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Co-financing irrigation water services: farmers' perspectives in the Mekong Delta, Vietnam

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Abstract: Insufficient financial resources pose a considerable obstacle to Vietnam's endeavors to alleviate the repercussions of climate change. The adverse impacts of extreme weather events, particularly drought and water scarcity, have inflicted severe consequences on rice production across diverse regions, imperiling both the livelihoods of farmers and the nation's food security. While international aid is crucial, involving farmers in co-financing irrigation water services is essential for addressing these challenges in the long run. This study employs a blended approach encompassing quantitative and qualitative methodologies to investigate the determinants influencing farmers' willingness to participate in co-financing irrigation water services. Data were meticulously gathered through direct interviews with 289 farmers in An Giang province within the Mekong Delta, Vietnam. The findings underscore that the majority of respondents (86.16%) reported encountering water-related stresses in rice production, with 76.47% experiencing productivity losses attributable to extreme weather events. The results of the binary logistic regression model reveal significant factors associated with a farmer's decision to engage in co-financing irrigation services, including household income, participation in non-farm employment, farmers' perceptions of water scarcity, the adverse impact of water scarcity on rice yields, and the assessment of associated risks. Based on these discernments, we offer several policy recommendations aimed at facilitating the efficacious implementation of the irrigation water service co-financing initiative.

Keywords: *Water stresses; willingness to pay; co-financing irrigation services; Mekong Delta; Vietnam*

Introduction

The escalating frequency of extreme weather events worldwide, as evidenced by global warming and climate change (WMO, 2021), is a matter of significant concern for humankind. These events have far-reaching impacts on ecosystems, weather patterns, and human societies, demanding urgent attention to mitigate their adverse effects (IPCC, 2021). In addition to addressing swift and destructive natural disasters like earthquakes, floods, and tsunamis, policymakers must also prioritize the development of clear and comprehensive strategies to mitigate the impacts of drought, which, despite its slow

onset, can lead to severe and widespread consequences, particularly in agricultural production (UNDRR, 2021; World Bank, 2016).

Vietnam, situated in Southeast Asia, faces significant climate change threats, particularly water scarcity and drought (Tan et al., 2023; Kien et al., 2023; Phuong et al., 2023; Ha et al., 2022). The country's economy and national welfare have already suffered, experiencing an estimated GDP loss of 3.2% in 2020, with expectations of escalating impacts in the future (World Bank Group, 2022). Vietnam ranks among the top 20 countries with the most extreme weather events, with droughts posing a major risk (Eckstein et al., 2021). Given that agriculture accounts for 17% of the GDP and employs over 40% of the labor force, the changing climate significantly affects the country's livelihoods and food security (UNDP, 2016; World Bank, 2021). Without proper adaptation and mitigation measures, the projected cost of climate change for Vietnam could reach 12-14.5% of the GDP annually by 2050, potentially pushing one million people into extreme poverty by 2030 (Vietnamese Government News, 2022; World Bank Group, 2020).

The Mekong Delta, the cornerstone of Vietnam's agriculture, faces a significant threat to its productivity by 2050 due to water scarcity (Ishikawa-Ishiwata & Furuya, 2022; Kontgis et al., 2019; Minh et al., 2022; Tran et al., 2022). Upstream dam constructions, climate change, and other factors have compromised the Mekong River, causing saltwater intrusion, water scarcity, and devastating agriculture. The worst drought in a century hit in 2019, resulting in over $1.3 billion in losses (Mekong River Commission, 2022; Thanh et al., 2023). The dry season droughts intensified, prompting a state of emergency and international assistance requests. In 2019-2020, 10 out of 13 provinces in the Mekong Delta suffered from water scarcity and rising salinity, damaging 58,000 hectares of rice and affecting 96,000 households (VDMA, 2020). The Mekong River Commission (2021) reported its lowest water level in a century, exacerbating saltwater intrusion and agricultural impacts. Households in the Mekong Delta face vulnerability due to water scarcity, impacting their agricultural livelihoods. Urgent implementation of adaptation measures is crucial to safeguard agricultural production, food security, and rural livelihoods (Nguyen et al., 2021).

Despite Vietnam's significant efforts in addressing water scarcity and drought in agriculture amid changing climates, financial constraints persist as a developing country. The government's irrigation policy has shifted from partial fee exemption to near-total subsidy. Government funds support the operation and maintenance of focal works and main canals, while secondary and infield canals rely on a combination of provincial budget allocations and minimal farmer contributions. A previous JICA (2013) study found that these financial contributions are often inadequate. Moreover, after extended implementation, the policy reveals notable drawbacks. Firstly, farmers lack incentives to conserve water as they do not directly pay for irrigation services. Secondly, irrigation financing relies on the government's constrained budget, contrasting with the escalating demand for investment. The complex disbursement procedures and decentralized management further impede efficiency. Proactive, sustainable, and long-term solutions are thus essential. Mobilizing co-financing from farmers is a potential remedy. A modest contribution from each household could create a substantial financial pool, alleviating government investment pressures and actively involving farmers in adopting sustainable practices. Beyond addressing immediate water scarcity concerns, this strategy promotes lasting impacts by instilling a culture of water conservation. Consequently, it contributes to building resilience against future water scarcity challenges.

Nonetheless, the government may face numerous challenges in enforcing this initiative in practice. These challenges could stem from economic hardships experienced by farmers, limited awareness and understanding of the importance of water resource

restoration within specific farming segments, as well as various cultural and social factors impacting farmers' willingness and ability to engage in such efforts. Therefore, conducting studies on farmers' willingness to participate in this initiative becomes crucial. The findings from these studies can assist policymakers in recognizing both tangible and intangible barriers, enabling more informed steps in policy enactment and implementation.

