

PROBLEMS AND STRATEGIES IN MANAGEMENT OF COMMUNAL IRRIGATION SYSTEMS: THE EXPERIENCE IN JOINT DECISION-MAKING BY FARMERS AND AGENCIES

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INTRODUCTION

Several thousand communal irrigation systems co-exist with large-scale government-managed irrigation systems in northern Thailand. Due to a growing concern over the capabilities of local people to perform irrigation development, management-intensive strategies and the integration of farmers into the process of irrigation development have become the policy of the Thai government in the last few years. However, because many of those committed to a large bureaucracy with highly trained personnel do not believe that the interests of farmers and farmers' organizations should take precedence in development activities, the attempt to encourage farmers' participation has dwindled in practice, and projects which attempt to integrate farmers meet with minimal success. Although northern Thailand is widely known for its active communal irrigation organizations (CIO), there is no specific policy to link these existing groups formally into the government development schemes.

Research that describes farmer-managed irrigation systems is available. That knowledge, however, has had little impact on current irrigation projects in Thailand. There is a need to sensitize government to the potential of this research and encourage cooperation among all parties if rational change is to occur in irrigation management. Difficulties in transferring knowledge into practice lie primarily in a lack of effective communication among agency staff (policy makers and developers), researchers, and farmers.

This paper has three objectives. First, to describe CIOs in northern Thailand. Second, to present the problem-solving method used in meetings between agency staff, researchers, and farmers to identify problems and strategies. Third, to show how this method can help the government to involve and sustain farmer participation in irrigation management.

COMMUNAL IRRIGATION SYSTEMS IN THAILAND

To most researchers, and some planners, the presence of a CIO is a precondition for good management. Many researchers (Moerman 1968, Calavan 1974, Potter 1975, Ishii 1978, Surarek et al. 1980, Tanabe 1981, Sirivongs 1982, and Tan-Kim-Yong 1983) have described the structural arrangement and management of CIO's in northern Thailand.

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Over time, some CIOs have successfully incorporated changes and retained effective management, while others have not. The parameters involved in communal irrigation systems in northern Thailand are defined below.

System Description

Communal irrigation systems are diversion dams with canal networks primarily supporting rice farming, and vary greatly. The systems can be found in both highlands and lowlands ranging in area from less than 2 hectares (ha) to more than 2,400 ha. Farmers from one or many villages may cultivate irrigated land in a single system. The system is constructed, operated, and maintained collectively by farmer members. Because temporary structures are involved, one or two cycles of major maintenance are required every year. Although this appears a heavy investment, the system structure depends mostly on local labor, local materials, and simple techniques.

Organization

A CIO is an organization of farmers that shares as a single community the water provided by an irrigation system and manages its own investments and services. Within the organization an individual's water rights are guaranteed through customary laws. As a result, all farmers identify the irrigation system as their own, and this sense of ownership is important in promoting farmers' participation.

Administrative functions and membership. Farmers control the management of the scheme. A group of elected leaders takes responsibility for operation, maintenance, and managerial work such as planning, financing, and accounting. Members are able to take turns in leadership roles. Where the system draws direct payment from members for administrative services, performance is good and organizational power is maintained.¹

Managing activities. Managing and coordinating communal task forces for routine, emergency, and special projects are complex tasks involving the mobilization of groups of farmers. Communal task forces are generally organized at system and canal management levels and coordinated to fit the cultivation schedule of farmers. Regularizing such activities and involving farmers in group tasks reinforce the sense of collective ownership and group cohesiveness.

Planning and decision making. Participatory decision making is an integral element of communal irrigation systems. The democratic election of leaders plays a vital role in promoting members' commitment. Decisions regarding such problems as disputes and conflicts over water allocations during peak times are based entirely on mutual agreement among members within the CIO. Long-term rehabilitation plans are made when necessary.

Communication. Good management of CIOs requires effective communication between leaders and members, and among members. Seasonal meetings, home visits, and messenger announcements keep members informed of on going activities and future projects.

