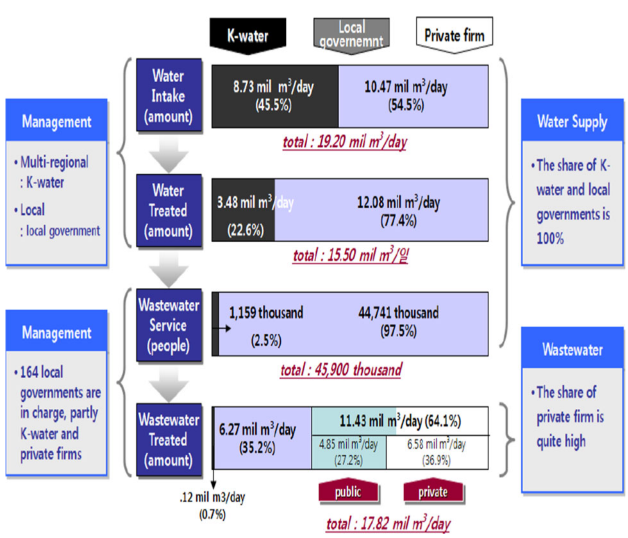

Fig. 5 Korean water management operator

For the development of SWG technologies, the Smart Water Grid Research Group has been organized and is working on it, and a total of 32 billion won (22.8 billion won from by the government and 9.2 billion won from participating institutions) will be invested for 4 years. However, it is considered that in the expanded application of SWG, water and sewage rates that fall short of costs and the burden of costs to invest in new systems will be crucial impeding factors. According to recent researches relevant to the costs coming from the introduction of the remote meter reading system, a core technology element of SWG, the cost for meter reading of incoming power for 8 years, the useful life of a meter, is 67,260 won for human meter reading and 207,839 for remote meter reading, with the latter costing three times as much as the former [11]. Efforts are necessary to heighten the profitability of SWG business by continuously developing technologies and new business models.

Water-related information systems developed so far include the following [12]:

1. The Water Resources Management Information System, the River Management Geographic Information System, and the National Groundwater Information Management and Service Center, under the Ministry of Land, Infrastructure and Transport.
2. The Water and Sewage Composite Information System (Purunuri) and Water Environment Information System, under the Ministry of Environment.
3. The Rural Agricultural Water Resource Information System and Soil Information System (Heug-Toram), under the Ministry for Agriculture, Food and Rural Affairs.
4. The Meteorological Information System, under the Korea Meteorological Administration.

Through individual construction and improvement processes, basic informatization has been embodied in each information system, but its function as a smart system including two way real-time exchanges of data and network construction through built-in sensors is still insufficient.

3.6 Implication

As a core strategy to nurture the water industry into a national brand industry, it is necessary to develop a new convergent water management technology with IT technology.

If the world's best domestic IT technology is combined with existing water and sewage management technologies, this linkage will contribute to create a brand value that might compete in the world market through the independent development of technologies.

4 Theory and framework

In relation to the bigger picture of IT adoption, the previous studies can be largely divided into technology acceptance studies that target individuals and organizations, respectively. Generally, Davis' (1990) technology acceptance model (TAM) has been used as the unified model for a technology acceptance study that targets the individual level, whereas no studies have yet recommended a unified model that could be used to target the organizational level; however, scholars have called for an unified model for both the individual and organizational levels [13].

While TAM is used to study specific technology acceptance and performance at the individual or consumer level, targeting members of an organization, the TOE framework and institutional theory is a representative technology acceptance model that can explain the organizational context in which the organization adopts and enforces innovative technologies at the organizational level.

This study used the TOE framework and institutional theory to review the factors affecting SWG adoption from the organizational perspectives.

The TOE framework concept includes three components: technology, organization and environment—as exogenous variables that affect how an organization adopts the innovative technology and each of these influencing factors affects the organization's willingness to accept the information technology, ultimately affecting the results of the innovation. A detailed explanation of the concept of the three TOE framework components is as follows (Fig. 6).

