Intention to Harvest of Rainwater for Household Consumption in Jakarta, Indonesia

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Abstract

Flooding in the city of DKI Jakarta is a problem that always comes every year and always causes huge financial losses for its residents. Not only that, but the problem of flooding in the capital city of Jakarta has also tarnished the good image of the city of Jakarta as the center of the government sector. The cause of flooding in the capital city of Jakarta has many factors, one of which is the relatively high rainfall rate in the city of Jakarta. The second thing that causes flooding in Jakarta is land subsidence in DKI Jakarta and one of the causes of land subsidence in DKI Jakarta is excessive groundwater extraction. Because most Jakarta residents use groundwater as a source of clean water, groundwater extraction occurs on a large scale and is almost uncontrollable. As a result of this massive groundwater extraction, the groundwater system bears a very heavy burden. One method to achieve alternative clean water resources is rainwater harvesting. Therefore, if there is a need for alternative water resources, they can help restore groundwater naturally and can help reduce land subsidence in DKI Jakarta. However, the community's interest in harvesting rainwater is very small. Therefore, it is necessary to know what factors influence the community's acceptance of rainwater harvesting. Primary data processing uses the Structural Equation Modeling (SEM) method to determine the relationship between the acceptance factors of rainwater harvesting.

Keywords
Rainwater Harvesting, Acceptance Model, Structural Equation Modeling, Land Subsidence.

1. Introduction
Each year, the city of Jakarta experiences devastating floods that cause great harm to its inhabitants and tarnish the capital's reputation as the center of government in Indonesia. The primary factor contributing to the flooding is the high level of rainfall, which is a consequence of the country's location on the equator. As a result, the temperature is exceedingly high, leading to increased water evaporation and subsequently high rainfall levels. Rainfall intensity at the Kemayoran station in Central Jakarta is particularly high, with a reduction only occurring during June and July.

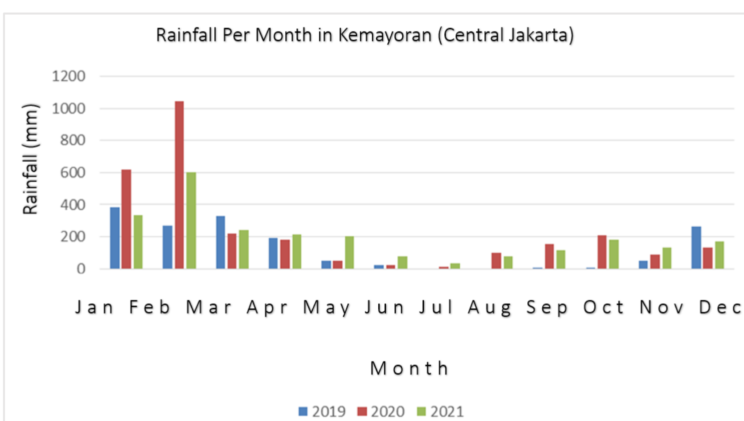

Figure 1. Rainfall Per Month in Kemayoran

Source: Badan Pusat Statistik, 2023

Excessive extraction of groundwater is one of the leading causes of land subsidence in DKI Jakarta, resulting in flooding. As a large number of Jakarta's inhabitants depend on groundwater for their clean water supply, the extraction is often unregulated and widespread. Consequently, the groundwater system is heavily impacted. Excessive use of groundwater in Jakarta has exceeded the natural replenishment rate of the ecosystem, resulting in a significant drop in water levels in the shallow aquifer and reduced pressure in the artesian aquifer. The problem is most severe in the northern part of Jakarta, where incidents of land subsidence have also been reported. While the sinking of the ground surface is not directly caused by the decline in the water table or artesian aquifer pressure, empty spaces between soil particles, created by the drop in water levels, can cause soil compression, which can contribute to land subsidence.

