



Article The Price of Sustainability of a Traditional Irrigation System in Northern Thailand

Arriya Mungsunti ^{1,2} and Kevin A. Parton ^{1,*}

- ¹ Institute for Land, Water and Society (ILWS), School of Management and Marketing, Charles Sturt University, Bathurst, NSW 2795, Australia; arriya.mungsunti@gmail.com
- ² Center for Sustainable Development Goals Studies (SDGs Center), Padjadjaran University, Bandung 40132, Indonesia
- * Correspondence: kparton@csu.edu.au; Tel.: +61-263657654

Abstract: In recent years in northern Thailand, the traditional surface-water irrigation system known as muang fai has been challenged by the introduction of small-scale, groundwater pumping technology. This trend presents concerns about the sustainability of the system, as the new technology uses more water but produces lower-quality agricultural outputs. In this paper, we provide evidence that farmers who use relatively modern irrigation technology (ground water pumping systems) are willing to switch to a more traditional (hundreds of years old) and more sustainable surface water irrigation system. In the Sop Rong region in northern Thailand, we surveyed 570 longan farmers, approximately half being muang fai members and half using pumped groundwater. We designed an experiment for the second group to check whether they were interested in becoming muang fai members in a scenario where they have access to the canal system. We found that almost half of them were willing to pay fees to become members and that the negative relationship between membership fees and the willingness to join is robust after controlling for all other relevant factors. Despite this positive result for sustainability, suggesting that there is a price at which many farmers would be willing to switch to a more water-saving system, few farmers are making the shift. We conclude that there are strong social pressures that discourage them from doing so. Such social influences are probably an important and often overlooked determinant of efforts to achieve sustainability.

Keywords: sustainability; traditional irrigation; Thailand; price; social relationships; water saving

1. Introduction

Presently, there are many different types of irrigation systems in use on farms. Modern systems are either in the form of large-/medium-size dams or small-scale irrigation systems using pumps to extract water from underground sources. These new modern systems are mostly used to replace traditional ones. In the case of northern Thailand, some farmers still are actively engaged in a traditional irrigation system that heavily relies on surface water from rivers or water streams. This communal irrigation system, called muang fai, was established more than 700 years ago. It has been managed through community-based participation and has undergone little change for generations ([1] p. 13).

We based our study at the muang fai Sop Rong irrigation system (see the next section for a more detailed description of the area). Previous studies of longan fruit farming in the area have shown that the muang fai farmers achieve higher water use efficiency on average than farmers who pump irrigation water from underground [2]. Moreover, the water tends to be of higher quality than that pumped from underground, resulting in larger longan fruit. This fruit generates higher revenues from the market and, hence, higher profits for those farmers who are members of the muang fai [2]. Hence, there would appear to be a financial incentive for farmers to switch from pumping water from underground to the muang fai system, and the muang fai system is more sustainable in terms of water use efficiency. In one part of the catchment, consisting of about 17% of the total area, groundwater is



Citation: Mungsunti, A.; Parton, K.A. The Price of Sustainability of a Traditional Irrigation System in Northern Thailand. *Sustainability* **2021**, *13*, 1375. https://doi.org/ 10.3390/su13031375

Academic Editor: Gonçalo C. Rodrigues Received: 31 December 2020 Accepted: 22 January 2021 Published: 28 January 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). reaching critical quantitative limits where the system is at risk of switching from being natural flow-dominated to being human flow-dominated if the muang fai system were replaced by underground pump irrigation [3]. A major constraint for many of these farmers is that they live some distance from a muang fai canal. Nevertheless, it is possible to extend the canal system and it seemed a worthwhile investigation to attempt to discover how much the non-members of the muang fai would be willing to pay to become members, and have the right to muang fai irrigation water.

Therefore, the objective of our research was to assess to what extent farmers who use relatively modern irrigation technology are willing to pay to become a member of a traditional, communal managed irrigation system. The paper also aims to identify which factors determine their willingness to pay to become a system member.

