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Water Management in Northern Thailand:

A Case Study of the Mae Taeng Irrigation Project

by

Sonya Marie Wytinck ©

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Name of Author: **Sonya Marie Wytinck**

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10735-165 Street
Edmonton, Alberta
Canada
T5P 3T4

Dec 13/96

Date

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled *Water Management in Northern Thailand: A Case Study of the Mae Taeng Irrigation Project* submitted by *Sonya Marie Wytinck* in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics.

Dr. Terry Veeman

Dr. David Chanasyk

Dec. 12, 1996

Date

Dr. Vic Adamowicz

ABSTRACT

This is a study of water management in Northern Thailand. It begins with a review of economic theory related to water management and pricing. A sketch of the current state of water management in Northern Thailand is then provided. This is followed by a discussion of the Mae Taeng Irrigation Project near Chiang Mai, the setting for the study.

A model of farmers' willingness to pay for irrigation water is developed. The following variables are found to have a significant impact on a farmer's willingness to pay for water: the distance from the main canal that the farmer's plot is located, the size of the farmers plot, ownership of the land, previous experiences of water shortage, the rating of the performance of the water user's group headman, and the farmer's perception of the cause of the water shortage.

The farmers' mean willingness to pay was found to be 50 baht/rai/year. This is significantly higher than their current irrigation access fee, and significantly lower than the prices charged to urban users. Some policy implications of these findings are discussed.

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Table of Contents

Chapter One; Introduction

Chapter Two: Irrigation Background Theory

Chapter Three: Water Management in Thailand

Chapter Four: The Study Area and Research Methods

Chapter Five: Model Specification, Estimation and Results

Chapter Six: Conclusion

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Background

In the past decade Thailand has achieved and sustained remarkable rates of economic growth. GDP growth rates reached double digits between 1986 and 1990 and have averaged approximately eight percent since (World Bank, 1993). This growth was driven by expansions in the manufacturing, construction and tourism sectors. The government has taken an active role in encouraging this growth through several policies such as the reform of taxation, the reduction of export barriers and the relaxation of interest rate controls. It created a stable macroeconomic environment and attracted foreign direct investment with its low wages and good export incentives. The success of these efforts has brought Thailand to a new development stage and the government is now seeking to change growth strategies from industrial widening to industrial deepening. However, the government must also address the growing infrastructural bottlenecks that come with rapid growth. Rural areas face problems of resource depletion and degradation and urban areas are overwhelmed by the labour influx accompanying industrialization.

The agriculture sector has been growing but not at the fast pace of the industrial and service sectors (see Table 1.1). This disparity of growth rates highlights the problems of inequality and poverty that Thailand still faces. GDP per capita is growing, but the growth is centred in urban areas, not in the rural regions where 60% of Thai people still reside. The ratio of the percentage of the labour force in the agricultural sector to the percentage of the GDP earned by the agricultural sector has declined from 3/1 in 1970 to 5.3/1 in 1990 (see Table 1.2). Difficult political issues have emerged as rural and urban incomes increasingly diverge and rural and urban people compete for scarce resources. Adaptive economic policies have brought new prosperity to Thailand but success brings with it new challenges.

Table 1.1: Thailand GDP Growth Rates by Sector

	1980-85	*1985-90*	*1990*	*1991*	*1992*
Agriculture	4.6	3.4	-4.0	3.6	3.5
Industry	5.4	13.5	16.1	10.8	9.6
Services	6.2	9.7	10.4	6.9	7.0
GDP	5.6	10.1	10.3	8.0	7.6

Source: World Bank, 1993

Table 1.2: Thailand, Basic Economic Indicators

	1970	*1975*	*1980*	*1985*	*1990*
Population (millions)	37.1	42.3	47	51.7	57.2
GDP (1987 US$, millions)	16240	21643	32036	42253	68148
GDP per capita (1987 US $)	454	523	686	818	1221
Rural Population (%)	74.2	70.7	67	63.9	60.1
Labour force in Agriculture (%)	79.8	75.4	70.9	67.7	64.3
GDP in Agriculture (%)	26	27	23	17	12

Source: FAO, 1993

One great challenge Thailand faces is resolving the growing number of conflicts over water allocation. Thailand's seasons are delineated by the monsoon. In the wet season rains are constant, there is enough water for the rice crops and Bangkok's streets flood. In the dry season rain is scarce, not all farmers receive enough water for their crops, and Bangkok's streets sink because of overdrawn aquifers. Who should receive the scarce dry season water is a politically charged question. Thailand's growth is being led by the industrial sector and political campaigns are funded largely by urban businessmen. However, sixty percent of Thailand's population work in the agriculture sector and are the strongest source for votes.

Currently the agriculture sector uses approximately ninety percent of the surface water withdrawals in Thailand (see Table 1.3). Agricultural demands for water are expected to increase by twelve percent in the next five years and the demands by the industrial and domestic sectors are expected to grow by at least twenty-five percent. Thus, while agriculture's water demands are expected to grow absolutely, they are going to decrease relative to other sectoral demands, giving Thailand's water institutions the task of both providing more water and changing its distribution patterns.

Table 1.3 : Estimates of Water Use in Thailand

	1991		1995		2000	
Sector	billion m^3/year	percent	billion m^3/year	percent	billion m^3/year	percent
Agriculture	30.89	90.4	34.26	89.1	38.48	86.1
Industry	1.611	4.7	1.869	4.9	2.339	5.2
Domestic	1.67	4.9	2.324	6	3.905	8.7
Total	34.171		38.453		44.724	

Source: Christensen and Boon-Long (1994)

This comes at a time when concerns are being raised that the amount of surface water available is decreasing. A reduction in surface flow was experienced in the 1993 and 1994 water years. The reason for this decrease is difficult to discern because of the extraordinary complexity of the hydrological cycle and its interaction with meteorological conditions; however, the finger is currently being pointed at deforestation caused by loggers and highland farmers.

The contention is that changes in land-use have led to decreased rainfall, increased water run-off in the wet season and a reduction in the amount of water stored in the soil during the wet season which finds its way to streams during the dry season. Whatever the reason for the decrease in surface water, this clearly adds stress to the growing water conflicts (TDRI, 1995.)

1.2 Research Problem

Thai solutions to water conflicts have traditionally been addressed by tapping new sources of water. In 1995 water use in Thailand was estimated at 38.5 billion m^3/year which is well below the annual renewable water levels which are estimated to be between 171.2 and 199 billion m^3/year (TDRI, 1995; TDRI, 1991.) This is because the large majority of renewable water is held in unusable forms such as vapor and water stored in plants. The ability to use renewable water is also constrained by its temporal and spatial distribution. The distribution of water over the year is one of overabundance in the wet season and shortages in the dry season. Spatially the water may be abundant in one area or basin but inadequate in other places. Construction of dams, reservoirs and canals can mitigate natural distribution problems but the cost of such solutions is ever-increasing in price. The best suited sites for dams have already been used in Thailand and opposition to dam building is growing. The financial cost, the displacement of communities and the environmental destruction associated with dam-building have made it an unpopular option (Kaosa-ard and Kositrat, 1993.)

Facing these constraints, Thailand's best solution seems to be to learn how to use water more effectively. Currently water use efficiency in irrigation is estimated to be between fifteen and thirty percent. This is well below feasible standards, such as the fifty percent level reached by Malaysia and China (Sethaputra, Panayotou and Wangwacharakel, 1990.) Given that agriculture uses 90 percent of water, an improvement in this sector could alleviate water demand conflicts.

1.3 Research Objective

Supply management has been the dominant strategy in Thailand's quest to mitigate water shortages. Demand management has been neglected but is starting to attract attention. This thesis looks at the potential of one government irrigation project in Northern Thailand to improve its management of scarce water resources. Specifically, the goals of this research project are:

(1) To provide a literature review of water management issues in Less Developed Countries.

(2) To relate this literature to the Mae Taeng Irrigation Project in Northern Thailand.

(3) To develop and administer a questionnaire to farmers on the Mae Taeng Project, seeking information about the their dry season crop production, water usage, and perceptions of irrigation management.

(4) To build a model of farmers' willingness to pay for an improvement in the allocation of their irrigation water.

(5) To explore the implications of the findings and generate recommendations for further research.

1.4 Thesis Organization

A review of relevant economic theory relating to irrigation systems is provided in Chapter 2. Trade-offs between the goals of efficiency and equity are discussed, ideal design principles for irrigation systems are introduced and water pricing as a tool of demand management is reviewed.

A sketch of the current state of water management in Thailand is created in Chapter 3. Traditional northern Thai irrigation systems are discussed and an overview of one government project, the Mae Taeng Irrigation Project, is presented. The chapter ends with a discussion of the Mae Taeng Irrigation system and its potential for improving water allocation management.

In Chapter 4 the stage is set for the willingness to pay study. The specific study area is described as are the questionnaire and research methods. Basic socioeconomic data for the respondents is presented and the problem of potential protest bids is discussed.

The willingness to pay model is introduced in Chapter 5. The variables used in the model are described, the functional form of the model is discussed and the results of the estimation are presented.

In Chapter 6 the implications of the results are discussed and the conclusions of the thesis are presented.

Chapter 2 : Background Theory

2.1 Introduction

Irrigation systems are created to meet local, macroeconomic, and social goals. Local goals might be maximizing the efficiency of water use and increasing access to irrigation. Farmers seek improvements in the quantity, quality and timing of water supply. To optimize their productivity and encourage their investment in irrigation technologies they must have guarantees of security. Security involves both security in tenure, that their access is certain, and physical security, that the source will continue to provide sufficient water (*Ciriacy-Wantrup*, 1967). Social goals may be to create equitable access to water for irrigation, health and improved sanitation conditions. In policy this often translates to providing a minimum amount of water for everyone at a minimum cost, but may neglect other important characteristics of water. Macroeconomic goals would be to create the most efficient allocation of water use over the whole economy. There may be a desire to feed the nation with staple crops, to create export opportunities through cash crops or to divert scarce water to municipal or industrial users. The ideally designed system would therefore provide proper incentives for the allocation of water across the nation and within irrigation districts. It would induce investment in technologies that best meet societal and individual productive goals.

2.2 Efficiency and Equity

Repetto (1986) found that although massive amounts of resources were being assigned to developing public irrigation projects, the results were significantly below planners' expectations. The World Bank found that "the irrigation projects it financed had, on average, the biggest cost and time overruns of all agricultural projects" (Repetto, 1986, p. 4). The cost recovery has been very low and the farmers have neglected their maintenance obligations. The poor response of farmers is a direct result of poor incentives. If the design of the project does not involve the community, internal assurance problems can lead to non-participation. This is coupled with the fact that pricing is generally set below the value of water to the irrigator for equity reasons. As such, farmers at the top-end of projects over-use water and farmers at the tail-end receive poor and unreliable supplies. Irrigators who cannot depend on the volume or timing of the water deliveries will not participate in maintenance and so the system may further erode and become less reliable. These irrigators will also find it more secure to use traditional technologies and plant traditional crops which may have lower average yields but a higher probability of producing the farmer's minimum requirements (*Bromley et al.*, 1980). Thus poor water institutions will be trapped in a low level equilibrium where inadequate maintenance and supply rules lead to irrigators opting out and to stagnating agricultural practices (*Altaf et al.*, 1993). This in turn leads to lower incomes, less trust in the institutions and lower future investments. Thus we see that improper incentives and motives and a lack of price signals lead to an inefficient system. This system is frequently inequitable and so we may find that efficiency has not been traded for equity but instead both have been neglected.

Subsidizing irrigation has several negative equity effects. The first, as discussed above, is that the tail-end user receives inadequate supplies. This can lead to macro-level equity effects if the tail-end user is able to make a case for further development of the water sources. For reasons of monument building and rent-seeking, capital which would be better used in other sectors of the economy may be allocated to new water projects. This is especially wasteful because rehabilitation of existing projects and changes in pricing or supply rules would often be adequate to eliminate excess demand and inefficient water use practices. Justification of transfers of capital to rural areas from other sectors are sometimes made because the terms of trade are often artificially turned against agriculture in less developed countries. *Repetto* (1986) counters this argument by reminding us that the beneficiaries of water subsidization are generally the rural elite. They are not generally found in the marginal dry land areas and their farms tend to be located at the head-end of the irrigation systems where they can best exploit the resource. With better access to irrigation these owners can improve their productivity or charge higher rents to their tenants. These are the successful rent-seekers, not the poor who may justify subsidization. The result is personal inequities within the project area, spatial inequities across the nation and functional inequities due to rent-seeking.

Rent-seeking is both created by and drives the inequalities discussed above. Economic rent is the difference between the marginal value product of the water and the actual price charged for it. It can be created through below cost pricing and rationing. Because of rationing, rents accrue to those with better access or allocations instead of farmers with superior efficiency or foresight (*Repetto*, 1986). As a result improving agricultural productivity is not necessary to increase income for those well placed and is more difficult for those with poor access. The former group becomes entrenched in the system and the latter group becomes displaced by it. This asymmetry in assurance leads to neglect in the system. The top-end irrigators need less maintenance to retain their supply and the tail-end irrigators have opted out. Tail-end irrigators will revert to more traditional supplies and farming techniques or may seek to have new systems built which would allow them to skim the rents. This again contributes to a low level equilibrium trap with poor performance and no incentive to improve.