The excessive usage of groundwater and high level of rainfall has caused devastating floods in DKI Jakarta, and therefore alternative water resources like rainwater harvesting can be used to help restore the natural balance of groundwater and mitigate flooding. However, the lack of public interest in rainwater harvesting is an obstacle that needs to be addressed. To increase acceptance, it is crucial to understand the factors that influence the public's willingness to participate in this method of alternative clean water supply.

1.1. Objectives

From the background and current conditions, the goal of this research is to develop a model that can explain the relationship between variables in the proposed model for the use of rainwater harvesting in Jakarta, Indonesia. The development of this research model is based on previous research related to rainwater harvesting acceptance in other locations, so this research is modified to adjust the object assessment factors to be more representative of the conditions in Jakarta. Therefore, seven hypotheses are proposed:

H1: Awareness of consequences affects the ascription of responsibilities.
H2: Awareness of consequences affects attitude.
H3: Ascription of responsibilities affects attitude.
H4: Attitude affects the rainwater harvesting intention.
H5: Perceived quality affects rainwater harvesting intention.
H6: Perceived benefits affect the rainwater harvesting intention.
H7: Intention to use rainwater harvesting affects rainwater harvesting acceptance.

2. Literature Review

Liu et al.'s study identified several factors that could affect the usage of rainwater harvesting, including perceived usefulness, ease of use, intention to use, subjective knowledge, technological environment, perceived risk, trust, social influence, and perceived cost. Technological environment and perceived risk were recognized as two potential factors that could affect public acceptance of rainwater harvesting. Moreover, the study found that perceived cost did not significantly influence the attitude and intention of the community toward rainwater harvesting (Liu et al. 2022).

Ignacio et al. researched the acceptance of a comprehensive water system that involves rainwater and identified attitude, subjective norm, perceived behavioral control, social influence, political climate, user demand, perceived usefulness, and perceived ease of use as key factors affecting the acceptance of the system. The results of the study showed that the attitude of the public had a significant impact in promoting their behavioral intention to use the components of the integrated water system. To improve the attitude of potential users, the study found that perceived usefulness and perceived ease of use had a positive impact on attitude (Ignacio et al. 2019).

Liu et al. researched the acceptance of using recycled water in Xi'an, China, and applied the Norm Activation Model (NAM) factors such as awareness of consequences, responsibility attribution, and personal norms to examine their impact on the acceptance of recycled water use. The results of the study showed that environmental motivation had a positive impact on residents' acceptance of recycled water use. The awareness of consequences resulting from human activities and responsibility attribution could strengthen their motivation to protect the environment. These results have enhanced the conventional NAM framework and presented novel insights into the utilization of recycled water and the realm of pro-environmental behavior research (Liu et al. 2018).

Hurlimann et al. conducted research on the acceptance of recycled water use in the Mawson Lakes community, Australia, and identified trust, perceived risk, perceived quality, perceived fairness, and behavior as key factors. The results of the study demonstrated that the factors that significantly contributed to user satisfaction with recycled water use were trust, perceived risk, and perceived quality, which provided significant positive perceptions toward the behavior of using recycled water. However, the study found that perceived cost did not have a significant impact on the attitude and intention of the community towards recycled water acceptance, which was similar to the findings of Liu et al. (Hurlimann et al. 2008).

3. Methods

In the field of social and behavioral science, theories and models are constructed based on theoretical concepts that are not directly observable or measurable. However, it is still possible to find indicators that can be used to study these concepts. The Structural Equation Modeling (SEM) method is a model that extends from path analysis and multiple regression, both of which are multivariate analysis models. Compared to path analysis and multiple regression, the SEM method offers more comprehensive data analysis. The reason for this is that, while the first two methods only consider the underlying variable level, the SEM analysis can provide a more thorough investigation by analyzing the individual responses to the questions included in each variable of the research instrument.

