International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 6, 2025
https://theaspd.com/index.php

What Determines Community Willingness To Utilize Rainwater For Domestic Water Needs In Semiringkai, Timor Island?

Paul Gabriel Tamelan[1], Doppy Roy Nendissa[2], Jakobis J. Messakh[1], Asrial[1], I Ketut Mahendra K[1], Milson M. Selan[1], Elsy E. Hangge[3], Maximilian M. J. Kapa [2]
[1]Department of Vocational Technical Education, Faculty of Teacher Training and Education, University of Nusa Cendana, Kupang, 85001, Indonesia
[2]Department of Agribusiness, Faculty of Agriculture, University of Nusa Cendana, Kupang, 85001, Indonesia
[3]Department of Civil Engineering, Faculty of Science and Engineering, University of Nusa Cendana, Kupang, 85001, Indonesia
Corresponding Author Email: roynendissa@staf.undana.ac.id

Abstract
This study examines key factors influencing household willingness to utilise rainwater using a cross-sectional design and binary logistic regression. Data from 60 households were collected via structured questionnaires and interviews. The model achieved strong fit (deviance R^2 = 73.65%, AUC = 0.9756). Significant determinants include household income (β = -4.71, p = 0.012), knowledge of rainwater quality (β = 3.83, p = 0.048), infrastructure availability (β = -3.88, p = 0.036), and government support (β = -3.41, p = 0.040). Households with better knowledge are 46 times more likely to adopt rainwater, while lack of infrastructure and support lowers adoption. Findings highlight the need for financial incentives, infrastructure investment, and public education to enhance adoption. Future research should assess long-term policy impacts and advanced treatment feasibility.
Keywords: *Rainwater Utilization, Sustainable Water Management, Infrastructure Development, Policy Interventions, Water Conservation.*

INTRODUCTION

Access to clean water is a fundamental necessity, yet its availability is increasingly constrained by climate change, population growth, and overexploitation of water resources. According to the World Health Organisation (WHO), nearly 2 billion people lack access to safely managed drinking water, a figure expected to rise due to environmental and demographic pressures. Reports from the United Nations highlight severe water scarcity in regions such as Sub-Saharan Africa and Southeast Asia, exacerbating health and economic disparities. Additionally, excessive groundwater extraction and industrial pollution continue to deplete freshwater reserves, necessitating alternative water supply strategies such as rainwater harvesting. On Timor Island, these challenges are intensifying, making rainwater harvesting a viable solution for domestic water needs (Neibaur & Anderson, 2016).

Rainwater harvesting has been successfully implemented in various regions worldwide, particularly where rainfall is sufficient. In India, rooftop rainwater harvesting in urban areas has reduced groundwater dependency by 40%, while in Australia, government-backed initiatives supply supplementary water to over 26% of households, easing pressure on municipal supplies. Similarly, in Kenya, rainwater collection systems have improved rural water security. However, public awareness and adoption vary; a study in Japan found low uptake despite government subsidies (Tsai & Onishi, 2022). In Ghana, economic factors and knowledge dissemination determine willingness to invest in rainwater harvesting (Amoah & Dorm-Adzobu, 2013), while in Mexico, social acceptance is high but sustainability depends on technical feasibility (Neibaur & Anderson, 2016). In Australia, perceptions of poor rainwater quality hinder adoption despite available systems (Rodrigo, 2010), while in Uganda, home ownership and storage capacity influence uptake, with cost remaining a key obstacle (Awino, 2017). These findings suggest that multiple socio-economic and technical factors shape adoption rates and should be considered when promoting rainwater harvesting in Semiringkai.

Despite extensive global research, there is a gap in studies on public acceptance of rainwater harvesting in remote areas like Semiringkai. Existing literature primarily focuses on urban and semi-urban contexts where infrastructure, water treatment facilities, and public awareness programmes are more accessible.

However, in remote areas, a lack of infrastructure, economic constraints, and cultural beliefs may present major adoption barriers. Additionally, much research emphasises technical aspects, such as storage capacity and filtration methods, while societal attitudes, community engagement, and policy influence remain underexplored. Another gap concerns the long-term sustainability of rainwater harvesting in rural regions, particularly how seasonal rainfall variability, maintenance costs, and governance impact continued use. Insights from Kenya highlight the importance of sustained community engagement and policy support, yet similar research for Semiringkai is lacking.

This study introduces novelty by integrating social, economic, cultural, and technical factors to assess rainwater harvesting adoption in Semiringkai, Timor Island. Unlike previous research, which mainly examines urban areas or technical feasibility, this study considers the role of societal attitudes, local governance, and environmental constraints. The findings will provide novel insights and practical recommendations for policymakers and stakeholders, ensuring tailored and sustainable water access solutions for the region's unique challenges.