This paper starts by providing background information on the traditional muang fai irrigation system of northern Thailand. Then, in the second section, we look at a comparison between the muang fai system and the system of pumping water from underground by investigating both systems in terms of water use efficiency and agricultural productivity that generates income for farmers. The data used are also explained in this section, including information on the data collection procedures and the design of the survey instrument. In Section 3, we then discuss the methods based on logistic regression and contingent valuation. Then, in Section 4, we report on and discuss the findings of this study, followed by the conclusions in Section 5.

2. Materials and Methods

2.1. Study Region

In northern Thailand, especially around Chiang Mai province, the topographical structure comprises mainly mountains and valleys with plentiful forests. This area is known as a high rainfall area. Despite this, data from the Meteorological Department of Chiang Mai show that the amount of rainfall across Chiang Mai province during the rainy season varies considerably and often limits agricultural production, necessitating irrigation. The study area is shown as the highlighted area in Figure 1.

Even though traditional irrigation is popular in this area, extracting underground water using an electric or diesel pump is also practiced. This water is used in households and in agricultural production. In this area, most farmers are engaged in rice farming or fruit orchards. The chosen study area of muang fai Sop Rong is located in the San Pa Tong district on the northwestern side of Chiang Mai province. The district has 12 major villages in the San Pa Tong district (Sai Mul, San Khok Chang, Mae Khong Tai, Mae Khong Krang, Rong Khut, Mae Khong Nua, Mae Ka, Pa Kuay, Mae Kung, Dong Pa Sang, and Dong Khi Lek villages) [4]. As shown in Figure 2, the system is located on the bank of the Ping River at Tambon Nong Tong.

Traditionally, a muang fai irrigation system is constructed from natural materials that are quite easy to find around the local area. The system is impermanent and so quite flexible to repair or restore. The system distributes water to orchards and paddy fields along dirt lateral canals by letting it flow to farmland naturally or by using pumps to speed up the water flow to the farms. The muang fai Sop Rong is one of the examples where almost all of the canals pass through the members' farmland or alongside the farm. These canals have been constructed by farmers by laboriously digging the ground deep enough to allow water to flow through. In contrast, the weirs and the main gates on the river are made of concrete and are, therefore, more permanent. Before the construction of a muang fai irrigation system, the characteristics of topography such as the slope of the hill, water flow rate, fluctuation in water depth, flood level, and water requirements for farm usage on both banks of the river are generally considered [5].

Modern alternative irrigation uses water pumped from underground sources. The main advantage of this underground pumped system is that water is always available whenever farmers need it, while the muang fai water is not always available when farmers need it as the system is based on a fixed rotation order that allows water users to have access to it only when their turn has arrived. Thus, muang fai members are disadvantaged relative to those pumping water from underground because there is less reliability and flexibility in the supply of their water. Despite such apparent disadvantages, membership of the muang fai has been relatively stable over time [3]. Nowadays, the depletion of groundwater resources is becoming a global concern as aquifers are being pumped at unsustainable rates. About 17% of the Sop Rong watershed faces this risk [3]. Enhanced irrigation efficiencies and conservation measures are being implemented where possible.



Figure 1. Map of study site of Chiang Mai province in northern Thailand.



Figure 2. The study area of the muang fai Sop Rong irrigation system. Source: [3].

2.2. Data Collection

In the Sop Rong area, we collected information on farmland characteristics and socioeconomic variables from 570 longan farmer households. We selected longan because it is the most important crop in the area. Over 90% of the households in the study region grow longan, compared with just over 10% growing rice [6]. We divided the sample into two groups (of approximately equal size) based on their type of irrigation. These two groups are the muang fai group and the underground water users. After all the data were collected and organized, we ended up with 481 households appropriate for data analysis.

First of all, we collected data on the characteristic of farmland size, which clearly affects the need for irrigation water. Farmers choose a particular type of irrigation that best suits their farmland and crop needs. Farmers mainly consider relevant features such as the reliability (in terms of continuity of water flow whenever it is used), flexibility (in terms of when and how long water flow can be directed to their farm land), and, importantly, water quality. It was expected that the larger the farm size, the more water it would need.

