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WATER CONTROL AND DEVELOPMENT IN THE CENTRAL PLAIN OF THAILAND

by

Leslie E. Small

Introduction

Water control has long been an element of Thai agriculture.[1] In the northern portion of the country, small village-operated irrigation systems are believed to have been in existence for over 600 years.[2] In the Central Plain, canal construction began at least 400 years ago, although most of the early canals were dug primarily for transportation.[3] Construction of the existing water control facilities in the Central Plain began about 1890, but the bulk of the construction has occurred since 1950.[4]

The largest of the projects in the Central Plain is that known as the Greater Chao Phya water control project, encompassing a total of 910,000 hectares. This is approximately 40 percent of the total area of all of the State water control projects, both existing and planned,

in Central Thailand.[5] In 1970 and 1971 I conducted research in the northern portion of the Greater Chao Phya project, to investigate questions concerning the success of this development project.[6]

Much has been written regarding the meaning of the term "development". Without denying the importance of the issues raised in these discussions, I prefer to avoid them in this paper. Most people would probably agree that the primary function of an agricultural water control system is to increase agricultural production. Increased agricultural production is, in turn, seen as one aspect of development. In this paper, I consider various questions dealing with the effectiveness of the water control system in increasing agricultural production. I am thus examining questions relating to one aspect of the complex phenomenon known as development. The construction and operation of water control systems involve other aspects of development as well, but an examination of them is beyond the scope of this paper.

Conceptual Framework

In a 1969 study, Jasper Ingersoll presented a conceptual framework to facilitate an examination of all aspects of the feasibility of a proposed water control project.[7] This framework is also useful for evaluating an existing water control system, and with some modifications, I will use it in discussing the achievements and problems of the Greater Chao Phya project.

Ingersoll identifies three "spheres" or systems which are involved in a water control project: physical, economic, and social. He defines the physical system as "a set of engineering structures in interaction with the natural resources of an environment."[8] The economic system is "an organization of agricultural effort in relation to material results,"[9] while the social system is defined as "an organization of people to achieve common goals."[10] Obviously these three systems are not independent, but interact with each other. Ingersoll describes this interaction as follows:

> If the physical system (water control) is ineffective, and the social system (social control) is ineffective, the economic system will not be profitable. Or, the less effective the physical system, the more capable the social system should be (but the less capable it is likely to be) to make the economic system profitable. An effective physical system does not depend on a profitable economic or an adequate social system; but a profitable economic system does depend on an effective physical system and an adequate social system; and an adequate social system does depend on an effective physical system and a profitable economic system. A successful irrigation project depends on all three systems functioning well.[11]

My only major disagreement with the above description concerns the statement that an effective physical system does not depend on the economic or social systems. I would argue that in the Greater Chao Phya project, certain problems in the social and economic systems have hindered the development of an effective physical system. This point is discussed more fully below.

In addition to the three systems identified by Ingersoll, I would add an agronomic system, defined as the interaction of the farmers' agricultural practices with the physical, chemical and biological factors impinging on plant growth. This system thus includes the interaction of cropping patterns with climatic factors (such as rainfall, light, and temperature), soil conditions, and insect and disease conditions. This agronomic system affects, and is affected by, each of the other three systems. The complex interactions of these four systems are illustrated schematically in Figure 1.

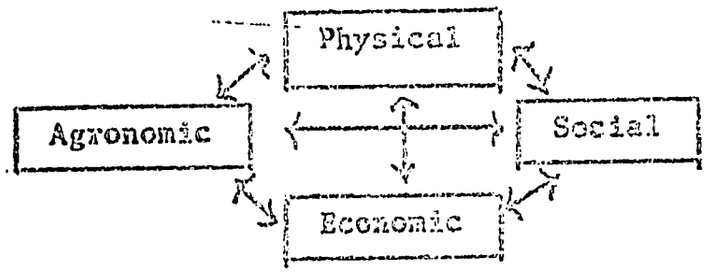

Figure 1. Schematic representation of the interactions of the four systems that affect the success of a water control project.

While all of the interactions indicated in Figure 1 exist within the Greater Chao Phya project, some are of greater importance than others. In particular, there are several physical and agronomic elements which have had a major impact on the economic system. In the following section, these elements of the physical and agronomic systems are first discussed. This

is followed by a discussion of the manner in which these factors affect the economic system. Finally, some of the interactions between these three systems and the social system are discussed.

Factors Affecting the Success of The Greater Chao Phya Project

Elements of the Physical System

There are two rather different situations requiring water control in the Central Plain. Wet season water control is needed (1) to prevent serious flooding and provide drainage of excess water from the fields; and (2) to provide supplemental water during periods when the natural supply of water (from rainfall and normal inundation) is inadequate. In the dry season, irrigation is necessary to provide most of the water required for crop production. Clearly, the physical water control facilities required for the two situations are not identical. The structures of the Greater Chao Phya project were designed primarily for wet season water control. Within the past decade, however, the physical system has undergone a gradual and partial transition toward one which would also support dry season production.[12]

The major physical facilities of the original system consisted of a diversion dam across the Chao Phya river at the northern tip of the Central Plain, and a network of primary

and secondary distribution canals. These facilities divert part of the water flowing in the Chao Phya river and distribute it over a large portion of the Central Plain. This distribution results in some reduction in local flooding, and also provides areas far from the river with supplemental water in periods when the natural supply would have been inadequate. As the system was originally constructed, effective water control generally ended at the points at which the water was discharged through the turnouts of the distribution canals. From these points of discharge, water flowed in a relatively uncontrolled fashion from one field to another. Individual farmers thus had relatively little ability to control either the timing or the volume of water deliveries.

