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RESEARCH ARTICLE

Determinants of Adoption Intention For Service Innovations in Brackish Water Management

Krisada Kaweeyarn[1]*, Natphasuth Patthirasinsiri[2], Amnuay Saengnoree[3]

[1,2,3] College of Innovation and Industrial Management, King Mongkut's Institute of Technology Ladkrabang

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***Corresponding Author:**

63618020@kmitl.ac.th

ABSTRACT

This study investigates the factors influencing the intention to adopt water usage from the ANSAT service, an innovation developed by the Metropolitan Waterworks Authority (MWA) to mitigate brackish water issues in Bangkok, Thailand. A quantitative survey was conducted among 300 households in eastern Bangkok, employing statistical analyses such as percentage, mean, standard deviation, Structural Equation Modeling (SEM), and Confirmatory Factor Analysis (CFA) to examine relationships between key variables and assess the model's goodness-of-fit. The results confirm that the model aligns with empirical data, supporting hypothesis testing. The findings reveal that the intention to adopt ANSAT's water usage service is significantly influenced by perceived value, innovation attributes, and subjective norms. Additionally, the study highlights the interrelationships between these factors, offering valuable insights for ANSAT stakeholders, policymakers, and researchers in fostering a supportive environment for adoption and long-term usage of this service innovation in brackish water management.

INTRODUCTION

Human-induced climate change, driven by deforestation and industrial expansion, has increased greenhouse gas emissions, particularly carbon dioxide, leading to severe environmental consequences. In Thailand, these changes have disrupted rainfall patterns, raised sea levels, and heightened seawater salinity, posing significant challenges to water resource management. A critical impact is saline water intrusion into freshwater systems, particularly the Chao Phraya River, a crucial source of water for domestic use, agriculture, and industry. During the dry season, salinity levels, especially at Klong Sam Lae, rise significantly, endangering tap water production, economic activities, and public health.

To mitigate this issue, the Metropolitan Waterworks Authority (MWA) developed the ANTI SALINITY TOOL (ANSAT), an innovative service that leverages historical and real-time water quality data, using Machine Learning to predict salinity levels 1–3 days in advance. This enables efficient raw water management, ensuring salinity remains below 0.25 grams per liter. ANSAT has significantly enhanced water management efficiency, reducing high salinity incidents in raw water. Its success earned the MWA the International Innovation Awards (IIA) 2020 in the "Services & Solutions" category, solidifying ANSAT as a key strategy for addressing salinity challenges in water supply management.

This research aims to identify and analyze the factors influencing the adoption of the ANSAT service innovation. Specifically, it examines perceived value, innovation attributes, subjective norms, and behavioral intention to use. The findings from this study will provide strategic guidance for the MWA to proactively and reactively address challenges, enhance service delivery, and improve operational efficiency.

LITERATURE REVIEW

1. ANSAT Service Innovation

ANSAT's service innovation showcases a strategic use of advanced technology to address water quality challenges. By leveraging Machine Learning and predictive analytics, ANSAT continuously monitors and forecasts water quality in real-time, allowing for efficient management of raw water intake. Integrating data from monitoring stations, historical records, and external collaborations, the system develops predictive models that help operators make timely adjustments, minimizing the risk of high salinity affecting water supply. This proactive approach has significantly reduced the impact of saline water, particularly during dry seasons, benefiting millions of households, industries, and agricultural sectors that depend on a stable and high-quality water supply.

Beyond predictive management, ANSAT collaborates with other agencies to implement innovative solutions, such as the "Water Hammer Flow" technique, which strategically controls water flow to push saline water away from critical intake points. This not only ensures water quality but also contributes to the protection and restoration of local ecosystems. Looking ahead, ANSAT is focusing on automation and artificial intelligence to further enhance operational efficiency. By integrating automated decision-making systems, the organization aims to establish sustainable and resilient water management practices that address evolving challenges and future demands.

2. Perceived value

Perceived Value (PV) is the consumer's evaluation of a product or service based on their needs, expectations, and experiences, influencing their purchasing decisions and post-purchase behavior. Sheth, Newman, and Gross (1991) define PV as a balance between perceived benefits and costs, shaped by consumer experiences that affect knowledge, thoughts, and attitudes. They identify five dimensions of PV: Functional Value (product utility and attributes), Social Value (status and societal acceptance), Emotional Value (feelings and experiences), Epistemic Value (novelty and learning), and Conditional Value (situational needs). These dimensions highlight the dynamic and multifaceted nature of PV in driving consumer motivation. Building on this framework, Sweeney and Soutar (2001) developed the PERVAL model, refining PV into three main components: Emotional Value (emotional benefits), Social Value (self-concept and identity enhancement), and Functional Value, further divided into price-related and quality/performance benefits. This model provides a practical approach for measuring PV in retail settings, emphasizing its role in shaping consumer perceptions, attitudes, and purchasing behavior.