We also collected farmers' socio-economic data such as data on economic status (as measured by expenditure per person). Economic status may have an impact on the probability of participation in the muang fai system because membership requires a certain amount of fees. Nevertheless, since the fees are relatively low at about 25 THB/rai/year (equivalent to about USD 5.20/ha), the effect on participation may not be substantial. Instead, for the richer farmers, being better-off makes underground pump irrigation more affordable. Thus, it may be that the richer the farmer is, the less likely he/she is to participate in the muang fai system as they have more access to the alternative choice of pumping water from underground. In addition to this, off-farm employment was expected to be negatively associated with muang fai participation. Becoming a muang fai member requires a regular contribution of time to maintain the system. Off-farm employment may, therefore, reduce the likelihood of participation.

5 of 10

Additionally, the survey questionnaire was constructed to include a contingent valuation experiment of non-members of the muang fai (users of underground pumped water). In particular, we asked them the following question:

"Suppose you have an access to muang fai canals, will you apply for a membership if the fee is THB?"

We randomized the fees, giving each respondent one of seven different fee levels. The objective was to ascertain whether lower stated fees were associated with a higher probability of willingness to become a member.

3. Method

For this study, a logistic regression or logit model was used to examine which factors determine a farmer's decision to adopt the communal muang fai irrigation system. In a similar manner, the approach was used to determine the factors influencing farmer adoption of water-saving technology in China [7]. A logit model regression was used in this case, where the dependent variable was muang fai membership, and the model was used to identify the main determinants of participation in the muang fai system. The independent variables were grouped into different farm, demographic, and socio-economic characteristics. The specification of the variables to be included in the model was based on the existing literature, expert interviews, and focus group discussions.

The logistic model is a binary response model, where the response probability is the logistic function estimated as a linear function of the explanatory variables. The primary focus of a binary response model is the response probability:

$$P(y = 1 | x) = P(y = 1 | x_1, x_2, \dots, x_k)$$
(1)

where x denotes a set of independent variables and the dependent variable y denotes a muang fai participation indicator. The variable y is a binary variable. It takes the value of 1 if the farmer participates in the system, while the value of 0 indicates that the farmer does not participate in the system. On the other hand, the independent variables x_i contained various farm and farmer characteristics such as farm size, age, gender, marital status, level of education, and other factors that could affect participation.

To ascertain the likely level of demand for membership of the muang fai by nonmembers, we used a contingent valuation (CV) method. As discussed in Section 2.2, this involved questioning respondents about their preferences for membership at various randomly assigned bid levels. A fundamental choice in stated preference studies is whether to select an attribute-based technique (such as a choice experiment) or a non-attribute-based technique (such as a contingent valuation method). Johnston et al. [8] observed that while choice experiments (CEs) have the ability to estimate marginal values, they can be complex and potentially lose incentive compatibility, while CV can estimate values when an item cannot be easily defined in terms of attributes. They recommend ([8] p. 333) that the choice between CE or CV should be based on "how respondents tend to perceive the good, the study objectives, and the information content of valuation scenarios". Contingent valuation was selected for use in our study because our goal was to estimate willingness to pay for the overall good and not product attributes and because our study was conducted in a context in northern Thailand, where there were possible issues with literacy and, consequently, complexity had to be avoided.

4. Results and Discussion

Table 1 shows the list of independent variables and the socio-economic characteristics of longan farmers in the Sop Rong region by the type of irrigation that they have selected. Non-members of the muang fai live, on average, about 31 m further than members from the closest muang fai canal and they are wealthier, as measured by expenditure per capita, by almost THB 300 per week (there are about THB 30.30 to one USD). These two results are significant at 5% using a *t*-test. Non-members also appear to have a slightly larger farm

size, but this difference is not significant. The contingent valuation results show that just over 48% of non-members would be willing to pay to be members if they had access to muang fai water.