The system can sustain itself because irrigators are not the only rent seekers. Irrigation supply agencies benefit from the need to continually develop new sources to satisfy the excess demand. Politicians can benefit because it is their influence which determines which projects and therefore which people will receive the rent-seeking opportunities. *Repetto* (1986) refers to these three groups (farmers, irrigation agencies and politicians) as the iron triangle and suggests that the only way to reform irrigation is to circumvent their power. This can be achieved by putting water resource development in private hands or by increasing the financial responsibility of public irrigation projects. In less developed countries the arguments for public development of water resources are often compelling (*Howe and Dixon*, 1993). Minimum access for all people is essential and capital costs may be prohibitive. So, while there may be scope for some private investment, it is likely that most investment will remain public. Thus, there is a need to create incentive systems which reflect the value of water and institutions which can maintain the incentive system.

2.3 Irrigation System Design

The ideally designed system would therefore provide incentives for the efficient allocation of water across the nation and within irrigation districts. It would induce investment in technologies that best meet societal and individual production goals. *Ostrom* (1989, 1907) suggests that planners who are crafting institutions must consider "how rules, combined with particular physical, economic and cultural environments produce incentives and outcomes." She then sets out eight design principles that she found were common to long-enduring irrigation institutions. Her first design principle is that the system must have well defined boundaries. This ensures that the households within the boundaries are able to capture any benefits which accrue from their personal investments in the system. It improves the possibility of collective action and creates an area of common property instead of open access property. *Bromley* (1991) discusses the important distinction between common property and open access and shows that *res nullius* leads to over-exploitation of fugitive resources whereas *res communes* can lead to group management and private incentives to conserve.

Ostrom's (1989) second design principle is that benefits and costs be proportionately equivalent: i.e. those who receive the most benefit from the system should incur a proportional amount of the costs. This fiscal equivalence is realized through the rules and regulations that govern appropriation and provision. The amount of water one receives is therefore proportional to the amount of fees they pay, the amount of labour they provide for maintenance and the amount of materials they contribute. These rules are related to *Ostrom*'s (1989) third design principle, that individuals affected by these rules should be participants in the creation of the rules. They should be involved in both the genesis of the rules and their evolution. Such involvement can overcome or avoid several problems which *Brookshire and Whittington* (1993) identified as leading to water project failures. These problems include insensitivity to local customs and needs, fees which are not affordable and the need for technological knowledge that is beyond community expertise. With the community involved in each decision making level the design and operation should never reach beyond its means. The project should be designed such that it is in the private interest of each farmer to follow the collective rules.

Ostrom's (1989) fourth principle concerns the functioning of these rules. She suggests that irrigation systems should have monitors to assess both physical and behavioral conditions, and that these monitors should be accountable to the irrigators. The most cost effective form of monitoring is that which is done by the irrigators themselves. This is very likely to occur where water is supplied on a rotational basis, as the receipt of water by one irrigator will require the cessation of diversion by another. Water guards may also be effective if they are given incentives which are correlated to the efficient use of the water. This may mean that their wage is a proportion of the fines they collect or a proportion of overall output from the system. *Easter* (1993) discusses this as being an internal assurance problem. It arises because of the jointness in supply of water. The interdependence among farmers creates potential problems of externalities in use and free-riding in operation and maintenance contributions. Contributions to the system and compliance with its rules will depend on the farmers' potential gain and their expectation of how others will behave. The assurance problem increases with the size and heterogeneity of the irrigation group and decreases with an increasing level of participation and group experience with collective action. *Easter* (1993) suggests that the assurance problem is diminished where property rights are clearly defined, monitored and enforced. He also suggests that farmer participation in construction may increase their future commitment to the system. This process may help to establish their property rights more securely as well as provide information about the commitment level of other farmers.

Ostrom's (1989) fifth and sixth design rules also address this problem of internal assurance. Her fifth rule is that there should exist graduated sanctions for the violation of the rules and the sixth principle is that there should exist low cost local resolution arenas. This will provide a forum to deal with any free-riders among the group. Enforcement increases individual confidence that they will receive benefits that are proportionate to their costs of participation. Penalties should be associated with the seriousness and the context of the violation. Conflicts should be resolved within the system. This allows discussion of the rules and what should or should not be considered a violation. It also allows for the unique characteristics of the local system to be incorporated and provides a process by which the rules can remain dynamic.

Ostrom's (1989) seventh principle moves from problems of internal assurances to discuss questions of external assurances. The seventh principle states that "the rights of users to devise their own institutions [should not be] challenged by external government authorities" (*Ostrom*, 1989, p. 1910). She suggests that subsistence agriculture may find *de facto* organizations sufficient but that as farming modernizes farmers require the increased security of recognized institutions. The official recognition of the institution provides assurance to farmers that as they modernize and are pulled into a more complex economic sphere, and potentially into more resource conflicts, they will retain secure access to their water rights. *Easter* (1993) discusses the external assurance problem in context of the government as part of the project management. He suggests that it is important that there is: a clear division of responsibilities between the government and the irrigation group; good communication between the two parties; and a guarantee that fees collected by the government will be used for the operation and maintenance of the specific project. To ensure this, there should be penalties for inadequate government management just as there are penalties for inadequate individual contributions or resource misuse. The trust built in these interrelations is particularly important when we consider *Ostrom*'s (1989) final point that "appropriation, monitoring, enforcement, conflict resolution, and governance activities [should be] organized in multiple layers of nested enterprises" (*Ostrom*, 1989, p. 1910). This provides scope for economies of scale while retaining smaller monitoring units. The smaller monitoring units speak to internal assurance problems but strong and clear cooperative ties between nested enterprises must exist for external assurances.

2.4 Water Pricing

To improve the functioning of public projects, *Ostrom* (1989) recommends fiscal equivalence and *Repetto* (1986) recommends financial responsibility. The question then is, how can this be achieved? Cost recovery through marginal cost pricing is the first instinct of the economist but may not be pragmatic in poorly developed areas. One must consider the humanitarian reasons as to why pricing water may not always be desirable but not ignore that when farmers live above the subsistence level (or improved irrigation could raise them above) there is scope for at least partial cost recovery. To account for problems of ultra-poverty it is generally suggested that life-line charges be implemented (*Repetto*, 1986). For water needs below the life line, there would be a nominal charge or no charge and for needs above this life-line cost-based pricing practices should be sought. Again there are two goals for the pricing system: equity and efficiency. Equity considerations include subsidization of food production, redistribution of wealth, and recovery of costs so that they can be reinvested in other areas of the country or economy. Efficiency calls for the reduction of excessive water use, proper price signals for water and land use decisions and maximizing irrigation's contribution to agricultural productivity (Flatters and Horbulyk, 1995.) When policies to meet each of these desires are contradictory prioritization of these objectives is necessary and pricing schemes will be dependent on the results.

The Economic and Social Commission for Asia and the Pacific (1981) set out several potential pricing schemes and discusses their limitations. The first is marginal cost pricing. This reflects the cost of producing an additional unit of water. Ideally it should include the added cost to operation and maintenance as well as reflect the distance of delivery and the yearly variation of the flow. Several problems are evident with marginal cost pricing. Capital costs in irrigation are sunk investments and as such they will not be included in marginal cost pricing and would not be recovered. The cost of providing an additional unit of water once the project is built may be very small but as it reaches capacity the cost becomes very large. This variation in water pricing is detrimental as farmers need stable prices in order to plan. A final problem with marginal cost pricing is in measurement. Determining the marginal cost would be challenging and measuring each person's use would require metering which is unlikely to be financially feasible in most LDCs.

A second pricing scheme is average cost pricing. This would involve dividing the entire project cost by units of water or land and charging each irrigator proportionally to the size of their water withdrawal or farm size. This system allows for total cost recovery and simplifies the measurement process but has its own set of problems. If the system is not utilized to capacity the price of water may become prohibitive and the project will fail. If average costs are determined by land units and not water, then there is no incentive to reduce water wastage. A third pricing scheme is benefit pricing. The cost and a proportion of the benefits from the project are recovered through a land betterment tax. This tax may be progressive and is more equitable to farmers in non-irrigated areas. However, this tax does not provide incentive for efficient water use and faces problems of evasion.

Subsidies (sociopolitical pricing) are often used in LDCs. This scheme only recovers the working cost and the capital costs are considered to be investments in development objectives. Subsidies redistribute wealth to poor rural areas by maximizing agricultural incomes. They can result in increased rural employment, decreased urban migration and stabilization of food prices. This is, of course, inequitable to the dry land farmers. It is also questionable whether subsidization of other inputs would not be more successful. The Economic and Social Commission for Asia and the Pacific (1981) found that decreases in the price of fertilizer more consistently induced higher crop yields than did water price decreases.

Seagraves and Easter (1983) discuss several factors which will affect the choice of a pricing and regulation system. If water has a low opportunity cost, pricing may not be practical as the cost of measurement and administration could exceed the value of the water. If streamflows fluctuate widely, then varying the price of water with its scarcity value may be too difficult and as such the price would be set at its minimum value and water would be rationed during shortages. When governments create irrigation projects for non-agricultural reasons or with little input from irrigators, full cost recovery may not be reasonable. Projects may be built to create rural employment, for flood control or for national defense purposes and benefits would not strictly accrue to the irrigators. This is also the case when irrigation projects are used to subsidize food prices; the whole nation gains and thus should contribute to the cost. In this situation a case could be made for the compensation of dry land farmers who would be hurt by low food prices but not benefited by irrigation. There is also a concern that prices could drop significantly enough to decrease irrigating farmers' incomes in which case cost recovery is less feasible (*Seagraves and Easter*, 1983). Repetto's comment that even in irrigation areas those who may benefit would likely be a rural elite must also be remembered (*Repetto*, 1986). As such the strength of this argument would be contingent on how equitable existing resource allocations and income distributions are.

Regulation and pricing structures should be shaped by existing traditions of ownership and water laws. *Seagraves and Easter* (1983) discuss three possible systems and their influence. Private property, if rights and their transferability are clearly defined, should result in private trading of water rights and the distribution of water to its most efficient uses. Common property rights may lead to efficient water distribution if the rules and responsibilities of use are well defined and enforced or may lead to over-exploitation if water is treated as a fugitive resource. The results of government ownership will depend on the political desires of the government. Government officials may choose to use irrigation to influence cropping patterns to grow food in national interest. They may sell water to the highest bidder or ration water to fit their political agenda. There are many potential assurance problems if their game plan is unclear.

The system of water delivery will also have an influence on how the water is priced. Whether it is equitable, reliable and managed by capable people will determine the likelihood of participation and the possibility of fee collection. What type of system it is will affect measurement and administration. The on-demand delivery system is the simplest to price because the delivery of water is equivalent to the demand, thus prices are based on measured volumes. Increasing block prices are often recommended for such situations to allow for a low cost life line base and then premiums for using the scarce resource above this level. On a rotation system the irrigator is charged for the share he/she receives, estimated if it is not measured. The charge may be based on estimated volume per hectare or the number of hectares multiplied by the estimated crop water requirement. A continuous flow system, where the farmers may take whatever water reaches their fields, makes it difficult to measure or estimate volumes used so an annual fee is often imposed. The charge, determined by the number of hectares served, may be an access fee or a contribution of labour hours for maintenance of the system.

Ultimately we must find prices and regulations which create incentives to use water efficiently and that encourage participation in the irrigation system. Through these, we can avoid the pit falls of rent-seeking and exploitive behavior. These prices and regulations are fundamental elements in an irrigation system and are linked to the design of the physical and institutional structures. While less developed countries may have less scope for cost recovery than rich nations we should not dismiss the possibility of at least partial cost recovery. This would provide economic incentives to create efficient systems and to monitor others in the construction and use of these systems.

Chapter 3 : Water Management in Thailand

3.1 Introduction

Water management in Thailand is controlled through a centralized top-down system where governance of allocation is shared by several agencies under the guidance of several pieces of legislation. *Christensen and Boon-Long* (1994) found that there were 30 department-level agencies under seven different ministries involved in managing water resources in Thailand. These agencies are supposed to be guided and coordinated through two national committees, The National Water Resources Committee and the National Rural Development Committee. These committees should in turn be guided by the five-year development plans designed by the National Economic and Social Development Board. While many agencies and committees exist, few have the mandate or power to implement the policies which they design. Pragmatically this leaves the management of water allocation to a few key agencies.

Foremost among these agencies is the Royal Irrigation Department (RID) which is legally mandated to allocate water amongst all users in Thailand. The other major agencies are the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Waterworks Authority (MWA) and the Provincial Waterworks Authority (PWA). EGAT is responsible for the management of hydroelectric dams and is mandated to keep power generation at sufficient levels to supply Thailand's needs. To this end, it is given control over how much water is stored and released from the dams it manages. The MWA and PWA operate water supply systems for domestic and industrial users. The MWA serves Bangkok and adjacent industrial areas and the PWA serves all other areas. They are responsible for securing water resources, constructing treatment plants, operating and maintaining their systems and collecting user fees.