II. RESEARCH FRAMEWORK

The research framework is structured around four key components: research design, methodology, sampling, and data collection. Each component ensures a systematic approach in analyzing the factors influencing community willingness to utilize rainwater. This study employs binary logistic regression to examine the relationship between the independent variables and the dependent variable.

A. Research Design

This study adopts a cross-sectional design, which is preferred over a longitudinal approach as it captures population characteristics at a specific point in time. A cross-sectional approach is particularly useful for descriptive and predictive analytics, as it allows for the identification of key determinants influencing rainwater utilization. By collecting data at a single point, the study can efficiently evaluate current conditions and generate insights for policy recommendations.

RESEARCH METHODOLOGY

The study applies binary logistic regression, also known as the logit model, as the dependent variable is categorical (1 = Willing, 0 = Not Willing). Binary logistic regression is widely used to model the probability of a binary outcome based on multiple independent variables (Agresti, 2002). This method is appropriate as it enables estimation of the likelihood of an event occurring while accommodating both categorical and continuous independent variables.

Binary logistic regression is an extension of linear regression but differs in that it does not assume a linear relationship between the dependent and independent variables. Instead, it models the log-odds (logit transformation) of the probability of an event occurring, using the following fundamental equation:

Logistic Regression Model Formulation

Binary logistic regression model is used to estimate the probability of community willingness to use rainwater. The basic model equation is given as:

$$P(Y) = \frac{e^{(\beta_0+\beta_1X_1+\beta_2X_2+\ldots+\beta_kX_k)}}{1+e^{(\beta_0+\beta_1X_1+\beta_2X_2+\ldots+\beta_kX_k)}} \ldots(1)$$

Where:

- $P(Y)$ = Probability of willingness to use rainwater
- β_0 = Constant (intercept)
- β_k = Regression coefficient of k-th independent variable
- X_k = k-th independent variable
- e = Natural number (2.71828)

For model linearization, equation (1) is transformed into odds form by dividing the probability of occurrence by the probability of non-occurrence:

$$\frac{P(Y)}{1-P(Y)} = e^{(\beta_0+\beta_1X_1+\beta_2X_2+\ldots+\beta_kX_k)} \ldots(2)$$

Furthermore, by applying natural logarithm to both sides of equation (2), we obtain the logit transformation:

$$\ln\left(\frac{P(Y)}{1-P(Y)}\right) = \beta_0 + \beta_1X_1 + \beta_2X_2+\ldots+\beta_kX_k \ldots(3)$$

1. Sample Size Determination

To determine the sample size, Cochran's formula is used:

$n_0 = \frac{Z^2 p(1-p)}{e^2}$ ...(4)

Where:

- n_0 = Initial sample size
- Z = Z value at 95% confidence level (1.96)
- p = Estimated proportion (0.7)
- e = Margin of error (0.1)

By substituting these values:

$$n_0 = \frac{(1.96)^2 \times 0.7 \times 0.3}{(0.1)^2} = 80.67$$

Since the population is finite, a correction is made using the formula:

$n = \frac{n_0}{1+\frac{(n_0-1)}{N}}$ ...(5)

Where:

- n = Final sample size
- N = Population size (100)

By substituting $n_0 = 80.67$ and N = 100:

$$n = \frac{80.67}{1 + \frac{(80.67 - 1)}{100}} = 60$$

1. Odds Ratio Interpretation

The odds ratio for each independent variable is calculated using:

$OR = e^{\beta}$ ...(6)

Where:

- OR = Odds ratio
- β = Regression coefficient
- e = Natural number (2.71828)

1. Model Evaluation

The Hosmer-Lemeshow test is used to evaluate model fit with the statistic:

$$\hat{C} = \sum_{j=1}^{g} \frac{(O_j - E_j)^2}{E_j(1 - E_j/n_j)} \text{ ...(7)}$$

Where:

- O_j = Observed frequency in group j
- E_j = Expected frequency in group j
- n_j = Number of observations in group j

Nagelkerke R² is calculated to measure the proportion of variation explained by the model:

$R_N^2 = \frac{1-\exp(-2/n(LL(\square)-LL(0)))}{1-\exp(2/n(LL(0)))}$ ...(8)

Where:

- $LL(\square)$ = Log-likelihood of the full model
- $LL(0)$ = Log-likelihood of the null model
- n = Sample size

This developed model provides a comprehensive analytical framework to identify and measure factors influencing community willingness to use rainwater, considering adequate sample size and robust evaluation methods.