Planners have long recognized the desirability of an additional network of smaller channels to carry the water closer to the individual farm fields.[13] But financial constraints led to a general governmental policy of placing responsibility for the construction and maintenance of these ditches on the farmers. Although this policy has been formally established in law,[14] very few ditches were ever dug by the farmers. Concerned that the lack of ditches was adversely affecting the success of the project, the government eventually decided to undertake the construction of a limited number of ditches. These were constructed in the 1960's under the Ditches and Dikes program. But the resulting network is still far from adequate to deliver water to the individual farms. And many of the ditches which the government dug do not function, either

because of deficiencies in the original construction, or because the farmers have failed to maintain them.

A second shortcoming of the physical system is its inability to remove excess water from the fields. The original system did not include a network of drainage canals, although plans exist to provide a skeletal network of such canals, and some construction has been undertaken in recent years. But even following the completion of those canals, approximately 50 percent of the project area will continue to flood to depths of from one to three meters for a period of several months during the wet season. The discharge capacity of the existing river system is inadequate to handle the increased volume of water that would result if the area were drained, and the provision of additional discharge capacity would be prohibitively expensive.[15] Drainage of this area will thus remain an impossibility for the forseeable future.

A third limitation of the physical system concerns the amount of water which can be made available for dry season irrigation. The original system, which had no facilities for the storage of water, was only able to provide as much water as could be diverted from the main river during the dry season. Considering the very low volume of flow in the river during this portion of the year, and the competing claims on this flow for purposes of navigation and control of salt water intrusion, very little water was made available for dry season irrigation. Storage of water first became possible following the completion in 1964 of the Bhumiphol dam on one of the major tributaries of

the Chao Phya river. Although this did result in some increase in the volume of dry season flow in the Chao Phya, the dam has been operated primarily for the production of electric power, and only secondarily for irrigation. Furthermore, dry season releases of water have been considerably below the amounts originally anticipated.[16] The quantity of water available for dry season irrigation has thus remained very limited.[17]

The fourth major limitation of the physical system concerns its capacity to deliver water in the dry season. The project was designed to deliver water during the wet season, when a large volume of water moves through the canals. With the much smaller flows that occur during the dry season, it is not always possible for the water to be delivered by gravity. A survey conducted by the Royal Irrigation Department in 1971 suggested that only about 11 percent of the area in the northern portion of the Greater Chao Phya project could be served by gravity distribution during the dry season.[18]

Elements of the Agronomic System

Throughout the project area, the dominant cropping pattern is that of a single crop of lowland rice produced during the wet season. In part, this cropping pattern has emerged in response to the natural hydrologic and soil conditions of the project area, which are distinctly unfavorable for the production of most crops, with the notable exception of rice. But even for rice, natural conditions are not entirely favorable. In particular, because of the annual variation in the amount of rainfall and in the timing and extent of the flooding, serious crop fail-

ures were frequently encountered prior to the construction of the project. One of the major reasons for the initial efforts to develop water control facilities in the project area was the desire to "stabilize" crop production, i.e., to reduce the serious crop failures that occurred in years when natural water conditions were not favorable.[19] It appears that the project has been quite successful in achieving this goal. My analysis of time series production data for the project area indicates that the improvement of water conditions has substantially increased rice production by reducing the frequency and severity of crop damage caused by unfavorable water conditions.[20] Thus the physical system has brought about a change in the agronomic system that has led to a substantial increase in agricultural production.

But the agronomic system also places some serious limitations on the extent to which further increases in agricultural production can be brought about by the water control project. Probably the most important of these limitations concerns the nature of the soils of the project area. Most of the project consists of heavy clay soils, which are typical of the alluvial soils found in large deltaic areas.[21] While these soils are quite suitable for rice production, they are generally much less suitable for most other types of crops. In a recent land suitability classification, less than two percent of the area was classified as most suitable for irrigated upland crops,[22] while over three-fourths of the area was classified completely unsuitable for irrigated production of upland crops.[23] And

experimental work which has been conducted to date demonstrates that even on land classified as satisfactory for irrigated upland crops, the successful production of such crops requires very careful water control and management at the farm level.[24]

Another potential limitation related to soil conditions concerns the effects of growing two crops of wet rice per year. Such a cropping pattern subjects the soil to a submerged environment for much longer periods of time, and does not permit the soil to become thoroughly dry at any time during the year. Over a period of years, this may result in detrimental effects to the soil. Without further research, it is impossible to state whether or not continuous double cropping of rice on the soils of the project area is feasible.[25]

There are several other agronomic factors which currently limit the possibilities of dry season crop production. Weeds have been found to be a serious problem in growing upland crops in the dry season. And there is still inadequate knowledge concerning the best cultural practices for producing many upland crops under farm conditions in the project area. Some rather unsuccessful efforts to demonstrate upland crop production in pilot areas can be attributed in part to this lack of knowledge.[26] It is reasonable to expect that many of these problems will be overcome as more knowledge is gained from experimentation.