First, the TOE component of technology refers to the technology factor that can be critically employed internally and externally, thereby contributing to an increase in an organization's productivity. Here, technology means not only the technology that exists internally in a company, but also the technology that can be used in the marketplace.

Second, the TOE component of organization refers to the structures that enable or limit the performance and adaptation of innovation and it represents processes within an organization. An organization is defined by the firm's size and the centralization, formalization, and complication of its business structure, the quality of its human resources, and the total amount of idle resources that can be used internally. It also includes informal meetings between employees and the internal communications and decision making that result from those informal meetings.

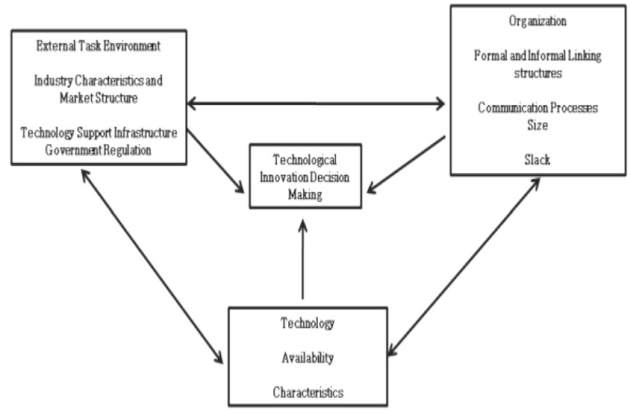

Fig. 6 TOE framework

Third, the TOE component of environment refers to the business environment in which the company performs its activities. Thus, it includes the firm's structures and size, the company's industry competitiveness, the level of available skilled labor, the relationship between the company's customers and suppliers, the macro-economic environment, and the legal environment such as government regulations.

According to the institutional theory, human behavior is determined by socio-cultural norms or the institutional environment. The theory sees that human behavior is limited by socio-cultural factors so that the limitation of reasonable selection is unavoidable and socio-cultural institutions provide a cognitive foundation for human behavior.

DiMaggio and Powell (1983) recognized that any form of change in organizations has nothing to do with rationality. He explained that the change in organizational structure is not due to competition or the need for efficiency, rather, it is due to the result of isomorphism, which is a process of making organizations more similar. Isomorphism is a concept used to explain how organizations become more homogeneous [14].

The three mechanisms of the institutional isomorphism proposed by DiMaggio and Powell are: (1) coercive isomorphism, caused by political influence, rules, or legal circumstances, (2) mimetic isomorphism, caused by the result of a standardized response to uncertainty, and (3) normative isomorphism, caused by professionalism and a normative approach. However, it is important to note that while these three mechanisms occur independently, they can also occur in a mixed and combined way, depending on the circumstances.

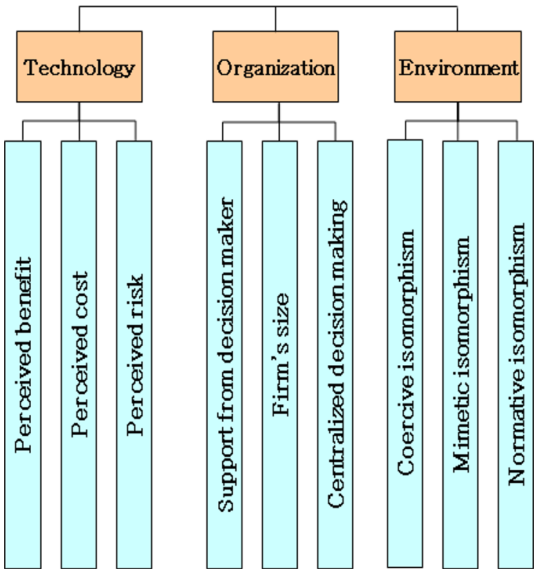

Fig. 7 SWG introduction hierarchy

5 Research methodology

The AHP method was employed to assess the priorities of the tasks to be implemented drawn by the analysis of conditions for Smart Water Grid adoption. The three areas for Smart Water Grid adoption were transformed into hierarchical structures to select tasks that must be considered first. The areas were expressed in the following hierarchical structures (Fig. 7).

