**PLANNING MALAYSIA:**
*Journal of the Malaysian Institute of Planners*
**VOLUME 23 ISSUE 2** (2025), Page 26 – 40

# ANALYSIS OF FARMERS' INCOME AND WILLINGNESS TO PAY FOR UPSTREAM WATERSHED IMPROVEMENT IN KRUENG KLUET ACEH INDONESIA

**Rahmat Suryanto Pirngadi[1], Rahmawaty[2], Sri Fajar Ayu[3], Abdul Rauf[4]**

[1]*Doctoral Program of Agricultural Science, Faculty of Agriculture,*
[2]*Faculty of Forestry,*
[2,4]*Natural Resources and Environmental Management Study Program,*
*Postgraduate School,*
[3,4]*Faculty of Agriculture,*
UNIVERSITAS SUMATERA UTARA, MEDAN, INDONESIA
[1]*Faculty of Agriculture,*
UNIVERSITAS MUHAMMADIYAH SUMATERA UTARA, MEDAN, INDONESIA

## Abstract

Krueng Kluet Aceh Watershed is one of the largest watersheds in the Aceh Province of Indonesia. Over the past three years, forest destruction in the upper part of the Krueng Kluet Aceh Watershed has resulted in the loss of 424.15 hectares of forest. This destruction has led to flooding during the rainy season, adversely affecting paddy fields. Farmers have incurred significant losses due to reduced production levels caused by flooding. The gap in this research lies in the analysis of farmers' income during flood events compared to non-flood situations, serving as a basis for assessing the extent of farmers' willingness to pay for environmental improvements—an approach that has not been undertaken previously. This research aims to compare farmers' income during the period of flooding versus period without flooding, as well as to assess farmers' willingness to pay for environmental improvement services in the upper Krueng Kluet Aceh Watershed. The findings of this study indicate that the average income of farmers during flooding periods is IDR 5,529,000 per hectare per planting season, equivalent to USD 354. In contrast, when flooding does not occur, farmers' income rises to IDR 26,027,000 per hectare per planting season, or USD 1,668. This means that farmers experience an income loss of IDR 21,020,000, which is USD 1,347, during flooding events. Notably, 71% of farmers expressed their willingness to pay for environmental improvements in the upper Krueng Kluet Aceh Watershed, with a total willingness to pay valued at IDR 1,078,500 per growing season, leading to an average of IDR 9,297 per farmer per growing season. The study also found that income variables, formal education, and land area positively influence farmers' willingness to pay for environmental improvements in the upstream areas of the Krueng Kluet Aceh Watershed. Furthermore, the formal education variable and the number of family dependents significantly affect farmers' willingness to pay for these environmental improvements.

***Keywords***: High-rise Residential, Strata Residential, Commissioner of Building, Strata Management Body

[2] Corresponding author. Email: rahmawaty@usu.ac.id

## INTRODUCTION

In the past three years, 424.15 hectares of protected areas in the upper Krueng Kluet Aceh Watershed have experienced deforestation. This deforestation has resulted in flooding of paddy fields (Pirngadi & Rahmawaty, 2022). Prior to the flooding, the total production of paddy rice in 21 villages within the North Kluet Sub-district was 9,827 tonnes, spanning approximately 1,627.34 hectares, yielding a productivity rate of 6.03 tonnes per hectare. However, during flooding events, paddy rice production decreased to 2,827 tonnes, with a productivity rate of 1.73 tonnes per hectare. This decline in production due to flooding has had a significant negative impact on farmers (Pirngadi et al., 2024). Losses for farmers in the Krueng Kluet Aceh Watershed due to flooding reached IDR 9,052,640,500, affecting an area of 1,391 hectares of paddy fields.

The objectives of this paper are (i) to analyze the income of wet-rice farmers during flooding events compared to periods without flooding, and (ii) to calculate the Willingness to Pay (WTP) of farmers for improvements in the upstream watershed of Krueng Kluet Aceh, as well as to analyze the factors that influence this willingness. The contribution of this research to the development of new knowledge lies in understanding the behaviors of wet-rice farmers regarding financial contributions for the improvement of the upstream area of the Krueng Kluet Aceh Watershed. Notably, the WTP of farmers for these improvements is not solely determined by the extent of their losses in rice production due to flooding; other factors also play a significant role in shaping their willingness to pay for enhancements to the watershed.