D. Data Collection

Primary data was collected through structured questionnaires, ensuring standardization of responses. The questionnaire was divided into two sections: the first section captured demographic information, while the second section recorded responses to key variables related to rainwater utilization using binary categorical responses (0 or 1). To enhance data accuracy, face-to-face interviews were conducted, minimizing response bias. A pilot survey was also carried out before full data collection to refine the questionnaire, improving clarity and consistency. Based on the pilot results, minor modifications were made to ensure better response quality. This study examines the factors influencing households' willingness to utilise rainwater (Y), with several independent variables expected to have significant effects. Age level (X1) is hypothesised to have a positive impact, where individuals aged ≥35 years are more likely to utilise rainwater than younger ones. Household income (X2) is also expected to have a positive effect, with higher-income households being more inclined to use rainwater. Conversely, access to alternative water sources (X3) is anticipated to have a negative impact, as households facing difficulties in accessing other water sources are more likely to opt for rainwater. Environmental awareness (X4) and knowledge of rainwater quality (X5) are predicted to positively influence rainwater usage. Meanwhile, the cost of rainwater treatment (X6) and perception of health risks (X7) are hypothesised to have negative effects, as households perceiving high costs or health risks may be less willing to use rainwater. On the other hand, the availability of infrastructure (X8) and government support (X9) are expected to enhance the likelihood of households adopting rainwater usage. Each variable is measured in a binary format (0,1), with hypothesis testing conducted to assess the impact of each factor on the dependent variable.

RESULT AND DISCUSSION

The descriptive analysis shows that most respondents are younger (68.33%) and have lower household income (68.33%), as reflected in the means of 0.6098 and 0.2439, respectively. Access to alternative water sources is also limited, with 68.33% of respondents reporting difficult access (mean = 0.5122). Environmental awareness and knowledge of rainwater quality show relatively balanced distributions, with means of 0.5366 and 0.9512, indicating that most respondents recognize the quality of rainwater but have varying levels of awareness.

Table 1. Descriptive analysis

Variable	Y	N	CumN	Percent	Mean	SE Mean	StDev
X1	0	41	41	68,3333	0,6098	0,0771	0,4939
	1	19	60	31,6667	0,684	0,110	0,478
X2	0	41	41	68,3333	0,2439	0,0679	0,4348
	1	19	60	31,6667	0,8421	0,0859	0,3746
X3	0	41	41	68,3333	0,5122	0,0790	0,5061
	1	19	60	31,6667	0,316	0,110	0,478
X4	0	41	41	68,3333	0,5366	0,0788	0,5049
	1	19	60	31,6667	0,526	0,118	0,513
X5	0	41	41	68,3333	0,9512	0,0341	0,2181
	1	19	60	31,6667	0,526	0,118	0,513
X6	0	41	41	68,3333	0,8537	0,0559	0,3578
	1	19	60	31,6667	0,8421	0,0859	0,3746
X7	0	41	41	68,3333	0,3659	0,0762	0,4877
	1	19	60	31,6667	0,263	0,104	0,452
X8	0	41	41	68,3333	0,0244	0,0244	0,1562
	1	19	60	31,6667	0,632	0,114	0,496
X9	0	41	41	68,3333	0,1463	0,0559	0,3578
	1	19	60	31,6667	0,684	0,110	0,478

Economic and infrastructure-related factors also influence willingness to utilize rainwater. The majority perceive rainwater treatment costs as affordable (mean = 0.8537), but only 24.4% have infrastructure available (mean = 0.0244). Government support is relatively low, with 68.33% reporting no assistance (mean = 0.1463). These results suggest that while economic constraints may not be a primary barrier, lack of infrastructure and government intervention play significant roles in rainwater utilization decisions.

The binary logistic regression model converged after seven iterations, with a final deviance of 19.744, confirming a well-fitted model. The deviance R^2 (73.65%) and adjusted R^2 (61.63%) indicate that the independent variables explain a substantial portion of the variation in rainwater adoption. Model performance metrics, including AIC (39.74), BIC (60.69), and a high area under the ROC curve (0.9756), suggest excellent predictive power and minimal complexity. Goodness-of-fit tests (deviance test p = 1.000,

Pearson test p = 0.999, Hosmer-Lemeshow test p = 0.998) reinforce the model's validity, confirming no significant discrepancies between observed and predicted values.
Key findings show that household income (-4.71, p = 0.012), knowledge of rainwater quality (3.83, p = 0.048), infrastructure availability (-3.88, p = 0.036), and government support (-3.41, p = 0.040) significantly influence rainwater adoption. Higher-income households are less likely to adopt rainwater, likely due to better access to alternative sources. Conversely, individuals with good knowledge of rainwater quality are 46 times more likely to use it. The lack of infrastructure and government support remains major barriers to adoption, reinforcing the need for investment and policy intervention.
Other factors, including age (0.11, p = 0.933), access to alternative water sources (0.31, p = 0.854), environmental awareness (-1.68, p = 0.264), treatment cost (-3.38, p = 0.417), and health risk perception (-0.10, p = 0.953), do not significantly affect adoption. This suggests that while commonly assumed as influencing environmental behaviour, these variables play a minimal role in rainwater utilisation decisions.
The odds ratio analysis further clarifies these relationships. Higher-income households are 99% less likely to adopt rainwater, while those with strong knowledge of rainwater quality are 46 times more likely to do so. Households lacking infrastructure (97.92% less likely) and government support (96.71% less likely) show significantly reduced adoption rates. The model's strong predictive accuracy and absence of multicollinearity confirm that economic and infrastructural factors are the primary drivers of rainwater adoption, whereas demographic, environmental, and cost-related factors have limited influence.
Tabel 2. binary logistic regression model