While the RID has legal authority to allocate water between all Thai users, in practice these decisions are not entirely its own to make. Because of the importance of urban and industrial users to the growth and strength of the economy, it has become policy that the RID must first defer to the needs of EGAT and the MWA and then allocate the remaining water to its irrigation projects. In the areas under PWA jurisdiction, urban users are also given some priority although not as clearly as the case of distribution decisions between Bangkok and the central plain.

The RID has authority to charge its clientele but does not. EGAT collects money for electricity supplied, the PWA and MWA collect money for water treated but neither are made to pay the RID for their raw water. Similarly irrigators receive their water free of charge. The RID maintains its organization through government funding, receiving the majority of the Agriculture Department's budget, and can also seek foreign loans through the Finance Department (Kaosa-ard and Kositrat, 1993).

3.2 Irrigation in Northern Thailand

Northern Thailand has a long tradition of community irrigation projects. Local irrigation systems called *muang fai* are gravitational systems where the river's water is blocked by an artificial weir (*fai*) and thus directed into a system of canals and sub-canals. The main canal is the *muang* and the sub-canals are called *muang soi*. Each *soi* has a series of gates which are opened to flood individual farm plots. These plots are sub-divided with mounds outlining each section. Bamboo tubes are placed under the mounds to regulate the flow of water between sections. One *muang fai* system may irrigate from fifty to five thousand *rai*, depending on local needs and conditions[1]. Smaller systems tend to dominate the more marginal and outlying areas and the larger systems are found in the centre of the basin. The size of the area to be served determines the size and permanence of the weir structure. Smaller weirs tend to be temporary structures which require yearly maintenance or rebuilding. Larger weirs are generally built strong enough to withstand normal wet season inundation but can be damaged by floods (Tanabe, 1994).

The *muang fai* is managed by the *mu fai* (group of the weir). The *muang fai* structures are considered to be communal property and the users of the system share the responsibility of maintaining the system and allocating water. The extent of individual obligations is dependent on the size of the plot they irrigate and the seasons in which they require water. The *mu fai* has a headman who coordinates the members' contributions to the operation and maintenance of the system. The headman is chosen by the members and generally remains in the position until he chooses to retire from it. The headman can be voted out but it is rare that this would be necessary. Larger systems may contain several *mu fai* and an elected official (*Kae Luang*) to coordinate the different headmen.

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[1] One rai is equal to approximately 0.16 hectares or 0.395 acres.

Administration is financed through the collection of members' fees paid in cash or in kind. The headman receives compensation for his work as do any *muang fai* members who are asked to perform specialized tasks (Tanabe, 1994).

The RID has had authority over these community projects since its inception in the 1930s. Its participation in these projects is generally through aiding in the construction of permanent weirs and the lining of canals with concrete. Once construction has been completed, smaller projects are left under the management of the *mu fai* groups.

The desire to improve the technical efficiency of local systems has also led to the creation of large state irrigation projects. They cover areas of over 100,000 rai and are managed by government officials. The *mu fai* organizations are incorporated into these projects. The RID makes water distribution decisions for the overall project but local decisions about water use are still made by Water Users' Groups (WUG). Headmen are still chosen, but they are now required to coordinate with the RID.

The RID has 12 regional offices in Thailand. Regional Office 1 is located in the city of Chiang Mai and manages irrigation projects in the northern provinces of Chiang Mai, Lamphun and Mae Hong Son. As shown in Table 3.1 this office is in charge of 219 different irrigation projects. Large scale projects cost more than 200 million baht and take more than 5 years to construct. Small scale projects cost under 15 million dollars and take less than 1 year to construct. Medium scale projects are those that fall in between the large and small scale boundaries (interview, RID Regional Office 1).

Table 3.1: Irrigated Area Managed by RID Regional Office 1

Project Size	Total Number	Irrigated Area (rai)	Irrigated Area (hectares)
Large Scale	4	461 500	73,840
Medium Scale	28	193,700	31,000
Small Scale	187	116,250	18,600
Total	219	771,500	123,440

Source: RID Regional Office 1, Chiang Mai.

The RID provides the majority of irrigation water to the farmers in Thailand, but some non-governmental projects continue to exist. These are classified as Peoples Irrigation Projects. These projects were initiated and constructed, and are operated and maintained by a group of farmers. These projects account for 20% of the irrigation in the provinces of Chiang Mai and Lamphun.

3.3 Mae Taeng Irrigation Project[2]

The Mae Taeng Irrigation Project is located in northern Thailand in the Chiang Mai basin in the province (*changwat*) of Chiang Mai. The Mae Taeng Irrigation Project was built to replace 5 existing temporary weirs which had been constructed by *mu fai* organizations. Construction began in 1967 and was completed in 1973. It supplies water for irrigation in the five districts of Mae Taeng, Mae Rim, Muang, Hang Dong and San Patong (see Figure 3.1). Additionally, it supplies the Umong water treatment plant in the city of Chiang Mai. The headworks are located on the Mae Taeng River six kilometres before it

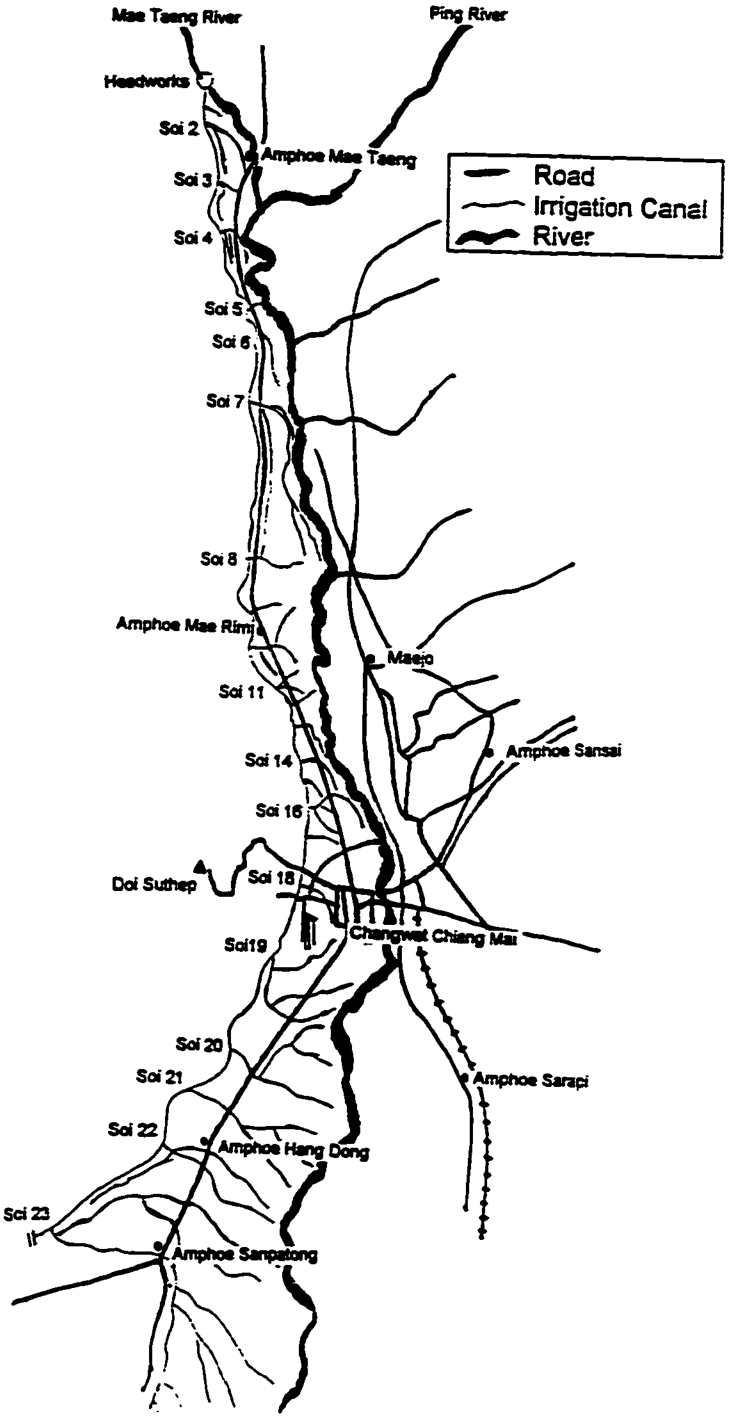
[2] Data in this section was collected from interviews (December, 1995) at the Mae Taeng Headworks office unless otherwise specified.

joins with the Ping River. The project area is bounded by the Ping River in the east and by hills and mountains to the west. The main canal traces the base of the western hills and the lateral canals (sois) branch out eastward toward the Ping river (see Figure 3.2). The project has no reservoir and consists of a 74 km main canal with 23 lateral canals (sois), 238 km of sub lateral canals and 710 km of farm ditches. The gross area of the project is 174 000 rai of which 148 000 rai is irrigable in the wet season and 60 000 rai is irrigable in the dry season. The maximum capacity of the weir is 24 m^3/s. The maximum, minimum and mean flow rates of the Mae Taeng river are 800, 4 and 23 m^3/s respectively.

Due to inadequate water flows into the weir during the dry season, distribution problems have occurred on several levels. The city of Chiang Mai has been expanding rapidly and urban water demands are increasing. Water in Chiang Mai is supplied through three treatment plants: the Pa Tan plant, the Umong Plant and the Wang Sing Kham plant. The Pa Tan plant and the Umong plant are the city's main sources and the Wang Sing Kham plant is used for reserved capacity. However, the Umong plant is often unable to draw water from the Mae Taeng canal in the dry season and Chiang Mai must seek ways to compensate. The plant has a reservoir to store excess wet season water flows, but this is not always sufficient. Construction of a pipeline from the Mae Ping river to the Umong plant is in progress. It will cost approximately 60 million baht

Figure 3.1: Map of the Districts of Chiang Mai Province

Figure 3.2: Map of the Mae Taeng Irrigation Project



Source: Royal Irrigation Department, Thailand.

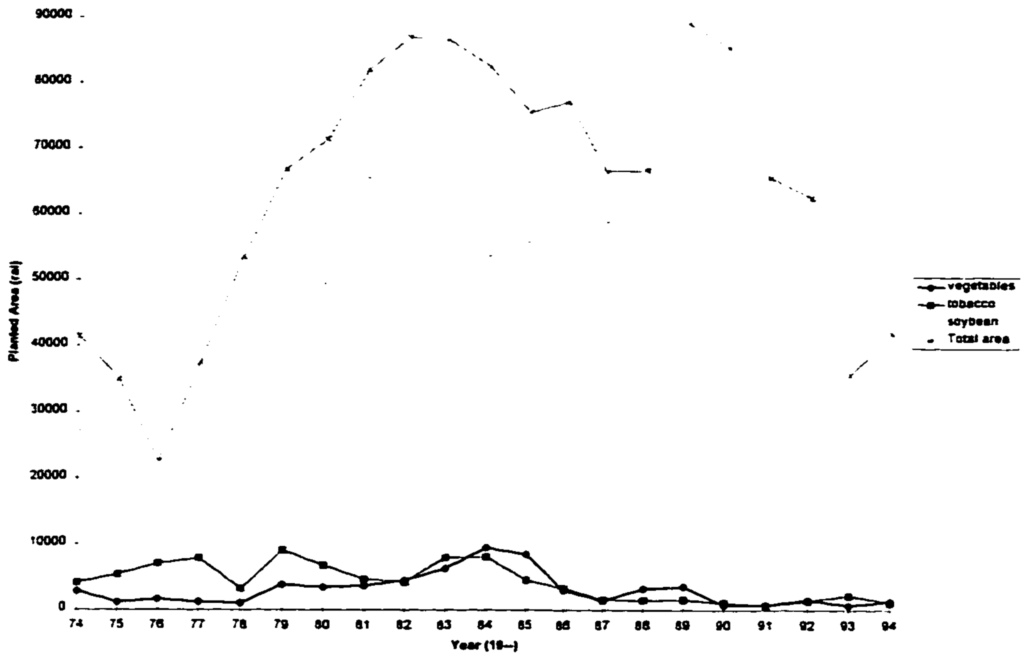
(3.3 million $CDN) and will provide between 1500-2000 additional m^3/h if the Mae Ping has the water to provide. There are also plans to divert water from the Mae Kuang dam, providing an additional 2000 m^3/h with a capital cost of 900 million baht (49 million $CDN)(TDRI. 1993).

Urbanization has also created conflicts among users on the lateral canals. As the city expands its boundaries, non-agricultural users have begun to buy land adjacent to the Mae Taeng project's main canal and lateral canals. These new residents do not participate in the Water Users Groups which manage the farm level distribution and tend to neglect or even harm the system. They do not participate in maintenance and problems have been reported such as home-owners filling irrigation or drainage canals with soil in efforts to landscape their property. Reports are also made of new residents stealing water by putting in unauthorized pipes (ghost tubes) or by pumping water from the canal. Residential users are not the only culprit in this crime. A June 1994 TDRI study found that "private firms such as hotels, restaurants, condominiums , real estate projects, resorts, factories, golf courses [and even] government agencies [such as] Chiang Mai university, the 41st Airflight Division, Nakorn Chiang Mai Hospital, the Queen Mother Public Park..." were also using water from the Mae Taeng project canal. One consequence of this is that Soi 19 no longer receives water and the land in sois 10 to 18 are no longer used for paddy. They have given over to urban users and horticultural crops, reducing the irrigated area by 28,000 rai to 120, 000 rai for the whole project. Clearly, as Chiang Mai continues to grow, so too will conflicts between urban and agricultural water uses.