Finance. In most cases, CIOs manage water fee and fine collections, direct cost sharing, and other fund raising activities. Water fees help pay for administrative services while fines help cover routine maintenance costs. Because traditional irrigation systems primarily serve rice farming, a fixed rate per unit of cultivated land is commonly used. In areas of diversified cropping and where crops are grown intensively, the same water rate is used but farmers who grow rice pay in-kind and those who grow cash crops pay in cash. Additional funds for maintenance and rehabilitation are contributed by farmers.²

Legal action. CIO members exercise the authority of customary law when their leaders perform poorly in their jobs. When a leader fails in his duties, he has to pay a fine or face termination of office. Similarly, members are judged under customary law and fined for such offences as theft.

Payment to a leader. CIO leaders are not paid at fixed rates but at variable rates according to performance. Usually, each member pays directly to the leaders. If a farmer/member is dissatisfied with a leader's performance -- perhaps his cultivation fails because of a wrong decision on water delivery -- he may withhold his payment.

Skills and Knowledge in Management

Although farmers' acquired skills and traditional knowledge appear to be effective for operating simple irrigation systems, improved irrigation technology and new cropping techniques may require specialization that automatically eliminates the participation of most farmers.

IRRIGATION DEVELOPMENT AND CIOs

At present, irrigation development in northern Thailand is applied to management problems in: 1) large-scale irrigation systems; 2) small-scale, traditional irrigation systems; 3) system rehabilitations; and 4) upstream reservoirs.

Large-scale Irrigation Systems

Large-scale irrigation systems, which include the complete canal system and all major and minor services, are the government's responsibility. Activities, including design, implementation, distribution, and maintenance, are allocated to the national and regional offices of the Royal Irrigation Department (RID). Frequently the command area of a large-scale system includes irrigated land operated by several CIOs, and integration into such government-controlled systems often brings dramatic changes to irrigation groups accustomed to traditional operating methods. Unfortunately, in practice, the government irrigation administration often works without satisfactory participation from local farmers despite many new irrigation groups being formed to control water and share maintenance duties. Integrating farmers and supporting local irrigation groups is a critical management objective that the government should address.

Small-scale, Traditional Irrigation Systems

Development of small-scale traditional irrigation systems is carried out independently by local communities, and presently there are a large number of such systems operating. Identifying methods that develop local capabilities fully and encourage cooperation among farmers should be a serious concern of the government. Policy makers should ask how, when, and to what extent the government should intervene in traditional systems to promote these objectives.

In addition to small-scale systems constructed by local communities, the government has recently constructed several hundred small-scale irrigation systems that are presently operating in the north. The local communities are being encouraged to take responsibility for irrigation system operation and maintenance (O&M) after construction. Organizing beneficiaries into groups is an important step in achieving effective O&M. However, because concentrating a large number of new small-scale irrigation systems along a particular river or tributary increases population density, new problems involving inter-system relationships, water-user rights, and O&M responsibilities must be addressed.

System Rehabilitation

The government's rehabilitation of traditional communal irrigation systems aims to improve irrigation efficiency and management performance by changing designs or adding new structures to existing systems. In such cases, the existing communal groups continue their responsibilities for O&M. However, this can involve an adjustment or reorientation of activities within the communal groups and the government should be aware of this possibility.

Upstream Reservoirs

The last type of irrigation development consists of constructing upstream³ reservoirs without major changes in downstream system design. After completion, a small RID crew manages the reservoir while the CIOs manage the canal systems, thus keeping the government's intervention to a minimum. These rehabilitations aim to sustain wet-season irrigation capacities and to increase dry-season capacities.

THE MEETINGS

Strategies and methods that address irrigation management problems and serve different irrigation requirements need commitment and concerted action from three parties -- agency staff, researchers, and farmers. To meet these requirements, a series of meetings was held in Chiang Mai, northern Thailand.

The meetings provided an opportunity for the three parties to exchange experience and knowledge, and to integrate their ideas on "participatory action planning." One objective was to produce an action plan for developing small-scale irrigation in the communal

irrigation systems and government rehabilitation schemes in Chiang Mai and other areas of northern Thailand.

The first meeting was held in September 1985. There were several on-site workshops sessions where researchers worked with communal irrigation groups to investigate irrigation problems and strategies for solving those problems. An action plan for development activities and research gradually evolved from these sessions. Researchers and agency staff also went on field trips together. A final meeting, scheduled for April 1987 in Chiang Mai, will discuss and plan a research and development pilot project.