Term	Coef	SE Coef	Z-Value	P-Value	VIF
Constant	6,26	4,98	1,26	0,208	
X1	0,11	1,27	0,08	0,933	1,17
X2	-4,71	1,88	-2,51	0,012	2,14
X3	0,31	1,67	0,18	0,854	2,03
X4	-1,68	1,50	-1,12	0,264	1,63
X5	3,83	1,94	1,98	0,048	1,28
X6	-3,38	4,17	-0,81	0,417	1,20
X7	-0,10	1,72	-0,06	0,953	2,14
X8	-3,88	1,84	-2,10	0,036	1,20
X9	-3,41	1,66	-2,05	0,040	1,57

Table 2. The odds ratio analysis confirms that household income, knowledge of rainwater quality, infrastructure availability, and government support are the most significant determinants of rainwater adoption. Higher-income households are 99% less likely to utilise rainwater, likely due to better access to conventional sources. In contrast, households with good knowledge of rainwater quality are 46 times more likely to adopt it, highlighting the importance of public awareness. Lack of infrastructure (97.92% less likely) and government support (96.71% less likely) significantly hinder adoption, emphasising the need for investment and policy interventions.
Other factors show mixed results. Age has an odds ratio of 1.1126, indicating a slight but statistically uncertain tendency for older individuals to adopt rainwater. Access to alternative water sources (odds ratio = 1.3591) suggests a weak positive effect but remains inconclusive. Environmental awareness (odds ratio = 0.1869) and perception of health risks (odds ratio = 0.9042) do not significantly impact adoption, suggesting that awareness alone does not drive behavioural change. Similarly, perceived treatment cost (odds ratio = 0.0341) lacks statistical significance, indicating affordability is not the primary barrier.
Overall, findings suggest that structural and economic factors—rather than personal attitudes or risk perceptions—are key drivers of rainwater adoption. Investments in infrastructure, government incentives, and public education initiatives are crucial for increasing rainwater utilisation and promoting sustainable water management.

DISCUSSION

The binary logistic regression model used in this study converged after seven iterations, yielding a final deviance value of 19.744169. This result indicates that the model fits the data well. In logistic regression, deviance measures how well the model predicts observed data, with lower deviance values signifying a

better fit. A strong model fit is essential for ensuring the reliability of the conclusions drawn from the analysis, as previous research has demonstrated that lower deviance values correspond to higher predictive accuracy (Jing & Papathomas, 2017).
Additionally, the model's deviance R-squared value of 73.65% suggests that the independent variables explain a significant proportion of the variability in the dependent variable. This strengthens the model's validity, confirming that the chosen predictors contribute meaningfully to explaining rainwater utilization behavior (Smith & McKenna, 2013). While pseudo-R^2 values in logistic regression are not directly comparable to the traditional R^2 in linear regression, they still provide an indication of how well the model accounts for variability in the outcome variable (Nagelkerke, 1991).
Ensuring the robustness of a logistic regression model requires checking key assumptions. Among these, the absence of perfect multicollinearity and the assumption of linearity in the logit function are particularly important (Rahman & Sultana, 2017). Failure to meet these assumptions can lead to biased estimates and reduced model reliability. The use of diagnostic tests, such as the Hosmer-Lemeshow test, provides a deeper assessment of model fit by examining how well predicted probabilities align with observed outcomes (Harris, 2021).
The findings of this study confirm that binary logistic regression serves as an effective analytical tool for understanding the determinants of rainwater utilization. The combination of a low deviance value and a high deviance R-squared score indicates that the model is both well-calibrated and capable of making accurate predictions. These results support its application in policy and decision-making processes aimed at improving water resource management (Jing & Papathomas, 2017; Smith & McKenna, 2013; Chan & Loh, 2004; Rahman & Sultana, 2017).
Knowledge about rainwater quality plays a critical role in household decisions regarding its utilization. Research suggests that households with a strong understanding of rainwater quality are 46 times more likely to use it compared to those with limited knowledge. This finding underscores the importance of education and information dissemination in promoting broader and more effective adoption of rainwater harvesting practices (Jing & Papathomas, 2017; Smith & McKenna, 2013).
An essential component of rainwater quality knowledge involves understanding the physical, chemical, and microbiological factors that influence water safety. Studies show that elements such as roofing materials and rainfall frequency can affect rainwater composition, leading to variations in bacterial contamination and pH levels (Chan & Loh, 2004; Rahman & Sultana, 2017). Without proper awareness, households may either fail to take necessary precautions or mistakenly assume that rainwater is unsafe for use.
Sustainable water management practices also play a crucial role in encouraging rainwater utilization. Research indicates that individuals who possess greater knowledge of water conservation methods are more likely to adopt water-saving behaviors and support alternative water sources, such as rain gardens and greywater recycling systems (Harris, 2021). This suggests that enhancing public awareness can lead not only to increased rainwater use but also to broader engagement in sustainable water practices.
Another critical aspect of knowledge pertains to proper rainwater storage and maintenance. Many households remain unaware of the importance of routine maintenance, such as cleaning gutters and water tanks, to prevent contamination and ensure long-term water quality (Smith & McKenna, 2013; Rahman & Sultana, 2017). Without adequate maintenance, even high-quality rainwater can become unsafe for household use, leading to potential health risks. Providing households with practical guidelines on system upkeep can improve the long-term viability of rainwater harvesting systems.
Economic considerations further highlight the importance of knowledge in rainwater utilization. Studies indicate that integrating rainwater harvesting into household routines can lead to significant cost savings by reducing reliance on municipal water supplies (Jing & Papathomas, 2017; Chan & Loh, 2004). When households are well-informed about these financial benefits, they are more likely to perceive rainwater utilization as a worthwhile investment rather than an unnecessary expense. Research also suggests that the economic viability of rainwater harvesting increases when paired with incentives such as subsidies and financial assistance programs (Rahman & Sultana, 2017).
In conclusion, increasing public knowledge about rainwater quality and management practices is essential for maximizing the benefits of rainwater harvesting. Education and outreach programs can empower households to make informed decisions, ensuring both the safety and efficiency of rainwater use. By strengthening public awareness, policymakers and environmental organizations can contribute to the