One major modification of the agronomic system which has taken place within the past decade has been brought about by the development of several varieties of rice which are highly responsive to fertilizer, and which are not sensitive to the length

of day. These characteristics give these varieties the potential to produce high yields in both the wet and dry seasons. These new varieties are most successfully produced under conditions of good water control. But the agronomic system of the Greater Chao Phya project places rather severe limitations on the extent to which these varieties can be grown in the wet season. All of the new varieties are relatively short, yielding the best results under conditions where the depth of water standing on the field is quite shallow--probably under 15 centimeters, and perhaps not more than 5 centimeters.[27] But under the existing hydrologic conditions in the project area, it is generally not possible to limit the depth of water to this amount. On the basis of the very limited data which are available, I have estimated that not more than 10 percent, and probably only about 5 percent of the project area has water conditions which are satisfactory for the production of these varieties.[28]

From this discussion, one could conclude that wet season production is limited by an inadequate physical system. On the other hand, the development of new varieties of rice which would produce high yields under conditions of considerably greater depths of water would also remove this limitation on production. Plant breeders in Thailand are currently working on this problem. There is thus a possibility that developments in the agronomic system could alter the requirements for the physical system.

Impact of the Physical and Agronomic Systems on the Economic System

Independent farmers will not engage for very long in a type of agricultural production which is unprofitable. Thus profitability is a necessary (but not a sufficient) condition for a water control system to result in increased agricultural production. Clearly, the physical and agronomic factors discussed in the preceding sections affect the profitability of production. In this section these interactions between the economic system on the one hand, and the physical and agronomic systems on the other, are explored.

It has already been noted that the primary effect of the water control system on agricultural production was to reduce the frequency and extent of wet season crop damage. This has substantially increased net farm incomes. I have estimated that the project has resulted in about a 25 percent increase in net farm incomes stemming from crop production.[29] Nearly all of this increase in income resulted from the improvement of water conditions in the wet season. But while the improved water conditions were thus economically beneficial to the individual farmers, the system did not significantly increase their ability to control the volume of water arriving on their fields, or the timing of its arrival. Farmers were thus generally able to reap the wet season benefits of the water control project without changing their agricultural practices.

One exception to this statement concerns the farmers' methods of planting rice. The water control project appears to have stimulated a large shift from planting rice by broadcasting the seed directly on the fields to planting by transplanting young seedlings. Although broadcasting requires much less labor than transplanting, farmers exhibit a definite preference for the latter method whenever water conditions make it feasible.[30] The reasons for this preference appear to lie partly in the farmers' belief that they will obtain higher yields if they transplant the crop, and partly in their feeling that production is less risky when the crop is planted by transplanting. In parts of the project, the water control system provided the conditions necessary to make transplanting feasible. Time series production data suggest that as a result of the project, the method of planting changed on about 15 percent of the project area.[31]

A second exception to the statement that farmers were able to receive the wet season benefits of the project without changing their agricultural practices relates to the use of the new varieties of rice, which were beginning to become available in 1970. In areas where the project provided adequate water control, farmers could receive additional wet season benefits by switching to the production of these new varieties. Although as yet there are very few farm-level data available on yields and costs of production, the broad outlines of the econo-

mics of the production of these varieties seem clear. Based on data from one study, it appears that farmers are obtaining yields which are, on the average, 30 percent higher than the yields of the local varieties.[32] Costs of production of the new varieties appear to be comparable to the costs incurred in the production of the local varieties, with the exception of the expenditures for fertilizer, which are considerably higher for the new varieties. Little difference in the total labor requirements seem to exist, as the additional labor needed to handle the larger volume of rice which is harvested appears to be approximately offset by the greater ease of harvesting the shorter varieties. Based on these yield and cost estimates, the marginal return resulting from a change to the new varieties would be on the order of three or four times the marginal cost.

It thus appears that the combination of the new varieties and good water control results in economic conditions which provide a strong incentive to change to the production of these varieties. The rapidity with which the production of these varieties has spread in one portion of the Greater Chao Phya project suggests that farmers have responded to this incentive. The fact that the production of these varieties has not spread throughout the project appears to be a result of the limitations of the physical system. As noted in the previous section, the existing high yielding varieties cannot be grown in much of the project area without improved water control to permit the removal of excess water from the fields.

In sharp contrast to the situation concerning the wet season economic benefits of the water control project, the achievement of economic benefits in the dry season requires the active response of the farmers. Traditionally, very little crop production has taken place in the dry season, with most of the land lying idle during the dry months. And in spite of a substantial increase in the amount of dry season production in the past few years, the total amount remains very small. For the 1971 dry season, I estimate that the water control system has resulted in dry season production of crops on only about two percent of the area which is planted in the wet season.[35] The failure of dry season production to expand more rapidly has led to considerable dissatisfaction with the project, and to many questions concerning the reasons for the apparent lack of farmer response to the water control system. An understanding of the economic system, as affected by the physical and agronomic systems, helps to answer these questions.