4. Data Collection

The data for this study were collected within two weeks, and subsequently, the adequacy of the survey data was tested using Structural Equation Modeling (SEM). It is recommended that researchers should have a sample size of at least 200 for conducting SEM if there are no issues with missing data or non-normal distributions. However, if there are few reliable measures of a construct, multiple measures that have weak associations, or measures that lack reliability, researchers should consider using larger sample sizes to increase the accuracy and statistical power of their analyses (Weston and Gore 2006).

The survey was distributed, and 215 respondents who met the criteria were included in the study. The demographic information of the respondents revealed that 133 respondents were male and 82 were female, as illustrated in the image below.

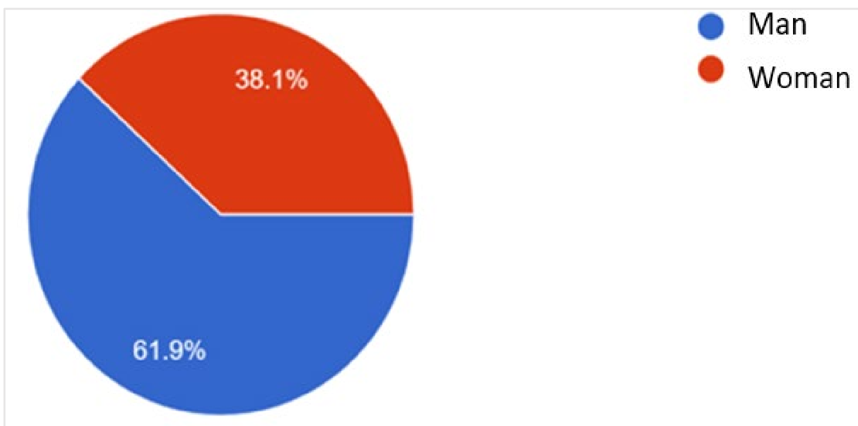

Figure 2. Gender Distribution of Respondents
Source: Surveyed from 9th to 22nd April 2023

In this study, it was found that there were 138 respondents in the age range of 20-35 years, 69 respondents in the age range of 36-50 years, and 8 respondents in the age range of 51-65 years.

The majority of respondents who completed the questionnaire were married, with a total of 145 individuals, while 70 individuals were unmarried. This is likely due to the greater water needs of married individuals.

5. Results and Discussion

The study employs a total of 7 variables, which include Awareness of Consequences (AoC), Ascription of Responsibilities (AoR), Attitude (Att), Perceived Quality (PQ), Perceived Benefits (PB), Rainwater Harvesting Intention (RHI), and Rainwater Harvesting Acceptance (RHA). During the questionnaire development phase, 25 question indicators were obtained from the conceptual model variables that had been designed. Among the variables, Awareness of Consequences, Rainwater Harvesting Intention, Perceived Benefits, and Rainwater Harvesting Acceptance had 3 question indicators each, while Ascription of Responsibilities and Attitude had 4 question indicators each. Perceived Quality had the most question indicators with 5.

Awareness of Consequences is a term that describes the degree to which individuals are conscious of the possible results or effects of their behavior. Awareness of Consequences can influence an individual's attitude towards a behavior by shaping their beliefs about the outcomes or consequences of that behavior. There is a clear relationship between these two concepts, as an individual's awareness of the consequences of their actions can influence their sense

of responsibility for those actions. If someone is highly aware of the potential negative consequences of a particular behavior, such as extracting groundwater excessively, they may feel a greater sense of responsibility to avoid that behavior.
H1: Awareness of consequences affects ascription of responsibilities.
H2: Awareness of consequences affects attitude.