## LITERATURE REVIEW

### Flooding from Forest Deforestation

The presence of forests, characterized by trees and woody vegetation, facilitates the gradual release of rainwater through springs and rivers, thereby mitigating the occurrence of flooding. When forest areas are damaged, their capacity to absorb rainwater during periods of heavy rainfall diminishes, resulting in increased runoff that leads to river overflow in low-lying areas. In the Janeberang Watershed in South Sulawesi, Indonesia, flooding is attributed to deforestation and degradation in the upstream forest areas, with a loss of 36.67 hectares due to deforestation and 770.14 hectares due to degradation. This flooding has significant adverse effects on the economic well-being of the local community. Effective flood mitigation strategies must focus on the restoration of forest areas and the enforcement of legal measures within the forestry sector (Widodo et al., 2021)

**Effects of Flooding on Paddy Farming**

The impact of flooding on rice fields can lead to reduced production due to crop failure. Research on the effects of flooding on food production has been conducted in Central Java Province, Indonesia (Pratiwi et al., 2020). The intensity of flooding in agricultural land in Central Java, which steadily increased from 2014 to 2018, adversely affected rice production. In 2014, 33,792 hectares of rice fields experienced crop failure, resulting in a production loss of 505,197 tons, which constituted approximately 5.24% of the total rice production in Central Java (Pirngadi & Rahmawaty, 2022). Additionally, 7,000 tons of rice production in the North Kluet Sub-district were lost due to flooding in the Krueng Kluet Aceh Watershed. This significant loss in production has substantially impacted the income of rice farmers in the North Kluet Sub-district.

**The Impact of Flooding on Farmers' Production and Income**

Before the flood, the total production of paddy rice across 21 villages in the North Kluet Sub-district was 9,827 tonnes, with a total land area of approximately 1,627.34 hectares, yielding a productivity rate of 6.03 tonnes per hectare. During the flood, paddy rice production decreased to 2,827 tonnes, with a productivity value of 1.73 tonnes per hectare. This decline in production due to flooding has been significantly detrimental to farmers (Pirngadi & Rahmawaty, 2022).

The estimated total losses incurred by wet-rice farmers during flooding in the Krueng Kluet Aceh Watershed reached USD 580,297, affecting 1,391 hectares of wet-rice land. The North Kluet Sub-district suffered the greatest losses, amounting to IDR 6,201,539,500, followed by the East Kluet Sub-district with losses of USD 180,142, and the South Kluet Sub-district with losses of USD 2,620 (Pirngadi et al., 2024).

Brémond & Grelot (2013) reviewed 42 studies on the economic evaluation of flood damage to agricultural land, concluding that flood losses result in decreased production and reduced farmers' income. Furthermore, Alamgir et al. (2021) noted that climate change has intensified flooding in paddy fields, leading to yield losses. The substantial reduction in rice production has contributed to an increase in the number of impoverished farmers in the Jamalpur and Netrokona Districts of Bangladesh.

**Willingness to Pay (WTP)**

Contingent Valuation Method (CVM) is a method for collecting information on preferences or WTP through direct questioning techniques. WTP can be defined as the maximum price an individual is willing to pay for a good or service (Haab & McConnell, 2002). Preference values are obtained through structured interviews. Supported by Christoph (2005) who defines willingness to pay as the highest amount a person is prepared to pay for goods and services. While WTP

is a robust method for measuring an individual's preferences regarding the payment for goods and services, it is not without weaknesses; biases may arise, as highlighted by Hanley & Spash (1993). These biases include strategic bias, design bias, respondent mood bias, and hypothetical market error bias. Despite its limitations, the willingness to pay method also possesses strengths, as noted by Breidert et al. (2006) the strength of this method lies in its methodological rigor in estimating the value of structured goods and services; while allowing respondents the freedom to provide a price they are willing to pay for the evaluated goods and services. In such conditions, models can be estimated using simple linear regression or multiple linear regression models.

This research employs a willingness to pay approach, drawing from previous studies related to the valuation of environmental services, such as in the work of Hanley & Spash (1993). Willingness to pay reflects an individual's readiness to invest in improving or preserving environmental conditions and natural resources, thereby enhancing environmental quality. The measure of WTP is based on how much individuals or communities are willing to contribute financially to mitigate the negative impacts of environmental degradation in line with their preferred standards (Pearce & Turner, 1991).

Farmers' attitudes and education are critical factors influencing their willingness to pay for environmental services, particularly in contexts like the Peruvian Amazon. These farmers are often willing to pay more, anticipating that they will benefit from environmental improvements. Typically, as environmental damage increases, so does the willingness of farmers to invest in environmental services (Smith et al., 1997). For instance, flooding in Sempayang Village, North Kalimantan, Indonesia, resulted from land degradation covering 541.08 hectares, adversely impacting agricultural land (Pratiwi et al., 2018). In this context, farmers expressed a willingness to pay between IDR 21,296 and IDR 50,000 per production period to enhance the condition of degraded lands. Additionally, using the willingness to pay approach, visitors to the CMC Tiga Warna area in Malang, Indonesia, have expressed support for conservation activities, with an average contribution of IDR 12,829 per individual for mangrove forest conservation initiatives (Zimo et al., 2023).