A number of studies have been conducted regarding co-financing initiatives involving individuals and households to promote environmental improvement, improve life quality, and mitigate the impacts of climate change. Most of the research in this area has focused on topics such as forest environmental services (Thuy et al., 2013), wastewater treatment (Le & Aramaki, 2019; Trang, Rañola, & Song, 2018), improving urban water supply systems (Bui et al., 2022; Hue, 2018), protecting groundwater (Vo & Huynh, 2017), restoring mangrove forests (Pham et al., 2018), ecosystem conservation (My, Kien, Hung, & Anh, 2023), and improving urban air quality (Nguyen, Nguyen, Le, & Kaneko, 2022). Our empirical review suggests a dearth of literature that delves into farmers' attitudes towards participating in the co-financing of irrigation water services to facilitate agricultural irrigation, notwithstanding their critical significance and urgency. Existing research has primarily concentrated on assessing the willingness of urban residents or tourists, with inadequate attention given to farmers and their livelihoods amidst the escalating challenges of climate change. Thus, this leaves a gap in the literature on factors driving farmers' willingness to pay for irrigation improvements for agricultural production. Bridging this gap holds significant implications for policymakers in Vietnam and analogous developing nations, allowing them to formulate and execute effective policies related to "irrigation water services." This, in turn, would ease the financial burdens on the government, foster sustainable agricultural practices, and mitigate the adverse effects of climate change. The objective of this study is to address this research gap by (1) examining how farmers perceive water scarcity and its impact on rice cultivation, (2) identifying the factors that influence rice farmers' willingness to co-finance irrigation water services, and (3) suggesting pertinent interventions for the successful implementation of this initiative.

Literature review

Given the limited research addressing farmers' willingness to co-finance irrigation water services, we examine previous works related to individuals'/households' behaviors and willingness to pay for mitigating climate change impacts and improving water-based ecosystem services. Integrating these insights into subsequent discussions is logical, given their common goals of environmental improvement, climate impact mitigation, and enhanced living standards.

Scholarly research links pro-environmental behavior to personal values, particularly self-transcendence, altruism, or openness to change (Corner, Markowitz, & Pidgeon, 2014; Karp, 1996; Nordlund & Garvill, 2002). Support for climate policies aligns with perceptions of scientific agreement on anthropogenic global warming, with skepticism hindering mitigation efforts (Ding, Maibach, Zhao, Roser-Renouf, & Leiserowitz, 2011; Haltinner & Sarathchandra, 2018). Other factors influencing public support for climate policies and mitigation behaviors include knowledge of the global warming roots (McCright, 2009), concern about climate change (Arıkan & Günay, 2021; Sartain et al., 2020), perceived risks (Sartain et al., 2020; Sullivan & White, 2019), and the experience of crop failure (Khong, Young, Loch, & Thennakoon, 2018). Public support for climate

policies and mitigation behaviors correlates significantly with demographic factors like education level, family income, marital status, and length of stay (Gravitiani, Suryanto, & Antriyandari, 2016). Furthermore, the inclination to financially support climate change efforts is impacted by additional variables, including the desire for increased knowledge about climate change and the trustworthiness of sources providing information on the subject (D'Amato, Giaccherini, & Zoli, 2019; Sartain et al., 2020), policy belief (Yang, Zou, Lin, Wu, & Wang, 2014), exposure to mass media (Akter & Bennett, 2011), perceived costs and benefits of climate change (Bradley, Babutsidze, Chai, & Reser, 2020; Tobler, Visschers, & Siegrist, 2012), and perceived personal role in reducing its adverse effects (Nezlek & Cypryańska, 2023).

Empirical studies also revealed various factors influencing residents' willingness to co-finance water-based ecosystem services. Perceived benefits are a crucial factor affecting individuals' willingness to pay for improvement, such as the health benefits of clean water (Brox, Kumar, & Stollery, 1996; Genius et al., 2008). Farmers are more willing to pay for pollutant-free irrigation, boosting yields, and reducing losses (Alhassan, 2012; Tang et al., 2022). Alhassan's (2012) study found that farmers recognizing irrigation's benefits to crop yields, income, and food security are more inclined to pay for it. Financial capacity, as seen in households or communities with greater resources, influences co-financing (Kidane, Wei, & Sibhatu, 2019; Le & Aramaki, 2019; Rodríguez-Tapia, Revollo-Fernández, & Morales-Novelo, 2017). Economic development levels in a region also impact willingness to pay, with developing countries prioritizing basic needs over water services (Nicholson et al., 2009). Awareness is pivotal in shaping willingness to pay for improved water-based ecosystem services. Individuals aware of water pollution sources are more likely to pay for wastewater treatment (Le & Aramaki, 2019). Farmers aware of water scarcity and the benefits of using clean irrigation water are more inclined to invest in enhanced irrigation water (Kidane et al., 2019). Trust in the service provider can influence willingness to pay (Mumbi & Watanabe, 2021; Rodríguez-Tapia et al., 2017). This trust is cultivated through transparent communication and efficient service delivery.

Various studies highlighted how respondents' household characteristics influence willingness to participate in and pay for water-based ecosystem services. Characteristics such as age, gender, education level of the household head, and cultivated land area are key predictors of willingness to pay (Biswas & Venkatachalam, 2015; Gebretsadik & Romstad, 2020; Phan, Bertone, Pham, & Pham, 2021; Rodríguez-Tapia et al., 2017; Tang et al., 2022; Hien, Kien, & Koji, 2023). For instance, older individuals show more concern about water quality and are willing to pay for improvements, while higher education levels correlate with increased willingness to pay for urban domestic water supply (Rodríguez-Tapia, 2017; Bui et al., 2022). Household income is another predictor, with higher incomes associated with greater willingness to pay (Biswas & Venkatachalam, 2015; Bui et al., 2022). Risk perception and experience also influence willingness to pay, with those who have experienced water-related problems more likely to invest in improvements (Biswas & Venkatachalam, 2015; Kidane et al., 2019; Mumbi & Watanabe, 2021). These findings suggest that efforts to promote the adoption and sustainability of improved water-based ecosystem services should take into account a wide range of socio-demographic and attitudinal factors, as well as the broader social and economic context in which these services are provided.