Most 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 numerous information systems. According to these studies, the concept of perceived benefits refers to the degree of perception that innovation is better than the products or processes being replaced [15]. Generally, it was recognized that when decisions are made about adopting innovation in an organization, if that innovation is perceived as providing more positive benefits than the existing products or processes, it is beneficial to introduce the innovation. Furthermore, studies on the adoption of new technology indicated that perceived cost was a vital factor in the adoption of innovation. If additional costs will affect the organization's structure, if the cost of implementing new business processes will change, or if the cost of providing employee training will become a burdened, it will be more difficult to adopt and integrate new information technology. The acceptance of new technology is also affected by not only objective and reasonable aspects but also by subjective and unreasonable aspects, such as emotion or image.

Perceived risk is an example of a typical subjective factor in relation to the adoption of information technology. State and Festor [16] found that the management of large scale infrastructures has a difficulty to cope with new threats from internet worms and malware. In addition, the adoption of Smart Meters, one of the core SWG technologies, is accompanied by concerns about customer information leakage, information theft, and usage and bill manipulation while collecting and storing the water use data of consumers. The malfunction and performance degradation of equipment, such as smart sensors or networks, are also major factors that influence a water supply provider's hesitation to adopt the SWG. RFID technology is one of major components in smart sensors or networks. Shankarapani et al. [17] classified risks regarding RFID technology as business process risk, business intelligence risk, privacy risk and external risk.

As mentioned in the previous studies, the characteristics of an organization, such as support from decision maker, especially the Chief Executive Officers (CEOs), the firm's size, and the centralization of decision-making authority, indicated that these factors have a significant effect on the adoption of a number of information systems. The previous study results for each of these characteristics are presented below.

Fedidelman [18] defined the CEO as a person who had authority over an organization's members and resources in relation to the overall activities with regard to developing information systems. Therefore, support from the CEO was the most important core element to implementing information systems successfully. Runge [19] also mentioned that support from the CEO was closely related to the adoption and implementation of information systems. Regarding the firm size, its criteria could be the number of employees, the employee turnover rate, the firm's capital, or its total assets. Kyung-Hoon Yang (2000) noted that, as a company employs more employees, information technology is necessary to effectively manage the organization and its information, which makes a company more dependent on information technology. Thus, he suggested that the number of employees influenced the adoption of information technology [20]. On the other hand, Muller and Tilton [21] reported that, in terms of organizational size as one of the factors that influence the adoption of innovation, a smaller company adopted new technologies more flexibly than a larger company. Summarizing the previous study results presented above, the relationship between a firm's size and the performance of its information system was not consistent at all times. However, the present study evaluated this relationship by setting up a hypothesis that a firm's size had a positive effect on the adoption of information technology.

The centralization of decision making authority refers to the degree of centrality of authority and control regarding decision making that is held by a small number of individuals within an organization. Whisler [22] found that the adoption of information technology increased the centrality so that a centralized organizational structure had a positive effect on the adoption of information technology. Burlingame [23] found that in an organization where decision making authority was centralized, information technology resulted in a trend towards greater centralization of decision making, while in an organization where the decision making authority was decentralized, information technology resulted in a trend toward more decentralization of decision making. Summarizing the above previous study results mentioned above, information technology did affect the centralization or decentralization of decision making. The present study set a hypothesis that the centralization of decision making had a positive effect on the adoption of information technology based on the viewpoint that information technology affected the centralization of decision making authority.