## RESEARCH METHOD

This research was conducted in the Krueng Kluet Aceh Watershed, Aceh Province, Indonesia. Within this watershed, three sub-districts—North Kluet, East Kluet, and South Kluet—are particularly prone to flooding of rice fields. To represent these three sub-districts, one village was purposively selected from each for the study. The sample size was determined using the Slovin formula, with a 10% margin of error. The total population of wet-rice farmers in the three selected villages was 513. Research data was collected using questionnaires given in

structured interviews with farmers. The questions were systematically organized to effectively address the research issues. The design of the questionnaire began with the identification of the farmers, including their name, age, education, number of dependents, and the area of rice land owned. Subsequently, a series of questions were posed to analyze the income of rice farmers during flood events and under normal conditions, focusing on aspects such as rice production, selling price, variable costs, and fixed costs incurred. Following this, additional questions were included to assess the extent of farmers' willingness to pay for the improvement of the upper catchment area of the Krueng Kluet River in Aceh, with the expectation of minimizing flood intensity on rice land in the future.

Additionally, this research categorizes the level of flood vulnerability of paddy fields in each village within the Krueng Kluet Aceh Watershed based on an assessment of flood categories, which are determined by the percentage of paddy fields affected by flooding:

- Very High Category: 80% - 100% of paddy fields affected
- High Category: 61% - 79% of paddy fields affected
- Medium Category: 30% - 60% of paddy fields affected
- Low Prone Category: 1% - 29% of paddy fields affected

Data analysis in this study was conducted in two stages:

1. Analysis of the income of wet-rice farmers when flooding occurs and when flooding does not occur using the following equation:

$$\pi = TR - TC$$

with:
π: Income
TR: Total Revenue (IDR)
TC: Total Cost (IDR)

with: TR = P.Q
TC = FC + VC

description:
P = Price (IDR)
Q = Production (Kg)
TC = Total biaya (IDR)
FC = Fixed Cost (IDR)
VC = Variabel Cost (IDR)

2. Contingent Valuation Method (CVM) using WTP approach and Multiple Regression equation model to see factors that influence farmers in paying for environmental improvements in the upper Krueng Kluet Aceh Watershed with the following model specifications:

$$\boldsymbol{Y} = \beta_0 + \beta_1\mathbf{X_1} + \beta_2\mathbf{X}_2 + \beta_3\mathbf{X_3} + \beta_4\mathbf{X}_4 + \beta_5\mathbf{X_5} + \mu$$

with:

$\beta_0$ = Constant
$\beta_0,\ldots, \beta_5$= The value of each variable
Y = nilai WTP petani (IDR/ Planting season)
$X_1$= Age (Year)
$X_2$= Income (IDR/ Month)
$X_3$= Number of family dependents (People)
$X_4$= Of education (Year)
$X_5$= Land area (Hectares)
$\mu$ = error term

The data on farmers' income was obtained from all responses to the questionnaire and compiled to calculate the average rice production, average selling price of rice, and total average costs incurred during a single planting season.

## ANALYSIS AND DISCUSSION

The Krueng Kluet Aceh Watershed encompasses an area of 232,600 hectares. The upstream region includes Gunung Leuser National Park, the Leuser Ecosystem Area, and other designated use areas. The map of the Krueng Kluet Aceh Watershed is presented in Figure 1.