Table 1. Awareness of Consequences Question Item

No	Code	Question Item	Reference
1	AoC1	I am concerned about the deteriorating environmental conditions in DKI Jakarta.	X. Liu et al. 2018
2	AoC2	I believe that the exploitation of water resources is a significant factor in the environmental degradation of DKI Jakarta.	X. Liu et al. 2018
3	AoC3	I believe that excessive groundwater extraction is a significant factor in the environmental degradation of DKI Jakarta.	X. Liu et al. 2018

The ascription of responsibilities is described as a sense of responsibility for the negative consequences of not acting socially. Ascription of responsibilities has been considered a moderating variable used to regulate the influence of behavioral decisions. In this view, it is believed that personal regulation has an objective influence on behavioral decisions and ascription of responsibilities is not considered a prerequisite to influencing an individual's moral foundation. Ascription of Responsibilities can influence an individual's attitude toward a behavior by shaping their sense of responsibility for the outcomes that may result from that behavior.
H3: Ascription of responsibilities affects attitude.

Table 2. Ascription of Responsibilities Question Item

No	Code	Question Item	Reference
1	AoR1	The environment of DKI Jakarta is my primary concern and responsibility.	X. Liu et al. 2018
2	AoR2	We are responsible for the environmental damage that occurs in our environment.	X. Liu et al. 2018
3	AoR3	All urban residents should be responsible for protecting the water environment in the city where we live.	X. Liu et al. 2018
4	AoR4	I am emotionally involved in environmental protection issues in DKI Jakarta through the use of alternative water sources.	X. Liu et al. 2018

Attitude refers to the extent to which an individual has a favorable or unfavorable evaluation or assessment of a particular behavior. A positive attitude towards a specific technology indicates a greater desire to use that technology. In this research, a good or positive attitude towards the environment can directly influence someone's intention to use a pro-environment technology and take protective actions towards the environment.
H4: Attitude affects the rainwater harvesting intention.

Table 3. Attitude Question Item

No	Code	Question Item	Reference
1	A1	I feel happy when practicing clean water conservation efforts.	Liu et al. 2022
2	A2	When I have to choose one of two similar products, I prefer the one that does not harm the environment.	Liu et al. 2022
3	A3	Practicing clean water conservation efforts makes me feel satisfied.	Liu et al. 2022
4	A4	Due to my values/principles, I feel obligated to behave in an environmentally friendly way.	Liu et al. 2023

The concept of perceived quality can be defined as an individual's subjective assessment of the superiority or excellence of a product (Zeithaml 1988). Thus, perceived quality is different from actual quality. Although some consumers may perceive that an object contributes to a particular phenomenon, the product may appear to be of lower quality or more contaminated. Perceived quality can influence an individual's beliefs about a product or behavior, which in turn can shape their attitudes toward it. For example, if an individual perceives the quality of a product to be high, they may develop a more positive attitude towards that product and be more likely to intend to use it.
H5: Perceived quality affects rainwater harvesting intention.

Table 4. Perceived Quality Question Item

No	Code	Question Item	Reference
1	PQ1	I believe that rainwater quality is better than main water sources such as groundwater.	Hurlimann et al. 2008
2	PQ2	I believe that rainwater quality is good for everyday use.	Hurlimann et al. 2008
3	PQ3	I believe that rainwater is good for the environment.	Hurlimann et al. 2008
4	PQ4	I believe that rainwater does not harm health.	Hurlimann et al. 2008
5	PQ5	I believe that rainwater quality is better than other alternative water sources.	Hurlimann et al. 2008

Perceived benefits refer to perceptions of the positive outcomes resulting from a particular action. The term perceived benefits are often used to explain individuals' motives for engaging in a behavior and adopting a certain action. Researchers and theorists attempt to measure positive perceptions because they believe that behavior is driven by individuals' cognition regarding acceptance, motives, and attitudes toward the behavior, especially if it is perceived positively.
H6: Perceived benefits affect the rainwater harvesting intention.