The results in Table 1 show that almost half of the non-muang fai farmers were willing to pay fees to become members, and the results in Table 2 show that the negative relationship between membership fees and the willingness to join is robust after controlling for other relevant factors. We also note that the decision to switch is more likely for farmers who have, up to a point, a larger farm and when they live in a village where muang fai membership is more common, meaning that social networking may influence a farmer's decision about which type of irrigation they choose to adopt.

Table 1. Socio-economic characteristics of longan farmers in the Sop Rong region by the irrigation they used.

	(1)	(2)	(3)	(4)	(6)	(7)	(8)	(9)
Variables		Non-MF	Member			MF N		
	Mean	SD	Min	Max	Mean	SD	Min	Max
Distance to closest muang fai (MF) canal (m)	86.43	71.60	0.0100	335.4	54.90	83.41	0.0676	1067
Gender, $1 = male 0 = female$	0.790	0.408	0	1	0.831	0.375	0	1
Age (years)	58.65	10.93	33	90	59.25	10.90	32	89
Elementary	0.782	0.413	0	1	0.747	0.436	0	1
Junior secondary	0.0573	0.233	0	1	0.0844	0.278	0	1
Senior secondary	0.0840	0.278	0	1	0.0909	0.288	0	1
College	0.0534	0.225	0	1	0.0519	0.222	0	1
Marital status, $1 = married 0 = otherwise$	0.870	0.337	0	1	0.883	0.322	0	1
Farming experience	28.24	14.55	0	65	26.44	14.86	0	70
Off-farm work days/week	2.481	2.805	0	7	2.016	2.525	0	7
Household size	3.336	1.354	1	7	3.256	1.280	1	7
Expenditure per capita (THB/week)	766.7	596.7	1	5000	666.3	469.6	60	3500
Percentage of members in the village (%)	57.40	16.36	25	90.48	70.61	20.37	25	90.48
Farm size (rai) ^a	4.545	4.220	0.500	30.00	4.907	4.275	0.500	37.00
Willing to pay to be MF member	0.485	0.501	0	1				

Note: No. of observations: MF members = 308, Non-MF members = 262. ^a: 1 ha = 6.25 rai.

A key message is that the service provided by the muang fai (irrigation water supply) system is similar to any normal marketable goods and services. They follow the same law of demand. Farmers are keen to have access to the water whenever the price is felt to be right and there is a negatively sloped bid curve, so that demand increases as price falls.

The percentage of muang fai members in the village was observed to have a positive relationship with the probability of participation (see Table 2). The results suggest that the number of muang fai members in a village plays an important role. It is statistically significant in shaping the demand/bid curve. It may be the case that those farmers who are not members and who live in a high muang fai member intensity area gather more information (indirect advertisement) from conversations with their fellow farmers. While Olsen [9] warned that an increase in numbers beyond a certain point could work against participation, the context was different in India with very high inequity, and this was not the case of muang fai Sop Rong. The motivation for farmers to participate in the muang fai system is likely to be influenced socially within the community. This concept of bonding social capital is commonly found in rural communities [10]. To maintain a sense of belonging to a family and a community, farmers could decide to engage in cooperative activities, even if, individually, they prefer more attractive forms of production. Individuals of a rural community are likely to be sensitive to the views of family, friends, or neighbors, and consequently, they often act the same way as other members of the family or their neighbors instead of making their own decision based on their own direct preferences.

	No Co	ontrol	With Control		
Amount of membership fee (bid) in THB	-0.00629 *	(0.00260)	-0.00805 **	(0.00298)	
Log of distance to closest canal (m)			0.01000	(0.0998)	
Log of area of the main crops (rai)			1.075 *	(0.431)	
Square of log area			-0.360 *	(0.172)	
Gender, $1 = male 0 = female$			0.214	(0.351)	
Log of age			1.116	(0.964)	
Marital status, $1 = married 0 = otherwise$			-0.490	(0.440)	
Elementary			-0.965	(0.826)	
Junior secondary			-0.744	(1.002)	
Senior secondary			-1.311	(0.976)	
College			-1.948	(1.137)	
Log of farming experience (years)			-0.413	(0.288)	
Log of expenditure per capita (bath/week)			-0.298	(0.195)	
Off-farm workdays/week			0.0708	(0.0563)	
Percentage of members in the village (%)			0.0181 *	(0.00893)	
Household size			0.0909	(0.111)	
Constant			-1.410		
Observations	258		248		
Pseudo R-squared	0.0166		0.0754		
Robust standard errors in parentheses					

Table 2. Result of regression analysis of willingness to pay for muang fai membership.