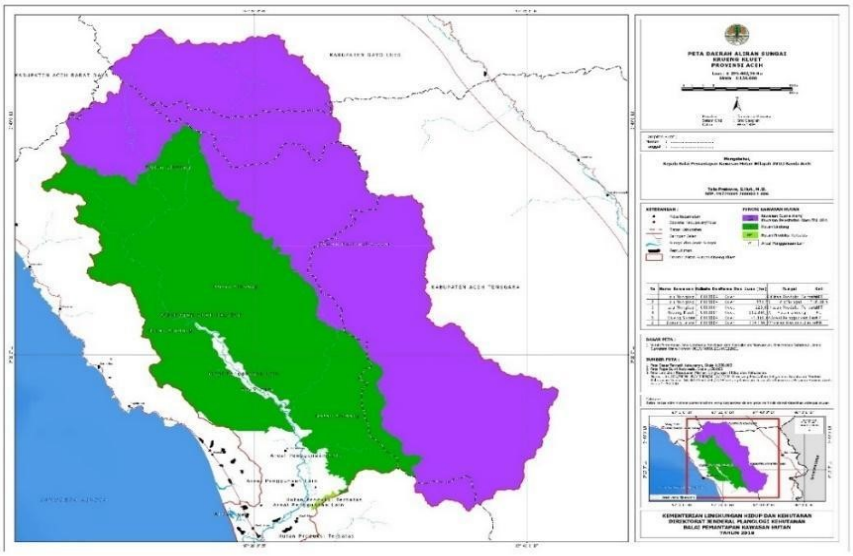

**Figure 1:** Watershed of Krueng Kluet Aceh

During the rainy season, flooding frequently occurs due to the overflow of the Krueng Kluet Aceh Watershed, which the river systems are unable to accommodate. This flooding has a detrimental impact on agriculture, particularly on paddy rice production. Currently, 1,319 hectares of paddy fields in the Krueng Kluet Aceh Watershed are affected by flooding. The locations of these affected paddy fields are illustrated in Figure 2.

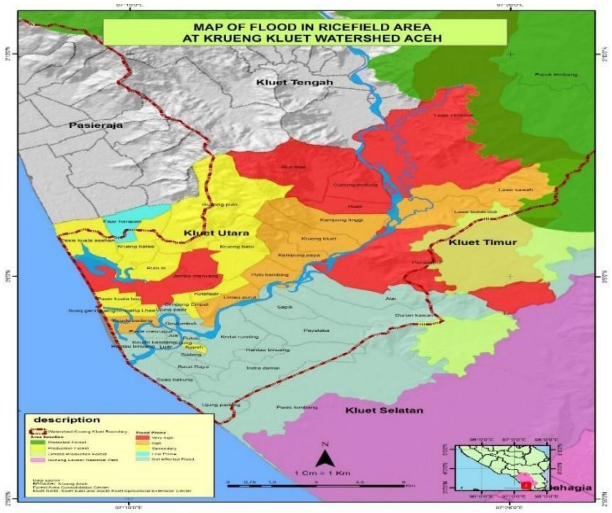


**Figure 2:** Map of flood-prone rice paddy fields in the Krueng Kluet Aceh Watershed

From the map in Figure 2, four categories of paddy fields with varying levels of flood vulnerability can be identified: areas coloured red indicate very high flood vulnerability, orange represents high flood vulnerability, yellow denotes medium flood vulnerability, and blue signifies low flood vulnerability.

Overall, 26 villages across three sub-districts have paddy fields affected by flooding in the Krueng Kluet Aceh Watershed. The extent of paddy fields impacted by flooding in this watershed is detailed in Table 1.

**Table 1:** The area of paddy fields affected by flooding within the Krueng Kluet Aceh Watershed 2022.

| District | Village | Flood Vulnerability Level | Rice Paddy Area (Ha) | Area of Rice Paddy Fields Affected by Flood (Ha) |
|---|---|---|---|---|
| North Kluet | Gunung Pudung | Very High | 85 | 68 |
| | Ruak | Very High | 135 | 115 |
| | Alur Mas | Very High | 112 | 95 |
| | Jambo Manyang | Very High | 112 | 90 |
| | Kampung Tinggi | High | 31 | 22 |
| | Krueng Kluet | High | 60 | 45 |
| | Kampung Paya | High | 118 | 77 |
| | Pulo Kambing | High | 66 | 49 |
| | Limau Purut | High | 35 | 26 |
| | Kedai Padang | High | 45 | 32 |
| | Krueng Batu | Medium | 185 | 111 |
| | Pulo Ie | Medium | 155 | 70 |
| | Krueng Batee | Medium | 34 | 15 |
| | Pasie Kuala Asahan | Medium | 51 | 15 |
| | Pasie Kuala Ba'u | Medium | 58 | 32 |
| | Simpang Empat | Medium | 84 | 37 |
| | Simpang Lhee | Medium | 35 | 18 |
| | Suaq Geuringgeng | Medium | 29 | 12 |
| | Gunung Pulo | Medium | 130 | 59 |
| | Kota Fajar | Medium | 31 | 14 |
| | Fajar Harapan | Low Prone | 54 | 8 |
| East Kluet | Lawe Cimanok | Very High | 122 | 103 |
| | Paya Dapur | Very High | 174 | 147 |
| | Lawe Sawah | High | 144 | 108 |
| | Lawe Buloh Didi | High | 17 | 12 |
| South Kluet | Kapeh | Medium | 28 | 11 |
| **Total Area of Rice Paddy Fields Affected by Floods** | | | | **1391** |

Table 1 indicates four categories of flood vulnerability levels for rice fields in the Krueng Kluet Aceh Watershed: very high, high, medium, and low vulnerability categories (Ata et al., 2023). To anticipate future floods, flood simulation using hydraulic technology is one potential alternative for mitigating the impact of flooding, as demonstrated in the Junjung Watershed (Said et al.,

2024). Effective flood mitigation through risk management is essential, necessitating the involvement of institutions responsible for flood control to minimize future flood-related risks.

