Extended theory of planned behavior on utilizing domestic rainwater harvesting in Bekasi, West Java, Indonesia

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Abstract. Sustainable water resources management is a challenge for the world, especially developing countries experiencing population growth, which triggers an increase in water demand. This condition harms the stability of water resources for humans and the ecosystem. Water conservation with rainwater harvesting is an adaptation and mitigation effort to these problems, but Indonesia’s application is still minim. This study scrutinizes rainwater harvesting by looking at literature review that had applied in various countries and discussed the advantages and challenges of these methods. Besides, to understand people’s behaviour intentions, this study uses self-evaluation as the data to be analyzed using an extended theory of planned behaviour model. This study indicates that rainwater harvesting can have a positive impact on water conservation, such as cut down surface water deterioration and mitigate seasonal disasters. These impacts can feel like a whole if those systems are implemented on a wide scale. On the other hand, the extended theory of planned behaviour model shows that 16.4% of the intention to utilize rainwater harvesting with the highest variable is the attitude variable. Recommended approaches for improving attitudes in rainwater harvesting are described in this paper.

1. Introduction
The extended theory of planned behaviour can use for addressing the predictor toward the individual behavioural intention. This study analyzes the behavioural intention to implement rainwater harvesting and provides recommendations for a general approach based on this model’s predictors. This concept is adapted from previous research using the extended theory of planned behaviour model to predict variables that affect people’s intention to conserve water[1], [2]. The research was motivated by water resources condition, which deteriorates in terms of quantity and quality, yet water conservation in Indonesia is still the lowest. The focus of this research is to analysis rainwater harvesting that has been implemented in various countries along with the advantages and challenges faced in this application, as well as providing recommendations to increase their participation in the application of rainwater harvesting based on the analysis of the extended theory of planned behaviour model.

Sustainable water resources management is a big challenge for the world to maintain water resources balance and sustainability. The availability of adequate water resources can maintain social and economic stability[3]. However, an increase in population and urbanization in an area urges water needs for essential activities and supports economic activity. This condition has decreased the groundwater level, increased pollution, and increased natural disasters[4], [5]. Various programs to adapt and mitigate water resource problems began to be implemented in countries in the world.
Water conservation is a program that aims to mitigate the decline in water resources to maintain the resilience of water resources and increase the efficiency of water resources[6], [7]. However, the mechanism for implementing water conservation often fails due to complex problems. It is technical aspects and social aspects, especially in Indonesia, a developing country with low awareness of environmental issues and long-rooted habits[3]. This research focuses on the application of rainwater harvesting as one of the methods for conserving water.

Rainwater harvesting continues to develop and is supported through various sustainability programs and has been implemented in numerous countries in the world [8], [9]. This method is still debated because of the uncertainty of rainwater and its quality. In general, research on rainwater harvesting only emphasizes the potential for harvesting rainwater, which is substitute water resources, and the low level of community intention to harvest rainwater due to easy access to water resources [10]–[13]. Therefore, one of this study’s objectives is to look at interventions that can increase intention to harvest rainwater by considering attitude variables, subjective norms, perceived behavioural control, awareness of water resource problems, knowledge, and demographic conditions (age, education, and income).

Theory of Planned Behavior (TPB) describes a person’s intention to behave or motivation to do a behaviour that is influenced by attitude variables, subjective norms, and perceived behavioural control [14]. Attitude to water conservation refers to how each individual has a positive or negative evaluation of water conservation behaviour [2]. Attitude is people’s willingness to respond to pleasant or unpleasant objects stably or permanently over time, formed through cognitive, emotional, and motivational processes [15].

Subjective norms refer to social pressure felt in engaging specific behaviours such as people who quit smoking when important people think it is unhealthy and want them to quit [1]. Subjective norms can be understood as other people’s opinions related to behaviour where that person is considered important (role model) so that their behaviour is followed and applied [15]. Perceived behavioural control is a psychological perspective in which humans believe that they have the ability and control over performance to perform difficult habits[14]. PBC enters the TPB model intending to work with situations that cause individuals to pay attention to control over an attractive behaviour [15].