The 74 km length of the main canal brings ample opportunities for water stealing and makes distribution among the sois particularly challenging. During the dry season water is rationed on a rotational basis. The sois are divided into three groups, sois 1 to 14, sois 15 to 22 and soi 23. Soi 23 receives water first, then sois 15-22 and lastly sois 1-14. The number of days given to each rotation is dependent on the availability of water. Villagers from soi 23 have the most complaints about distribution among the 23 sois. While the system is supposed to be monitored, soi 23 farmers have found that each year they must go to the headwork to meet with officials to ensure that they receive their entitled allotment of water. In March 1994 villagers of the San Patong district (soi 23) found it necessary to monitor the other sois themselves and they discovered that the soi 7 gate was open out of turn. Once found, the gate was closed but there was no disciplinary action for this violation (TDRI, 1994). The result in San Patong is a mistrust of the irrigation officials and many farmers having to turn to other sources of water.

The result of the increased competition for water has been a reduction in dry season cropping. As can be seen in Figure 3.3, the 1990s have witnessed a drastic decline in the dry season crop area within the Mae Taeng project area. This is due to the decline in water available, the conversion of rural land to non-

Figure 3.3: Dry Season Planted Area in Mae Taeng Project



Source: Mae Taeng Irrigation Project Headworks Office

farm uses and the increased availability of alternative employment in the dry season. Many farmers find it more profitable to sell their labour in the booming construction industry than to farm.

3.4 Mae Taeng Irrigation Project System Design

The Mae Taeng Project must confront growing conflicts among users and find new ways to manage its increasingly scarce water flow. How the Mae Taeng project's officials address these challenges is partly determined by the project's design. Using Elinor Ostrom's eight design principles common to long-enduring irrigation institutions as a yard stick, we find that the Mae Taeng Irrigation Project has the foundation to deal with water allocation problems, but has failed in executing its mandate.

When the Mae Taeng Project was built, existing *mu fai* organizations were incorporated into the project. This gave the water users an opportunity to be involved in the creation of the project and to influence the rules of use. A permanent weir replaced the *mu fais'* temporary weirs and government officials replaced their *kae luang* but the *mu fais* remained and continue to regulate local distribution. Maintenance of the weir is now the job of the government but the maintenance of the soi canals are the responsibility of the *mu fais* in coordination with their zonemen. Overall authority now rests with the RID but the rules that are used to govern have been adopted from Northern Thai community traditions. The *mu fai* are now one layer of a multi-layered nested enterprise. The *mu fais* seek efficient water use at the farm gate level, the Mae Taeng officials at the irrigation project level and the RID on a country wide basis.

An important aspect of a multi-layered nested enterprise is that users must have external assurances of their rights. The rights of the *mu fai* to govern local water allocation have not been challenged, so long as the farmers have fulfilled their obligations to these groups. What may be challenged is the irrigators priority of water use over urban areas. Rights of access to water are not explicitly defined in Thailand. Water is considered the property of the state, to be used for the benefit of all the Thai people. Farmers may count on the moral suasion of the King as well as the strength of their votes but in a time of increasing scarcity, their access to water is not guaranteed.

Ostrom's first principle was that the project should have well defined boundaries. In its original inception the project clearly defined who was meant to receive water, but as the city of Chiang Mai has grown the project's boundaries have blurred. Water demands and water stealing by non-agricultural users must now be addressed. The boundaries must be redefined to clearly include or exclude non-agricultural users. Inclusion would enable authorities to ensure that those who benefit from the project also fulfill their responsibilities to the project (i.e. pay their fees and participate in maintenance). Exclusion would give the authorities an explicit mandate to put an end to water stealing.

Clear boundaries are essential to reduce water stealing but this must be combined with effective monitoring. Clearly the farmers of soi 23 lack faith in the irrigation officials' ability to monitor water use. The zonemen are responsible for monitoring the sois they manage but are not accountable to the farmers they serve. Their paycheques come from the government and are not based on performance. There is no penalty for poor management but the spite of the farmer. The most effective monitorers may be the farmers themselves. They are acutely aware of what their neighbours are doing. Thus within the *mu fai* area monitoring is not a problem but between separate sois and near urban areas project employees must be given better incentive to fulfill their monitoring duties.

Disputes among farmers about water use are generally settled locally with the headman or zoneman persuading an end to the objectionable activity. These local resolutions are effective and widely respected as a temporary solutions, but they do not act as a deterrence. Penalties do exist to deter farmers from abusing the system. Monetary fines can be imposed on those who do not fulfill their maintenance obligations and those who do not follow allocation rules. Penalties are dependent on the severity of the infraction and can be as harsh as exclusion from using the irrigation system. These sanctions are imposed by the zoneman but may be at the request of the *mu fai* headman. In Mae Taeng these penalties seem not to be used. Interviews with farmers and with the zoneman indicated that penalties have not been imposed in the past few years, although rules have been broken.

Another under-used tool of water management is pricing. Legislation exists which gives the RID a mandate to charge a price for water and fees for the operation and maintenance of the water delivery systems. The Dikes and Ditches Act and the Agricultural Land Consolidation Act allow the RID to charge irrigators for operation and maintenance costs as well as the capital costs of land improvements (Christensen and Boon-long, 1994). In the Mae Taeng project, farmers are levied a fee of 10 baht/rai/year, half of which is used to pay for mu fai administrative costs and half of which goes to the mu fai headman as remuneration for his work. In practice this fee is not consistently paid. The State Irrigation Act authorizes the RID to charge a maximum of 2 baht/m^3 for its raw water. The Mae Taeng Crop Research Centre estimates that soybeans require between 351 m^3 and 560 m^3 per rai for their entire growth cycle, and tobacco requires between 375 m^3 and 599 m^3 per rai. The TDRI (1995) estimated the marginal value of irrigation water in the Mae Taeng Project in nominal baht (Table 3.2), based on revenue changes. This technique may overstate the true marginal value, how much this is overvalued is dependent on the farmer's profit margin. If this profit margin were 20 %, a farmer's maximum willingness to pay for irrigation water in 1991 would have been 0.316 baht /m^3, thus, a soybean farmer should be willing to pay between 111 and 177 baht /rai /year for dry season irrigation.

Table 3.2: Marginal Value of Irrigation Water in the Mae Taeng Project

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Marginal value (baht / m^3)	1.06	0.97	1.04	.091	1.04	1.02	1.02	1.12	1.55	1.66	1.52	1.58

Source: TDRI ,1995

Chapter 4: The study Area and Research Methods

4.1 Introduction

This chapter introduces the area in which the willingness to pay study was conducted. A description of the area and the reasons for its selection are provided. This is followed by a brief description of how the questionnaire was implemented. The design of the questionnaire is outlined and a brief overview of the socioeconomic characteristics of the respondents is offered. The chapter closes with a discussion of the problem of respondents giving protest bids.

4.2 Selection of the Study Area

The study was conducted on soi 7 of the Mae Taeng Irrigation Project. Soi 7 was chosen for this study after discussions with the Mae Taeng Irrigation officials, the manager of the Mae Rim Cooperative and farmers in Sanpatong and Mae Rim districts. Soi 7 was selected because it was long enough that distance could be considered a factor in farmers' willingness to pay for water, it was far enough from the city of Chiang Mai that only irrigators used its water, and it was a relatively convenient location in relation to Maejo University. It was also chosen because it was in an area where the farmers had only two alternatives for getting irrigation water, the Mae Taeng Project or pumping ground water.

4.3 Description of the Area

The soi 7 turnout is located 18.8 km south of the Mae Taeng headworks and about 22 km north of Chiang Mai, in the district (amphoe) of Mae Rim. The zoneman's office is situated adjacent to the turnout which he controls. The zoneman is an employee of the Mae Taeng Project and is responsible for managing water allocation in soi 7. He is expected to arrange maintenance and to monitor water usage. Soi 7 consists of the lateral canal, 7L, plus three sub-lateral canals, 1R, 1L and 2L (as can be seen in Figure 4.1). The area allocated to soi 7 covers 10,981 rai (1757 ha, 4338 acres) of which 9,334 rai (1493 ha, 3687 acres) are irrigated during the wet

Table 4.1: Soi 7: Total Service Area

	Length (km)	Total rai	Irrigated rai	Capacity (m^3/s)
7L	9.95	5700	4846	1.4
1R	6.36	1621	1377	0.206
1L	5.98	1485	1282	0.189
2L	6.13	2175	1849	0.277
Total	28.42	10981	9334	

Source: Zoneman interview, Dec. 1995

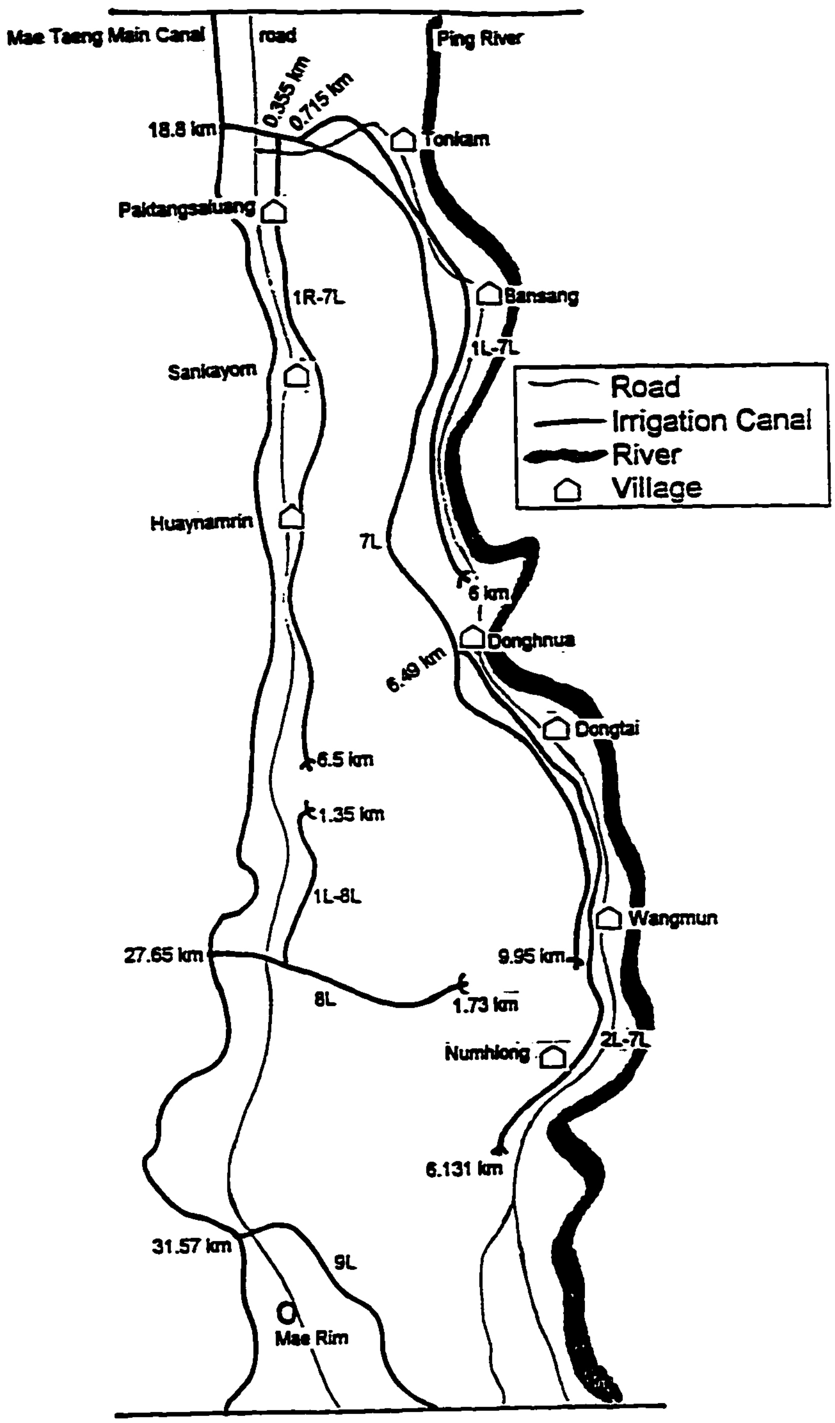
season. During the dry season its service area is constricted by the amount of water flow in the Mae Taeng River. In the 1996 dry season soi 7 served 572 farmers with a total of 4530 rai (724 ha, 1789 acres).