## Income Analysis of Rice Paddy Farmers during the Flood of Krueng Kluet Aceh Watershed

Farmers' income was analysed by subtracting the total costs of rice production from total revenue for one growing season. The income of wet-rice farmers during flooding in the Krueng Kluet Aceh Watershed is presented in Table 2.

**Table 2:** Analysis of the Average Income of Rice Paddy Farmers during Floods in the Krueng Kluet Aceh Watershed

| No | Description | Average value (IDR) |
|---|---|---|
| | Income (TR) = P.Q | |
| 1 | a. Production (Q) (Kg/Ha) | 2,300 |
| | b. Production price (P) (Kg) | 6,000 |
| | **Total Revenue** | **13,800,000** |
| | A. Variabel Cost (VC) | |
| | Fertilisers and Other Materials: | |
| | - Urea | 840,000 |
| | - Phonska | 840,000 |
| 2 | - Pestisida | 800,000 |
| | Labour | 1,400,000 |
| | Tractor Rental Land Cultivation | 2,200,000 |
| | Harvest Equipment Rental (CHB) | 1,058,000 |
| | Seeds (Inpari 32) | 675,000 |
| | Sacks | 138,000 |
| | **Total Variabel Costs** | **7,951,000** |
| | B. Total Fixed Costs (FC) | |
| | Tool Depreciation Cost | |
| | - Hoe | 80,000 |
| | - Hand Sprayer | 240,000 |
| | **Total Fixed Costs** | **320,000** |
| | Total Cost (TC) | |
| 3 | a. Variabel Cost (VC) | 7,951,000 |
| | b. Fixed Cost (FC) | 320,000 |
| | **Income = TR – TC** | **5.529.000** |

As Table 2 shows, the average income of wet-rice farmers affected by flooding in the Krueng Kluet Aceh Watershed is IDR 5,529,000 per hectare per planting season, which is equivalent to USD 354.

## Analysis of Rice Paddy Farmers in the Non-Flooding Period of Krueng Kluet Aceh Watershed

The results of income analysis of wet-rice farmers in the Krueng Kluet Aceh Watershed area when there is no flood are presented in Table 3.

**Table 3:** Analysis of the average income of rice paddy farmers when there is no flood in the Krueng Kluet Aceh Watershed

| No | Description | Average Value (IDR) |
|---|---|---|
| | Income (TR) = P.Q | |
| 1 | c. Production (Q) (Kg/Ha) | 6,000 |
| | d. Production price (P) (Kg) | 6,000 |
| | **Total Revenue** | **36,000,000** |
| | C. Variable Cost (VC) | |
| | Fertilisers and Other Materials: | |
| | - Urea | 840,000 |
| | - Phonska | 840,000 |
| 2 | - Pestisida | 800,000 |
| | Labour | 1,400,000 |
| | Tractor Rental Land Cultivation | 2,200,000 |
| | Harvest Equipment Rental (CHB) | 2,760,000 |
| | Seeds (Inpari 32) | 675,000 |
| | Sacks | 138,000 |
| | **Total Variable Costs** | **9,653,000** |
| | D. Total Fixed Costs (FC) | |
| | Tool Depreciation Cost | |
| | - Hoe | 80,000 |
| | - Hand Sprayer | 240,000 |
| | **Total Fixed Costs** | **320,000** |
| | Total Cost (TC) | |
| 3 | c. Variable Cost (VC) | 9,653,000 |
| | d. Fixed Cost (FC) | 320,000 |
| | **Income = TR – TC** | **26,027,000** |

Table 3 indicates that the income of wet-rice farmers in the Krueng Kluet Aceh Watershed, when there is no flooding, is IDR 26,027,000, equivalent to USD 1,668. The analysis reveals that the income disparity between farmers during flooding and in the absence of flooding amounts to IDR 20,498,000, or USD 1,313. In other words, farmers' income increased by 270% when there was no flooding.