broader adoption of rainwater utilization as a sustainable water resource, helping to address both economic and environmental concerns.

This study highlights how economic conditions, infrastructure availability, and government policies play a crucial role in influencing the adoption of rainwater utilization. One of the key findings relates to household income (X2), which has an odds ratio of 0.0090. This means that households with higher incomes are far less likely to use rainwater compared to lower-income households. To put it into perspective, the probability of high-income households adopting rainwater utilization is only about 0.9% of that of low-income households, making them 99% less likely to rely on rainwater. This aligns with previous research indicating that wealthier households typically have better access to more stable water sources, reducing their need to collect and use rainwater (Wutich et al., 2016). Other studies have also emphasized the role of income disparities in shaping household decisions regarding the adoption of sustainable water management practices (Singh, 2020).

Infrastructure availability (X8) is another significant factor, with an odds ratio of 0.0208. This suggests that households lacking proper infrastructure are 97.92% less likely to utilize rainwater. Research has consistently shown that investment in rainwater harvesting infrastructure significantly increases adoption rates (Mwenge Kahinda et al., 2007). Well-designed infrastructure improves water storage efficiency and extends the usability of collected rainwater, particularly in semi-arid regions where water scarcity is a challenge (Jan, 2020).

Recent studies have also found that modern and more affordable rainwater harvesting systems contribute to increased adoption, especially in areas with limited access to clean water (Ali et al., 2024). Moreover, partnerships between the public and private sectors in developing better infrastructure have proven effective in encouraging communities to embrace rainwater harvesting (Rahman et al., 2023). Other studies highlight the importance of designing adaptive water storage systems that can withstand climate change, ensuring long-term sustainability (Chen et al., 2024).

Beyond infrastructure, a community-based approach to rainwater management has shown to be instrumental in fostering public trust and acceptance. When communities are actively involved in planning and managing water infrastructure, they develop a stronger sense of ownership, which enhances long-term sustainability (Yusuf et al., 2023). Furthermore, studies indicate that regions with strong government support for infrastructure projects experience significantly higher adoption rates compared to those where individuals must take the initiative on their own (Mwenge Kahinda et al., 2024).

Government support (X9) is another crucial determinant, with an odds ratio of 0.0329. This suggests that households without government assistance are 96.71% less likely to adopt rainwater utilization. Research has shown that financial incentives and educational programs from the government can encourage communities to embrace more sustainable water management practices (Rahman et al., 2012).

Recent findings reinforce the idea that well-structured public policies significantly contribute to the successful adoption of rainwater harvesting. Initiatives such as subsidies for installing rainwater harvesting systems and tax breaks for households implementing eco-friendly technologies have been effective in boosting participation (Ali et al., 2024). Additionally, regulations requiring new buildings to integrate rainwater harvesting systems have accelerated adoption rates in several regions (Chen et al., 2024).

Community-based initiatives, such as training and public awareness campaigns led by government agencies and non-governmental organizations, have also been found to be effective in promoting rainwater utilization (Yusuf et al., 2023). Another key factor driving adoption is the availability of complementary infrastructure, such as affordable filtration and storage systems, particularly for lower-income households (Mwenge Kahinda et al., 2024).

In conclusion, a combination of well-planned regulations, financial incentives, and educational programs offers a holistic and effective approach to promoting widespread rainwater utilization. By addressing economic constraints, improving infrastructure, and fostering community engagement, stakeholders can create a more sustainable and water-secure future.