In the previous studies, environmental characteristics, such as environmental uncertainty and pressure from competitive companies, had a significant effect on the adoption of information technology. Thus, the present study defined the following external organization factors as having an influence on decision making related to IT adoption, and set up a hypothesis, according to the viewpoint of institutional theory, which is based on technical, social, and political environments. The first external factor, institutional pressure applied by public and governmental institutions, could result in homogenization within an organization. In particular, in many companies market pressures, such as personal information protection policies mandated by governmental institutions to protect individual human rights, directly affect decision making related to investments in security-related IT. Such coercive isomorphism circumstances had a strong effect on decision making related to IT adoption more than any other aspects. Second, if a decision maker is not sure about the circumstances, an organization follows an exemplary standard that its members can follow. For example, if uncertainty over an IT environment is large and no confidence on the firm's internal resource capability can be found, a company is naturally more apt to imitate and follow the good examples provided by other employees at the firm. Based on this viewpoint, in a real sense, mimetic isomorphism is a phenomenon that occurs frequently in the process of decision making in relation to the adoption of IT. Third, when decision makers in a business field proceed with their decision making, in general, they are affected by their colleagues and related persons who have the same normative background with respect to support of the decision being made. In terms of the process of decision making relevant to the adoption of IT, in a real sense, the effect of such a normative isomorphism is very strong.

Pair-wise comparisons were conducted for priorities among the three areas; 'technology', 'organization', 'environment' drawn considering all environmental conditions surrounding the adoption of Smart Water Grid as well as

Table 1 AHP comparison matrix (1st layer)

	Technology	Organization	Environment
Technology	1	2.82	0.60
Organization	0.35	1	0.50
Environment	1.68	2.00	1

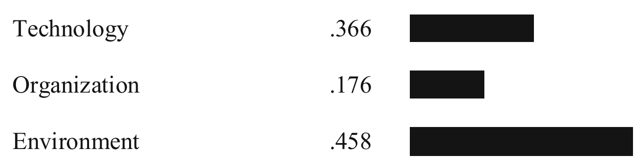

Fig. 8 Relative importance

Table 2 AHP comparison matrix (2nd layer_1)

	Perceived benefit	Perceived cost	Perceived risk
Perceived benefit	1	1.29	1.60
Perceived cost	0.78	1	1.83
Perceived risk	0.63	0.55	1

for major factors to be considered in individual areas. A questionnaire survey was conducted on a total of 13 selected experts currently engaged in related research and practical work and their responses were received.

6 Key findings

6.1 AHP comparison (1st layer)

The relative importance of the three areas on Smart Water Grid adoption was measured using AHP: 'technology', 'organization' and 'environment' (Table 1).

The highest score was found to be environmental factor (46 %), followed by technological factor (37 %), and organizational factor (18 %), respectively in order. The Consistency Index (CI) was 0.04, the Random Consistency Index (RI) was 0.52, and the ratio of CR (CR = CI/RI) was 0.08 (Fig. 8).

6.2 AHP comparison (2nd layer)

The relative importance of sub-characteristics in the area of technological factor was measured using AHP: 'perceived benefit', 'perceived cost' and 'perceived risk' (Table 2).

The result showed that 'perceived benefit' was the highest (41 %) followed by 'perceived cost' (36 %), and 'perceived risk' (23 %) (Fig. 9).

The importance of sub-characteristics in the area of organizational factor was measured using AHP: 'support from

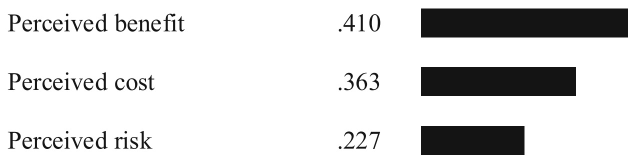

Fig. 9 Relative importance

Table 3 AHP comparison matrix (2nd layer_2)

	Support from decision maker	Firm's size	Centralized decision making
Support from decision maker	1	3.23	1.26
Firm's size	0.31	1	0.50
Centralized decision making	0.80	1.99	1