While existing literature sheds light on the factors influencing payments by individuals and households to address the impacts of climate change and improve water-based ecosystem services, there remains a gap in understanding the determinants of farmers' readiness to co-finance irrigation water services, particularly in developing countries such as Vietnam. This study seeks to bridge this gap by investigating farmers'

willingness to co-finance irrigation water services in the Mekong Delta of Vietnam, thereby contributing valuable insights to the current body of knowledge.

Through a comprehensive analysis of the existing body of literature, taking into account the production characteristics and local context, and consulting extensively with experts in the field, we have formulated a proposed conceptual framework for this study. The visual representation of this framework is presented in Figure 1.

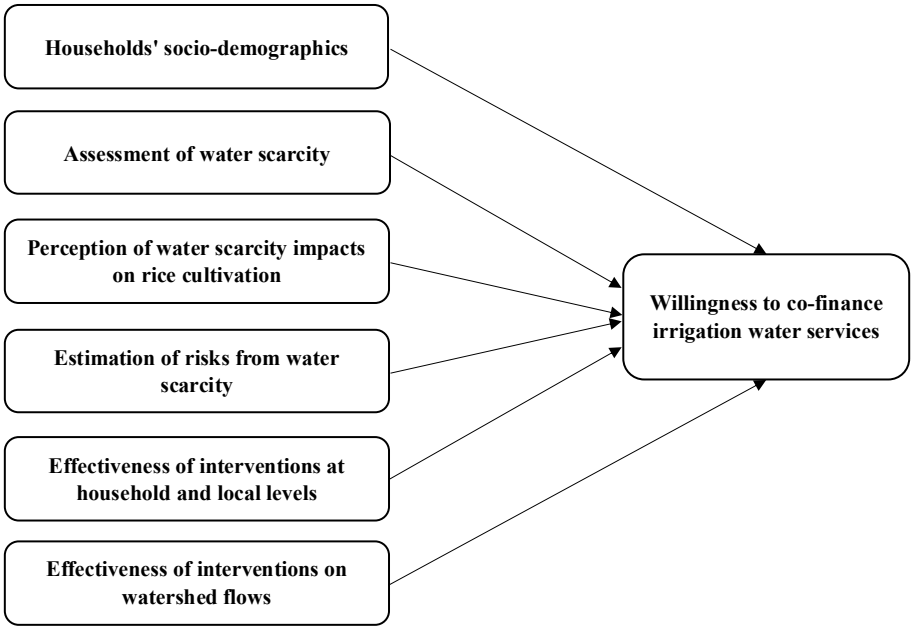

Figure 1 - Conceptual framework of willingness to co-financing irrigation water services

Study design

Study sites

This study was carried out in An Giang province, one of the largest rice producers located in the southern region of Vietnam's Mekong Delta (Figure 2). The province is situated upstream of the Mekong River and has a population of approximately 2 million people. An Giang boasts an extensive arable land area, with a total agricultural land area of 246,821 ha, of which rice land makes up over 82%. This province is recognized as the second-largest rice-growing area in the country and the critical rice producer and exporter of the entire Mekong Delta region. This province presents a multitude of highly efficient rice production-consumption models that positively impact the development of the commodity industry and substantially increase the earnings of rice growers. In 2022, An Giang's rice production reached 604 thousand hectares (producing 3 crops/year with a land use coefficient of 2.43 times), yielding nearly 4 million tons, with 80-90% being high-quality rice varieties. The province's annual rice export revenue is projected to be approximately 280 million USD. With a prime location at the headwaters of the Mekong Delta, An Giang is widely acknowledged as the region that reaps the most benefits from the Mekong River. The Tien and Hau Rivers, two tributaries spanning approximately 100 kilometers, supply fresh water and alluvium, facilitating favorable conditions for agricultural development. Notwithstanding its advantageous location, An Giang province is exceptionally sensitive and vulnerable to climate change's potent and escalating

effects. The most conspicuous manifestation is the mounting prevalence of extreme weather events, particularly the high temperatures during the dry season, which engenders drought and depletes the quality of water resources for agricultural purposes. As per the climate change projections of the Ministry of Natural Resources and Environment (MONRE), An Giang province is poised to encounter significant challenges in the future. Precisely, the average temperature is predicted to surge by at least 3°C by the close of the 21st century, leading to an increase in sea level by 33 centimeters in 2050 and by 1 meter in 2100. Additionally, El Nino events are expected to become more frequent. Given that An Giang is a critical watershed province of the Mekong Delta, it will likely continue experiencing saltwater intrusion, heat waves, and extended droughts, particularly during the dry season (Figure 3). The fact emphasizes the concerning issue of water scarcity, not only in An Giang, but across the entirety of the Mekong Delta. Within this context, a pressing need exists for the expeditious implementation of interventions aimed at reinstating the natural flow of water in rivers and canals, thereby guaranteeing a sufficient and adequate water supply for agricultural purposes.