** *p* < 0.01, * *p* < 0.05.

After gathering all the results, we found that almost half of the non-muang fai members (127 from 262 in total) are willing to pay to become a member or to join the water user group. The probability of them joining the muang fai is negatively associated with the amount of fees that they are offered. This finding suggests that the longan farmers are rational economic agents. They are willing to become muang fai members whenever they see that the price is "right", which is the price that they are willing to pay to gain access to water, considering the higher revenue that they gain from better quality fruits produced using the surface water of the muang fai system. Moreover, the negative relationship between membership fee and willingness to join is robust and statistically significant at 5% after controlling for other relevant factors.

In Figure 3, the results are shown of a projection using the regression equation of Table 2 (with control). To obtain this plot, the membership fee was varied between zero and 300 THB/rai, with all other explanatory variables at their mean level. Figure 3a plots the results of all non-muang fai farmers treated as a single group. In Figure 3b, for comparison, non-muang fai farmers living in villages with low muang fai membership are compared with non-muang fai farmers in villages with high membership of the muang fai. As shown by the rightward shift of the curve, the intensity of membership in a village clearly has a direct influence on bid levels and the probability of membership.

In addition, the size of farm is another statistically significant determinant of willingness to join the muang fai. There was a non-linear relationship here, with probability of membership first increasing as area of the main crop increased; then, beyond a particular point, the probability of membership reduced with an increase in area (see Table 2). This is shown in Figure 4, which is a projection using the regression equation of Table 2 (with control). To obtain this plot, the area of longan was varied between 2 and 15 rai, with all other explanatory variables at their mean level. Hence, holding the other variables at their mean level, Figure 4 shows the relationship between the probability of membership and farm size. This reveals that the critical crop area is about 4.5 rai (about 0.7 hectares). Below this level, the probability of membership increases as size increases, while above this critical area, it reduces. About 68% of those non-muang fai farmers who expressed interest in becoming members have farms smaller than 4.5 rai.



Figure 3. Relationship between amount of bid and willingness to pay for muang fai membership (**a**) with the whole sample and (**b**) by the level of village muang fai membership intensity. Source: Authors' calculation.



Figure 4. Relationship between probability of membership and farm size. Note: 1 rai is about 0.16 ha.

5. Conclusions

We set out to discover to what extent farmers who use relatively modern irrigation technology, using a diesel or electric pump to harvest water from underground, are willing to pay to become a member of a traditional, communal managed irrigation system. Another objective was to identify the factors that determine their willingness to pay to become a system member.

The central result of this study is that more than 48% of the farmers who currently pump irrigation water from underground and are not members of the muang fai system indicated that they would become members to gain access to muang fai water. They would be willing to pay fees above the current membership charges. At face value, this sounds like an extremely positive result for environmental sustainability of the system, because those in the muang fai, on average, consume smaller amounts of the system's water per unit of production than non-members. However, a perplexing question remains. Why have they not become members already? There is no restriction on membership of the muang fai; indeed, it encourages membership. However, for some, there is a physical barrier as their farm is too far from the nearest muang fai canal. About 41% of the farmers are in this category because they have farms that are more than 75 m from the nearest canal, which is considered the limit for current members. Hence, about 59% of non-members who state that they want to be members face no physical barrier to becoming members. This is just over 28% of all farmers who are pumping water from underground. So, why are these farmers not already members? For a few, the explanation possibly lies in individuals exaggerating their level of participation during a stated preference survey. Furthermore, from evidence gathered during the focus group discussions, there are strong social constraints that define whether a family belongs to the muang fai or not. Hence, there are social pressures that stand in the way of increased membership of the muang fai. A non-member is more likely to belong to a social group of non-members who may be strongly persuasive in halting a shift of an individual towards becoming a member. So, even though in a survey, many

actually becoming members. In summary, research to estimate the price of a sustainable system (muang fai) has revealed that there is an interest from a sizable minority (just over 28%) of farmers in switching from a resource-intensive system of pumping water from underground to a more sustainable communal surface-water system. This is an encouraging result that supplements a previous observation that membership of this environmentally sustainable system is already quite stable.