The Theory of Planned Behavior model is a model that is open to additional predictors so that the addition of variables can increase the predictive power of a model [1], [2]. Previous research has shown that adding variables such as personal norms, age, education, income, vulnerability, and personal effectiveness of alternative solutions can increase the power to predict a person’s intention to conserve water,[1], [2].

Bekasi City is experiencing an average population growth of 2.6%, and it reported that in 2020 the population reached 3,083,644 people. This condition can trigger increasing water demand. Based on data from the Central Bureau of Statistics, Bekasi City experienced an increase in groundwater by 29% from 2012 to 2016 based on the permit issued. However, some of the groundwater in Indonesia is still illegal and does not require a permit [15]. On the other hand, there is no evidence of the water conservation program’s success in Bekasi City, especially on a domestic scale. Therefore, this study aims to provide recommendations in the form of interventions that can be carried out by the government or other organizations to increase the intention of community behaviour in harvesting rainwater as one of the water conservation efforts.

2. Method

2.1. Population and sample

This research was conducted in Bekasi City, one of Indonesia’s cities that experienced rapid population growth of 13% from 2015 to 2018. In 2018, Bekasi City in 2017 was 725,559 families based on data from the Indonesian Central Statistics Agency. This data becomes the population value, which calculated by using the Z score method, whose equation developed by Cochran (1963):

\[(1)\]
The Z value is the abscissa of the normal curve that intersects the α area on the back (1 - α equals the desired level of confidence), e is the level of precision desired, p is the estimated proportion of attributes present in the population (standard deviation), and q is one minus the p-value. In this study, the precision used was ± 5%, assuming the standard deviation (p) was 0.5. Furthermore, this study uses a 95% confidence level so that the Z score becomes 1.96, so that the total sample size is 385 people.

The determination of respondents from 385 people divided by district based on the number of families in each sub-district in Bekasi City so that the sub-district that has the most number of families, the number of respondents in that district will higher. A more detailed approach carried out using the stratified random sampling method using a lottery with returns that describe the number of samples by sub-district in each district.

2.2. Data collection
The research data obtained by using a questionnaire. This study’s questionnaire contains questions about the variables to be tested, such as behaviour intention, attitudes, subjective norms, perceived behaviour control (PBC), knowledge, awareness of water resource problems, and demographic variables. Table 2 outlines the questions presented in this study.

Contrary, an understanding of rainwater harvesting is taken based on an evaluation of the application of rainwater harvesting implemented in various countries in the world. A comprehensive discussion was carried out by looking at the performance aspects of rainwater harvesting, its advantages, and disadvantages in environmental, economic, and social impacts.

2.3. Data analysis
This study analyzes a person’s behavioural intention to harvest rainwater using the extended TPB model. This study’s fixed variable is a person’s behavioural intention to harvest rainwater, while the independent variables are attitude, subjective norms, behaviour control (PBC), knowledge, awareness of water resource problems, and demographic variables. All variables except demographic variables were calculated using the average value of all their statements representing each question regarding the variable.

This study’s behavioural intention is the community’s response to harvest rainwater to obtain economic benefits and conserving water. The survey instrument includes various rainwater harvesting characteristics, which represent their knowledge for carrying out rainwater harvesting. Various environmental issues, especially water resources, were presented in the survey to see how the respondents’ awareness of these problems. These three variables use the same weighting of values depending on each respondent (Table 2).

The core TPB variable is weighted using 4 points (0 to +3) based on the response. Attitude variables were analyzed based on three questions that looked at people’s perceptions of harvesting rainwater in their homes. Subjective norms were analyzed using three questions to see how important the income and input of the people around them were for harvesting rainwater. Perceived behavioural control is analyzed based on four statements that see their beliefs to exercise control over rainwater harvesting based on their conditions.

Demographic variables consist of age, education, and income. In this research survey instrument, the age variable is expressed in interval data, which is transformed into ordinal data that states that the higher the value, the higher the respondent’s age. Education is expressed in ordinal data based on a person’s learning year under normal conditions. The income variable has been arranged in the survey in the form of income group interval data, which can be directly translated into ordinal data. The weighting description of demographic variables is presented in Table 2.