In the aggregate, economic benefits from dry season irrigation are limited by the nature of the physical system. As previously noted, the system has not been able to provide enough water to permit irrigation of the entire area. And while the amount of water available for dry season irrigation should increase substantially as a result of the operation of the Sirikit dam and reservoir, it will still be impossible to irrigate more than a portion of the project area. But regardless of the amount of water available, the system is not capable of handling the volume of water which would be necessary to crop the entire area. This

is a direct result of the fact that the system was designed for use in the wet season, when a substantial portion of the total water requirement comes from rainfall. From the estimates which have been made, it seems unrealistic to consider that more than about half of the area could be irrigated in the dry season.[34]

But officials of the Royal Irrigation Department frequently point out that while these aggregate limitations exist, farmers have not fully utilized even the small amount of water available. From the perspective of these officials, the appropriate question is why individual farmers have not utilized a resource which has been provided to them, free of charge. Underlying this question is the belief that enough water is available so that for an individual farmer who decides to engage in dry season production, yields would not be limited by inadequate water. It is thus appropriate to consider the economics of the production of alternative crops, under the assumption that water is not a limiting factor on yields. Unfortunately very few farm production data are available, so that this discussion must be considered only tentative in nature.

Considering the area of dry season production which is dependent on irrigation water provided by the water control system, 75 percent is planted to rice; therefore, the economics of the production of this crop is considered first. Compared with the wet season, production of rice in the dry season is

more costly. Dry season production thus requires a larger cash outlay by the farmer, which increases his financial risk. The additional costs are mainly for fertilizer and for the use of small pumps. Farmers feel that more fertilization is needed under a system of double cropping. The need for pumps stems from the fact that even though adequate water may be available in the canals or ditches, throughout much of the project area, gravity delivery of the water to the fields is not possible.

There are two important implications of this higher cost of production. First, profitability will be less than in the wet season unless considerably higher yields can be achieved. It appears that in general, only with the use of the new high yielding varieties of rice can the profitability of dry season rice production be expected to be comparable with that of wet season production. Significantly, dry season rice production has increased very rapidly since 1970, when the seed of the new varieties began to become available. Survey data indicate that <u>in general, only</u> these new varieties are grown in the dry season.[38] The second implication of the higher cost of production is that the profitability of dry season production is considerably more sensitive to changes in the price of rice than is the profitability of wet season production. Since the price of rice in Thailand has, for many years, been strongly influenced by government policy, the possibility exists that the government could actively promote or discourage dry season rice production through its price policies.

No simple statement can be made regarding the economics of upland crop production, because of the number and diversity of crops included in this category. Some crops appear highly profitable, with the profits per hectare several times that of rice. But these are mostly speciality crops for which there is a very limited demand. Vegetable production, for example, appears highly profitable. Traditionally vegetable production has been in small, hand-irrigated garden plots around the houses of the farmers. The vegetables are either consumed on the farm, or marketed in a local market. Any substantial increase in production would probably glut these local markets, causing a very sharp decline in prices. Time series data do not indicate that the water control system has had any significant effect on the production of vegetables. Another speciality crop which generally appears quite profitable is watermelons. Unlike the situation with vegetables, watermelon production has been stimulated by the water control system. Production rose from virtually nothing in 1966 to about 4,500 hectares in 1970. Even though the watermelons are marketed outside the project area, the 1970 production glutted the market, causing a sharp decline in prices. The following year, less than 1,000 hectares were planted. Thus for both watermelons and vegetables, dry season production appears to be rather severely limited by the size and nature of the market.[36]

There has been little farm experience with other upland crops, such as peanuts and soybeans. Some demonstration work, especially with soybeans, has shown that profitable production is possible under some circumstances. But the profitability depends heavily on the yields obtained, and as indicated in the discussion of the agronomic system, there are some serious technical problems which have frequently resulted in quite low yields. Some of these problems will undoubtedly be resolved as more experience is gained in the production of these crops under the conditions prevailing in the project area. But perhaps the major obstacle to obtaining yields high enough to make production profitable to the farmer is the nature of the soils of the project area. On those soils where irrigated production of crops such as soybeans and peanuts is possible, very careful control and management of the water are required at the farm level. Experimental evidence suggests that the land should be levelled considerably more precisely than can be done by a farmer using his own equipment, and that the crops should be furrow-irrigated. If this is not done, the likely result is a crop suffering from inadequate water on the higher portions of a field, and from waterlogging in the lower parts. With the exception of a few pilot areas that have been developed to test the feasibility of this approach to land levelling and water management, the physical and agronomic systems in the project area do not provide these conditions. As a result, the profit-

ability of upland crop production is likely to be less than would be suggested by the data obtained under experimental conditions.

Thus far the discussion of the economics of irrigated crop production in the dry season has been based on the assumption that yields are not limited by the amount of water available. This assumption was based on the observation of the officials of the Royal Irrigation Department that farmers do not make use of all of the water which is available in the dry season. But farmers have a different perspective on this matter. If a farmer is asked why he does not grow crops in the dry season, he frequently answers by saying that there is not enough water. If the question is asked in the dry season, the farmer may attempt to support his claim by showing his questioner a ditch or canal which is dry or in which the water level is too low to permit water to be delivered to his farm. If the farmers are correct in their claim that they are unable to obtain adequate water for dry season crop production, then the profitability of such production would be less than indicated in the above discussion.