Table 4.2: Soi 7, 1996 Dry Season Service Area

Village	Number of Farmers	Cultivating Area (rai)
Bansang	84	987
Dong Tai	55	397
Ban Mai	53	553
Wangmun	28	182
Numhlong	29	220
Donghnua	76	611
Tonkam	136	816
Huaynamrin	34	244
Paktangsaluang	25	184
Sankayom	52	336
TOTAL	572	4530

Source: Zoneman survey, Jan. 1996

Figure 4.1: Map of Soi 7 of the Mae Taeng Irrigation Project



Source: Royal Irrigation Department, Thailand

There are 10 villages within the soi 7 boundaries as listed in Table 4.2. Each village has a Water Users Group (WUG) and elects a headman for the group who acts as an intermediary between the farmers and the zoneman. The zoneman meets with the Mae Taeng irrigation officials once a month to discuss allocation and system management. Water allocation among soi 7 users is done on a rotational basis. If the soi is to receive 6 days of water flow, then half the farmers will draw water for the first three days and half will draw water for the last 3 days. The farmers are divided into the 2 groups by their location in the soi area, farmers in the last half of the main lateral and the last half of the 3 sub-laterals are one group and farmers in the first half are the second group. The zoneman informs the headmen of the times which water will be available to their group. Formally the headmen in soi 7 meet with the zoneman once a year to discuss overall needs and problems. For the rest of the year, they are informed of allocation decisions and visit the zoneman as problems arise.

4.4 Selection of the Sample and Data Collection

A representative sample of farmers was taken by visiting different field areas and villages throughout the day. Interviews were not prearranged and were generally conducted in the farmer's field. Some interviews were conducted in villages with the permission of the village headman. Eighty-three farmers were interviewed in January and February of 1996. Forty-three of the farmers interviewed drew water from lateral 7L, 18 from sub-lateral 1R, 16 from sub-lateral 1L and 6 from sub-lateral 2L. The number of farmers from sub-lateral 2L was quite small because few farmers were able to get sufficient water to farm in the dry season.

Approximately half of the interviews were conducted by the author and a language translator from Maejo University. The other interviews were completed by three graduate students from Maejo University who joined the researcher and translator on several trips to the site and then later returned to the site on their own. All interviews were done in the Thai language.

4.5 The Questionnaire

The questionnaire was originally written in English and then translated into Thai by the author's Thai advisor. The author then went over the questionnaire with her translator to assure that the questions were clear, eliciting the desired information and could be understood by the Thai farmers. The questionnaire was then pre-tested at the soi seven site by the researcher, her advisor and her translator. After this, the results were discussed and revisions were made to increase the clarity of some questions and create a more logical order. These modifications produced the final questionnaire.

The questionnaire had four main components (see Appendix A). First, it sought some basic socioeconomic data: age, gender, family size and education level. This was followed by a series of questions eliciting production information about the farmer's previous year's dry season crop. Farmers were asked to recount the amount of family labour, hired labour and material inputs used in each stage of production. They also were asked for the wage rates, rental rates and costs of the material inputs. After reviewing all the inputs farmers were asked what their final dry season crop output was, and the price which they received for it. This was followed by questions about their use of irrigation water, its availability and their satisfaction with the irrigation system. The willingness to pay question was then posed. The questionnaire ended with questions about the respondents' 1995 income levels from farming and non-farm sources.

4.6 The Willingness to Pay Question

Where markets do not exist for a commodity several methods can be used to infer a value for the commodity. One such method is the contingent valuation method. With this method the researcher creates a hypothetical market in which individuals are asked what they would be willing to pay for (or willing to accept in lieu of) a specific change in the supply of an unpriced good. In this study, farmers were asked for their willingness to pay for an improved supply of irrigation water from the Mae Taeng Irrigation Project.

Setting up a contingent market requires a description of: the good, its baseline level of provision, the structure under which it is provided, the range of available substitutes and the method of payment (Mitchell and Carson 1989.) Once the contingent market is set up the willingness to pay question is asked. Because the farmers are very familiar with the commodity (irrigation water) and its current state of usage, a description of this state was not provided. Initial questions allowed the farmers to recall the current level of provision of water, the structure under which it is provided, how much they pay for the water and any alternate sources of water available. This reduces the potential for the researcher introducing information bias by creating an unrealistic scenario. Hypothetical bias should be mitigated by the fact that irrigation water is used directly by the respondents and a fee payment mechanism already exists. One potential problem is if respondents do not believe that an improvement could be made or that the payment would be instituted.

The willingness to pay question was:

> Currently water is delivered from the Mae Taeng canal to your lateral, you are asked to pay an access fee and to do maintenance twice a year for the upkeep of the system but water is free. If the Royal Irrigation Department was to implement a program which improved the distribution of water and could ensure that you receive a minimum level of water which would meet your crop water requirements, would you be willing to pay ___ baht / rai / year for your water supply in the dry season?

The question was posed with one of four different values, 100, 150, 200, or 250 baht/rai/year given as a starting point.[3] Respondents were asked to reply yes or no to the question and then the interviewer began a bidding game to determine the maximum willingness to pay for the water. This is the "take-it-or-leave-it with follow-up" method described by Mitchell and Carson (1989: 103.) Because the willingness to pay question is initially asked as a discrete choice question, a discrete binomial model can be set up if the final bids exhibit starting point bias.

[3] The starting points were initially chosen on the basis of the maximum willingness to pay values estimated in section 3.4 of this thesis. A soybean farmer with a 20% profit margin, who uses the minimum water requirement to grow his crops (351 m^3/ rai/ dry season), receives water with a value of 111 baht/ rai. A soybean farmer with a 30% profit margin, who uses the maximum water requirement to grow his crops (560 m^3/ rai/ dry season), receives water with a value of 265 baht/ rai.

After the bidding process was completed, respondents who were unwilling to pay the original amount were asked the reason for their lower bids.

4.7 Socioeconomic Profile of the Respondents

Of the 572 dry season farmers using the soi 7 canal, 83 were interviewed for this study. Sixty of these farmers were male and 23 were female. The average age was 47.1, 41.5 for the females and 49.3 for the males. The youngest person was 28 and the oldest was 66. Seventy-two of the 83 farmers had a grade four education, 2 had no schooling and 3 had reached grade three. Three women and one man had reached grade 7 and 3 men had reached grade 6. The average household had 4 members.

The average yearly gross income from farming for the 1995 dry season was 34,140 baht. The average yearly net income was 12,370 baht. Forty-seven of the respondents also sold their labour receiving an average of 11,255 baht per year. Thirteen people had businesses out of their homes which made an average of 58,646 baht per year.

Soybeans and tobacco were the two types of crops grown in this area. Of the respondents only 3 farmers grew tobacco exclusively, 7 farmers grew both soybeans and tobacco, and 73 grew soybeans exclusively. The production data collected from the farmers was used to determine the profitability of their 1995 dry season crop. The average profits, average profits per rai, and average profits per day of family labour earned for the 1995 dry season crops are reported in Table 4.3. Farm labourers in this area are paid between 80 and 100 baht per day depending on the type of work they contribute. Twenty farmers actually earned less than 100 baht in profit per day of labour by a family member. This would suggest that these farmers encountered unexpected problems in production or have low opportunity costs for their (or their family's) time.

Table 4.3: Profitability of 1995 Dry Season Crops (in baht), Reported by Questionnaire Respondents

	All Crops	Soybean Crops	Tobacco Crops
Average Profit	10,181	12,269	14,682
Average profit per rai	1,226	982	4,593
Average profit per day of labour by a family member	685	685	458

Table 4.4: Number of Farm Holdings by Size and Location

Size of Holding (rai)	Farmers interviewed		Northern Thailand		Thailand	
	number of holdings	percentage of total	number of holdings	percentage of total	number of holdings	percentage of total
less than 2	4	4.8	33702	2.4	121005	2.1
2 to 5	32	38.6	340671	24.2	880176	15.6
6 to 9	21	25.3	225239	16	728108	12.9
10 to 19	22	26.5	364325	25.9	1613322	28.6
20 to 39	3	3.6	285460	20.3	1513203	26.8
more than 39	1	1.2	158657	11.2	791502	14
Total	83		1408054		5647316	

Source: Thailand National Statistics Office, 1994

The average farm size was 8 rai (1.28 ha ,3.16 acres), the smallest being 1 rai and the largest 47 rai. The average size of a soybean plot was 7.85 rai and the average size of a tobacco plot was 3.7 rai. The distribution of the the landholdings by farm size is shown in Table: 4.4.

Thirty-eight people owned their land, 38 rented, 5 owned some property and rented additional area and one man used his relatives' property free of charge. Of the renters, 17 paid cash at an average rate of 519 baht / rai, 19 paid in kind at an average of 18.9 tang of soybeans per rai and one person paid 33 tang of tobacco per rai. Six farmers used rented land year round but were only required to pay rent from their wet season rice crop.

The Mae Taeng irrigation project supplied sufficient water for 75% of the soybean farmers and 60% of the tobacco farmers in the 1995 dry season (see Table 4.5). Of the 20 soybean farmers who did not receive enough water, 18 supplemented their supply with ground water at an average total cost of 466 baht for the dry season. Three of the 4 tobacco farmers who were short of water used ground water at an average cost of 480 baht. When asked if they received sufficient water for their 1994 dry season crop only 49% of soybean farmers, and 50% of tobacco farmers, responded positively. Seventeen respondents did not personally experience problems of shortage in the past few years.

Table 4.5: Number of Respondents Who Experienced Water Shortages in the Previous Two Dry Seasons

Dry Season Crop Year	Number of Soybean farmers who did not receive sufficient water	Number of Tobacco farmers who did not receive sufficient water
1995	20	4
1994	39	5

Farmers were asked why they thought that water was sometimes inadequate (for themselves or others). Forty-five farmers attributed shortages to misuse of water by farmers (26 thought the problem was farmers in other sois and 19 felt there was misuse in soi 7), 28 felt that there were physical inadequacies in the system (7 thought the lack of reservoir was the problem, 7 others suggested sedimentation of the catchment area and 14 said it was just poor rainfall) and 11 felt the problem was poor management by Mae Taeng officials (5 blamed poor monitoring, 2 cited poor enforcement of rules, and 4 felt there was inadequate maintenance.)

That only 4 farmers were concerned with poor maintenance is interesting, as the researcher observed large accumulations of dirt and weeds in the lateral 7L and its sub-laterals. This was first observed when soi 7 was empty of water during the harvesting of the 1995 wet season rice (late November / early December 1995.) It remained uncleaned through to the last visits to the site in January and February 1996 when the farmers were receiving water for their dry season crops. Interviews with the zoneman indicated that maintenance was supposed to occur in December but that they lacked labour power.

4.8 Protest Bids

Of the 83 farmers interviewed, 20 gave very low bids (10 baht / rai / year or less) and were asked why they gave such low bids. Nine of these responded that they would be unable to pay more and continue to farm in the dry season. The other 11 indicated that they did not believe that farmers should have to pay for their irrigation water; these 11 were treated as potential protest bidders.[4]

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[4] Whether or not these farmers were voicing protest bids was not conclusively determined as the farmers were not further questioned about the reasoning for their low bids. As a result the forthcoming model will be estimated twice, including and excluding the potential protesters.

Five of these 11 farmers were female, meaning 21% of the female respondents and 10% of the male respondents gave potential protest bids. The average age of the 11 was higher than that of the whole group at 49.6; 43.2 for the females and 55 for the males. All but one of the 11 had a grade 4 education, the exception being a female with a grade 2 education. For 1995, they reported an average gross income from farming of 23,679 baht and an average net income from farming of 7,273 baht. This net income level is very low compared

Table 4.6: Socioeconomic Profile of Questionnaire Respondents, Comparison of Potential Protest Bidders and Non-Protest Respondents

		All respondents (n = 83)	Respondents excluding potential protest bidders (n = 72)	Potential protest bidders (n = 11)
Average age		47.1	46.7	49.6
Number of males		60	54	6
Number of females		23	18	5
Average family size		3.96	3.99	3.82
Average year of education		4.04	4.07	3.82
Average farm size		8.0	8.1	7.45
Number who own the land		43	36	7
Number who rent the land		43	39	4
Av. # of km from main canal		4.78	5.05	3
Receive water from sub-lateral	1R	18	14	4
	1L	16	11	5
	2L	6	6	0
	7L	43	41	2
Average access fee paid (baht)		4.69	4.78	4.09
Number who finance through	loans	52	44	8
	savings	38	34	4
Average gross farm income (baht)		34,140	35,738	23,678
Average net farm income (baht)		12,370	13,148	7,272
Average willingness to pay for irrigation water (baht)		54.02	61.11	7.64

to the average net income reported by the whole group of respondents. The average net farm income for the whole group was 12,370 baht and the average net income for the group excluding the potential protest bidders was 13,148 baht (Table 4.6). These discrepancies suggest that the potential protest bidders may be unable to pay more than their offered bids, but does not necessarily mean that their bids were not protests. These bids may have reflected an inability to pay as well as an unwillingness to participate fully in the study. Four of these farmers gained income from selling their labour, earning an average of 8,250 baht in 1995, and 2 had home businesses which earned 80,000 and 30,000 baht.

Eight of the 11 owned their property and 3 rented. Ten grew soybeans in the 1995 dry season and one grew tobacco. The average size holding was 7.8 rai for soybeans and a 4 rai plot for the tobacco farmer. These 11 tended to live closer to the main canal than the other farmers, averaging a distance of 3 km away. Six farmers were 2 km or less away, 4 farmers were 5 km or less away and one farmer was 6.5 km away from the main canal. Four of these farmers received water from sub-lateral 1R, 5 from 1L and 2 from 7L.