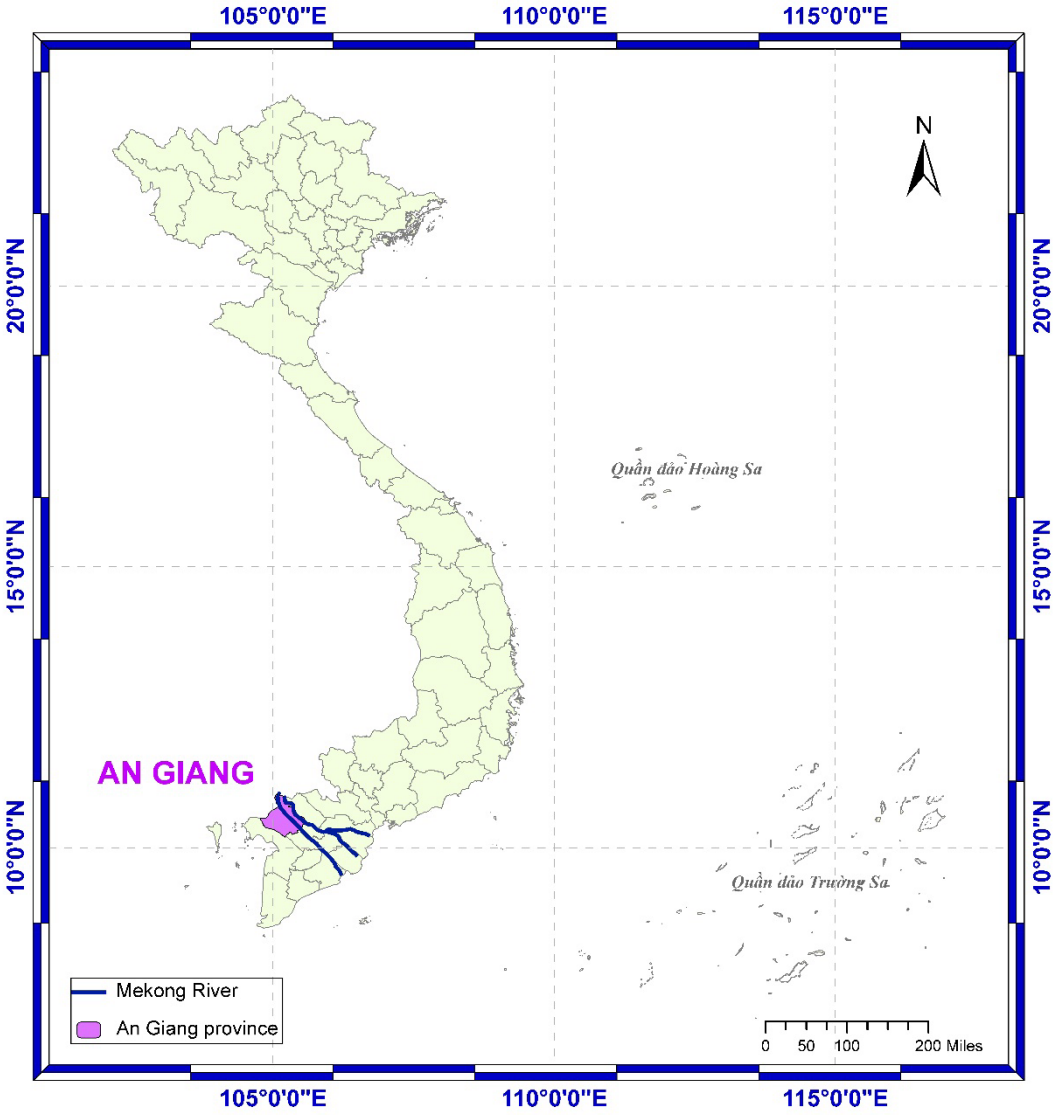

Figure 2 - Map of An Giang province in the Mekong Delta

Figure 3 - Dry canal menaces the blooming rice fields

Methods

Data collection

The data utilized in this study were collected from three districts in An Giang province, specifically Tri Ton, Thoai Son, and Chau Phu, in the years 2021 and 2022. We employed an unstructured in-depth interview method in the initial data collection phase. This approach aimed to gather secondary socioeconomic data, the current situation in rice cultivation, water use and issues associated with water scarcity (e.g., signals of reduced water level in irrigation canals particularly in summer, severity, reduced rice productivity, etc.) by acquiring information from relevant government agents operating at the provincial, district, and commune levels (e.g., Department of Agriculture and Rural Development; Department of Natural Resources and Environment, People's Committees of Districts; People's Committees of communes, etc.). Through this phase, we were able to identify the key rice production areas heavily impacted by water scarcity in recent years, which guided us in selecting the most appropriate survey sites. We employed the same methodology to carry out interviews with individuals who are in charge of rice production in the localities, allowing us to obtain a more profound comprehension of the obstacles that impede rice production, especially those related to climate change and extreme weather events.

Semi-structured questionnaires were then distributed to rice farmers in the three selected districts, with a total of 120 questionnaires allocated per district. In each district, we utilized stratified sampling techniques, considering the degree of irrigation water scarcity evaluated by local authorities in different areas to distribute the surveyed households appropriately. In consultation with local authorities, a deliberate selection process was employed to identify three distinct areas within each district characterized by varying degrees of water scarcity: high, medium, and low. This approach was

implemented to guarantee that farmers' perspectives are comprehensively considered, irrespective of the severity of water scarcity they encounter. To execute the survey, 40 farming households were chosen randomly within each designated area. We disseminated 360 questionnaires, but only 289 comprised complete information and were considered for analysis (80.28%), with those with missing data excluded. Our target interviewees were heads of households, either the husband or the wife, who thoroughly comprehended rice cultivation operations and hold the most significant decision-making power within their families. Households with absent heads were either ignored or revisited later. The interview content followed a structured approach, with interviewees initially providing demographic and livelihood information. Subsequently, we examined the results and effectiveness of recent rice crops, paying particular attention to the benefits and drawbacks, explicitly focusing on extreme weather conditions (such as rising temperatures, salinity intrusion, etc.) and water scarcity in rice production. Farmers were then given a concise explanation about the imperative of improving the irrigation system in light of the escalating severity of drought, water scarcity, and climate change. Our explanation also addresses the government's financial constraints in responding to extreme weather events and climate change, as well as their policy of gradually shifting from "irrigation subsidies" to "irrigation services," attaching responsibility to both service providers and users. The main emphasis of "irrigation water services" in this study lies on the following key activities: enhancing watershed, river, and canal flows; refurbishing the lake, dam, and infield canal system; and effectively maintaining and operating irrigation pumping stations during the dry season. The objective of these activities is to guarantee sufficient water, both in terms of quantity and quality, for rice production through irrigation.