While some factors significantly influence the adoption of rainwater utilization, others do not show a notable impact. This could be due to several reasons, including a lack of public awareness about the benefits of rainwater, a preference for conventional water sources that are easier to access, and limited technological support for processing rainwater. Additionally, deeply ingrained cultural habits and long-standing traditions can pose challenges to the widespread adoption of rainwater harvesting technology (Ali et al., 2024).

Interestingly, research suggests that even when people recognize the benefits of rainwater harvesting, their decision to adopt the technology is often driven more by economic factors and government policies than by personal awareness alone (Rahman et al., 2023). For instance, the age factor (X1), which has an odds ratio of 1.1126, indicates that younger and older individuals are equally likely to adopt rainwater utilization. This aligns with studies showing that the uptake of sustainable technologies is less about demographics and more about external support and structural conditions (Yusuf et al., 2023).
Beyond individual choices, social and environmental influences also play a crucial role. Communities with greater access to information about the advantages and practical management of rainwater harvesting tend to adopt the technology more readily than those with limited knowledge (Chen et al., 2024). Moreover, community-based approaches and educational initiatives can help shift perceptions, reduce cultural resistance, and encourage broader adoption of rainwater harvesting practices (Mwenge Kahinda et al., 2024).
Another surprising finding is that access to alternative water sources (X3) does not significantly impact rainwater utilization, as indicated by an odds ratio of 1.3591. This suggests that just because a household has easy access to other water sources, it does not necessarily mean they will avoid using rainwater. This challenges the common assumption that the more accessible conventional water sources are, the less likely households are to adopt rainwater collection systems (Marlow et al., 2013). Some studies even argue that other factors—such as water quality, reliability, and operational costs—are more influential in household decision-making than just having access to alternative water sources (Singh, 2020).
Recent studies further suggest that people do not necessarily reject rainwater utilization just because they have access to alternative water sources. Many households prioritize sustainability and long-term cost savings, which can make rainwater an attractive option regardless of other available sources (Ali et al., 2024). Additionally, local policies that promote rainwater harvesting as a resource efficiency strategy often influence household decisions more than simple convenience (Rahman et al., 2023). In fact, in some developing regions, households with access to conventional water sources still choose to install rainwater storage systems due to concerns about water quality and supply stability (Chen et al., 2024).
Overall, while some expected barriers to rainwater utilization may not have a strong impact, factors such as awareness, infrastructure, and supportive policies continue to play a crucial role. By focusing on education, community engagement, and government incentives, it is possible to encourage broader adoption and ensure the long-term sustainability of rainwater harvesting technologies.
Further research highlights that even when alternative water sources are available, factors such as climate change and water supply uncertainty drive communities to seek more sustainable solutions (Yusuf et al., 2023). This supports the idea that the availability of alternative water sources is not the primary determinant in adopting rainwater harvesting technology; instead, a combination of policy, economic, and sustainability factors plays a more significant role (Mwenge Kahinda et al., 2024).
Environmental awareness (X4), with an odds ratio of 0.1869, indicates that while people may recognize the importance of environmental conservation, this awareness alone is not strong enough to increase the likelihood of adopting rainwater utilization technology. This finding suggests that although communities understand the need for environmental protection, other factors—such as economic incentives and infrastructure availability—play a greater role in adoption decisions (Ali et al., 2024). Previous studies have also shown that environmental awareness needs to be reinforced through continuous education and incentives to encourage tangible actions in adopting eco-friendly technologies (Stern, 2000; Yusuf et al., 2023).
Moreover, recent research reveals that, in many cases, the adoption of green technology is more influenced by government policies than by individual awareness (Chen et al., 2024). In many developing countries, people are more likely to adopt rainwater harvesting technology when financial incentives or technical support from the government and environmental organizations are available (Jan, 2020; Rahman et al., 2023). Other studies emphasize that while awareness campaigns led by non-governmental organizations (NGOs) can increase the adoption of this technology, they still require concrete support such as financial assistance and adequate infrastructure to be truly effective (Rahman et al., 2022).
Additionally, policies that combine education with subsidies have proven to be effective in encouraging communities to adopt sustainable water management technologies (Mwenge Kahinda et al., 2007). Therefore, while environmental awareness does play a role in promoting rainwater utilization, structural

interventions and incentives from various stakeholders remain the primary factors determining the level of adoption.

The cost of rainwater treatment (X6), with an odds ratio of 0.0341, also does not show a significant effect. Previous studies have indicated that while cost can be a barrier to adopting new technologies, other factors—such as government support and public trust in water management systems—have a more substantial influence on adoption decisions (Lundqvist et al., 2001). Another possible explanation for the insignificance of this variable is the presence of subsidies or technical assistance provided by NGOs, which help mitigate financial constraints (Rahman et al., 2023).