In light of these apparently conflicting claims, the question of the adequacy of water might appear to be an empirical question which could be answered fairly easily. I would suggest, however, that this is not the case, and that in effect the government officials and the farmers are both right (or both wrong, depending on how one wishes to view the problem) in their claims

regarding the adequacy of water. The reason for this lies in the fact that the amount of water which is adequate for the production of a crop depends not only on physiological and climatological variables, but also on the efficiency with which it is possible to utilize the water. This efficiency is determined by the degree of water control, and by the level of skills in water management, both within the water control system and on the individual farm.

This point can best be illustrated by the use of a diagram which was developed by Gilbert Levine, an agricultural engineer at Cornell University.[37] The diagram (figure 2) shows the relationship between the amount of water required to produce a rice crop and the degree of water control which has been achieved. The amount of water required is indicated on the vertical axis, while inputs reflecting the degree of water control are measured, at least qualitatively, on the horizontal axis. The diagram indicates that with poor water control, the amount of water required to produce a crop will be quite large. Improvements in water control (either at the system level or at the farm level) can reduce this requirement toward some minimum which is determined by the physiological requirements of the plants in relation to the climatic and soil conditions under which they are grown.

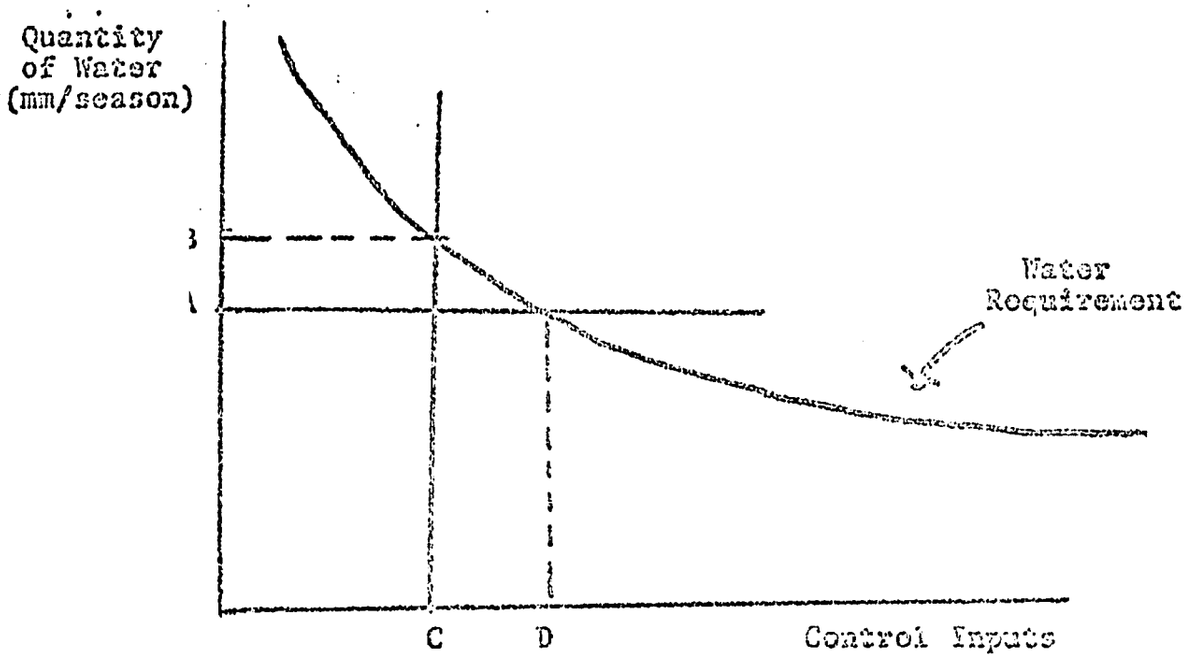

Figure 2

Relationship between the quantity of water required for the production of one rice crop and the degree of water control.

The difference in viewpoints between the officials of the Royal Irrigation Department and the farmers can now be indicated schematically on this diagram. Assume that the amount of water available to the system in the dry season is OA. Based on experimental data, the irrigation officials state that this amount of water is adequate to produce a crop. But this statement implies that the water control inputs are at the level indicated by OD. On the other hand, the farmer, who is operating with less effective water control (OC) finds that he needs OB of water to produce a crop. From the farmer's point of view, the volume of water available is inadequate by the amount AB. From the irrigation engineer's point of view, there is a control "gap" (CD) which is caused by poor management of the water at the farm level. Thus it is common for irrigation officials to note that farmers have not yet learned how to utilize irrigation water effectively, and that they tend to "waste" water.

From an economic viewpoint, however, it makes little difference whether the problem is considered to be one of inadequate water, or one of inadequate skills in the utilization of the water. In either case, it must be concluded that under the existing physical and agronomic systems, the profitability of dry season cropping has been limited by the availability of water to the plants.