## Farmers' Willingness to Pay for Improvements to the Upper Krueng Kluet Aceh Watershed

There are three categories of farmer perceptions regarding the willingness of paddy farmers to pay for services aimed at improving the upstream watershed of Krueng Kluet Aceh: (1). Farmers who are unwilling to pay for environmental improvements in the Krueng Kluet Aceh Watershed; (2). Farmers who are willing to pay moderate amounts for environmental improvement services in the upstream Krueng Kluet Aceh Watershed; and (3). Category not specified; please provide additional information to complete this section.

The first category consists of farmers who express no desire to pay for environmental improvement services in the upstream Krueng Kluet Aceh

Watershed area. In the second category, farmers are willing to pay moderate amounts for environmental improvements in the upstream Krueng Kluet Aceh Watershed, specifically between IDR 2,000 and IDR 10,000. These farmers understand both the direct and indirect values of forests in the upper watershed. In-depth interviews with farmers in this category revealed that they believe the responsibility for improving the upstream area of the Krueng Kluet Aceh Watershed should not rest solely on farmers but should be shared by all communities that utilize the watershed. In the third category, farmers are willing to pay higher amounts for environmental improvement services, ranging from IDR 10,000 to IDR 20,000. The results of in-depth interviews with farmers in this category indicate that they view the damage to the upstream region as a collective responsibility of all communities living in the Krueng Kluet Aceh Watershed, particularly those affected by flooding.

Farmers believe that the greater the financial contribution they make, the more likely it is to minimize future flooding in their paddy fields. The total willingness to pay for environmental improvement services in the upper Krueng Kluet Aceh Watershed from all respondents was IDR 1,078,500, equivalent to USD 69 per growing season, with an average contribution of IDR 9,297, or USD 0.60 per farmer per growing season.

Analysis of the field data indicates that 71% of paddy field farmers are willing to pay for environmental improvements, while 29% are not. The analysis will further explore the value of regression coefficients as specified in the following model:

$$\boldsymbol{Y} = \beta_0 + \beta_1\mathbf{X_1} + \beta_2\mathbf{X_2} + \beta_3\mathbf{X_3} + \beta_4\mathbf{X_4} + \beta_5\mathbf{X_5} + \mu$$

$$\boldsymbol{Y} = -7172.011 - 32.997\mathbf{X_1} + 0.001\mathbf{X_2} - 601.701\mathbf{X_3} + 1407.052\mathbf{X_4} + 2264.169\mathbf{X_5} + \mu$$

Farmers' willingness to pay for environmental improvement in the upper Krueng Kluet Aceh Watershed = - 7172.01 - 32.997 Age + 0.001 Income - 601.701 Number of Family Dependents + 1407.052 Formal Education + 2264.169 Land Area + μ.

From this model specification, it can be concluded that three variables significantly affect farmers' willingness to pay for environmental improvements in the Krueng Kluet Aceh Watershed: income, education, and land area. Specifically, an increase in income of 1 rupiah is associated with an increase in willingness to pay of 0.001 rupiah. Additionally, a one-year increase in formal education results in an increase in willingness to pay by IDR 1,407.052, while an increase in land area of 1 hectare leads to an increase in willingness to pay by IDR 2,264.169.

A study conducted in the canal irrigation area of Rahim Yar Khan, Punjab, Pakistan, found that higher levels of education among farmers, along with increased income and greater concern about climate change, were directly proportional to their willingness to pay for climate change programs that impact agricultural production and mitigate frequent natural disasters (Ahmed et al., 2015). This literature strongly supports the findings of our research, indicating that as farmers' education increases, so does their willingness to pay for environmental improvement services. This correlation is confirmed by both joint (F-test) and partial (T-test) analyses, where education emerged as a significant variable influencing the willingness to pay for services aimed at improving the upstream area of the Krueng Kluet Aceh Watershed.

Additional studies further substantiate these findings. For instance, Prasmatiwi et al. (2011) identified factors such as farmer education, income, knowledge of forest functions, land area, land productivity, and family labour as contributors to increased willingness to pay for environmental improvements in West Lampung District. Similarly, Pirngadi (2019) demonstrated that formal education and age positively influence farmers' willingness to pay for environmental services in the Sarap sub-watershed. Furthermore, Tao et al. (2012) found that 61.8% of farmers were willing to pay for environmental improvement services in the upper Heshui Watershed, with education, age, income, and family size as key influencing factors.

### *Results of the Coefficient of Determination ($R^2$)*

The coefficient of determination ($R^2$) measures the extent to which the independent variables explain the variation in the dependent variable. The results of the data processing are presented in Table 4.