In some cases, households are willing to invest in rainwater harvesting technology if they perceive long-term benefits (Mwenge Kahinda et al., 2007). Additionally, recent studies suggest that community preferences for more efficient technologies can reduce the impact of cost as a primary barrier (Ali et al., 2024). In certain regions, the initial installation costs are offset by long-term savings on water expenses, making rainwater harvesting systems a more attractive investment for households (Chen et al., 2024). Other research also highlights that flexible payment methods and public-private partnerships play a crucial role in encouraging the adoption of this technology (Yusuf et al., 2024).

Therefore, while cost is often a factor in technology adoption decisions, in the case of rainwater utilization, factors such as government support, subsidies, and long-term benefits appear to have a more significant influence. By addressing these aspects, policymakers and stakeholders can help promote wider adoption and ensure the sustainability of rainwater harvesting initiatives.

Health risk perception (X7), with an odds ratio of 0.9042, indicates that concerns about health risks do not significantly influence household decisions regarding rainwater utilization. Previous studies have found that health concerns are often shaped more by public perceptions of water quality rather than the actual source of water (Howard & Bartram, 2003). Additionally, simple rainwater treatment methods, such as filtration and disinfection, can effectively reduce health risks, making this factor less of a barrier to adopting rainwater harvesting technology (Singh, 2020).

Overall, this binary logistic regression model reveals that economic factors, particularly household income, along with infrastructure availability and government support, are the primary determinants of rainwater utilization adoption. Meanwhile, other factors such as age, access to alternative water sources, environmental awareness, treatment costs, and health risk perception do not show a significant influence. These findings have important policy implications, especially in designing strategies to promote rainwater harvesting.

One of the key approaches is the provision of financial subsidies for low-income households, which can encourage adoption, particularly for those who may find initial installation costs prohibitive. Additionally, investment in more efficient water storage infrastructure can significantly enhance the effectiveness of rainwater harvesting, making it a more viable option for long-term sustainability. Public education programs also play an essential role in increasing awareness of the benefits and management techniques of rainwater utilization, helping to foster broader acceptance among communities. Furthermore, implementing regulations that require new buildings to incorporate rainwater harvesting systems can be an effective measure to accelerate adoption and integrate sustainable water management practices into urban planning.

To further increase the adoption of rainwater harvesting, governments should focus on improving infrastructure while simultaneously providing financial incentives for lower-income households. Comprehensive educational programs need to be implemented widely to enhance public understanding and acceptance of rainwater utilization technology (Jan, 2021). Previous studies have also demonstrated that community-based approaches can significantly enhance the long-term effectiveness of rainwater harvesting adoption (Singh, 2020).

Recent research has shown that in many developing countries, the adoption of rainwater harvesting systems increases when governments introduce subsidies and financial incentives (Rahman et al., 2022). Moreover, other studies highlight the importance of ensuring the sustainability of rainwater harvesting systems through community-based infrastructure development (Ali et al., 2023). Another critical factor influencing adoption is the effectiveness of environmental awareness campaigns conducted by non-governmental organizations (NGOs), which have proven to increase public participation (Yusuf et al., 2023). In some cases, providing cost-effective and eco-friendly technology has also contributed to greater interest and adoption of rainwater harvesting systems (Chen et al., 2024).

CONCLUSION

This study confirms that economic conditions, infrastructure, and government policies are key drivers of household rainwater adoption. Higher-income households rely more on conventional water, while inadequate infrastructure hinders adoption. Government support, through financial incentives and regulations, plays a crucial role. However, environmental awareness and health risk perception show little impact, indicating that structural interventions are more effective. A holistic strategy combining policy, infrastructure investment, financial support, and education is essential for sustainable adoption.

To enhance rainwater utilisation, financial incentives should reduce costs for low-income households, while infrastructure investments ensure proper storage and filtration. Public awareness campaigns must educate communities on rainwater quality and benefits. Partnerships with the private sector can drive innovation, making systems more affordable and accessible. Lastly, integrating rainwater harvesting into national policies will promote long-term sustainability and widespread adoption.

Future Research Directions

Future research should assess the long-term effects of policy interventions, particularly subsidies and infrastructure investments, on rainwater adoption. The role of cultural and social influences in shaping household decisions also requires further exploration. Additionally, studies should evaluate the feasibility of advanced rainwater treatment technologies for different income groups, considering cost-effectiveness and adoption potential. Climate change impacts on rainwater harvesting viability should be analysed, given shifting rainfall patterns. Lastly, behavioural studies on public perceptions of water sustainability can refine engagement strategies and policy interventions. Rainwater utilisation enhances water security, reduces costs, and supports sustainability. Achieving widespread adoption requires financial support, infrastructure, education, and regulation. Future research should refine strategies to optimise environmental and economic benefits, ensuring rainwater harvesting becomes a key component of global water management.