Then, farmers were asked to express their willingness to co-finance these irrigation water services. The concept of "co-finance" in this study involves making a monthly payment through the households' water bill to maintain, enhance, and operate irrigation services specifically for rice production. The payment amount may vary among farmer households, depending on the size of the cultivated area and the number of rice crops they grow yearly. The interviewers clearly explained the assumed payment level to the farmers, enabling them to estimate the total amount to be paid based on the total cultivated area and the number of rice crops yearly if the program is implemented in practice. To help farmers calculate the total service fee more easily, we used the local area unit known as "Cong" (1 Cong = 1,296 m² or about 0.13 hectares). In this study, we offered a service payment of 5,000 VND/Cong/rice crop/year (equivalent to 0.21 USD). We established this service fee level after consulting with experts and village heads in the study area and then discussed its relevance in focus group discussions. Based on the feedback received, it is widely agreed that this fee level is appropriate for the income range of most farmers in the Mekong Delta. This fee will be doubled or tripled if farmers produce two or three rice crops per year, respectively. Accordingly, households are required to pay approximately 77,000 VND/hectare/year (for two crops/year) and about 115,500 VND/hectare/year (for three crops/year) (equivalent to 3.17 - 4.76 USD). Based on the households' cultivated area and crops per year, the interviewer initially calculated the monthly service fee, which serves as the basis for households to make a payment decision.

Data analysis

This research employed both qualitative and quantitative approaches. The quantitative approach was utilized to examine the relationships between output variables and predictors, whereas the qualitative approach was employed to interpret the implications

of the predicted numerical data. A simple binary logistic regression model was used to examine the factors driving farmers' willingness to co-finance irrigation water services. The dependent variable was defined as "farmers' willingness to co-finance irrigation water services." It was dichotomized as either "agree to co-finance" or "do not agree to co-finance," which were assigned a value of 1 and 0, respectively, in the regression model. IBM SPSS Statistics 22 software was employed to analyze the data. By examining pertinent literature, this research took into account 18 explicatory factors that pertain to household characteristics, the perception of water scarcity in rice production, the perception of the negative consequences of water scarcity on rice production, the perception of the level of risk faced by households due to water scarcity, the effectiveness of current measures at the household and local levels in addressing water scarcity, and the effectiveness of watershed interventions in securing irrigation water. Table 1 provides a brief description of these variables. We anticipate detecting several statistically significant influences on farmers' willingness to co-finance irrigation water services. After examining published literature, we hypothesized that households exhibiting one of the following characteristics are more willing to co-finance irrigation water services: male-headed households, younger and better-educated householders, having fewer laborers, engaging in off-farm occupations, wealthier households, with larger rice-cultivated areas, more severe assessment of the problem of water scarcity and its adverse impacts, and underlying measures at household and local scale in addressing water scarcity.

Table 1 – Brief description of the key variables

Variable	Type	Explanation	Min	Max	Mean	SD
Farmers' willingness to co-finance irrigation water services *(dependent variable)*	Binary	1 = Agree to co-finance 0 = Do not agree to co-finance	0	1	0.44	0.497
1. Householder's gender	Binary	1 = Male 0 = Female	0	1	0.98	0.131
2. Householder's age	Ordinal	1= Under 30 years old 2 = 30-45 years old 3 = 46-60 years old 4 = Over 60 years old	1	4	2.467	0.607
3. Householder's highest educational attainment	Ordinal	1 = Elementary school 2 = Secondary school 3 = High school 4 = University and higher	1	4	1.32	0.653
4. Number of laborers	Binary	1 = 2 labors or less 2 = Over 2 labors	1	2	1.75	0.433
5. Engaging in non-farm jobs	Binary	1 = Yes 0 = No	0	1	0.21	0.409
6. Household's monthly income	Ordinal	1 = Under 3 million VND 2 = 3-6 million VND 3 = 6-9 million VND 4 = 9-12 million VND 5 = 12-15 million VND 6 = Over 15 million VND	1	6	2.63	1.101
7. Rice growing area	Continuous	Total rice cultivation area (hectares)	0.3	40	4.37	3.885
8. Water scarcity is a serious problem in your area	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	3.75	0.842
9. Water scarcity will be aggravated by human interventions	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	4.43	0.714
10. Climate change will exacerbate water scarcity	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	4.40	0.715
11. Water scarcity reduces yield or increases crop failure	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	4.46	0.686
12. Water scarcity increases input costs	5-level Likert Scale	1= strongly disagree – 5= strongly agree	2	5	4.42	0.703
13. Water scarcity increases pests and diseases	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	4.13	0.939
14. Estimation of household risk level posed by water scarcity	5-level Likert Scale	1= very low risk – 5= very high risk	1	5	3.66	0.936
15. Household-level measures will solve the problem of water scarcity	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	2.57	1.482
16. Local government-level measures will solve the problem of water scarcity	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	3.79	1.254
17. Restoring upstream flows will ensure sufficient water for rice production	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	3.62	1.158
18. Restoring upstream flows will improve water quality for rice production	5-level Likert Scale	1= strongly disagree – 5= strongly agree	1	5	4.09	0.860