Table 5. Perceived Benefits Question Item

No	Code	Question Item	Reference
1	PB1	Harvesting rainwater reduces my water bills.	Hurlimann et al. 2008
2	PB2	Harvesting rainwater gives me a backup water source.	K. Liu et al. 2018
3	PB3	Harvesting rainwater helps me save water.	K. Liu et al. 2018
4	PB4	Harvesting rainwater makes me feel healthier.	K. Liu et al. 2018

Behavioral intention is influenced by attitude. Behavioral intention indicates the extent to which a person is willing to try, and the amount of effort they plan to make, to engage in a particular behavior. A strong intention to engage in behavior will ultimately lead to involvement in that behavior (Lili et al. 2021).
H7: Intention to use rainwater harvesting affects rainwater harvesting acceptance.

Table 6. Rainwater Harvesting Intention Question Item

No	Code	Question Item	Reference
1	RHI1	I would consider using rainwater harvesting as an effort to improve the environment in Jakarta.	Liu et al. 2022
2	RHI2	I would consider implementing rainwater harvesting as an alternative water source.	Liu et al. 2018
3	RHI3	I will apply and use rainwater harvesting in the near future.	Liu et al. 2022

Acceptance is the act of recognizing and embracing something, whether it be a situation or an idea, without attempting to alter it. This can be viewed as a psychological process of accepting and adapting to a reality that may be undesirable or unexpected.

Table 7. Rainwater Harvesting Acceptance Question Item

No	Code	Question Item	Reference
1	RHA1	I accept the implementation of rainwater harvesting.	Ignacio et al. 2019
2	RHA2	I will use rainwater harvesting in an effort to reduce land surface degradation in Jakarta.	Bulteau et al. 2011
3	RHA3	I will recommend the implementation of rainwater harvesting to others.	Y. Liu et al. 2022

The model of the study can be described in the image below.

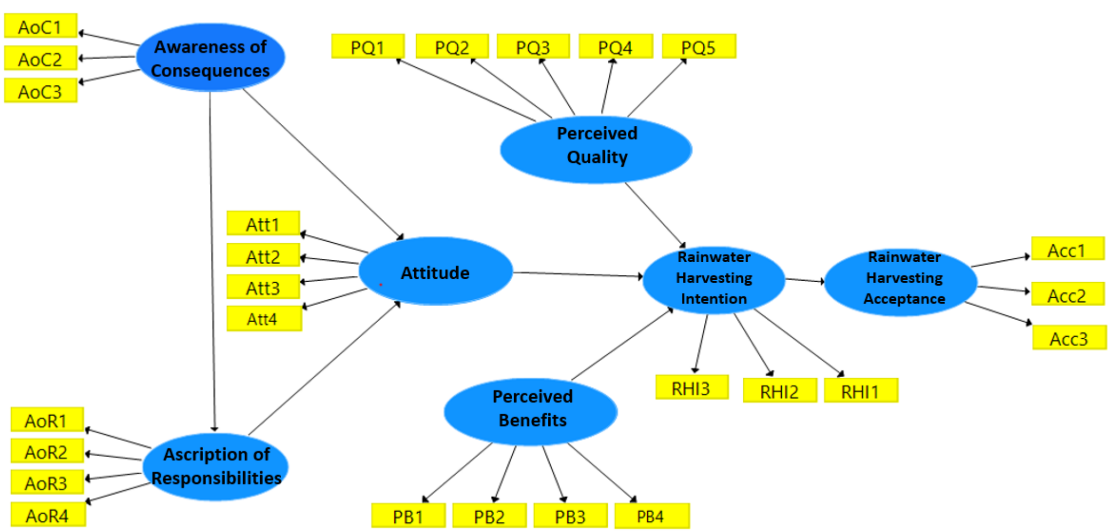

Figure 3. Intention to Harvest of Rainwater for Household Consumption in Jakarta Proposed Model