Validation and instrument reliability tests were also carried out based on 30 respondents who were not part of the respondents in this study but residing in Bekasi City, who was randomly obtained.
Validity and reliability tests using Microsoft Excel software refer to Muhidin&Abdurahan (2007), who used the product-moment correlation method and the Cronbach’s alpha coefficient method (1951). The value of the validity and reliability test of each question item in the instrument is shown in Table 2.

This study used a linear regression test by testing a person’s intention to harvest rainwater as a fixed variable, with the TPB core variable (model 1). Model 2 uses the TPB core variable plus the knowledge variable and adds the awareness variable (model 3). Finally, in model (4), all demographic variables were added.

3. Results and discussion

3.1. Rainwater harvesting

Rainwater harvesting has been known in the Neolithic era to collect and store rainwater[16]. Rainwater harvesting has been implemented by various people globally, both developing countries and developed countries. When viewed from the storage area, the rainwater utilization system is divided into 2, centralized and non-centralized storage[17]. At low population densities, alternative water sources can be applied on a domestic scale (not centralized). On the other hand, it will increase the potential use of a communal (centralized) system[18].

Research conducted by Leong et al. (2019) stated that the RWH system saved 19.1% of water use for commercial scale and 95.3% for domestic activities. On the other hand, the application of rainwater harvesting, which was tested in 7 housing sectors in Iran, demonstrated the ability to save water by 15 to 30% to support home activities and watering plants [19]. Research conducted in Pakistan shows that harvesting rainwater’s water-saving efficiency can be as high as 2% to 40%, depending on the region and the region’s water requirements [20]. Rainwater harvesting in China has an efficiency of 15-70% with a storage capacity of 200 m³[21]. Also, rainwater harvesting can contribute positively to environmental degradation, reducing runoff, erosion, and flooding. In other words, harvesting rainwater is part of mitigation and adaptation to face climate change.

The results of various studies on water-saving efficiency by harvesting rainwater always emphasize that the size of the tank and rainfall in an area are challenges in implementing rainwater harvesting[11], [12], [22]–[24]. Water-saving efficiency in rainwater harvesting can achieve a high-efficiency level if it has a larger tank size that can increase the holding capacity and require less water[19]–[21]. There are many debates regarding the feasibility of harvesting rainwater, such as (1) uncertainties rainfall, especially due to climate change that causes rainwater harvesting cannot become a reliable water resource in terms of its continuity, (2) the quality of rainwater sources, (3) investment with a long return cost so that people need to consider the risk of failure and also the maintenance of this system [22], [25], [26]. It is in line with another research that states the barrier to utilizing rainwater harvesting on a domestic scale are limited information, high cost of the system, limited institutional support and focus by developers, and negative perception on sustainability [27].

Several studies emphasize the initial flushing method in the context of the quality of rainwater, and it can be added with additional processing to improve its quality. This addition increases the cost of implementing rainwater harvesting. However, the cost of harvesting rainwater has low economic benefits (especially in Indonesia). Therefore, various policies had been successful in implementing rainwater harvesting by making policies that provide greater benefits.

3.2. Behaviour intentions towards rainwater harvesting

The variable theory of planned behavior used in this study was used to predict their intention to behave. This is expressed in other studies that use variables in planned behavior theory as predictors to intervention someone intended to do such behaviour [1], [2]. This regression test’s value shows that four models are significant predictors for harvesting rainwater (Table 1). This statement is based on the value of ρ (sig.) below 0.005. The regression results show that model 4 shows that the R2 value is 0.164, which means that this model represents 16.4% of the variance in harvest rainwater. The
variable theory of planned behaviour (TPB) represented 14.1% of the variance of intention to harvest rainwater. This value is in line with research by Lam (2006), which states that TPB’s core variables can affect 13-18% of the intention to harvest rainwater and have a value below 25.1% from other studies.

Knowledge variables only give an additional 1.8% influence on a person’s intention to behave. In other words, if the TPB core variable is controlled, their behaviour influences 1.8% of the intention to harvest rainwater. These results agree with a previous study that shows the attitudes explain more variation in behaviour than does knowledge [28]. The awareness variable towards environmental problems and the demographic variable only affected 0.2% and 0.3%, respectively (Table 1).