Chapter 5 : Model Specification, Estimation and Results

5.1 Introduction

In this chapter an econometric model of farmers' willingness to pay for an improvement in the supply of their irrigation water is developed. The chapter begins with a description of the independent variables which are expected to influence the farmers' willingness to pay. The process of choosing the proper functional form and the relevant variables for estimation is then described. Two data sets are used for the estimation of the models: one data set which includes all respondents (models 1-A, 1-B, 1-C and 1-D) and one data set which excludes the potential protest bidders (models 2-A, 2-B, 2-C and 2-D.) Models 1-A, 1-B, 2-A and 2-B are linear models and the remaining models are in log-linear form. The results from all eight models are recorded in Tables 5.1 and 5.2. Tests for the validity of the models are presented and these results are discussed. The preferred model is then chosen and its results are reviewed.

5.2 Description of the Variables

The farmers' willingness to pay (WTP) for an improvement in the supply of their irrigation water is hypothesized to be a function of the following variables:

WTP = f (AGE, FEMALE, AREA, OWN, L2, KM, ENOUGH, FEE, HEADMAN, ZONEMAN, FAIR, PHYSICAL, MANAGEMENT, SAVINGS, TOTAL Y)

The farmer's age, AGE, is expected to have a negative impact on his/her willingness to pay. Older farmers may feel more secure about the traditional provision of free irrigation water and less willing to change the status quo than younger farmers. A variable for gender (FEMALE) was included to assess whether female farmers would bid differently than male farmers. In the questionnaire, farmers were asked for the grade they reached in school as it was thought that more education would positively influence a farmer's WTP. However, a variable representing their education is not included in the model, as almost no variation existed among farmers in their education level.

The farmer's ability to pay for irrigation water should influence his/her WTP bid. It is expected that farmers with higher income levels should be willing to pay more for their water. Several measures of income were elicited in the questionnaire: gross farm income, net farm income, income from selling labour, and income from home production. TOTAL Y, total income, is used for estimating the model; it is the sum of the latter three measures. How the farmer's choice of financing options influences their WTP is also considered. The dummy variable SAVINGS was created to represent financing alternatives. SAVINGS is equal to one if the farmer finances production with his savings, and is equal to zero if the farmer borrows money to finance the dry season crop production. The coefficient on savings is expected to be positive if farmers are choosing to use their savings as an alternative to external financing, but, should be negative if farmers are limited to using their savings because external financing is unavailable.

The variable AREA represents the size of the farmer's land holding as measured in rai. AREA is expected to have a positive influence on WTP, as larger farm sizes indicate a greater investment in the farming community and greater potential returns from improved water service. For those farmers who own their land, the variable AREA is also an indication of their wealth. The variable OWN is a dummy variable which is equal to one if the farmer owns his/her land and equal to zero if the land is rented. Ownership of the land is taken to indicate a stronger commitment to farming in future years and is expected to have a positive influence on WTP. The value of the land will be increased by an improved irrigation system, giving owners further incentive to invest in such an improvement.

The location of the farm in the soi 7 system is also hypothesized to have an effect on farmers' WTP. Location was determined in two ways; the first was the number of km away from the main canal that the farmer's turnout was located (KM), and the second was whether the farmer drew water from the lateral (7L) or one of the sub-laterals (1R, 1L or 2L.) Because the distribution of water is split into two rotational turns, with the second halves of 7L, 1R, 1L and 2L receiving water together and the first halves of 7L, 1R, 1L and 2L receiving water together, it was decided that KM was the most important variable in discussing distance. KM should best capture the of head-end and tail-end issues of distribution. Thus, KM is expected to have a positive influence on farmer's WTP, with the tail-enders being further away from the main canal, more in need of water, and thus willing to pay more for improved water service. Of the variables representing the lateral and sub-lateral canals, only 2L was included in the model. This is because only the service to 2L seemed to differ significantly from the other three. Sub-lateral 2L had the poorest maintenance and the poorest water delivery record (the very end no longer received any water.) During interviews and casual discussions with villagers, attitudes of disenfranchisement from the Mae Taeng canal system appeared much stronger in 2L than in other areas. The expected sign on the coefficient of 2L is uncertain, as the greater need for water should have a positive influence, but the disenfranchisement may have a negative influence on WTP.

The amount farmers are currently paying for access to the irrigation system is represented by the variable FEE. It is anticipated that the coefficient of FEE will be negative. It is assumed that those farmers who are currently satisfied with the Mae Taeng system are the ones who are paying their full 10 baht obligation, and those who are less satisfied or dissatisfied are paying less than 10 baht.

In the questionnaire farmers were asked several questions about their perception of water distribution in the Mae Taeng system. Several variables were created from these questions. The first variable is ENOUGH. Farmers were asked whether they received enough water from the Mae Taeng project in the 1995 dry season as well as in the 1994 dry season. The yes responses to the two questions were added to create the variable ENOUGH. ENOUGH is equal to zero if the farmer did not have enough water in either dry season, equal to one if the farmer received enough water in one of the two dry seasons, and equal to two if the farmer received enough water in both dry seasons. The coefficient on ENOUGH is expected to be negative as farmers who do not need more water will not be willing to pay for more water. The second variable indicating perception was FAIR. This is a dummy variable indicating whether or not the farmer believed that the water in the Mae Taeng irrigation project is distributed fairly. The coefficient on FAIR is expected to be negative, as the farmers who are happy with the system should be less willing to pay for an improvement.

Farmers were asked to rate their zoneman's and their headman's performance on a scale of one to five, 1 being very poor, 2 being poor, 3 being adequate, 4 being good and 5 being very good. These ratings are represented by the variables HEADMAN and ZONEMAN. It is expected that the coefficient of HEADMAN should be positive, as high ratings indicate a trust in the system on a basic level. The coefficient on ZONEMAN is expected to be negative, as a high rating indicates satisfaction with the way the Mae Taeng irrigation project is operating on the whole.

The last two variables specified are PHYSICAL and MANAGEMENT. They were created from farmer responses to the question 'Why do you think water supply is sometimes inadequate?' Responses to this question where grouped into three categories, those who thought shortages where due to other farmers misusing the water (FARMER), those who thought environmental or natural reasons were to blame (PHYSICAL) and those who thought poor management created shortages (MANAGEMENT). The variable FARMER was left out of the regression as it would be linearly related to the other two. It is expected that MANAGEMENT will have a positive coefficient because farmers who believe poor management (as opposed to farmer mis-use) is causing water shortages should be willing to pay more for an improvement. The coefficient on PHYSICAL is expected to be negative as irrigation officials cannot change the environmental conditions which create shortages.

5.3 Model Specification and Estimation

The existence of starting point bias was tested for both data sets by regressing the starting point onto the willingness to pay bid. In both cases a null hypothesis of starting point bias was rejected. This is an uncommon result in contingent valuation studies, but may be ascribed to the fact that the respondents were very familiar with the commidity that they were asked to value. Given that there was no starting point bias, the models were estimated using Ordinary Least Squares (OLS). All of the models are estimated twice; once with data which includes the potential protest bidders (model 1) and once with data which excludes them (model 2).

In the first calculations (Models 1-A and 2-A), all of the dependent variables discussed in section 5.3 were used to estimate a linear equation. The significance of the entire regression and each variable within the regression was then tested. F-tests for regressions 1-A and 2-A found both to be significant at the 5% level. Those variables with t-values which are less than 1 in both regressions were then noted, and a joint F-test of their significance was performed. The null hypothesis that the coefficients of FEMALE, L2, ZONEMAN, SAVINGS and TOTAL Y were not jointly significant was not rejected. Two additional linear regressions (Model 1-B and Model 2-B) were estimated excluding the aforementioned variables. F-tests showed these regressions to be significant at the 5% level.

These same models were estimated with the log-linear functional form and the log-log functional form. The log-log form produced very poor results and is not reported in this text. The log-linear form is used in Models 1-C, 2-C, 1-D and 2-D, shown in Tables 5.1 and 5.2. F-tests of the log-linear regressions confirmed that each regression was significant over-all.

All eight models were then tested for the presence of heteroskedasticity, which is most commonly found in models using cross-sectional data. The Breusch-Pagan-Godfrey test and the Goldfeld-Quandt test were applied to each of the regressions (Judge et al., 1988). In the Goldfeld-Quandt test the observations are ordered by increasing variance and then split into three groups. A regression is then estimated with the middle group of observations excluded. It is assumed that under the alternative hypothesis the first and third group will

Table 5.1: Model 1, WTP Regressions Using Full Data Set (n=83)

	Model 1-A	**Model 1-B**	**Model 1-C**	**Model 1-D**
Dependent Variable	**WTP**	**WTP**	**lnWTP**	**lnWTP**
AGE	**-0.062126** (-1.163)[5]	**-0.62064** (-1.28)	**-0.01657** + (-1.351)	**-0.0155** + (-1.39)
FEMALE	**-1.9952** (-0.1669)		**-0.11587** (-0.4224)	
AREA	**1.6322** * (1.949)	**1.7599** * (2.277)	**0.02769** + (1.441)	**0.0329** * (1.85)
OWN	**12.154** (1.161)	**12.103** (1.229)	**0.41589** * (1.73)	**0.39814** * (1.757)
L2	**-10.33** (-.04196)		**-0.16043** (-0.2839)	
KM	**5.5582** * (2.469)	**5.0063** * (2.723)	**.012519** * (2.423)	**0.11672** * (2.76)
ENOUGH	**-9.4626** * (-1.806)	**-9.7103** * (-1.967)	**-0.10136** (-0.8427)	**-0.10885** (-0.9585)
FEE	**-2.4391** * (-1.887)	**-2.1565** * (-1.882)	**-0.03097** (-1.044)	**-0.023367** (-0.8867)
HEADMAN	**11.552** + (1.605)	**9.9764** + (1.533)	**0.16976** (1.027)	**0.13911** (0.9294)
ZONEMAN	**-2.7636** (-.03271)		**-0.01397** (-0.072)	
FAIR	**-21.16** (-1.115)	**-21.632** + (-1.384)	**-0.15514** (-0.3673)	**-0.14232** (-0.3958)
PHYSICAL	**24.433** * (2.601)	**25.384** * (2.908)	**0.36113** * (1.675)	**0.40909** * (2.038)
MANAGEMENT	**23.225** * (1.63)	**26.309** * (2.014)	**0.63046** * (1.928)	**0.69558** * (2.315)
SAVINGS	**-3.7055** (-0.3162)		**-0.17828** (-0.6627)	
TOTAL Y	**0.00077** (0.6561)		**0.00000214** (0.7881)	
CONSTANT	**34.607** (0.7240)	**29.569** (0.7154)	**2.9402** * (2.68)	**2.8107** * (2.956)

[5] t value is in parentheses

* significant at the 5% level.

+ significant at the 10% level

Table 5.1: Model 1, WTP Regressions Using Full Data Set (n=83), ***continued***

		Model 1-A	**Model 1-B**	**Model 1-C**	**Model 1-D**
Degrees of Freedom		67	72	67	72
R-squared		0.4331	0.4268	0.3522	0.3422
R-squared Adjusted		0.3062	0.3472	0.2072	0.2508
Goldfeld-Quandt Test H_0: homoskedastic		F=0.3517 D.F.(4, 27) do not reject null[6]	F=1.122 D.F.(9, 32) do not reject null	F=-0.0016 D.F.(4, 27) do not reject null	F=1.619 D.F.(9, 32) do not reject null
BPG Test H_0: homoskedastic		χ^2=22.493 15 D.F. do not reject null	χ^2=20.835 10 D.F. do not accept null	χ^2=16.316 15 D.F. do not reject null	χ^2=15.161 10 D.F. do not reject null
LM Test H_0: normally distributed residuals		χ^2=7.2087 2 D.F. do not accept null	χ^2=8.0903 2 D.F. do not accept null	χ^2=4.9722 2 D.F. do not reject null	χ^2=3.4361 2 D.F. do not reject null
Ramsey Reset Test H_0: no mis-specification	Reset (2)	7.7387 do not accept null	5.8109 do not accept null	1.1792 do not reject null	0.85049 do not reject null
	Reset (3)	3.8678 do not accept null	2.8651 do not reject null	2.304 do not reject null	2.1943 do not reject null
	Reset (4)	2.5405 do not reject null	1.8988 do not reject null	1.5426 do not reject null	1.4922 do not reject null

[6] All tests are at the 5% significance level

Table 5.2: Model 2, WTP Regressions Excluding Potential Protest Bids (n=72)