Before conducting a mass distribution of questionnaires, a pilot survey was carried out to test the validity of the questions on a sample of respondents, and to see if the distribution of their answers is normally distributed. This would indicate if the indicators used are appropriate and accurate in describing the purpose of each variable. The pilot survey was conducted on April 29-30, 2023 with 30 respondents who match the targeted respondents for the main data collection. This questionnaire is distributed to individuals aged 20 to 65 years old, who have implemented or are currently implementing rainwater harvesting and are domiciled in DKI Jakarta. The respondents' data were analyzed to determine the demographic summary and to see the distribution of respondents who answered the questionnaire.
The data were tested using two methods, namely to see the reliability of variables using Cronbach's alpha method and to see the validity of the distribution of question indicators using the geometric mean function. With a minimum Cronbach's alpha value of 0.6 and a geometric mean function value of 3.43. Values below the minimum criteria will be eliminated and not included in the mass distribution of questionnaires. The results of the reliability and validity test of this pilot survey can be seen in the following table.

Table 8. Pilot Survey Validity and Reliability Test Results

No	Variable	Cronbach's Alpha		Indicator	Geomean	
		Value	Status		Value	Status
1	Awareness of Consequences	0,782	Reliable	AoC1	4,269	Reliable
				AoC2	4,143	Reliable
				AoC3	4,206	Reliable
2	Ascription of Responsibilities	0,649	Reliable	AoR1	3,934	Reliable
				AoR2	3,913	Reliable
				AoR3	3,930	Reliable
				AoR4	2,637	Not Reliable
3	Attitude	0,672	Reliable	Att1	4,070	Reliable
				Att2	4,031	Reliable
				Att3	4,327	Reliable
				Att4	3,252	Not Reliable
4	Perceived Quality	0,722	Reliable	PQ1	4,204	Reliable
				PQ2	4,424	Reliable
				PQ3	4,204	Reliable
				PQ4	3,920	Reliable
				PQ5	4,090	Reliable
5	Perceived Benefits	0,645	Reliable	PB1	4,117	Reliable
				PB2	4,308	Reliable
				PB3	3,944	Reliable
				PB4	2,102	Not Reliable
6	Rainwater Harvesting Intention	0,650	Reliable	RHI1	4,317	Reliable
				RHI2	4,373	Reliable
				RHI3	4,510	Reliable
7	Rainwater harvesting Acceptance	0,717	Reliable	RHA1	4,563	Reliable
				RHA2	4,529	Reliable
				RHA3	4,632	Reliable

It was found that 3 indicators were not valid, namely indicators AoR4, Att4, and PB4. Indicators that did not pass the validity test were not included in the mass distribution of the questionnaire. The new model proposed can be described in the image below.

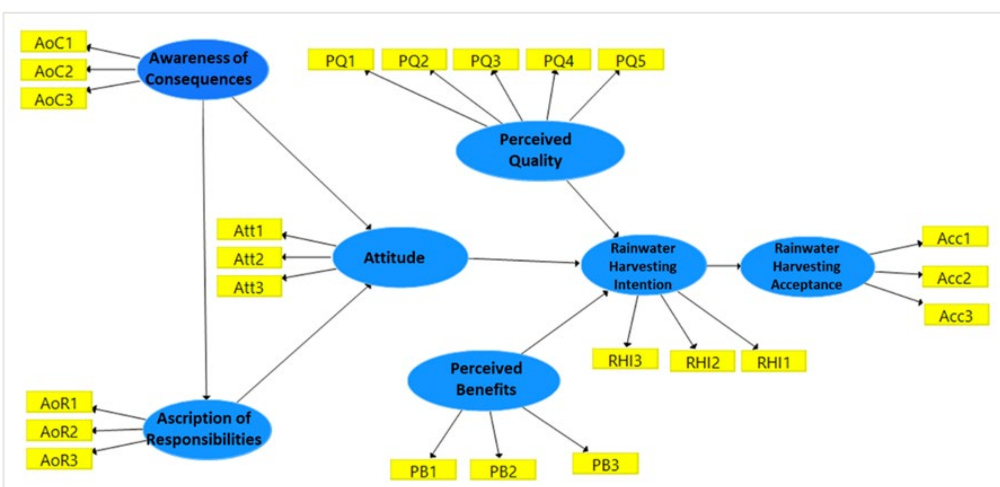

Figure 4. Intention to Harvest of Rainwater for Household Consumption in Jakarta's New Proposed Model