3. Innovation Attributes

Rogers and Shoemaker (1917) identified five key characteristics that influence the adoption of innovation. Relative Advantage refers to the perception that an innovation is more beneficial than existing methods, offering greater convenience, speed, or economic returns, with social status and cost efficiency playing a role in acceptance. Compatibility reflects how well an innovation aligns with users' existing values and past experiences, reducing uncertainty and increasing the likelihood of adoption. Complexity refers to how difficult an innovation is to understand and use; higher complexity tends to hinder adoption and may lead to resistance. Trialability allows users to test an innovation before full adoption, increasing confidence in its effectiveness if the trial is successful. Observability refers to how visible the benefits of an innovation are within society, with more tangible outcomes leading to higher acceptance (Rogers, 2003). Today, these characteristics remain essential in evaluating new technology adoption, particularly in the digital age, where trialability and observability play a critical role in consumer and organizational decision-making.

4. Subjective norm

Subjective Norm refers to an individual's perception of societal expectations and the influence of reference groups on their behavior. These reference groups can include close individuals such as parents, spouses, and friends, as well as influential figures like supervisors or community members. When individuals perceive that these groups support a particular behavior, they are more likely to conform. Conversely, if they believe their reference groups disapprove of a behavior, they tend to avoid it. Additionally, reference groups serve as a standard for behavioral comparison, influencing individuals' acceptance of norms and values, which in turn affects their actions (Quester et al., 2007).

Reference groups can be categorized based on key criteria. Membership and non-membership groups include those where individuals are formally accepted as members or aspire to join, as well as groups they intentionally avoid. Primary and secondary groups differ in the level of interaction, with primary groups, such as family and close friends, exerting stronger influence, while secondary groups, such as professional associations or business clubs, have a lesser impact. Aspirational and dissociative groups represent those that individuals desire to be part of, adopting their values and norms, while dissociative groups are those they deliberately avoid (Peter & Olson, 2008, cited in Panisa Meejinda, 2012).

5. Intention to adopt Usage

The concept of Intention to Adopt Usage is fundamental in understanding individuals' behavior toward adopting new technologies and innovations. Rooted in the Technology Acceptance Model (TAM) by Davis (1989), it suggests that adoption intention is influenced by Perceived Usefulness and Perceived Ease of Use. Later, the Theory of Planned Behavior (TPB) by Ajzen (1991) expanded this perspective by incorporating Subjective Norms and Perceived Behavioral Control, emphasizing the role of social and psychological factors in shaping adoption behavior. These models highlight that individuals' willingness to adopt technology is not solely driven by its functionality but also by external influences and perceived control over its use.

Further developments in technology adoption research, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003), identified Performance Expectancy, Effort Expectancy, and Social Influence as key determinants of adoption. Trust and Satisfaction also play crucial roles, reinforcing user confidence in new technologies. Additionally, environmental factors, including organizational support and infrastructure availability, significantly impact adoption likelihood (Venkatesh et al., 2012). These theories provide a comprehensive framework for analyzing the factors influencing technology adoption, making them essential for understanding user behavior in various contexts.

Hypothesis And Conceptual Framework

A conceptual framework provides a clear visualization of the relationships between variables in a study. In examining the factors influencing the intention to use the service innovation to address brackish water issues, the framework includes independent variables (perceived value, innovation attributes, and subjective norms) and the dependent variable (intention to use). This framework helps to define the connections among these elements based on insights from the provided references. In this study, the researcher formulated the following hypotheses:

H1: The perceived value of use significantly influences the intention to adopt the innovation.

H2: Innovation attributes significantly influence the intention to adopt the innovation.

H3: Subjective norms significantly influence the intention to adopt the innovation.

The researcher concluded the study with the research framework presented in Figure 1.