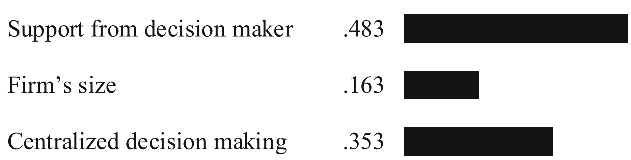

Fig. 10 Relative importance

Table 4 AHP comparison matrix (2nd layer_3)

	Coercive isomorphism	Mimetic isomorphism	Normative isomorphism
Coercive isomorphism	1	0.53	0.45
Perceived cost	1.87	1	0.74
Perceived risk	2.21	1.36	1

decision maker', 'firm's size' and 'centralized decision making' (Table 3).

The result showed that 'support from decision maker' was the highest (48 %) followed by 'centralized decision making' (35 %), and 'firm's size' (16 %) (Fig. 10).

The importance of sub-characteristics in the area of environmental factor was measured using AHP: 'coercive isomorphism', 'mimetic isomorphism' and 'normative isomorphism' (Table 4).

The result showed that 'normative isomorphism' was the highest (45 %) followed by 'mimetic isomorphism' (35 %), and 'coercive isomorphism' (20 %) (Fig. 11).

The result of AHP is summarized as follows (Table 5).

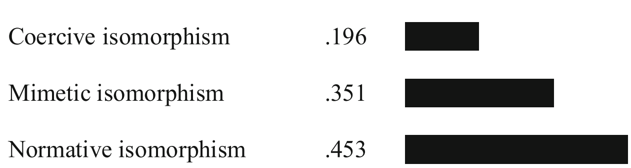

Fig. 11 Relative importance

The AHP analysis to assess the priorities of the factors shows that, in order to prepare a time when the demand for SWG will be greater, a support should be provided first to create a favorable environment with respect to SWG between interest parties. In conclusion, a partnership should be created to cooperate and communicate with not only between existing project parties, such as K-water and local municipalities, but also related companies and consumers, in order to apply the SWG extensively in Korea. It is also necessary to make efforts of active promotion and persuasion in order to publicize the needs for SWG to citizens, and consumers.

For the successful introduction and application expansion of SWG, the nation should be fully equipped with laws and systems that will support it. As the systematic development of smart grid business is supported by the enactment of "the Special Act on Smart Grid Network Construction and Support" in the power area, the enactment of "the Special Act on Smart Water Grid Construction and Support" is necessary in the water area. Revision of laws on tap water and rivers is also needed.

6.3 The importance of privacy protection and security in the Smart Water Grid

In the AHP analysis performed earlier, the weight of the 'perceived risk' was evaluated as relatively low. However, if the SWG is established in earnest in the future, the issue of privacy protection is likely to emerge as a significant risk factor. In existing water supply networks, one-sided communications are realized by water suppliers. In the SWG environment, suppliers and consumers can exchange two-way, real-time information on the use of water by utilizing information and communications technologies.

Some companies in major countries such as the US and in Europe, which are participating in SWG projects, are operating water services by either using the existing ZigBee technology or by developing their own non-standard wireless transmission technology for the wireless transmission of simple metering data. The SWG network consists of several differentiated subsystem networks. The subsystem networks include a variety of mutually differentiated networks such as supervisory control and data acquisition (SCADA), land mobile radio system (LMRS), wireless, microwave, optical communication, dedicated or switched, and wired/wireless regional networks. As this shows, amid growing attention to the SWG, Australia and the US are increasing revenues and saving operating costs by conducting real-time meter reading via the advanced metering infrastructure (AMI) system.