The next step is to evaluate the respondent's answer with Structural Equation Model (SEM). The first step is to check the convergent validity of the model. Cross Loading is a method that compares the loading factor of an indicator to the indicators of other variables. The value of an indicator towards its variable must be greater than the value towards other variables. For example, the indicators Acc1, Acc2, and Acc3 have values of 0.755, 0.702, and 0.833, respectively, which should not be lower than their correlation with other variables, namely awareness of consequences (AoC), ascription of responsibilities (AoR), Attitude (Att), Perceived Benefit (PB), Perceived Quality (PQ), and Rainwater Harvesting Intention (RHI). Although these values have reached the minimum threshold to be categorized as reliable indicators (0.5), they still need to be lower than the indicators possessed by the Rainwater Harvesting Acceptance variable. Thus, in the Perceived Quality (PQ) variable, the resulting values have become reliable indicators. Another example is the PQ1, PQ2, PQ3, PQ4, and PQ5 variables, where each indicator has values of 0.954 and 0.950. These values are reliable since they are not lower than their value towards other variables. As shown in Table 4.6, the loading factors of each indicator are already greater than the loading factors of indicators from other variables. In this case, cross-loading testing can be considered reliable. The results of the cross-loading measurement are as follows.

Table 9. Cross Loading Results

	Acc	**AoC**	**AoR**	**Att**	**PB**	**PQ**	**RHI**
Acc1	**0,755**	0,403	0,398	0,340	0,419	0,465	0,391
Acc2	**0,702**	0,328	0,349	0,431	0,299	0,412	0,416
Acc3	**0,833**	0,425	0,412	0,359	0,377	0,451	0,476
AoC1	0,415	**0,724**	0,424	0,395	0,414	0,518	0,392
AoC2	0,408	**0,761**	0,446	0,339	0,374	0,479	0,505
AoC3	0,322	**0,788**	0,398	0,393	0,407	0,490	0,502
AoR1	0,306	0,320	**0,699**	0,379	0,312	0,406	0,430
AoR2	0,374	0,449	**0,740**	0,414	0,330	0,497	0,441
AoR3	0,437	0,464	**0,797**	0,466	0,487	0,563	0,523
Att1	0,333	0,406	0,408	**0,756**	0,389	0,486	0,468
Att2	0,428	0,420	0,515	**0,858**	0,457	0,611	0,516
Att3	0,374	0,312	0,368	**0,685**	0,361	0,472	0,371
PB1	0,282	0,351	0,283	0,271	**0,670**	0,314	0,363
PB2	0,426	0,426	0,440	0,479	**0,805**	0,523	0,490
PB3	0,348	0,404	0,411	0,408	**0,770**	0,413	0,446
PQ1	0,339	0,387	0,380	0,407	0,286	**0,648**	0,466
PQ2	0,436	0,451	0,431	0,491	0,409	**0,700**	0,470
PQ3	0,411	0,472	0,504	0,543	0,465	**0,765**	0,555
PQ4	0,368	0,529	0,486	0,481	0,364	**0,684**	0,437
PQ5	0,524	0,534	0,582	0,542	0,502	**0,811**	0,542
RHI1	0,417	0,458	0,483	0,444	0,444	0,525	**0,796**
RHI2	0,490	0,517	0,526	0,506	0,502	0,584	**0,876**
RHI3	0,510	0,574	0,570	0,545	0,522	0,623	**0,859**

The second step is to test the variable reliability. Reliability refers to the extent to which a measure or instrument consistently produces the same results or scores over time, across different raters, or across different versions of the measure. This study used Cronbach's alpha function to check the reliability of this study instrument. It is known that in measuring the value of Cronbach's alpha, the value can be considered reliable if it exceeds 0.6. For the variable of acceptance of rainwater harvesting, the value obtained is 0.643, for the variable of awareness of consequence, the value obtained is 0.629, for the variable of the ascription of responsibility, the value obtained is 0.605, for the variable of perceived benefit, the value obtained is 0.612, for the variable of Attitude, the value obtained is 0.653, for the variable of perceived quality, the value obtained is 0.771, and for the variable of intensity, the value obtained is 0.799.