Results

Respondents' demographics

Table 2 presents the primary characteristics of the study population. The majority of the respondents were males, constituting 98.3% of the sample. The sample also consisted mostly of middle-aged individuals, with 94.1% of respondents falling into this age group. The educational attainment of the household heads was predominantly low, with only 3.1% and 2.4% of individuals attaining high school and university education, respectively. The majority of the respondents attended only primary school, accounting for 76.1% of the sample, while 18.3% attended secondary school. On average, each household had 3.4 laborers, with 75.1% having more than two laborers. Non-farm work was undertaken by 21.1% of farmers as a means of augmenting household earnings, while the remainder relied solely on agricultural production. Of the households interviewed, almost half (49.5%) reported owning between 3 and 6 hectares of rice, whereas only 17.6% reported owning more than 6 hectares.

Table 2 – Respondents' demographic characteristics

Characteristics		Number	Percentage
Householder's gender	Male	284	98.3
	Female	5	1.7
Householder's age	Under 30 years old	6	2.1
	30-45 years old	153	52.9
	46-60 years old	119	41.2
	Over 60 years old	11	3.8
Householder's highest educational attainment	Elementary school	220	76.1
	Secondary school	53	18.3
	High school	9	3.1
	University and higher	7	2.4
Number of laborers	≤ 2 labors	72	24.9
	> 2 labors	217	75.1
Engaging in non-farm jobs	Yes	61	21.1
	No	228	78.9
Household's monthly income	< 3 million VND	31	10.7
	3-6 million VND	128	44.3
	6-9 million VND	69	23.9
	9-12 million VND	44	15.2
	12-15 million VND	12	4.2
	> 15 million VND	5	1.7
Total rice cultivation area (hectares)	< 3 hectares	95	32.9
	3-6 hectares	143	49.5
	> 6 hectares	51	17.6

Factors affecting farmers' willingness to co-financing irrigation water services

Table 3 summarizes the model's predictive accuracy. The results indicate that the model accurately predicted payment disagreement in 134 out of 162 cases, resulting in an 82.7% success rate. Additionally, the model misjudged only 41 out of 127 cases where

farmers agreed to co-finance, resulting in a success rate of 67.7%. The model achieved an average success rate of 76.1%, which attests to its robust reliability. As the dependent variable in this study is binary, the Hosmer-Lemeshow goodness of fit test was employed to evaluate the model's adequacy. Despite some limitations, such as potential discrepancies when covariate samples are fewer than object numbers (Bertolini, D'Amico, Nardi, Tinazzi, & Apolone, 2000; Hosmer, Hosmer, Le Cessie, & Lemeshow, 1997; Kramer & Zimmerman, 2007), this test has been commonly adopted by prior researchers (Abdillah, Tinaprilla, & Adhi, 2022; Ha et al., 2022; Kwadzo & Quayson, 2021).

Table 3 – Percentage accuracy in classification (PAC)

Observed	Predicted		
	Do not agree to co-finance	Agree to co-finance	Percentage Correct
Do not agree to co-finance	134	28	82.7
Agree to co-finance	41	86	67.7
Overall percentage			76.1

The results of the binary logistic regression model predicting factors driving farmers' willingness to co-finance irrigation water services are shown in Table 4.

Effects of socio-demographic characteristics

Our analysis of the socio-demographic characteristics of householders/households revealed that just two of the seven variables had a statistically significant correlation with the household's willingness to co-financing irrigation water services. These findings suggest that household head characteristics have limited predictability in farmers' willingness to co-finance. Only engaging in non-farm jobs showed a statistically significant association with the targeted variable among the several characteristics examined. The negative coefficient means that farmers who regularly engage in non-farm jobs tend to be less willing to pay for irrigation water services (B = -0.922, p = 0.025). The odds of the willingness to co-finance decrease by 60.2% if farmers are participating in non-farm jobs (OR = 0.398). This result contradicts our initial hypothesis that non-farm income would increase farmers' willingness to co-finance. Our in-depth interviews reveal that farmers involved in non-farm work tend to pay less attention to rice production. A middle-aged man in Chau Phu confided: *"Rice farming involved strenuous labor and low profits. With the crops affected by drought and saltwater intrusion, I also suffered a heavy loss of income. I have to work regularly as a construction worker to ensure the family's income. This kind of job provides me with a higher income and less risk than rice farming with weekly pay. Of course, I was forced to reduce the time for rice cultivation."* This opinion is consistent with prior research by Vo et al. (2021) and Dinh et al. (2023), demonstrating that off-farm employment significantly boosts farmers' income but distracts them from agricultural activities. This fact threatens the sustainability of rural society. Meanwhile, the remaining characteristics, including the householder's gender, householder's age, and householder's highest educational attainment, are separate from farmers' willingness to pay (p = 0.149, p= 0.560, p = 0.932, respectively). This suggests that such variables of household heads lack efficiency in anticipating the payment behavior for irrigation water services. Our results, however, differ from those of Mumbi and Watanabe (2021), Kidane et al. (2019), (Rodríguez-Tapia et al. (2017), Biswas and Venkatachalam (2015), and Bui et al. (2022). For instance, the study by Kidane et al. (2019) in Eritrea demonstrated that age and gender are significant factors influencing smallholder farmers' willingness to pay for

irrigation water. Likewise, Gebretsadik and Romstad's (2020) research in Ethiopia highlighted the importance of householders' gender, age, and education in determining their attitudes toward improving irrigation water supply.