However, the largest emerging problem in operating the SWG is the protection of user privacy and safety. In the new environment, the personal information and water consumption of existing users are collected together. Therefore, if the

Table 5 Summary of relative importance

Level 1 (weight) (A)	Level 2	Weight of level 2 (B)	Combined weight (C = A*B)	Ranking
Technology (0.366)	Perceived benefit	0.410	0.1503	3
	Perceived cost	0.363	0.1329	4
	Perceived risk	0.227	0.0830	7
Organization (0.176)	Support from decision maker	0.483	0.0850	6
	Firm's size	0.163	0.0288	9
	Centralized decision making	0.353	0.0622	8
Environment (0.458)	Coercive isomorphism	0.196	0.0898	5
	Mimetic isomorphism	0.351	0.1605	2
	Normative isomorphism	0.453	0.2075	1

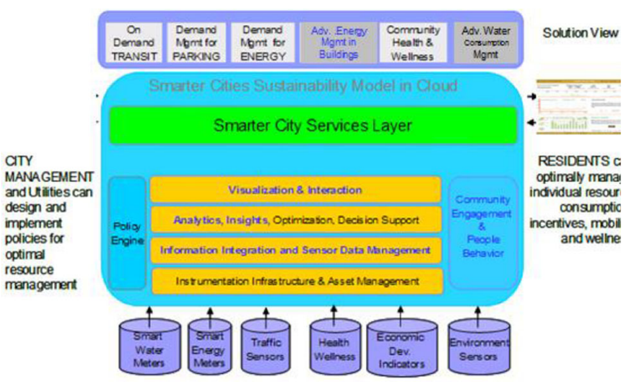

Fig. 12 IBM Smarter City Sustainability Model

two sets of information are combined, the lifestyle and water consumption patterns of specific consumers can be identified in real time. Such information can cause not only the mere exposure of information, but also additional damage. In particular, it can cause an increase in robbery cases in which robbers check the daily time slot during which specific consumers mainly use water, and then break into their houses and steal items after checking whether the houses are empty. In fact, the 'IBM Smarter City Sustainability Model', which was developed by IBM and applied in Dubuque, Iowa, in the US, analyzes water consumption in real time, and based on the outcome, can identify the water consumption patterns of household users and indirectly check whether people are staying at home [25] (Fig. 12).

In addition, in applying the SWG, there is a high risk of illegal forgery of water consumption. In conventional systems, water supply companies were able to measure water consumption using closed networks. Therefore, they were safe from external invasion. However, the SWG environment that utilizes open networks is relatively more exposed to vulnerabilities.

In conventional settings, users cannot check water consumption in real time. Therefore, the forgery of currently supplied water consumption is not easy. However, in the SWG environment, users can easily identify their accumulated water consumption, and thus are more likely to attempt to derive benefits by altering their water consumption illegally. Likewise, malicious hackers can cause damage to users by forging their water consumption so as to register larger amounts of water consumption than their actual consumption. Therefore, measures to protect the exposure of private information are required to protect user privacy and improve safety in the SWG environment. To resolve the problem with the protection of user privacy, transmitted information should be encoded. Moreover, new protocols should be developed to configure systems in a manner that prevents outsiders from identifying actual information even if the user's water consumption and personal information are exposed to attackers.

7 Conclusion

The SWG has been spotlighted as the next-generation water management system that overcomes the problems that exist in the current water management system. In the previous research on the feasibility of SWG, strategic approaches were introduced to promote SWG in Korea [24]. It also showed the directions to apply SWG technologies into water resources management. However, such approaches have not successfully identified the factors that influence the adoption of SWG.

Although there is a high risk of security due to hacker's attack in applying the SWG, it is expected to have a variety of positive effects, such as improvements in the production and treatment of water, a reduction in costs and energy, the ability to systematically and preventively manage water facilities, the increased ability to manage water resources, the ability to resolve the regional inequality of water resources, and the establishment of water security. Through the cooperation between the government, public institutions, and private companies, a new convergent water management technology combined with IT technology, in other words, a world class SWG component technology will be developed, and as a result, a new business model will be created, thereby playing an important role in an organization's ability to enter the overseas SWG market.

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