**Table 4:** Coefficient of determination ($R^2$) test results

| Model | R Square |
|---|---|
| 1 Regression | 0.711 |

Table 4 indicates that the $R^2$ value is 0.711. This means that 71.1% of farmers' willingness to pay for environmental improvements in the upper Krueng Kluet Aceh Watershed can be explained by the variables of age, income, number of family dependents, formal education, and land area. The remaining 28.9% is attributed to other variables not included in the model.

### *F-test results*

The F-test is used to determine whether the independent variables simultaneously affect the dependent variable. The results of the data processing are presented in Table 5.

**Table 5:** F-test results

| Model | F | Signifikansi | (α) |
|---|---|---|---|
| 1 Regression | 77.676 | 0.000 | 0.05 |

Table 5 indicates that the variables of age, rice paddy farming income, number of family dependents, formal education, and land area have a significant simultaneous effect on farmers' willingness to pay for environmental improvements in the upper Krueng Kluet Aceh Watershed.

### *Partial Test Results (t-test)*

The t-test is used to assess whether each independent variable individually affects the dependent variable. The results of the data processing are presented in Table 6.

**Table 6:** T-test results

| Model | B | T | Signifikansi | (α) |
|---|---|---|---|---|
| (Constant) | - 7172.011 | -3.220 | 0.002 | 0.05 |
| Age | -32.997 | -1.053 | 0.294 | 0.05 |
| Rice Paddy Farming Income | 0.001 | 1.490 | 0.138 | 0.05 |
| Number of Family Dependents | -601.701 | -2.343 | 0.020 | 0.05 |
| Education | 1407.052 | 16.937 | 0.000 | 0.05 |
| Land Area | 2264.169 | 1.756 | 0.081 | 0.05 |

Table 6 indicates that the variables of formal education and the number of family dependents have significance values less than α (0.000 < 0.05), indicating that these variables have a significant effect when considered individually. Higher levels of formal education among farmers are associated with a greater willingness to pay for environmental improvement services, while fewer family dependents correspond to an increased willingness to pay within the Krueng Kluet Aceh Watershed.

Additionally, Xiong et al. (2018) found that education, type of work, and location of residence significantly influence individuals' willingness to pay for ecological improvements in the Ganjiang River basin, with 75.03% of respondents expressing a willingness to pay an average of USD 47.62 per year.

## CONCLUSION

The income of rice farmers during floods was IDR 5,529,000, while in the absence of floods, the income increased to IDR 26,027,000. A total of 71% of farmers expressed a willingness to pay for environmental improvements in the upper Krueng Kluet Aceh Watershed, with an overall contribution amounting to IDR 1,078,500 per growing season and an average of IDR 9,297 per farmer per growing season. The willingness of farmers to pay for improvements in the upstream Krueng Kluet Aceh Watershed was influenced by income, formal education, and land area in the simultaneous test. In the partial test, formal

education and the number of family dependents were found to have a significant effect. A limitation of this research is that it only analyses farmers' incomes during floods and in drought conditions, assessing their willingness to pay and the factors influencing that willingness for watershed improvements. It is recommended that further research should identify all factors contributing to flooding in rice fields and develop strategies for flood mitigation in these areas.

## ACKNOWLEDGEMENTS

Thank you to the Directorate of Research and Community Service, Ministry of Research and Technology/National Research and Innovation Agency for fiscal year 2021-2022 for funding this research, based on research contract numbers 12/E1/KP.PTNBH/2021, March 8, 2021 and 70/UN5.2.3.1/PPM/KP-DRTPM/L/2022, March 18, 2022.

## REFERENCES

Ahmed, A., Masud, M. M., Al-Amin, A. Q., Yahaya, S. R. B., Rahman, M., & Akhtar, R. (2015). Exploring factors influencing farmers' willingness to pay (WTP) for a planned adaptation programme to address climatic issues in agricultural sectors. *Environmental Science and Pollution Research*, *22*(12), 9494–9504. https://doi.org/10.1007/s11356-015-4110-x

Alamgir, M. S., Furuya, J., Kobayashi, S., Mostafiz, R. B., & Ahmed, M. R. (2021). Farm income, inequality, and poverty among farm families of a flood-prone area in Bangladesh: Climate change vulnerability assessment. *GeoJournal*, *86*(6), 2861–2885. https://doi.org/10.1007/s10708-020-10231-2

Ata, F. M., Toriman, M. E., Desa, S. M., San, L. Y., & Kamarudin, M. K. A. (2023). Development of hydrological modelling using HEC-HMS and HEC-RAS for flood hazard mapping at Junjung river catchment. *Planning Malaysia*, *21*(6), 116–129. https://doi.org/10.21837/PM.V21I30.1390