For household characteristics, we found a statistically significant relationship between the household's monthly income and farmers' willingness to co-financing irrigation water services (B = 0.988, p = 0.000). Farmers with higher incomes tend to accept the co-financing program. For every household's extra income level, the odds of willingness to pay for irrigation water services will increase by nearly 2.7 times (OR = 2.686). The role of income on willingness to pay for water-based ecosystem services has been elucidated by previous studies (Bui et al., 2022; Hue, 2018; Kidane et al., 2019; Le & Aramaki, 2019). For example, Kidane et al. (2019) discovered through a case study in Eritrea that the income of households significantly influences the farmers' willingness to pay for irrigation water supply improvement. Meanwhile, the number of laborers and rice growing area was entirely separated from farmers' willingness to pay for efforts to avoid water scarcity (p = 0.109, p = 0.587, respectively). While this result corresponds well with Gravitiani et al. (2016) conclusion that family size had no significant influence, it contradicts the findings of Tang et al. (2022) that households with a larger cultivated land area are more willing to support irrigation water improvement.

Effects of farmers' perception of water scarcity

The regression model results indicate that farmers' perception of water scarcity in rice production has a positive effect on their willingness to pay for irrigation services (B = 0.550, p = 0.007). Specifically, farmers who face more severe water scarcity are more likely to be willing to pay for irrigation services. For each higher assessment level of water scarcity severity, the odds of willingness to pay increase by nearly 1.733 times (OR = 1.733). Similarly, we also found a significant positive association between farmers' perceptions of climate change impacts on water scarcity and their willingness to pay for irrigation services (B = 0.994, p = 0.001, OR = 2.702). This suggests that farmers are more likely to accept payment for irrigation services if they are adequately aware of the impact of climate change on drought in the area. However, we did not find a significant relationship between farmers' perception of human activities' impacts on water scarcity and their willingness to pay (p = 0.076). This correlation concurs well with previous findings that people who are facing more severe water-related problems tend to accept payment for water-based ecosystem services (Antwi-Agyei, Amanor, Hogarh, & Dougill, 2021; Khong et al., 2018; Kidane et al., 2019). A recent study by Sartain et al. (2020) also highlighted that concern about the impact of climate change on agriculture is an important determinant of payment willingness for mitigating climate change impacts. During the interviews, most farmers expressed concern about the adverse effects of climate change in recent years. For instance, a man in the Tri Ton district explained, *"The water upstream from our area has been very erratic and tends to be lower than in previous years, causing drought and saltwater intrusion. The situation is becoming more and more serious in this area, and rice cultivation is becoming increasingly difficult. The rice yield is also low. I think this is due to the effects of climate change, as frequently mentioned on television."* He also emphasized the need for improving watershed flows and dredging the infield canal system to increase the water supply for rice production.

Effects of farmers' perception of water scarcity impacts

Our study shows that farmers' perception of the impact of water scarcity on rice production is significantly associated with their willingness to pay for irrigation services.

Specifically, we found that the water scarcity effects on rice yield had a positive effect on farmers' willingness to pay (B = 0.766, p = 0.007, OR = 2.151), while the impact of water scarcity on increasing input costs and pests did not influence their participation willingness (p = 0.760, p = 0.959, respectively). As an extremely important input for rice cultivation, water shortage, and saline intrusion seriously affect rice yield. According to our survey, the majority of respondents (76.47%) reported experiencing productivity losses due to extreme weather events, such as droughts and water shortages. The findings of this study resonate with those of Khong et al. (2018) and Mumbi and Watanabe 2021). For instance, in a case study of the Mekong River Delta, Khong et al. (2018) highlighted that groups affected by high salinity intrusion had the highest willingness to pay levels. While respondents acknowledged that drought significantly increased production costs (mean = 4.42, 5-level Likert Scale) and disease control (mean = 4.13, 5-level Likert Scale), these factors did not seem to impact farmers' willingness to co-finance. This shows consistency in farmers' assessment of these issues.

Effects of estimation of risk level posed by water scarcity

More than half of the respondents (50.9%) underestimated the effectiveness of measures at the household level, while about 60.9% agreed that measures at the local government level were effective. Despite a notable 64.36% of households owning water pumps, their limited capacity restricts their effectiveness for large fields. Simultaneously, the high operational fuel costs often confine their usage to genuinely necessary situations. Additional measures, such as embanking fields and dredging canals, prove less effective. Generally, farmers tend to be passive in dealing with water scarcity and rely mainly on local authorities' natural water supplies and irrigation services. They believe that the government has the financial resources to improve these measures and can mobilize the community to provide additional support, which can partly improve the water scarcity situation. However, in cases where the water source is limited, these measures may not be effective. The regression model also negates the effectiveness of the above two variables in predicting farmers' willingness to pay (p = 0.724, p = 0.905, respectively).

Effects of perception of watershed flow intervention's effectiveness

In this study, watershed improvement is considered a crucial component of irrigation water services. As indicated in the study area section, the Tien River and Hau River, two tributaries approximately 100 km long, provide fresh water and alluvium, creating favorable conditions for agricultural development in An Giang province. However, in the current water scarcity context, if no measures are taken to improve the upstream flow, the downstream water flow will be severely limited, leading to water shortages for agricultural production on a large scale. Local experts have emphasized the urgent need to improve the upstream flows and river systems, canals, and channels to ensure sufficient water for agricultural production in the face of a complicated drought. The findings reveal that most respondents highly value the effectiveness of watershed interventions in addressing drought and water scarcity issues. Specifically, 54.0% of respondents appreciated the role of watershed interventions in ensuring sufficient water availability for irrigation, while 71.6% acknowledged its role in improving irrigation water quality. A farmer in Thoai Son district elucidated, *"The downstream availability and irrigation water quality depend heavily on upstream water abundance. Acknowledging the pivotal role of optimizing upstream flows to secure an ample water supply for rice cultivation, I am willing to financially support the government's efforts in implementing this intervention."* However, this study did not observe any statistically

significant correlation between farmers' perception of the effectiveness of watershed interventions and their willingness to pay (p = 0.114, p = 0.382, respectively). This highlights farmers' concentrated opinions and high consensus regarding improving watershed flow restoration.