individuals may express an interest in becoming a member, this may be far from them

Author Contributions: Conceptualization, A.M. and K.A.P.; methodology, A.M.; validation, A.M. and K.A.P.; formal analysis, A.M. and K.A.P.; investigation, A.M. and K.A.P.; data curation, A.M.; writing—original draft preparation, A.M. and K.A.P.; writing—review and editing, K.A.P.; supervision, K.A.P.; project administration, A.M. and K.A.P.; funding acquisition, A.M. and K.A.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially funded by a research grant from Padjadjaran University to Arief Anshory Yusuf as the research coordinator. We would like to thank Universitas Padjadjaran for the financial assistance. All disclaimers apply.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Human Ethics Research Committee of Charles Sturt University.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: A.M. is the custodian of the original data. If there are relevant research needs, the data can be obtained by sending an email to arriya.mungsunti@gmail.com. Please indicate the purpose of the research and the statement of data confidentiality in the email.

Acknowledgments: This research was partially funded by a research grant from Padjadjaran University to Arief Anshory Yusuf as the research coordinator. We would like to thank Universitas Padjadjaran for the financial assistance. All disclaimers apply. Thanks are also offered to Catherine Read for comments on an earlier draft of the paper.

Conflicts of Interest: The authors declare no conflict of interest.

References

- 1. Surarerks, V. *Historical Development and Management of Irrigation System in Northern Thailand;* Chareonwit Printing: Bangkok, Thailand, 1986.
- 2. Mungsunti, A.; Parton, K.A. Estimating the economic and environmental benefits of a traditional communal water irrigation system: The case of muang fai in northern Thailand. *Agric. Water Manag.* **2017**, *179*, 366–377. [CrossRef]
- Mungsunti, A.; Parton, K.A. The sustainability of the *muang fai* irrigation system of northern Thailand. *AIMS Environ. Sci.* 2019, 6, 77–93. [CrossRef]
- Ounvichit, T.; Wattayu, S.; Masayoshi, S. Participatory management structure of large-scale people's irrigation system: The case of the Soprong muang fai system, northern Thailand. *Southeast Asian Stud.* 2008, 46, 145–162.
- 5. Na-Tarang, E. Local Knowledge of Lanna; Ammarin Printing and Publishing: Bangkok, Thailand, 2001.
- 6. Chiang Mai Provincial Office. Chiang Mai Provincial Population Report; Chiang Mai Provincial Office: Chiang Mai, Thailand, 2010.

- 7. Zhou, S.; Herzfeld, T.; Glauben, T.; Zhang, Y.; Hu, B. Factors affecting Chinese farmers' decisions to adopt a water-saving technology. *Can. J. Agric. Econ.* **2008**, *56*, 51–61. [CrossRef]
- 8. Johnston, R.J.; Boyle, K.J.; Adamowicz, W.; Bennett, J.; Brouwer, R.; Cameron, T.A.; Scarpa, R. Contemporary guidance for stated preference studies. *J. Assoc. Environ. Resour. Econ.* **2017**, *4*, 319–405. [CrossRef]
- 9. Olsen, W.K. Methodological triangulation and realist research: An Indian exemplar. In *Realism and Empirical Research;* Carter, B., New, C., Eds.; Routledge and Taylor & Francis: London, UK, 2004; Chapter 6.
- 10. Sorensen, J.L.F. Rural-urban differences in bonding and bridging social capital. Reg. Stud. 2016, 5, 391–410. [CrossRef]