Objectives

The 1985 meetings had four major objectives:

- 1) To encourage interaction among participants to find alternative solutions to irrigation management problems in northern Thailand.
- 2) To suggest strategies and methodologies for improving irrigation management and applying relevant research to CIO activities.
- 3) To generate locally-relevant policy guidelines for government assistance programs and for cooperation with CIOs.
- 4) To develop closer collaboration between national and regional government irrigation agencies and university researchers.

Methods and Procedures

Preliminary consulting meeting. This was a brainstorming session among RID authorities, researchers from Chiang Mai University, developers from local non-governmental organizations (NGOs), regional committees of small-scale irrigation projects, and leaders and members of the *muang fai*^a CIOs (see Appendix 1). The meeting encouraged participants to define current problems and future needs of irrigation development. It emphasized the active participation of farmers or CIOs from five traditional irrigation systems of Chiang Mai. The participants identified possible means of integrating local capabilities into the irrigation development process and the need for research in this area.

Project design activities. Following the preliminary meeting, participants worked to design an activity plan for research, training, study tours, and researchers' consultancy services. In doing so, agency staff and farmers interacted and gradually gained confidence and commitment, while researchers facilitated and studied the process. Additionally, the field workshop sessions proved an efficient tool to improve problem-solving capabilities and to sensitize RID officials and researchers to local needs. This process strengthened linkages between the government and the CIOs, and built confidence in CIOs and their continuing involvement in management.

Workshop. The final stage was a workshop to discuss the draft of the proposed activity plan. The participants focused on launching a joint pilot project between Chiang Mai University and RID. Unfortunately, the pilot project was postponed due to changes in the government and RID management. Also, the pilot project has yet to be submitted to a donor agency. Post-meeting activities will encourage informal discussions to provide CIOs with access to available information as soon as possible, including contact with RID and the Provincial Committee on Small-scale Irrigation (PCSSI).

AN OBSERVATION ON ACTUAL INTERACTION AMONG THE THREE PARTIES

The farmers from CIOs initially expressed more interest in meeting RID authorities than vice versa. However, as the discussions progressed, this attitude changed. The interaction between farmers and RID authorities was more active during the first session. Farmers who had more experience in interacting with government authorities led discussions. However, in the second session interaction between the more- and less-experienced farmers increased: communication among those who shared similar interests and experience proved effective as a learning process.

RID authorities who were trained in engineering and confident in technical design raised questions about inappropriate irrigation management by local groups, while farmers who had confidence in the management-intensive systems of CIOs raised questions about technical errors. Thus there was a failure to understand the potentials and limitations of the other party, and the need for continuing interaction between farmers and RID officials was confirmed.

Some CIO leaders expressed misgivings about the government's development scheme. Less-experienced leaders tended to accept the need for development but requested more government assistance to construct technically advanced weirs similar to those of their neighbors. However, such government interventions require the involvement of CIOs if they are to succeed. The researchers maintained a low profile at the meetings and performed best as facilitators of the discussions.

GOVERNMENT'S STRATEGIES IN FIVE IRRIGATION DEVELOPMENT PROJECTS

Mae Taeng Project

Begun as early as 1955, the Mae Taeng Project was designed to boost multiple cropping in the Chiang Mai-Lampun Valley; construction was completed in 1973. The project has a large-scale diversion dam with a 75 kilometer (km) main canal, 23 secondary canals, and 38 tertiary canals, all with concrete lining. The total area irrigated is 24,000 ha. Almost 100 villages and several hundred communal irrigation systems lie within the command area. The project services the full command area during the wet season but about 40 percent in the dry season. The RID staff and project engineer administer the system down to the secondary canal level, and leave the tertiary and farm-level canals to the farmers.

Following project completion, government intervened to restructure some of the traditional irrigation groups. Because the farmers were not asked to participate in this process, the restructuring became a threat to both the existing leadership and the members. Despite conflicts among farmers and other problems, some success has been reported. In the new groups, leaders are elected and earn their income from water-users as in traditional systems. They are responsible for adjusting water supply to satisfy demand among the members of their group, and for mobilizing labor for maintenance.

Khun Kong Project

Khun Kong is one of 11 traditional irrigation systems on the Mae Wang River. The project covers about 1,280 ha and more than 10 villages. Evidence indicates several decades of irrigation development through communal effort with external assistance. Therefore, traditional weirs and canals have been rehabilitated over time. In recent decades, this area has become a highly intensive cropping region, with triple- and double-cropping commonly practiced. Increased cropping intensity results in a need for improved irrigation performance to achieve timely and equitable water distribution.