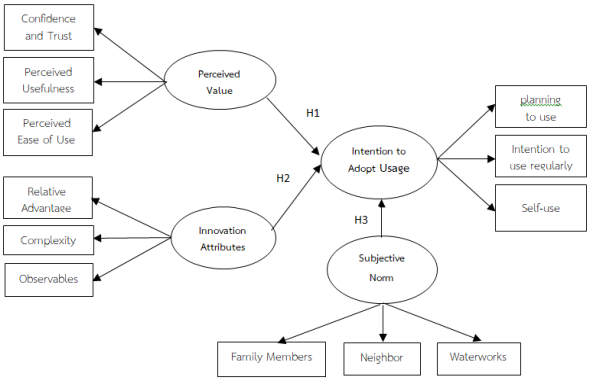

Figure 1 Conceptual framework for user intention to adopt the ANSAT Innovation

RESEARCH METHODOLOGY

This quantitative research investigates the factors influencing the adoption of service innovation to address brackish water issues. Utilizing a questionnaire-based approach, the study targets households receiving tap water services from the MWA in Bangkok's eastern districts, including Klong Sam Wa, Khan Na Yao, Bang Kapi, Bueng Kum, Prawet, Min Buri, Lat Krabang, Saphan Sung, and Nong Chok. The selected households must have been using tap water during the implementation of the ANSAT Innovation. A sample size of 300 participants was determined using a non-specific random sampling strategy within these districts. To ensure representativeness, a proportional stratified random sampling method was applied, aligning the sample distribution with the population proportion across districts. The proportion for questionnaire distribution was calculated based on the ratio of households in each district to the total number of households served, usinghousehold data year 2023 from the Community Development Office, Department of Social Development, Ministry of Interior.

The research utilized a structured questionnaire as the primary data collection instrument, divided into two sections. The first section gathered demographic and household information, including gender, age, marital status, education, occupation, household characteristics, water usage volume, and water-related activities. The second section assessed respondents' perceptions of key factors such as perceived value of use, innovation attributes, subjective norms, and intention to adopt usage, using a 5-point Likert scale. To ensure validity, five experts reviewed the questionnaire, resulting in a content validity index (CVI) of 1.00. Additionally, a reliability test was conducted with 30 individuals in Bangkok who had used the ANSAT Innovation, excluding them from the main sample. Data collection specifically targeted households in Bangkok's eastern districts that receive tap water from the MWA.

In this study, partial least squares structural equation modeling (PLS-SEM) was employed for data analysis, as recommended by Hair, Hult, Ringle, and Sarstedt (2017).PLS-SEM is specifically designed for regression analysis involving latent variables and is particularly effective for complex models that include multiple dependent and independent latent constructs. This method is widely used in research due to its ability to handle small sample sizes, non-normal data distributions, and intricate relationships between variables. By utilizing PLS-SEM, this study ensured a robust and reliable analysis of the proposed research model.

RESEARCH RESULTS

General Characteristics of the Sample Group

As shown in Table 1, the majority of the sample group were male (53.70%), aged between 41 and 50 years (49.70%), and held a bachelor's degree (73.00%). Most were company employees or workers (36.70%) and lived in detached houses or townhomes (26.70%). The average water consumption was approximately 8.50 cubic meters per month (45.00%), with bathing being the primary water usage activity (96.70%).

Table 1 General Characteristics of the Sample Group

Items	Number	Percentage
Gender		
Male	161	53.7
Female	139	46.3
Age		
Under 31 year	43	14.3
31 - 40 year	79	26.3
41 - 50 year	149	49.7
Over 50 year	29	9.7
Educational level		
Below bachelor's degree	51	17
Bachelor's degree	219	73
Above bachelor's degree	30	10

Items	Number	Percentage
Occupation		
Officer/Employee	110	36.7
Government official/State enterprise	89	29.7
Trading/Self-employed	100	33.3
Other	1	0.3
Type of household of water users		
Single house	80	26.7
Townhouse	80	26.7
Rental house/Rental room	63	21
Condominium/Flat	77	25.6
Approximate amount of tap water used/month		
Less than 7.50 cubic meters	37	12.3
7.50 – 7.99 cubic meters	35	11.7
8.00 - 8.49 cubic meters	50	16.7
8.50 – 8.99 cubic meters	135	45
9.00 – 9.49 cubic meters	21	7
More than 9.49 Cubic meter	22	7.3

Analysis of Perception Levels on Each Factor

The study analyzed respondents' perceptions regarding several key factors: the perceived value of use, innovation attributes, subjective norms, behavioral intention, and the intention to adopt usage. The questions were measured using a 5-point Likert scale. The findings revealed the following average scores for factors influencing the use of tap water during the implementation of the ANSAT innovation to address brackish water issues. Statistical data on the levels of opinion for each factor were presented. The results of the study on opinion levels for various factors were shown in Tables 2–4, as follows.