	Model 2-A	**Model 2-B**	**Model 2-C**	**Model 2-D**
Dependent Variable	**WTP**	**WTP**	**lnWTP**	**lnWTP**
AGE	**-0.5161** (-0.8875) [7]	**-0.56567** (-1.066)	**-0.011264** (-1.052)	**-0.010024** (-1.023)
FEMALE	**1.3242** (0.09847)		**-0.13863** (-0.5599)	
AREA	**1.7502 *** (2.002)	**1.7986 *** (2.213)	**0.030024 *** (1.865)	**0.031004 *** (2.065)
OWN	**12.414** (1.08)	**12.391** (1.159)	**0.45369 *** (2.144)	**0.44156 *** (2.235)
L2	**-6.0932** (-.02488)		**-0.09656** (-0.2142)	
KM	**4.4689 *** (1.875)	**4.0536 *** (2.085)	**0.071402 +** (1.628)	**0.071628 *** (1.994)
ENOUGH	**-10.879 +** (-1.608)	**-11.785 *** (-1.856)	**-0.18791 +** (-1.508)	**-0.19819 *** (-1.69)
FEE	**-3.0224 *** (-2.356)	**-2.8088 *** (-2.412)	**-0.036521 +** (-1.547)	**-0.030615 +** (-1.423)
HEADMAN	**15.998 *** (2.059)	**13.999 *** (2.025)	**0.32246 *** (2.254)	**0.26123 *** (2.045)
ZONEMAN	**-5.7689** (-0.6338)		**-0.1561** (-0.9315)	
FAIR	**-15.587** (-0.8158)	**-19.096** (-1.189)	**0.083077** (0.2362)	**-0.043731** (-0.1474)
PHYSICAL	**22.988 *** (2.307)	**22.867 *** (2.473)	**0.30542 *** (1.665)	**0.30123 *** (1.763)
MANAGEMENT	**18.074** (1.223)	**20.925 +** (1.562)	**0.48851 *** (1.796)	**0.53797 *** (2.174)
SAVINGS	**-3.49741** (-0.2712)		**-0.070323** (-0.2962)	
TOTAL Y	**0.000042** (0.636)		**0.0000006** (0.4961)	
CONSTANT	**28.673** (0.5729)	**21.77** (0.5039)	**2.919 *** (3.168)	**2.5593 *** (3.206)

[7] t value is in parentheses
* significant at the 5% level.
+ significant at the 10% level

Table 5.2: Model 2, WTP Regressions Excluding Potential Protest Bids (n=72), ***continued***

		Model 2-A	Model 2-B	Model 2-C	Model 2-D
Degrees of Freedom		56	61	65	61
R-squared		0.4331	0.4226	0.4010	0.3856
R-squared Adjusted		0.2813	0.3280	0.2406	0.2848
Goldfeld-Quandt Test H_0: homoskedastic		F=0.103 X 10^{-8} D.F.(9, 21) do not reject null[8]	F=1.73 D.F.(14, 26) do not reject null	F=-0.00129 D.F.(9, 21) do not reject null	F=1.663 D.F.(14, 26) do not reject null
BPG Test H_0: homoskedastic		χ^2=19.945 15 D.F. do not reject null	χ^2=18.724 10 D.F. do not accept null	χ^2=10.138 15 D.F. do not reject null	χ^2=6.330 10 D.F. do not reject null
LM Test H_0: normally distributed residuals		χ^2=3.4727 2 D.F. do not reject null	χ^2=3.9398 2 D.F. do not reject null	χ^2=2.1267 2 D.F. do not reject null	χ^2=2.6081 2 D.F. do not reject null
Ramsey Reset Test H_0: no mis-specification	Reset (2)	9.0631 do not accept null	6.9239 do not accept null	0.21813 do not reject null	0.2164 do not reject null
	Reset (3)	5.1266 do not accept null	4.7133 do not accept null	1.2268 do not reject null	1.0816 do not reject null
	Reset (4)	3.7281 do not accept null	3.4537 do not accept null	1.4546 do not reject null	1.0883 do not reject null

[8] All tests are at the 5% significance level

have variances which are constant within the group but differ between the two groups. The null hypothesis for each test is that the regression is homoskedastic. Using the Goldfeld-Quandt test, the null hypotheses of homoskedasticity were not rejected for any of the regressions. Using the Breusch-Pagan-Godfrey test, the null hypotheses were not rejected for all the regressions except for the linear models 1-B and 2-B.

In estimating regressions using OLS, it is assumed that the residuals of the regression are normally distributed. This assumption was tested using the Jarque-Bera Lagrange multiplier test of normality. This test makes a comparison of the skewness and the kurtosis of the distribution of the residuals in the regression to the normal distribution. The test statistic is a Wald statistic which measures the degree of excess, how much the residuals diverge from the normal distribution (Greene, 1993). The null hypothesis for this test is that the residuals are normal. This hypothesis was rejected for the linear regressions 1-A and 1-B, but accepted for all others.

The Ramsey Reset test was performed on each of the eight models to test for model mis-specification. The Reset (2) test takes the squares of the predictions from a model and includes them in that model as explanatory variables, Reset (3) includes the cubes of the predictions and Reset (4) uses the predictions taken to the fourth power. The model is then re-estimated and the single and joint significance of these additional variables are tested. If these coefficients are found to be singly or jointly significant, the model is likely misspecified. This mis-specification may be the result of omitted variables or the wrong choice of functional form (Griffiths et al., 1993). The null hypothesis in each case is that there is no mis-specification. The null was not accepted in all four of the linear regressions but was not rejected for the log-linear regressions. This suggests that the correct functional form is the log-linear form. Thus the results for the four log-linear models will now be discussed.

5.4 Results

5.41 Coefficients in a Log - Linear Regression

The four log-linear models utilized both discrete and continuous independent variables. The coefficients of continuous independent variables (β_n) "measure the constant proportional or relative change in Y [the dependent variable] for a given absolute change in X [the independent variable]" (Gujarati, 1988).

$$\beta_n = \frac{\text{Relative change in Y}}{\text{Absolute change in X}}$$

Multiplying the relative change in Y by 100 gives the percentage change in Y for an absolute change in X. For a unit change in X the percentage change in Y will simply be the coefficient of X multiplied by 100.

For the discrete variables, "the coefficient (α_n) of a dummy variable measures the discontinuous effect on Y of the presence of the factor represented by the dummy variable" (Halvorsen and Palmquist, 1980). To determine a percentage change in Y in the case of a dummy variable it is necessary to take the anti-log of the estimated dummy coefficient, subtract 1 from it and multiply it by 100 (Gujarati, 1988).

5.42 First Estimations, Results from Models 1-C, 2-C

Model 1-C and model 2-C are estimated with all 15 variables described in section 5.3. As with the linear models, t-tests performed on the variables FEMALE, L2, ZONEMAN, SAVINGS and TOTAL Y indicated that they were not significant. A joint F-test of their significance was also performed and the null hypothesis that the coefficients were not jointly significant was not rejected. In both models the coefficient of FEMALE was negative but it was not significant. Thus, the gender of the respondents did not influence their willingness to pay for irrigation water. The location on 2L was also negative as expected but did not have a significant impact on WTP. The correlation between the coefficients of 2L and KM is relatively high in both Model 1-C and 2-C (-0.49847 and -0.47188 respectively) suggesting that the information provided by the variable 2L is already contained in the variable KM. Sub-lateral 2L begins at the 6.5 km mark of lateral 7L and only receives enough water for its first portion, thus farmers on sub-lateral 2L are limited to a small range of distances from the main canal.

The farmers' rating of their zoneman's performance (ZONEMAN) does not significantly alter their willingness to pay for an improved distribution of irrigation water. The coefficients of ZONEMAN and FAIR were found to have a correlation of -0.41588 in model 1-C and -0.43550 in model 2-C. This correlation is not surprising as the zoneman is responsible for managing water distribution and poor management would lead to unfair distributions. The coefficient on ZONEMAN was negative in both models as expected. The variable FAIR also produced the expected negative coefficient but was not statistically significant in regressions 1-C or 2-C.

SAVINGS is a dummy variable representing those who financed their dry season production from their savings instead of borrowing money. It was expected that this would have a positive impact on willingness to pay if the use of savings was not the result of poor access to credit. The coefficient on savings was negative and not significant in both model 1-C and 2-C.

The farmers' ability to pay for an increase in irrigation water costs was expected to positively influence their willingness to pay. This ability was represented by their total yearly income (TOTAL Y) in the above regressions. The coefficients were positive but not significant in each case. This seemed a surprising result and so several alternative representations of ability to pay were used in new regressions. These alternatives were: yearly income from non-farm sources, yearly income from farming and profit per day of family labour from last dry season's crop. All of the alternative specifications had positive coefficients but none were significant.

5.43 The Preferred Models (1-D and 2-D)

Models 1-D and 2-D have identical dependent and independent variables but differ in the data sets used for their estimation. Model 2-D's data set excludes the potential protest bidders and model 1-D's data set includes them. The exclusion of these potential protests improves the fit of the model (see Table 5.3.) Using the truncated data set also increases the number of significant variables. The signs on the coefficients are the same in both regressions.

Models 1-D and 2-D were estimated without the variables FEMALE, L2, ZONEMAN, SAVINGS and TOTAL Y. The exclusion of these variables improved the R^2-adjusted values, and caused a slight decrease in the R^2 values

Table 5.3: R^2 Values for Log-Linear Models 1-C, 1-D, 2-C and 2-D.

Model	1-C	1-D	2-C	2-D
R^2	0.3522	0.3422	0.4010	0.3856
R^2-adjusted	0.2072	0.2508	0.2406	0.2848

Excluding these variables also reduces the problems of correlation, all values in model 1-D and 2-D's correlation matrices are below 0.31. The significance of individual variables did not change at all from model 1-C to 1-D, but 2 variables which were significant at the 10% level in Model 2-C became significant at the 5% level in model 2-D. Models 1-D and 2-D are considered improvements on models 1-C and 2-C.

Model 1-D (which includes potential protest bids) has three variables which are not significant at the 5% level, AGE, FAIR and FEE. AGE has a negative coefficient in regressions 1-D and 2-D as expected but is not significant in 2-D and is significant only at the 10% level in 1-D. FAIR has the anticipated negative coefficient but is not significant in either regression. FEE has the expected negative sign and is significant at the 10% level in 2-D but not significant in 1-D.

The variables ENOUGH and HEADMAN are both significant in model 2-D but not significant in model 1-D. ENOUGH has a negative coefficient as predicted, indicating that farmers in need of more water will pay more for it than those farmers who are satiated. The variable ENOUGH decreases by one for every dry season crop that they did not receive enough water in the last 2 years, its maximum value is 2 and minimum value is zero. Thus, the coefficient of ENOUGH in model 2-D indicates that the farmer's willingness to pay will decrease by 19.8% for each crop that received sufficient water. The coefficient of HEADMAN has the anticipated positive coefficient, suggesting that those who have more confidence in their local power will invest more in the whole system. For a one point increase in the headman's performance rating, willingness to pay for irrigation water will increase by 26%.

The remaining variables are significant in both regressions. The size of the farmer's landholding, AREA, has a positive effect on the farmer's willingness to pay. Increasing the size of the farmer's plot by one rai would increase WTP by 3.1% in model 2-D and 3.3% in model 1-D. Owning the land also has a positive impact on a farmer's willingness to pay. This impact is one of the strongest in the regression. Using the method described in Gujarati (1988), a change from renting land to owning land would cause a 55.5% (48.9% for model 1-D) increase in a farmer's willingness to pay for an improved distribution of water. An owner of land may benefit from better water supply through improved crop output, but can also benefit through increased property value. Ownership reflects the farmer's wealth and thus reflects the farmer's ability to pay for irrigation water. Thus, while measures of the farmers current income did not prove to be significant in the regressions, a measure of the farmer's wealth is significant.

The variable KM has a positive influence on willingness to pay as was predicted. This confirms that there are disparities between head-end and tail-end irrigation users. An increase of one kilometre in the respondent's distance from the main canal will increase his / her willingness to pay by 7.2% (11.62% in model 1-D.)

The final two variables represent the farmer's perception of what causes the water shortages. If the farmer believes that management (MANAGEMENT) problems are to blame, as opposed to the base case of farmer mis-use, the farmer's willingness to pay will be 71.3% higher (100.4% for model 1-D). If the farmer believes that environmental (PHYSICAL) problems are to blame, as opposed to the base case of farmer mis-use, the farmer's willingness to pay will be 35.1% higher (50.5% for model 1-D).

5.6 Summary

Willingness to pay for an improved supply of irrigation water was found to be influenced by several factors. Farmers who owned their land were willing to pay more than farmers who rented. Willingness to pay increased with the size of the farm plot and the distance from the main canal. Farmers with higher ratings for their water users' group headman were willing to pay more that those who gave poor ratings. Farmers who believed that the problems of water shortage were caused by poor management or physical circumstances were willing to pay more than farmers who believed that the problems were caused by farmer mis-use of water.

Chapter 6: Conclusion

6.1 Water Management in Thailand

As Thailand's economy grows so too does pressure on its resources. Demand for water is increasing in all sectors of the economy and conflicts over limited water supplies are mounting. There is little scope for tapping new water supply sources. This makes improved demand management essential to mitigate growing water allocation problems. The agricultural sector uses the vast majority of Thailand's water and thus small improvements in its water use efficiency could alleviate water scarcity problems. To better manage the demand for water it is necessary to provide water users with incentives to use water efficiently. This requires the creation of policies in which prices and penalties reflect the true value of water, as well as institutions that are able to implement these policies.