Government strategy has involved replacing traditional weirs with concrete weirs in several development schemes constructed by different government agencies. Complex inter-system management problems have caused tension and conflict among both upstream and downstream water-users during the dry season. Such situations demonstrate that complex problems are sometimes created by too many projects, too many agencies, and probably too much government intervention. To solve these problems, the government must focus on a management-intensive policy to strengthen CIOs and link them effectively with related agencies. In the Khun Kong Project, the management at all levels has been left to the CIOs.

Muang Mai Project

This project is one of four traditional irrigation schemes along the Mae Klang River. The Muang Mai Project covers 1,600 ha of cultivated land, with more than 10 villages. All weirs have been replaced by concrete weirs. Though expansion of irrigated land and cropping intensity have increased rapidly, Muang Mai's CIO has effectively performed the irrigation activities to sustain production. Leadership is good, and resources are efficiently mobilized for routine tasks and new development projects. So far, the system has a low record of disputes and conflict, and the CIO has been able to manage those that did occur.

Local farmers requested government assistance to construct the concrete weirs because of a shortage of local construction materials. After the weir was built, the CIO continued in full control at all levels. But problems of recurring silt required increasing maintenance. Whether this was a result of poor weir design or of inefficient O&M needs careful study. If evidence of poor O&M is found, it may be due to the farmers' inexperience with new irrigation technology.

Nong Plaman Project

This project is a small-scale traditional irrigation system covering 176 ha, and a single village. Weir construction was an initiative of local farmers and approved through the Sub-district Council under the national Job Creation Program⁶. Small-scale irrigation of all types is a priority of the program and, each year, several hundred weirs are constructed in villages. After construction, full control at all levels is left to the existing CIOs or the newly established water-users groups. Again, CIOs should be involved directly in planning and decision making of small-scale irrigation development.

Mae On Project

Mae On is a mini-basin RID reservoir construction project to solve the problem of water deficiency in existing communal irrigation systems. The project, when completed, will increase the dry season irrigation capacity of more than 10 small-scale systems on the Mae On River. The reservoir is designed to store water and divert it back to the natural river. In this way the project mainly provides more reliable and continuous water supply for the existing systems which will continue to be under CIO management.

Mae On is the most recent RID irrigation project in the north and direct intervention is minimized. However, when completed, there must be cooperation between RID staff who manage the reservoir and the CIOs along the river. This will be a new experience for CIOs. A CIO-RID linkage has to be developed in the early stages of the project. However, some difficulties are expected in coordinating three different RID teams -- survey and design, construction, and O&M -- and this may weaken the CIO-RID linkage without support from the RID extension service to promote post-project activities.

A SET OF PROBLEMS

The preliminary meeting pointed out the following management problems in the five different cases of irrigation development:

1. Construction is emphasized and management performance is given low priority.
2. Interaction between agencies and CIOs is not encouraged.
3. RID and implementing agency personnel have not yet recognized the local irrigation management capabilities of active CIOs.
4. The irrigation project staff generally encourages farmers' involvement only at the O&M stage and not during the planning and design stages.
5. There is insufficient government staff to help CIOs to solve recurring irrigation management problems.

6. Engineers believe many irrigation schemes involve only simple technology, but farmers find almost all new schemes to be technologically sophisticated.
7. Management becomes more complex as cropping intensity and diversification increase. In many cases such complexity is beyond the capabilities of CIOs.
8. Conflict and corruption among the water authorities and CIO leaders, and complex operations, may result from increasing the numbers of new members -- and especially if they are big land owners and upstream orchard operators.
9. Economic resources of farmers are overemphasized; farmers' knowledge and skill tend to be ignored. CIOs should be encouraged to improve opportunities for exchanging knowledge.
10. Assistance to weak and uncompetitive CIOs should aim to strengthen management capability and appropriate organizational arrangements.
11. Some inexperienced CIOs are unable to cope with the problems of inter-system cooperation to manage irrigation. In some cases, larger associations might attract more experienced farmers and manage water distribution better.
12. Many attempts to promote farmers' participation have been superficial. There is no formal channel for CIOs to communicate their problems and needs to agencies. Agencies do not understand CIOs and lack interest in them.