Table 1. Linear model regression in intention to conduct rainwater harvesting.

| Model   | R   | R²   | F     | Sig. |
|---------|-----|------|-------|------|
| Model 1 | 0.375 | 14.1% | 20.83 | 0.000 |
| Model 2 | 0.399 | 15.9% | 17.977 | 0.000 |
| Model 3 | 0.401 | 16.1% | 14.522 | 0.000 |
| Model 4 | 0.405 | 16.4% | 9.241  | 0.000 |

Model 1 = TPC core (attitude, subjective norms, perceived behavioral control), Model 2 = Model 1 + knowledge, Model 3 = Model 2 + awareness, Model 4 = Model 3 + demographic (income, ages, and education)

Sources: Author’s Analysis, 2020

The attitude variable has a significant influence on behavioural intention to harvest rainwater. Models 1 to model 4, the attitude variable has a significance value below 0.05, with an influence of 11.3% on behavior intention. Perceived behavioural control significantly affects model 1, but not in models 2 to 4, and the knowledge on rainwater harvesting significantly affects model 2, not on models 3 and 4. Other determinants (awareness, education, income, and age) have little effect on someone’s intention to harvest rainwater. It even has a negative beta value that does not influence a person’s intention to behave.

Table 2. Scoring and Validation Instrument.

| Variables   | Statements                                                                 | Scoring | Validity | Reliability |
|-------------|-----------------------------------------------------------------------------|---------|----------|-------------|
| Knowledge   | Rainwater can be used for activities at home                                 | 0.71    | 0.73     |
|             | Rainwater can be collected from the roof of the house                       | 0.56    | 0.72     |
|             | The use of groundwater harms water availability                             | 0.57    | 0.73     |
|             | Rainwater is an alternative water resource that can replace the use of      | 0.77    | 0.73     |
|             | groundwater and PDAM water                                                  |         |          |
|             | Rainwater quality is relatively lower in urban areas than in rural areas    | 0.84    | 0.73     |
| Attitude    | Agree to do rainwater harvesting                                             | 0.93    | 0.86     |
|             | Rainwater harvesting is important in their house                            | 0.86    | 0.86     |
|             | Think rainwater harvesting is a good idea to implement                      | 0.88    | 0.86     |
| Subjective | Agree to do rainwater harvesting when the people around to do it             | 0.85    | 0.72     |
| Norms       | Agree to harvest rainwater, if the                                          | 0.89    | 0.72     |
people around consider it important

1. Care about the opinions of the people around 0.65
2. Believe that it can reduce the use of groundwater / PDAM by harvesting rainwater 0.82
3. Confident to implement rainwater harvesting with the current condition of house facilities 0.85

Perceived Behavioral Control

1. Harvesting rainwater is own decision 0.79
2. Know that the availability of water, especially groundwater on the island of Java, is running low 0.66
3. Harvesting rainwater is own decision 0.79
4. Believe that the application of rainwater harvesting is easy to implement 0.75

Awareness

1. Know that they have to protect environmental conditions, especially water resources Yes = 3 and No = 1 0.69 0.37
2. Know that one of the problems with water is the quality of water resources that are polluted 0.69
3. Will do rainwater harvesting to reduce water costs per month Yes = 3 and No = 1 0.84

Behavioural Intention

1. Will harvest rainwater as an effort to conserve water Yes = 3 and No = 1 0.89 0.77
2. Will harvest rainwater if the cost is low 0.76

Sources: Author’s Analysis, 2020.

Besides, the subjective norm variable has a low value compared to other variables. This condition is contrary to research conducted by Lam (2006) and Chaudary (2007), which states that subjective norms have a strong influence on a person’s intention to conserve water. In this study, the attitude variable has a strong influence on the behavioural intention of the Bekasi City community in applying rain harvesting. Therefore, an approach in education and outreach is needed to provide a clear picture of the positive and negative impacts of rainwater harvesting. Although education about conservation is a common strategy, there is little evidence that this education can change people’s conservation [29], [30].