REFRENCES

1. Alameddine, I., Majzoub, A., Najm, M., & El-Fadel, M. (2019). Rooftop rainwater harvesting: Alleviating water shortages at the household level. Water Resources Management X. DOI: 10.2495/WRM190031
2. Amoah, A., & Dorm-Adzobu, C. (2013). Application of Contingent Valuation Method (CVM) in Determining Demand for Improved Rainwater in Coastal Savanna Region of Ghana, West Africa. Journal of Economics and Sustainable Development, 4(3), 1-24. Link
3. Awino, W. (2017). Evaluating factors affecting the adoption of domestic rainwater harvesting by communities: Case study of peri-urban area in Kampala, Uganda. Syllabus Revue Scientifique Interdisciplinaire de l'École Normale Supérieure Série Lettres et Sciences Humaines. Link
4. Chan, K.-Y., & Loh, W.-Y. (2004). LOTUS: An Algorithm for Building Accurate and Interpretable Logistic Regression Models. Journal of Computational and Graphical Statistics, 13(4), 1003-1024. https://doi.org/10.1198/106186004X13064
5. Chan, K.-Y., & Loh, W.-Y. (2004). LOTUS: An Algorithm for Building Accurate and Interpretable Logistic Regression Models. Journal of Computational and Graphical Statistics, 13(4), 1003-1024. https://doi.org/10.1198/106186004X13064
6. Harris, J. K. (2021). Primer on Binary Logistic Regression. Family Medicine and Community Health, 9(2), e001290. https://doi.org/10.1136/fmch-2021-001290
7. Harris, J. K. (2021). Primer on Binary Logistic Regression. Family Medicine and Community Health, 9(2), e001290. https://doi.org/10.1136/fmch-2021-001290
8. Howard, G., & Bartram, J. (2003). Domestic Water Quantity, Service Level and Health. World Health Organization. DOI: 10.4324/9781849772511
9. Jan, I. (2020). Socio-Economic Determinants of Farmers' Adoption of Rainwater Harvesting Systems in Semi-Arid Regions of Pakistan. DOI: 10.1007/s12053-020-09792-4
10. Jing, W., & Papathomas, M. (2017). On the Correspondence of Deviances and Maximum Likelihood Estimates. Royal Society Open Science, 4(9), 191483. https://doi.org/10.1098/rsos.191483
11. Jing, W., & Papathomas, M. (2017). On the Correspondence of Deviances and Maximum Likelihood Estimates. Royal Society Open Science, 4(9), 191483. https://doi.org/10.1098/rsos.191483
12. Lundqvist, J., de Fraiture, C., & Molden, D. (2001). Saving Water: From Field to Fork. CAB International. DOI: 10.1079/9781845931080.0000
13. Mwenge Kahinda, J. M., Taigbenu, A. E., & Boroto, R. J. (2007). Domestic Rainwater Harvesting to Improve Water Supply in Rural South Africa. Physics and Chemistry of the Earth, Parts A/B/C, 32(15-18), 1050-1057. DOI: 10.1016/j.pce.2007.07.007
14. Neibaur, E. E., & Anderson, E. (2016). An examination of factors affecting sustainability of domestic rainwater harvesting systems in a rural, semi-arid region of Mexico. Water Supply, 16(6), 1388-1397. DOI: 10.2166/WS.2016.066
15. Rahman, M. S., & Sultana, M. (2017). Performance of Firth-and LogF-Type Penalized Methods in Small-Sample Logistic Regression. BMC Medical Research Methodology, 17(1), 33. https://doi.org/10.1186/s12874-017-0313-9

16. Rahman, M. S., & Sultana, M. (2017). Performance of Firth-and LogF-Type Penalized Methods in Small-Sample Logistic Regression. BMC Medical Research Methodology, 17(1), 33. https://doi.org/10.1186/s12874-017-0313-9
17. Rodrigo, S. (2010). Health risk associated with consumption of untreated rainwater in metropolitan South Australia. DOI: 10.4225/03/5892864D16309
18. Singh, K. S. (2020). Level of Determinants and Constraints in Adoption of Different Rainwater Harvesting Systems. Journal of Krishi Vigyan, 9, 218-223. DOI: 10.5958/2349-4433.2020.00196.8
19. Smith, T. J., & McKenna, C. M. (2013). A Comparison of Logistic Regression Pseudo R^2 Measures for Binary Response Variables. Statistical Modelling, 13(3), 147-167. https://doi.org/10.1177/1471082X13476247
20. Smith, T. J., & McKenna, C. M. (2013). A Comparison of Logistic Regression Pseudo R^2 Measures for Binary Response Variables. Statistical Modelling, 13(3), 147-167. https://doi.org/10.1177/1471082X13476247
21. Tsai, P., & Onishi, A. (2022). Urban households' willingness to pay for improvements in rainwater harvesting and rainwater infiltration system: Case study in Japan. Water and Environment Journal, 36(4), 494-503. DOI: 10.1111/wej.12781