THE NEED FOR RESEARCH AND DEVELOPMENT

Research

- 1) *Irrigation development and its effects on the local irrigation community.* Research is needed to investigate the social, cultural, and ecological influences of large- and small-scale irrigation construction.
- 2) *Relationships among cropping intensity and diversification, irrigation management requirements, and irrigation performance.* The research should be carried out on farmers' fields in areas of highly intensive and diverse cropping. Operations under various actual management and decision making conditions should be studied.
- 3) *Identifying the factors that cause management deficiencies and successes among CIOs.* Knowing these factors will facilitate training of RID and CIO personnel, and strengthen irrigation performance.
- 4) *Irrigation bureaucracies and legal action.* The influence of these on organizational linkages between RID and CIOs needs to be better understood. Frequently, new irrigation projects introduce modern technology without consideration for traditional mechanisms. Departmentalization in the Thai administrative structure can retard this understanding.

5) Government intervention strategies. What should be the government's intervention strategy? When and to what extent should the government intervene in CIO activities?

6) Other research. Exploratory studies are needed on irrigation management schemes and management problems, and performance evaluations of pre-project and post-project activities. RID and CIO staff should take part in such studies together.

Training and Consultancies

Training activities and consultancy services should be emphasized to strengthen CIO and RID strategies. Farmer-to-farmer training is economically feasible and socially desirable. Also, mobile teams of professionals and consultancy services play an important role by supporting the exchange of information.

Public intervention in farmer-managed irrigation systems.

a) The government should minimize intervention in communal irrigation development and provide assistance through policies that are responsive to farmers' needs. This will provide an environment in which CIOs are able to work.

b) The government should attempt to involve CIOs directly in decision making regarding irrigation tasks through all stages of rehabilitation. Communication and feedback linkages between RID and the CIOs must be established. There is a need to have mobile teams of RID to organize and regularly schedule field workshops with CIOs.

c) RID should train CIO members so they will be familiar with the new technology for irrigation development.

d) An emphasis on a management-intensive system and a participatory irrigation development requires a new orientation and training for RID personnel. RID personnel should be trained and given knowledge and skills to work cooperatively with CIOs.

e) RID should have complete up-to-date information about CIOs and their irrigation systems, and work with CIOs to gather data, such as making an inventory of all watersheds, to facilitate decision making.

f) To avoid duplication and excessive effort among the 16 government agencies now involved in water resource development, a master plan for water resource and watershed development should be prepared.

g) Irrigation development planning should include a social science component. Local educational institutes can provide this component and have the resources to manage relevant research, training, and monitoring of irrigation development.

h) RID should emphasize problem-solving or rehabilitation of communal systems rather than creating new construction projects.

i) The problems of watershed destruction and resulting water shortages are critical in many areas of Thailand. Irrigation development must be integrated with forestry, watershed, and land development.

Strengthening CIOs

Four tools are suggested to strengthen CIOs, as well as to create an effective linkage between RID and local groups.

Policy and plan dialogue. This method allows agency personnel to exchange ideas on problems, strategies, and plans with local communal irrigators at various stages of development. This should be a continuing process and part of the regular activities of RID personnel at local levels. The method has a two-way effect: the agency is able to communicate government policy to the people, and in return they can communicate problems and ideas to the government for adjustment of future development policies and plans. The responsibility in this task should be with the mobile team. Through this method, linkages are strengthened and real participation is achieved.

Inventory. The recording of new developments and emerging problems in the systems can best be done by the CIOs because they are on-site. A CIO could obtain data and information through an inventory. The inventory has several advantages: a) it provides low-cost, efficient, up-to-date data; b) the method provides a continuous process of two-way communication; c) it will make farmers feel more confident and involved in the development process; d) it will integrate farmers' problems and ideas into the planning process; and e) it promotes a participatory attitude and strengthens the relationship between farmers and agencies. The inventory form, designed by university researchers before the project starts, must be simple and workable. Training CIO and agency staff to use the form correctly is necessary. Recording the inventory could be designed as a routine activity and the results could be kept at the CIO offices. Feedback to RID could be made when the mobile team visits the CIOs as part of the policy dialogue described above.

Community/leader network. The plan for irrigation development should motivate links among the CIOs. An attempt should be made to encourage meetings and visits to share ideas and promote self-help capabilities. Inter-CIO assistance should occur in two ways: first, the more-experienced CIOs can provide consultations to help the less-experienced CIOs solve specific urgent problems; second, the more-experienced CIOs can transfer their knowledge about problem-solving on modern technology, and management practices to the less-experienced groups in a regular program of assistance.