This study shows that the attitude to utilizing rainwater harvesting has a significant effect on utilizing rainwater harvesting in their house. There is a need for intervention by emphasizing attitude variables to developing rainwater harvesting in Bekasi City. The results of this study indicate that the community needs to get an education, socialization, and empowerment to provide information to the community that rainwater harvesting has a positive impact on economic factors by reducing water bill payments, environmental factors by reducing groundwater use, and social factors by increasing positive values of harvesting rainwater in the community. Briefly, to adjust the community’s attitudes toward rainwater harvesting, there is a need for intervention toward their knowledge. It is in line with other research that states a strong link between knowledge and attitudes [31]. These programs can encourage public participation to build trust between stakeholders and form compliance and support for policymakers [32].
Also, this program needs support by the government with additional intervention to minimize the negative impacts of rainwater harvesting that the community feels, such as providing incentive assistance or tax subsidy. These supports can encourage the community’s belief to utilize rainwater harvesting themself. The implementation of these approach to the public requires consistency from the government, such as providing incentives and tax subsidies so that it can reduce the burden on people who have the intention but do not have the confidence to carry out rainwater processing [8], [17], [33]. This statement is in line with the opinion of previous research, which states that three main mechanisms provide the best reasons for someone to harvest rainwater, namely (1) conservation habits have economic value, (2) The benefits of conservation are greater than previous behaviour, (3) give power to local resources and make community empowerment [30]. Also, there is proof from Australia and Austin that success escalated rainwater harvesting by giving their community with incentive and subsidy program [6], [17]. This statement is strengthened by another research that claims policymakers need more aggressive to promote water conservation by rewarding those who show a significant reduction in their water usage when most communities have positive attitudes toward it [34].

Table 3. Linear Regression to Analysis the Predictor in Behavioral Intention to Utilize Rainwater Harvesting.

| Predictors     | Model 1 (β) | Model 2 (β) | Model 3 (β) | Model 4 (β) | R² Change |
|----------------|-------------|-------------|-------------|-------------|-----------|
| Attitude       | 0.21**      | 0.181*      | 0.182*      | 0.182*      | 0.113     |
| Subjective Norms | 0.072      | 0.067       | 0.071       | 0.069       | 0.009     |
| PBC            | 0.173*      | 0.151       | 0.151       | 0.156       | 0.019     |
| Knowledge      | 0.143*      | 0.14        | 0.138       | 0.018       |           |
| Awareness      | 0.041       | -0.045      | -0.045      | 0.002       |           |
| Education      | -0.015      | 0           | -0.015      | 0.001       |           |
| Incomes        | -0.015      | 0           | -0.015      | 0           |           |
| Ages           | -0.05       | 0           | -0.05       | 0.002       |           |

*p ≤ 0.05
**p ≤ 0.01
β are standardized regression coefficient
Sources: Author’s Analysis, 2020.

4. Conclusion
Rainwater harvesting can be a promising option as an alternative to water resources and facing climate change. Several studies have shown that consistent and widespread application of rainwater harvesting can positively impact the environment and water resources. Rainwater harvesting has a positive impact on environmental, social, and economy through water bill payment. However, environmental (uncertain rainfall that means uncertain benefit on water saving) and economic condition (long payback period) become the system’s barrier. Intervention through education, socialization, training, and empowerment can encourage the community’s knowledge and attitudes. Besides, a policymaker can also promote rainwater harvesting by incentives and tax subsidy to adjust the community perceived to utilize rainwater harvesting. It can reduce the barrier to economic factors and stimulate their attitudes.

Further research needs to analyze the volume of rainwater harvested in Bekasi City by involving data on the frequency, intensity, and duration of rainfall in Bekasi City, by creating a scenario of tank
size and volume of community water demand so that the volume of rainwater that can be collected and utilized can be modeled. Besides, additional analysis is needed to analyze predictors that have a greater influence than the attitude variable. This study has only provided 16.14% of variables that affect a person’s intention to harvest rainwater, and there are still 83.86% other unknown variance.

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