Table 10. Cronbach's Alpha Reliability Test

Variable	Cronbach's Alpha
Rainwater Harvesting Acceptance	0,643
Awareness of Consequences	0,629
Ascription of Responsibilities	0,605
Attitude	0,653
Perceived Benefit	0,612
Perceived Quality	0,771
Rainwater Harvesting Intention	0,799

Lastly, t-statistic values represent examining the relationship between various variables related to rainwater collection and its acceptance. The t-statistic values indicate the strength and significance of the relationships between variables in a statistical context. The analysis shows that several important factors influence public acceptance of rainwater collection.

Table 11. T-Statistic Result

Hypothesis	T Statistics
Awareness of Consequences -> Ascription of Responsibilities	13.324
Awareness of Consequences -> Attitude	3.254
Ascription of Responsibilities -> Attitude	6.035
Attitude -> Rainwater Harvesting Intention	2.138
Perceived Benefit -> Rainwater Harvesting Intention	4.328
Perceived Quality -> Rainwater Harvesting Intention	5.783
Rainwater Harvesting Intention -> Rainwater Harvesting Acceptance	11.681

The t-statistic value represents examining the relationship between various variables related to rainwater collection and its acceptance. The t-statistic values indicate the strength and significance of the relationships between variables in a statistical context. The analysis shows that several important factors influence public acceptance of rainwater collection.

People who are more aware of the consequences of not collecting rainwater tend to feel more responsible to do so. This relationship is very strong, with a t-value of 13.324, indicating that the relationship is highly significant.

Awareness of consequences also affects people's attitudes toward rainwater harvesting, with a t-statistic value of 3.254. This suggests that people who are more aware of the consequences of not collecting rainwater tend to have a more positive attitude toward it. Perceived sense of responsibility for harvesting rainwater also influences people's attitudes toward it, with a t-statistic value of 6.035. This indicates that people who feel more responsible for rainwater collection tend to have a more positive attitude toward it. Public attitudes toward harvesting rainwater also influence their intention to practice it, with a t-statistic value of 2.138. This suggests that people who have a more positive attitude toward rainwater collection are more likely to intend to practice it. The perceived quality of harvesting rainwater also influences people's intention to practice it, with a t- statistic value of 4.328. This indicates that people who have a more positive quality of rainwater perceived are more likely to intend to practice rainwater harvesting. The perceived benefits of rainwater collection also influence people's intention to practice it, with a t- statistic value of 5.783. This indicates that people who have more positive benefits perceived of rainwater collection are more likely to intend to practice it.

Finally, public intention to practice rainwater collection is strongly related to its acceptance as a valid practice, with a t- statistic value of 11.681. This indicates that people who intend to practice rainwater collection are more likely to accept it as a valid and beneficial practice. Overall, this analysis shows that several important factors influence public acceptance of rainwater collection, including awareness of consequences, sense of responsibility, attitude, perceived benefits and quality, and intention to practice it.

6. Conclusion

The factors influencing consumers in accepting household rainwater harvesting implementation are influenced by Rainwater Harvesting Intention. The Attitude factor is influenced by Awareness of Consequences and Ascription of Responsibilities. The Rainwater Harvesting Intention factor is influenced by Perceived Benefits, Perceived Quality, and Attitude. The perceived quality and benefits of the harvested rainwater have a significant impact on the acceptance of household rainwater harvesting by users.

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