The Mae Taeng Irrigation Project has the potential to introduce such a system. This project was created to combine the engineering improvements afforded by a large government project with the managerial efficiency of local governance. Rules of use are based on those which existed in the *mu fai* organizations which preceded the Mae Taeng Irrigation Project. Farmers were left to choose headmen and manage their local water distribution. Fees were imposed to pay for management and farmers were required to participate in the maintenance of the system. Penalties were created for mis-use of the irrigation water and the neglect of maintenance responsibilities. Monitoring of the system was left to farmers and headmen on the local level, zonemen at the soi level, and officials from the headworks for the overall project.

Since the inception of the Mae Taeng Irrigation Project the city of Chiang Mai has grown, both physically and economically. This growth has brought new challenges to the management of the Mae Taeng Irrigation Project. The conversion of agricultural lands to urban and industrial usage has blurred the boundaries of the project. Irrigation water is being used for non-irrigation purposes. These new users are not part of the official system and so are not necessarily aware of the rules and regulations in the irrigation project. They do not pay fees or provide maintenance. These new users must be explicitly included or excluded from using the Mae Taeng water so that their usage can be managed or ended.

The irrigators in this project are supposed to pay fees, provide maintenance and suffer penalties for mis-using the system. In reality these things are not consistently carried through. The system is well monitored by farmers but penalties are not always imposed for mis-use. Maintenance is mandated but not always fulfilled. Zonemen are responsible for the levying of these penalties and the organization of soi maintenance; these officials require better incentives to improve their management. User fees are also levied but not always paid. The fees which are collected do not reflect the value of the water: the value of water in its highest use; the value of water in crop production; or the farmer's willingness to pay for the water.

6.2 Willingness to Pay for an Improved Supply of Irrigation Water

Several factors were found to have a significant influence on a farmer's willingness to pay for irrigation water. Farmers who owned their land were willing to pay more than farmers who rented. These owners would have greater payoffs from improved water distribution through increased crop outputs and increased land values. Farmers who owned larger plots were also willing to pay larger fees. Farmers who experienced shortages in the past 2 years were willing to pay more than those who received sufficient water as they anticipate a higher risk of continued shortage. Farmers whose plots are closer to the tail end of Soi 7 are willing to pay more than those at the head end. The tail-enders must rely on the quality of distribution, whereas the head-enders can always resort to taking water out of their turn. Farmers who believe that their water users' group headman was doing a very good job were willing to pay more than those who rated his performance as poor. Farmers who did not believe the problems of scarcity were caused by farmers misusing the water were willing to pay more than those farmers who blamed other farmers for the shortage.

The farmers interviewed for this study reported paying an average fee of 4.69 baht/rai/year (4.79 when potential protest bidders are excluded.) The fee which is supposed to be collected by the headmen is 10 baht/rai/year. The mean willingness to pay for an improved supply of irrigation water is 50 baht/rai/year for all respondents, and 61 baht/rai/year when the potential protest bids are excluded. The standard deviations for these means are 50 and 50.25

respectively. In both cases, the median willingness to pay values are 50 baht/rai/year. Thus, the average farmer is willing to pay approximately 10 times the amount currently paid, or 5 times the amount farmers are supposed to be paying for access to irrigation water. If a fee of 50 baht per rai had been collected for the 1996 dry season, farmers using soi 7 would have contributed 226,550 baht (12,411 CDN$) in revenue.

If soi 7 farmers were to pay 50 baht/rai/year for access to irrigation water and use the minimum crop water requirement to produce their dry season crops, they would be paying an equivalent of 0.1425 baht/m^3. This is significantly lower than the prices received for water in the city of Chiang Mai. Water users in Chiang Mai are charged block rates which differ by type of use, as shown in Table 6.1. These rates are charged for treated water and do not consider the

Table 6.1: Sample of Chiang Mai Water Rates, baht / m^3
(Effective March 1, 1993)

Volume of Water used (m^3/month)	Household Users	Government Agencies and small businesses	Industrial Users	Industrial Estates	
				Volume	Rate
0-10	3.75	5	6	0-10	5
11-20	4.5	6	7	11-20	6.2
21-30	6.5	7.25	9	21-30	6.45
31-50	8.5	8.5	12.5	...	...
51-80	9	9	13.75	161-200	10.99
81-100	9.5	9.5	14.75	201-2000	11.18
101-300	10	10	16.75	2001-4000	10.92
301-1000	10.25	10.25	17.75	...	...
1001-2000	10.5	10.5	16.75	30,001-40000	7.8
2001-3000	10.75	10.75	16.5	40,001-50000	7.15
3001→	11	11	15.5	50,001→	6.5

Source: TDRI, 1995

operating and capital costs involved in treating the raw water or the costs due to water losses in the system (water which is treated but not sold). When data about treatment costs and water losses were included the 1995 TDRI study found that the marginal values of raw water were approximately 0.6 baht/ m^3 for industrial estates, 6.99 baht/m^3 for industrial users and 3.79 baht/m^3 for households, government offices and small businesses (TDRI, 1995). Households, government offices and small businesses make up 90% of current municipal water use. The marginal value of raw water is significantly higher for municipal users than it is for irrigation users (3.79 baht/m^3 compared to 1.58 baht/m^3). Their is an even greater difference between what farmers are willing to pay for irrigation water and what urban users do pay for raw water (0.1425 baht/m^3 compared to 3.79 baht/m^3). Clearly urban water users are capable of bidding water away from irrigators. The question is whether they will be allowed to do so.

6.3 Suggestions for Further Research

The city of Chiang Mai and the area surrounding it are in transition. Rural property is being converted into urban housing developments and rural labourers are beginning to be drawn into the urban labour market. This transition will bring with it some hard choices about resource use. The urban/ industrial sectors are driving Thailand's economic growth and they will require an increased supply of water. However, the majority of Thai people live and work in rural areas, and their share in the country's income is shrinking. If water is given over to its highest value uses, the growing of dry season crops will decrease. The effects of such a decrease must be considered and the goals of efficiency must be balanced with those of equity. Subsidization of irrigation may be important in sustaining rural communities and their cultural traditions. Subsidization in the agricultural sector may be necessary to manage the pace of people entering urban employment sector, allowing cities time to manage their growth.

The Mae Taeng Irrigation Project has a continuous flow water delivery system. As such, an increased access fee for dry season water use may keep some farmers from growing crops but will not encourage efficient water use for those who continue to farm in the dry season. The continuous flow system would have to be converted to a system in which individual water use is measured before the pricing of water could be used to manage demand. The cost of such a conversion would likely be prohibitive in the face of low values for irrigation water.

One alternative that is in need of study is a system of individual or group water rights. In such a system farmers would have an explicit right to a share in the water supply and could choose to sell or rent their right to urban users. These rights would be very valuable as they are a source of economic rent. Deciding how and to whom they should be allotted would require close study and great care. If farmers are asked to forgo water use in favor of urban users a study of farmers' willingness to accept a decrease in their supply of water may be needed.

In this study, the willingness to pay question was asked in a take-it-or-leave-it with follow-up form. In answering this question, the farmer is making a individual choice as to whether he/she would pay a specified fee for an improved supply of irrigation water. An alternative would be to set up the question in a referendum form. A referendum question would ask the farmer to vote yes or no to a proposed increase in the fee. The decision is a group choice. The individual cannot receive the increased supply unless the majority of farmers are willing to pay. The challenge in setting up such a question is choosing the willingness to pay amount. If the specified fee is too high (low) everyone may vote no (yes).

Rural areas hold 60 % of the voters in Thailand and use 90% of the water. This makes the farmers' opinions extremely important in dealing with water scarcity issues. What they are willing to pay for, or willing to accept in lieu of, receiving their irrigation water needs to be considered by those who make Thailand's water use policies.

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Appendix 1

The Questionnaire

Part I

[1] Date _____/_____/_____ [2] Interviewer ________________

[3] Interview number _______ [4] Farmer's Name ________________

[5] Address ____________ [6] Village ______________ [7] Sub-district ________________

[8] Age ________ [9] Male Female [10] Family size ______

Land Ownership

[12] Number of pieces of land farmed __________

Piece 1

[13] Total area of land Farmed (rai) ____________

[14] Owned Rented Other [ ] ________________

[15] Rental Rate : In cash _________________ baht/rai
In kind __________________tang/rai

[16] Which do you receive water from : 1R 1L 2L 7L

[17] How many km away from the Mae Taeng main canal is your field turnout? ________km

What type of crop did you grow in the last dry season (1995)?

[18] Soybeans area _______rai

[19] Tobacco area _______rai

[20] Other area _______rai

Piece 2

[21] Total area of land Farmed (rai) ____________

[22] Owned Rented Other [ ] ________________

[23] Rental Rate : In cash _________________ baht/rai
In kind __________________tang/rai

[24] Which do you receive water from : 1R 1L 2L 7L

[25] How many km away from the Mae Taeng main canal is your field turnout? ________km

What type of crop did you grow in the last dry season (1995)?

[26] Soybeans area _______rai

[27] Tobacco area _______rai

[28] Other area _______rai

Part II: Production information (previous dry season's crop)

A Soybeans

[1] Variety ________________ [2] Amount of seeds _______

[3] Seed price ________________ [3a] Total cost of seeds ________________

Activity	Labour Type	Man days devoted to Activity	Cost (wages, lump sum payment, products price etc.)	
[4]Cut Straw	Family			
	Hired			
	Mower			
[5] Cover Straw	Family			
	Hired			
[6] Base	Family			
	Hired			
	Tractor			
[7] Bacteria	———	———————		
[8] Growing	Family			
	Hired			
[9] Mae Taeng water	Family			
	Hired			
[10] ground water	Family			
	Hired			
	Rented equipment			
	Fuel			
			Product cost	Labour cost
[11] Herbicide	Family			
	Hired			
[12] Insecticide/ Fungicide	Family			
	Hired			
[13] Fertilizer	Family			
	Hired			
[14] Cut	Family			
	Hired			
[15] Collect	Family			
	Hired			
[16] Thrash	Family			
	Hired			

[17] Output amount ____________ kg ___________ tang

[18] Who did you sell your output to? Cooperative store Village trader

[19] What price did you get? ______________baht / kg
______________baht / tang

[20] Did you receive enough water from the Mae Taeng project to produce your 1995 dry season crop? enough not enough almost none

[21] Did you receive enough water from the Mae Taeng project to produce your 1994 dry season crop? enough not enough almost none

B. Tobacco

[1] Amount of seeds ____________ [2] Seed Price _________ [2a] Total cost ___________

Activity	Labour Type	Man days devoted to Activity	Cost (wages, lump sum payment, products price etc.)	
[3] Seedling Prep	family			
	hired			
[4] Tractor	Time 1			
	Time 2			
[5] Base Prep	family			
	hired			
			Product cost	Labour Cost
[6] Chemical fertilizer	family			
	hired			
Manure	family			
	hired			
[7] Insecticide	family			
	hired			
[8] Growing	family			
	hired			
[9] Mae Taeng water	family			
	hired			
[10] Ground Water	family			
	hired			
	Rented Equipment			
	Fuel			
			Product cost	Labour Costs
[11]Insecticide	family			
	hired			
[12 Fertilizer	family			
	hired			
[13] Bedding	family			
	hired			
[14] Cut	family			
	hired			
[15] Collect	family			
	hired			

[

16] Output amount ___________kg

[17] Price ____________baht/kg

[18] Did you receive enough water from the Mae Taeng project to produce your 1995 dry season crop? enough not enough almost none

[19] Did you receive enough water from the Mae Taeng project to produce your 1994 dry season crop? enough not enough almost none

Part 3

[1.A]Are you told how many rai it will be possible to irrigate in the dry season?

yes no

[1.B]If yes, Did you receive enough water to irrigate the suggested number of rai?

yes no

[2]Do you think the water allocation is fair unfair

[3]How would you rate the zoneman's performance? 1 2 3 4 5

1=very poor 2=poor 3= adequate 4=good 5=very good

[4]How would you rate the headman's performance? 1 2 3 4 5

[5]Why do you think water supply is sometimes inadequate?

a. over-use of water in other sois

b. over-use of water by some soi 7 farmers

c. no reservoir

d. poor monitoring by officials

e. poor enforcement of rules by officials

f. inadequate maintenance

g. sedimentation of catchment area

h. supply is adequate

i. other (specify) ______________________________

[6]What do you pay for access to the water from soi 7?

In cash:______________________

In kind:______________________

[7.a] Currently water is delivered from the Mae Taeng canal to your lateral, you are asked to pay an access fee and to do maintenance twice a year for the upkeep of the system but water is free. If the RID was to implement a program which improved the distribution of water and could ensure that you receive a minimum level of water which would meet your crop water requirements; would you be willing to pay ____ baht / day of water supply in the dry season?

[7.b]If you are unwilling to pay, is it because

a. more water is not important to you

b. you cannot afford to pay for water

c. you do not think that you should be charged for water

d. other (specify) ____________________

[8] How did you finance last year's investment? a. savings b. loans c. both

[9] What was your income from the last crop year from your farm output?

[a.] Gross:______________

[b.] Net ______________

[10] What was your income last crop year from:

[a.]selling your labour? ______________________________

[b.]home production? ______________________________

[c.]renting out land? ______________________________

[11] What was your net profit last crop year from:

[a.]renting your tractor? ______________________________

[b.]curing tobacco? ______________________________