The removal of this limitation could be accomplished by any one of three alternative approaches, or by some combination of the three. One approach would be to increase the quantity of water made available to the farmers. The additional water

might be obtained by limiting the size of the area served in the dry season, or by increasing the volume of water flowing into the system. A second approach would be to improve the degree of water control by improving the delivery and drainage systems. With greater control of the water as it moves to the individual farms, it would be possible for the farmer to receive a larger proportion of the water flowing into the system. The third alternative would be to improve the level of water management on individual farms. This might be achieved by levelling the land; constructing more on-farm water control facilities; and increasing the knowledge and capabilities of the farmers regarding the management of irrigation water in the dry season.

It is likely that in the Greater Chao Phya project, elements of all three approaches will be followed. The operation of the Sirikit reservoir should soon result in a substantial increase in the volume of water flowing into the system. Some improvements in the physical system, such as the construction of drainage canals, are underway. Other improvements, such as the construction of additional check structures in the distribution canals, are being planned. And in a few pilot areas, work is being done at the farm level to improve the farmer's ability to control and manage the water which he receives. All of these policies should help to increase the profitability of dry season cropping by removing the existing limitations related to the availability of water.

Interactions with the Social System

It appears that the social system which exists in the Greater Chao Phya area is inadequate for supporting a water control project. Officials of the Royal Irrigation Department commonly note that the success of the Greater Chao Phya project has been limited by the lack of cooperation of the farmers. In a 1969 study, Rose Frutchey identified a number of social norms which appeared to be important to the success of a small irrigation project in northern Thailand. After a brief period of observation in a portion of the Greater Chao Phya project, she noted that these norms had not become well established among farmers of that project.[38] It is not my purpose to attempt to fully explain the reasons for the failure of a more adequate social system to develop. Rather, I will attempt in this section first to note some of the effects that the inadequate social system has had on the other systems, and then to identify some of the factors in the other systems which may increase the difficulty of developing a more adequate social system.

One of the norms which Frutchey identified was that all farmers should be responsible for the maintenance of the canals in direct proportion to the area served.[39] In the absence of this norm, farmers in the Greater Chao Phya project have generally neither dug the small ditches needed to control the flow of the water from the canals of the projects to the individual plots of land, nor maintained those ditches which were eventually dug by the Royal Irrigation Department. Another norm identified by Frutchey was that everyone should be responsible for the pre-

vention of damage to the system.[40] But farmers in the Greater Chao Phya project frequently engage in actions (such as permitting their water buffalo to go up and down the banks of the distribution canals) which cause damage to the system. It seems clear that one of the consequences of an inadequate social system has been a less effective physical system. Thus in contrast to Ingersoll's statement quoted previously, the effectiveness of the physical system does depend in part on the adequacy of the social system.

By reducing the effectiveness of the physical system, an inadequate social system also reduces the profitability of the economic system. The lack of ditches has probably reduced the wet season economic benefits of the system somewhat, although it is very difficult to quantify the magnitude of this reduction. The economic consequences are more obvious in the dry season, since the lack of ditches may make it very difficult or impossible for many farmers to obtain the water that would be necessary for the successful production of a crop.

But while an inadequate social system has adversely affected other systems, there are also elements in these other systems which have at least contributed to the difficulties of establishing an adequate social system. The original physical system was designed to cause only minor modifications in the agronomic system. Although this was probably a very sensible approach, it has caused the individual farmer to be unable to clearly identify the effects of the water control project. Water still arrives

on his farm in much the same way that it did prior to the construction of the project. Now, as then, he has very little control over either the timing or the amount of water which he receives. I suggest that under such conditions, it is likely to be harder to develop a feeling of responsibility among the farmers for the maintenance of the system than in a situation where the physical system has resulted in a more pronounced change in the agronomic system.

A related consideration involves the operation of the physical system. With a small system such as that in northern Thailand, it is possible for the operation to be controlled at a local level. But with a large system, operating decisions must become somewhat more centralized, since some decisions will affect a very large area. Many of the important decisions affecting the operation of the Greater Chao Phya project are made in Bangkok. It appears that farmers have very little input into the process by which operating decisions are made. It has been reported, for example, that in some cases farmers have planted dry season crops, only to have them die for lack of water after a decision was made to close a canal for repairs. If the farmers see the system as one operated on the basis of arbitrary decisions over which they have no influence, it will probably be more difficult to obtain their active cooperation in the maintenance of the project. This suggests that attention might be given to the possibilities of some decentralization in the operation of the Greater Phya project in order to permit

greater participation by farmers, and thus to stimulate the development of a more adequate social system.

The economic system also affects the development of the social system. Obtaining the participation of the farmers in the construction and maintenance of the ditches will almost certainly be very difficult if the ditches do not result in increased returns to the farmers. It is possible to identify several situations existing in the Greater Chao Phya project in which the construction or maintenance of ditches is unprofitable to the individual farmer. Given the lack of control over the water once it leaves the main canals of the system, a farmer close to one of these canals may find that a ditch simply facilitates the flow of water off from his fields and onto lower fields. To him, the ditch provides no economic benefit, and may result in an economic loss. And while a functioning ditch might be economically beneficial to farmers with land further from the canal, it will serve no useful purpose to maintain their portion of the ditch if the head of the ditch is not maintained. Maintenance of ditches would also be unprofitable in those cases where the ditches are unable to function due to faulty construction. Finally, there are large portions of the project area which flood deeply every year. In these areas, it is doubtful that ditches serve any useful purpose. Significantly, it is in these areas that maintenance of the ditches appears to be the poorest. The economic value of the ditches is likely to be greatest in those areas where dry season production is possible. Not surprisingly, maintenance appears to have been best in the

northwest portion of the project, which has long had priority on the water available in the dry season, and which is where most of the existing production of irrigated dry season crops takes place.