Breidert, C., Hahsler, M., & Reutterer, T. (2006). A review of methods for measuring willingness-to-pay. *Innovative Marketing*, *2*(4), 8–32. https://doi.org/10.4337/9781788974912.W.28

Brémond, P., & Grelot, F. (2013). Review article: Economic evaluation of flood damage to agriculture - review and analysis of existing methods. *Natural Hazards and Earth System Sciences*, *13*(10), 2493–2512. https://doi.org/10.5194/nhess-13-2493-2013

Christoph, B. (2005). *Estimation of willingness-to-pay theory, measurement, and application*. Vienna University of Economics and Business. https://doi.org/10.57938/481ea1e7-2166-4b6f-a041-e074ac7e1275

Haab, T. C., & McConnell, K. E. (2002). *Valuing environmental and natural resources: The econometrics of non-market valuation*. Edward Elgar.

Hanley, N., & Spash, C. L. (1993). *Cost-benefit analysis and the environment*. Edward Elgar Publishing. https://doi.org/10.2307/2235480

Pearce, D. W., & Turner, R. K. (1991). Economics of natural resources and the environment. *Land Economics*, *67*(2), 272. https://doi.org/10.2307/3146419

Pirngadi, R. S. (2019). Faktor-faktor yang mempengaruhi petani dalam membayar jasa lingkungan air padi sawah. *Jurnal Agrifo*, *4*(1), 51–57.

Pirngadi, R. S., & Rahmawaty. (2022). The impact of flooding on rice production in the Krueng Kluet watershed, Aceh province, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *977*(1), 1–6. https://doi.org/10.1088/1755-1315/977/1/012113

Pirngadi, R. S., Rahmawaty, Ayu, S. F., & Rauf, A. (2024). Estimation of loss of rice farmers due to flood at Krueng Kluet watershed (with the ECLAC method approach). *IOP Conference Series: Earth and Environmental Science*, *1302*(1), 0–9. https://doi.org/10.1088/1755-1315/1302/1/012125

Prasmatiwi, F. E., Irham, I., Suryantini, A., & Jamhari, J. (2011). Kesediaan membayar petani kopi untuk perbaikan lingkungan. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi Dan Pembangunan*, *12*(2), 187. https://doi.org/10.23917/jep.v12i2.192

Pratiwi, E. P. A., Ramadhani, E. L., Nurrochmad, F., & Legono, D. (2020). The impacts of flood and drought on food security in Central Java. *Journal of the Civil Engineering Forum*, *6*(1), 69. https://doi.org/10.22146/jcef.51872

Pratiwi, S. R., Purnomo, E., Usman, S., & Gravitiani, E. (2018). Farmers' willingness to pay for the environmental restoration of the critical land at North Kalimantan. *IOP Conference Series: Earth and Environmental Science*, *200*(1), 1–5. https://doi.org/10.1088/1755-1315/200/1/012015

Said, M. Z., Gapor, S. A., & Hamat, Z. (2024). Flood vulnerability and adaptation assessment in Padang Terap district, Kedah, Malaysia. *Planning Malaysia*, *22*(2), 1–16. https://doi.org/10.21837/pm.v22i31.1450

Smith, J., Mourato, S., Veneklaas, E., Labarta, R., Reategui, K., & Sanchez, G. (1997). Farmers in the Peruvian Amazon: Implications for deforestation and. *Alternatives*, *1*-7. *(Note: The original entry was incomplete at the end of the title. I have formatted what was provided.)*

Tao, Z., Yan, H., & Zhan, J. (2012). Economic valuation of forest ecosystem services in Heshui watershed using contingent valuation method. *Procedia Environmental Sciences*, *13*(2011), 2445–2450. https://doi.org/10.1016/j.proenv.2012.01.233

Widodo, T. N., Zubair, H., & Padjung, R. (2021). Land use change study and the increased risk of floods disaster in Jeneberang watershed at Gowa Regency, South Sulawesi, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *824*(1). https://doi.org/10.1088/1755-1315/824/1/012045

Xiong, K., Kong, F., Zhang, N., Lei, N., & Sun, C. (2018). Analysis of the factors influencing willingness to pay and payout level for ecological environment improvement of the Ganjiang river basin. *Sustainability (Switzerland)*, *10*(7), 1–17. https://doi.org/10.3390/su10072149

Zimo, H., Omar, S. I., Bachri, S., & Sumarmi. (2023). Visitor willingness to pay conservation fees at CMC Tiga Warna in Malang, Indonesia. *Planning Malaysia*, *21*(4), 452–466. https://doi.org/10.21837/pm.v21i28.1345

Received: 7th December 2024. Accepted: 5th March 2025

 