Table 2. Reliability assessment

variables	Cronbach's alpha	Eigen value
Perceived Value: PV	0.815	2.34
Innovation Attributes: IA	0.810	2.06
Subjective Norm: SN	0.877	1.51
Intention to adopt usage: IAU	0.925	1.94

The reliability assessment was determined using Cronbach's coefficient. The acceptable confidence value for the questionnaire must be at least 0.7. Additionally, the correlation coefficient of the item scores was analyzed using the corrected item-total correlation, which should be greater than or equal to 0.5 to indicate that the questions were well classified. The reliability analysis, conducted by calculating Cronbach's Alpha, found that the highest value was 0.925 and the lowest was 0.810. All obtained values were greater than 0.70, indicating that the analyzed data was highly reliable (Zikmund et al., 2010).

Analysis of convergence validity

As shown in Table 3 below, the analysis of convergence validity was conducted by examining the factor loadings of the observed variables. The results indicated that every observed variable had a factor loading greater than 0.50, demonstrating high data accuracy (Hair et al., 2010). Additionally, composite reliability (CR) and the average variance extracted (AVE) were examined. AVE represents the average variance of the latent variables that explain the observed variables. The total composite reliability should be greater than 0.70. The analysis found that the highest CR value was 0.83, and the lowest was 0.75, with all values exceeding 0.70. The AVE should be greater than 0.50, and the results

showed that the highest AVE value was 0.75, while the lowest was 0.63, with all values exceeding 0.50. These findings indicate that each latent variable was able to consistently explain the variance of the observed variables. The evaluation of the measurement model provided clear evidence that all latent variable definitions were valid and reliable (Zikmund et al., 2010).

Table 3 Loadings of indicator variables

Constructs	**Item**	**Factor loading**	**AVE)>0.5(**	**Composite reliability)>0.7(**	**R^2**
Perceived Value	1	0.83	0.67	0.78	0.81
	2	0.99			0.00
	3	0.83			1.70
Innovation Attributes	1	0.88	0.75	0.82	0.56
	2	0.85			0.87
	3	0.92			0.64
Subjective Norm	1	0.69	0.74	0.83	1.02
	2	0.92			0.86
	3	0.62			0.62
Intention to adopt usage	1	0.58	0.63	0.75	0.34
	2	0.71			0.94
	3	0.46			0.64

Discriminant validity is assessed by examining the square root of AVE for each construct, which should be greater than the corresponding construct intercorrelations (Wu & Zhang, 2014). In Table 3, the loadings of indicator variables are presented. The construct cross-loadings are shown in Table 4, while the correlation of the constructs and the square root of AVE are displayed in Table 5. When a self-reported survey is used, as in this case, common method bias should be considered (Yang, Lee, & Zo, 2017). Discriminant validity was used to check for common method bias. Table 4 shows that discriminant validity is established, as there are no strong cross-loadings.

Table 4. Construct cross-loading

	Perceived Value	**Innovation Attributes**	**Subjective Norm**	**Intention to adopt usage**
Perceived Value 1	0.900	0.023	0.012	0.041
Perceived Value 2	0.005	0.141	0.024	0.421
Perceived Value 3	1.305	0.070	0.106	0.014
Innovation Attributes 1	0.205	0.751	0.201	0.174
Innovation Attributes 2	0.134	0.935	0.034	0.208
Innovation Attributes 3	0.184	0.805	0.041	0.301
Subjective Norm 1	0.156	0.412	1.013	0.410
Subjective Norm 2	0.011	0.300	0.932	0.020
Subjective Norm 3	0.024	0.026	0.786	0.078
Intention to adopt usage 1	0.138	0.208	0.207	0.969
Intention to adopt usage 2	0.114	0.171	0.171	0.799
Intention to adopt usage 3	0.143	0.214	0.214	0.140

Convergent validity as evidenced by: AVE all above 0.5 and reliability as evidenced by CR all above 0.7. We have discriminant validity based on the square root of AVE being greater than any inter factor correlation on this matrix.