Conclusions

In spite of the criticisms which have frequently been directed at it, the Greater Chao Phya water control project has resulted in substantial economic benefits. Farm income in the project area has increased significantly as a result of the project. And at the national level, I have estimated that the internal rate of return on the investment in the project is on the order of from 6 to 9 percent. But most of the benefits have occurred during the wet season, while most of the criticisms of the project center on the low level of dry season benefits. Considering the nature of the physical and agronomic systems, it seems that much of this criticism has been based on unrealistic expectations regarding the capabilities of the system. While critics have sometimes suggested that the problem is one of the lack of farmer initiative to respond to the opportunities presented by the system, it is clear that there are many other factors which would limit the response of even the most innovative of farmers. Current experience in pilot areas is demonstrating that many of these limitations can be overcome only at considerable expense.

While the prospects for the future depend to a considerable degree on the kinds of additional investments made to improve the physical system, three points can be made. First, the improvement of the physical system to permit control of water to the individual farm is very costly, and probably cannot be successfully carried out unless greater participation of the farmers can be obtained. The need for an improved social system is great. Second, given present technology, the existing physical system seems unlikely to be able to support any large additional increase in wet season production. Only with improved drainage can the technology of the "Green Revolution" be applied to much of the project area. But the development of high yielding varieties which could produce well under conditions of relatively deep water could dramatically alter this situation. Developments in plant breeding may thus determine in part the nature of the improvements needed in the physical system. Finally, it appears that improvements designed to promote dry season production are much more likely to increase the production of rice than of upland crops. While some of the existing limitations on upland crop production can probably be removed by additional experimentation, the major limitation appears to be the nature of the soils in the project area. Major additional investments designed solely for the purpose of increasing the production of upland crops in the project area would probably not be economically justified.

FOOTNOTES

[1]The term "water control" is defined to include irrigation, drainage, and flood control. It is intended to be roughly equivalent to the Thai term "chonlaprathan". Although the word "irrigation" is a common translation for this Thai term, the broader term "water control" more accurately reflects the meaning given to the term by the Thai government. See Thailand, Royal Irrigation Department, "Royal Irrigation Department" (Bangkok, September 1970), p. 1.

[2]O. W. Israelsen and J. B. Smith, eds. Irrigation and Drainage Practices, Progress, and Problems in [illegible], Thailand and West Pakistan. (SEATO Graduate School of Engineering, Bangkok, 1965), p. 112.

[3]Robert V. Hubbard, "The Canals of the Chao Phraya River Delta in Thailand." (MA thesis, University of Michigan, 1969 (?), draft), pp. 2, 17-18.

[4]For a fuller discussion of the development of the water control facilities, see Leslie E. Small, "Historical Development of the Greater Chao Phya Water Control Project: An Economic Perspective," Journal of the Siam Society, January, 1973.

[5]Thailand, Royal Irrigation Department, op. cit.

[6]The northern portion of the Greater Chao Phya project (hereafter referred to as the "project area") consists of 660,000 hectares divided into the following 16 subprojects: Pholathep, Tha Bot, Sam Chuk, Sam Chuk Extension, Pho Phraya, Boromethat, Channasut, Yang Mani, Phak Hai, Maharat, Noi-Maharat Extension, Manorom, Chong Khao, Khok Krathiam, Roong Rang, and Nakhon Luang. Nearly all of water control facilities which have been constructed are in this area.

[7]Jasper Ingersoll, "The Social Feasibility of Pa Mong Irrigation: Requirements and Realities." (Report to the U.S. Bureau of Reclamation and the U.S. Agency for International Development, July, 1969, mimeo), Chapter 1.

[8]Ibid., p. 2.

[9]Ibid., p. 3.

[10] Ibid.

[11] Ibid., pp. 8-9

[12] See Small, op. cit., for a fuller discussion of these developments.

[13] See J. Homan van der Heide, "General Report on Irrigation and Drainage in the Lower Menam Valley" (Report to the Ministry of Agriculture, Kingdom of Siam, Bangkok, 1903) and Thailand, Royal Irrigation Department, "Project Estimate for Works of Irrigation, Drainage and Navigation to Develop the Plain of Central Siam" (Ministry of Lands and Agriculture, Bangkok, 1915, 4 vol.), vol. 3, p. 4.

[14] Thailand, "The Field Dykes and Ditches Act, B. E. 2482," in Laws Concerning Irrigation. (Published by Royal Irrigation Department, Bangkok (?), second edition, 1960), pp. 28-28.

[15] Thailand, Royal Irrigation Department, Northern Chao Phya Study. (Report prepared by Netherlands Engineering Consultants, The Hague, 1970, 3 vol.), vol. 3, pp. 134-138.