Federation of CIOs. It is evident that problems in irrigation are getting more complex as agricultural intensity increases and diversification is encouraged. Furthermore, increased population, more diverse agricultural activities, and natural resource scarcity and related

problems mean greater complexities in irrigation planning and problem-solving. Greater cooperation is needed among farmers, as well as between farmers and agencies.

CONCLUSION

The action plan described in this paper has been discussed with farmers and agencies (RID and many NGOs). It will be presented at the meeting in April 1987 to be discussed and developed further. Preparations for the final workshop are underway. After the meeting, the plan will be submitted to donor agencies which will be asked to consider funding the pilot project.

NOTES

¹However, communal irrigation schemes may eventually turn into a mixed control system of farmers and agencies when government intervenes. In contrast to CIOs, government agencies control major structures at system and canal levels and leave control at the tertiary level to farmers in all large-scale and some medium-scale irrigation systems. Medium-scale systems projects are those with costs of over 4 million baht (US\$152,497), and construction time of more than one year. (The exchange rate in 1987 was US\$1.00 = 26.23 baht).

²Because most farmer-managed irrigation schemes are management- and labor-intensive, they are appropriate for low cash-generating communities of rural farmers. Undoubtedly, where capital-intensive systems are introduced, water users have no incentive to participate and lack the ability to finance the system even partially.

³That is, upstream of small river basins to store and divert water back to the natural rivers which feed the existing irrigation systems.

⁴See Coward and Levine's paper in this volume for a discussion of the muang fai of northern Thailand.

⁵This was because the forest land surrounding the irrigated region was declared a national park.

⁶There are more than five government agencies involved with small-scale irrigation projects under the Job Creation Program. RID is responsible for roughly 30 percent. Besides this agency, private agencies, including NGOs and private contractors, are involved.

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APPENDIX 1. Communal irrigation system and government's rehabilitation scheme, Chiang Mai.

Communal irrigation system	Irrigated area (ha)	Government rehabilitation scheme*
<i>Mae Klang River</i>		
Huey Kang Bok Fai	400	
Fai Muang Mai	1600	RID ^a (1982)
Fai Muang Luang	1440	Sub-district Council ^b
Fai Mokala	320	RID
<i>Mae Rim River</i>		
Fai Mae Rim	n/a	
Fai Chao Pu	576	
Fai Huey Sai	424	
Fai Nong Plaman	176	RID (1985)
Fai Sai Moon	219	
<i>Mae Wang River</i>		
Fai Non	40	RID (1986)
Fai Nong Yen	2880	
Fai Huey Pueng	240	
Fai Khun Kong	1280	ARD ^c (1983)
Fai Na Sai	304	ARD
Fai Ta Kam Pa	576	
Fai Ta Sa	80	RID (1982)
Fai Don Pin	96	
Fai Sri Boon Rueng	136	RID (1982)
Fai Kam Pilo	80	
Fai Pu Loh	80	RID (1983)
<i>Mae On River</i>		
Pha Lad	60	
Pang Ma Takien	120	RID, (1980)

Appendix 1 (cont.)

Communal irrigation system	Irrigated area (ha)	Government rehabilitation scheme*
Pana Sak	42	
Mae Na Guen	72	
Hua Ta-ad	88	
Pha Plu	88	
Ko Kok	32	RID, (1979)
Fai Luang	92	ARD
Huey Sai	96	
Mae Len	112	
Ku Bia	400	RID, (1980)
Muang Ho	544	
Muang Pao	640	RID, (1980)
San Ko-ong	400	
Sai Mun	480	
Muang Luek	480	
Muang Pao	480	
Muang Mai	815	
Pa Pao	11	
Buak Kang	106	
Kao Lung	6	
Len Long Halao	3	
Sri Suk	3	
Phaya Kam	13	
Pha Tan	32	
Pha Kaem	48	
Nai Nuan	5	
Yai Pai	192	
Ton Bong	64	RID, (1983)

*All projects listed involved the construction of concrete weirs; n/a = not available; ^aRoyal Irrigation Department;

^b*Sapha tambon*; ^cOffice of Accelerated Rural Development.