Table 5 Correlation of the constructs and square root of AVE

variables	CR	AVE	PV	IA	SN	Intention
Perceived Value: PV	0.78	0.67	0.762			
Innovation Attributes: IA	0.82	0.75		0.805		
Subjective Norm: SN	0.83	0.74			0.812	
Intention to adopt usage: IAU	0.75	0.63				0.741

RESULTS OF HYPOTHESIS TESTING

The results of research hypothesis testing, conducted using PLS-SEM at a statistical significance level of 0.01, revealed that the perceived value of use, innovation attributes, and subjective norm have a significant positive influence on the intention to adopt usage. The total influence size of the perceived value of use on the intention to adopt usage was 0.14, while the total influence size of both innovation attributes and subjective norm was 0.21 each. The model explains 48% of the variance in the intention to adopt water usage (R^2 = 0.48), suggesting a moderate predictive capability. This highlights the significance of both technological and social influences in driving adoption behavior. The results of the hypothesis testing are summarized in Fig. 2.

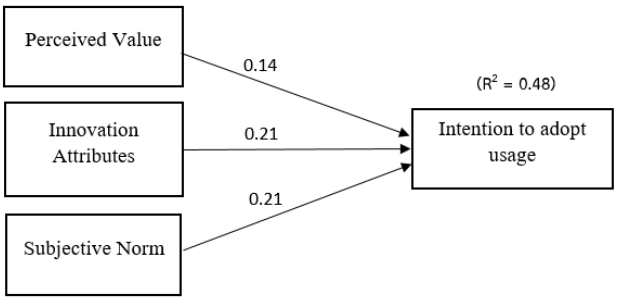

Fig. 2 Result of testing the research model for Intention to adopt water usage

DISCUSSION

The findings revealed that perceived value, innovation attributes, and subjective norms had a direct and significant influence on the intention to adopt water usage from service innovations in brackish water management. The study highlights that perceived value positively affects users' adoption intentions, as individuals who find service innovations easy to use are more likely to perceive them as beneficial and necessary. These results align with previous research emphasizing the strong correlation between perceived value and adoption intention (Amin, 2007; Venkatesh & Davis, 1996). Moreover, the findings are consistent with studies by Yulianto & Tanamal (2019) and Molina, M. E. R., Saura, I. G., & Frances, D. S. (2017), which demonstrate that perceived value—comprising confidence, trust, perceived benefits, and ease of use—plays a critical role in influencing users' willingness to adopt innovative solutions.

Additionally, the statistical analysis confirmed that all three tested hypotheses were significant at the .01 level, reinforcing the predictive strength of the proposed model in explaining users' behavior toward adopting ANSAT innovation for brackish water management. The study further revealed that innovation attributes and subjective norms significantly shape user motivation, leading to consistent engagement with the innovation. These factors contribute to sustained adoption, increased frequency of use, and a shift toward autonomous decision-making regarding water usage.

Based on these insights, the Metropolitan Waterworks Authority (MWA) can leverage the findings to refine its strategic management approach and enhance the ANSAT innovation's effectiveness. By addressing key adoption drivers such as perceived value and trust, the MWA can further improve user confidence and satisfaction. Additionally, efforts to strengthen communication strategies, raise

awareness, and ensure seamless integration of the innovation into users' daily lives will be instrumental in promoting long-term adoption and continued use of ANSAT.

Research Findings

The findings from this study can be applied in various ways to improve water management and address the issue of brackish water in affected areas. These applications include:

Since Innovation Attributes significantly influence the intention to adopt water usage from service innovation, relevant agencies such as the Metropolitan Waterworks Authority (MWA) should improve and develop the ANSAT innovation to better meet user needs. This includes enhancing ease of use, optimizing efficiency in managing brackish water, and ensuring cost-effectiveness to encourage widespread adoption.

Subjective Norms play a crucial role in influencing users' intention to adopt the innovation. Therefore, promoting community engagement, launching public awareness campaigns, and utilizing influential community leaders to advocate for ANSAT adoption can increase acceptance and encourage broader use of the innovation.

Although Perceived Value has a relatively lower influence compared to other factors, it remains an essential component in adoption. Authorities should focus on effectively communicating the benefits of ANSAT through accessible channels such as online media, social platforms, and educational campaigns. This will enhance public awareness, build trust, and encourage greater adoption of the innovation.

Suggestions For Future Research

The findings of this research reveal that the perceived ease to use has a positive influence on the intention to adopt usage, while also positively affecting attitudes toward usage and the behavior of intention for continuous use. When consumers perceive the value of an innovation or technology, it fosters a stronger desire to adopt and utilize such innovations and technologies. Perceptions of benefit from the innovation enhance operational efficiency. Future research should explore the factors influencing consumer satisfaction with the use of the service innovation provided by the MWA. This will help the organization make informed decisions on the deployment of future innovations and technologies in the water services industry, ensuring the maximization of benefits for the public.

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