[16] See United States Bureau of Reclamation, Report on Yanhee Project, Thailand, for Power, Flood Control, and Irrigation. (Prepared for the Royal Irrigation Department of Thailand, n.p., 1955, 2 vol.), vol. 1, p. 49; Thailand, Royal Irrigation Department, "General Information on Dry Cropping of Greater Chao Phya Project and Petchburi Project Areas in 1969-1970." (mimeo, n.d.); and Thailand, Royal Irrigation Department, "General Information on Dry Cropping Greater Chao Phya Project and Petchburi Project for 1970-1971." (mimeo, n.d.).

[17] A second upstream storage dam, the Sirikit, is about to go into operation. It is anticipated that the operation of this dam will provide a much larger volume of water for dry season irrigation in the project area.

[18] Thailand, Royal Irrigation Department, unpublished data on areas that can be irrigated by gravity, provided by the Irrigation Agronomy Section, 1971.

[19] See Small, op. cit., for a more detailed discussion of the meaning of the term "stabilization."

[20] Leslie E. Small, "An Economic Evaluation of Water Control in the Northern Region of the Greater Chao Phya Project of Thailand," Bangkok Bank Monthly Review, Vol. 13, No. 9 (September 1972), pp. 397-407.

[21]For a discussion of the soils in the project area, see F. R. Moormann and S. Rojanasoonthon, "Soils of Thailand," (Thailand, Department of Land Development, Soil Survey Reports No. 72), 1968; and also Thailand, Department of Land Development, Soil Survey Reports No. 37, 39, 40, 53, 54, 57, 61, and 69.

[22]The term "upland crops" is used to refer to all crops other than rice.

[23]Thailand, Royal Irrigation Department, "Chao Phraya Project Land Classification Feasibility Report." (Prepared by Clarence C. Burnham and Somthob Sonawongse, Bangkok, 1970, mimeo).

[24]Philip Judd, "Irrigated Agriculture in the Central Plain of Thailand." (Paper presented at the Seminar on Contemporary Thailand, Australian National University, 6-9 September, 1971).

[25]Food and Agriculture Organization of the United Nations, "Water and Soil Resources Development for Continuous Cropping in Tropical Coastal Areas in Asia." (Prepared by B. D. van't Woudt for the Second Symposium on Development of Deltaic Areas, Tokyo, November 1969, n.p., n.d.), p. 84.

[26]See, for example, Thailand, Royal Irrigation Department, "Report on the Growing of Some Field Crops Under Furrow Irrigation During the Dry Season in 1970 in the Chanasutr Land Consolidation Project." (Prepared by Netherlands Engineering Consultants, August 1970, mimeo).

[27]University of the Philippines, College of Agriculture, Rice Production Manual. (Compiled in cooperation with the International Rice Research Institute, Revised edition, 1970), pp. 89-95; 361-363.

[28]Leslie E. Small, "An Economic Evaluation of Water Control in the Northern Region of the Greater Chao Phya Project of Thailand." (Cornell University, Ph.D. thesis, 1972), pp. 269-272, (hereafter referred to as "An Economic Evaluation").

[29]Ibid., pp. 225-228.

[30]Farmers do not generally consider transplanting to be feasible if the rice is subject to deep flooding, or if a very rapid rise in the depth of the water standing on the field is expected. Inadequate water for field preparation may also make transplanting difficult or impossible.

[31] See "An Economic Evaluation," pp. 175-185.

[32] William R. Burton and Tongruay Chungtes, "Preliminary Observations on the Production of New High Yielding Rice Varieties and Traditional Rice Varieties in Suphan Buri, Thailand." (Cornell University, Department of Agricultural Economics, Occasional Paper No. 52, February 1972), p. 4. Considering the potential yields of these varieties, as demonstrated on experimental plots, this figure of 30 percent may seem surprisingly low. But the degree of water control under which these varieties are grown is far from optimum, and considerably more fertilizer is used on the experimental plots than is used by the farmers. This situation is not unique to Thailand. Some recent farm survey data from Indonesia also suggest that farmers are obtaining yields from the new varieties of rice that average 30 to 40 percent higher than the yields of the traditional varieties. See William L. Collier, "Impact of the High Yielding Varieties on the Farmers' Production of Rice in Indonesia." (Research Notes for the Agro Economic Survey, Indonesia, No. 5, January 1972, mimeo).

[33] "An Economic Evaluation," pp. 210-219

[34] Thailand, Royal Irrigation Department, Northern Chao Phya Study, op. cit., vol. 2, pp. 182-184.

[35] William Burton and Tongruay Chungtes, op. cit., p. 5.

[36] "An Economic Evaluation," pp. 216-214.

[37] G. Levine, "The Water Environment and Crop Production," in Kenneth L. Turk, ed., Some Issues Emerging from Recent Breakthroughs in Food Production. (Published by the New York State College of Agriculture, Cornell University, Ithaca, New York, 1971), pp. 378-395.

[38] Rose H. Frutchey, "Socio-Economic Observation Study of Existing Irrigation Projects in Thailand." (Prepared for U.S. Bureau of Reclamation and U.S. Operations Mission to Thailand, April 1969, mimeo), pp. 145-158.

[39] Ibid., pp. 149-151.

[40] Ibid., pp. 151-152.