Table 4 – Binary logistic regression results on factors influencing farmers' willingness to co-finance irrigation water services

Indicators	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Householder’s gender	-1.552	1.074	2.087	0.149	0.212	0.026	1.739
Householder’s age	-0.147	0.252	0.340	0.560	0.863	0.527	1.415
Householder’s highest educational attainment	0.021	0.245	0.007	0.932	1.021	0.631	1.652
Engaging in non-farm jobs *	-0.922	0.413	4.997	0.025	0.398	0.177	0.893
Number of laborers	-0.561	0.350	2.565	0.109	0.571	0.287	1.134
Household's monthly income **	0.988	0.175	31.717	0.000	2.686	1.904	3.788
Rice growing area	-0.024	0.044	0.296	0.587	0.977	0.896	1.064
Water scarcity is a serious problem in your area **	0.550	0.205	7.187	0.007	1.733	1.159	2.591
Water scarcity will be aggravated by human activities	-0.460	0.260	3.147	0.076	0.631	0.379	1.049
Climate change will exacerbate water scarcity **	0.994	0.290	11.761	0.001	2.702	1.531	4.770
Water scarcity reduces yield or increases crop failure **	0.766	0.284	7.250	0.007	2.151	1.232	3.755
Water scarcity increases input costs	0.077	0.253	0.093	0.760	1.080	0.658	1.774
Water scarcity increases pests and diseases	0.009	0.180	0.003	0.959	1.009	0.709	1.437
Estimation of household risk level posed by water scarcity **	0.704	0.209	11.370	0.001	2.021	1.343	3.043
Household-level measures will solve the problem of water scarcity	-0.045	0.128	0.124	0.724	0.956	0.743	1.229
Local government-level measures will solve the problem of water scarcity	-0.016	0.134	0.014	0.905	0.984	0.756	1.280
Restoring upstream flows will ensure sufficient water for rice production	-0.309	0.196	2.497	0.114	0.734	0.500	1.077
Restoring upstream flows will improve water quality for rice production	-0.209	0.239	0.765	0.382	0.811	0.507	1.297
Constant	-7.543	2.273	11.008	0.001	0.001		
Model summary	-2 Log likelihood			294.362			
	Cox & Snell R Square			0.297			
	Nagelkerke R Square			0.399			
	Chi-square			13.721			
	Sig.			0.089			

**, ** Significant at 5% and 1%, respectively*

Conclusions and policy considerations

The adverse impact of climate change-induced drought on rice production in Vietnam's Mekong Delta is a pressing concern. As a developing nation, Vietnam encounters financial challenges in addressing water scarcity and drought. Mobilizing farmers and fostering their participation in co-financing initiatives to enhance irrigation services is paramount in addressing this issue. Consequently, this study was undertaken in An Giang province of the Mekong Delta to explore the factors influencing farmers' willingness to pay for or co-finance irrigation water services. The findings from this study are essential for informing policymakers to pursue and implement this initiative effectively.

Findings from the study indicate that household head characteristics, such as gender, age, and education, have limited predictive power for farmers' willingness to co-finance irrigation services. However, engaging in off-farm work tends to decrease farmers' willingness to co-finance, as higher income and lower risks from non-agricultural jobs can reduce interest in rice farming. To address this, local authorities should use effective communication methods to highlight the importance of rice farming and encourage a balanced approach between agricultural and non-agricultural activities. The study emphasizes the crucial role of household income in determining farmers' willingness to pay for irrigation services. Policymakers should tailor payment levels to suit economic conditions, considering fee reductions for marginalized households to encourage participation in co-financing irrigation services.

Farmers' awareness of climate change-induced water scarcity significantly influences their willingness to pay for improved irrigation services. Recognizing the positive relationship between climate change and water scarcity encourages farmers to support co-financing initiatives. Authorities should prioritize communication efforts to raise awareness among farmers about global climate change trends and potential consequences for agricultural livelihood security. This underscores the importance of mobilizing financial resources from individual farmers to address water scarcity challenges.

Experiencing crop failure or yield loss due to water scarcity positively impacts farmers' willingness to co-finance irrigation services. Farmers are more willing to pay if they have firsthand experience with the severe effects of water scarcity in their rice fields. It's essential to acknowledge that a reduction in water supply upstream, coupled with inadequate dredging and maintenance of water systems, can lead to a widespread shortage of irrigation water. Assessing households' potential risk of water scarcity positively contributes to their readiness to accept payments for combating water scarcity. Communication measures analyzing risks during droughts are vital, and exploring new ways, such as information contests or dramatizations, can enhance communication efficiency.

One limitation of this study lies in its geographical specificity, focusing exclusively on the Mekong Delta region in Vietnam. The findings may not be directly generalizable to other geographic locations or cultural contexts where the dynamics of collective irrigation services and farmers' willingness to pay may differ. Additionally, the study primarily relies on self-reported data obtained through direct interviews with farmers, which may introduce response bias or social desirability effects. The cross-sectional nature of the research design also limits the ability to establish causal relationships between the identified factors and farmers' willingness to co-finance irrigation services. A potential avenue for future investigation could involve longitudinal studies to capture temporal changes in farmers' willingness to pay and to assess the long-term sustainability of their co-financing commitments. Despite these limitations, it is important to note that

the co-financing initiative is promising for climate change adaptation under financial constraints in many developing countries.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Ethics declaration

All procedures in human participatory studies adhered to ethical research standards and were conducted with the participants' informed consent.

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