RICE IRRIGATION WATER MANAGEMENT

WATER MANAGEMENT SYNTHESIS PROJECT

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INTRODUCTION

For thousands of years man has used the earth's resources -- land, air, and water -- as though they were limitless. Today, agriculture is wrestling with the legacy of that idea. While all the potential cultivable land and useable water sources haven't yet been developed, it has become obvious that the land and water available for agriculture is finite. Expansion as a means to increase agricultural production will continue to be an option for only a short time and in only a few areas of the world. Recognizing the limits of our land and water resources, we are grasping the idea that improving water management can provide an avenue to increased agricultural production.

This paper responds to the demand for general information on how improved irrigation water management can affect rice cultivation and production. Rice Irrigation Water Management discusses:

*the benefits of improved water management to rice agriculture;

*rice agriculture, particularly in south and southeast Asia;

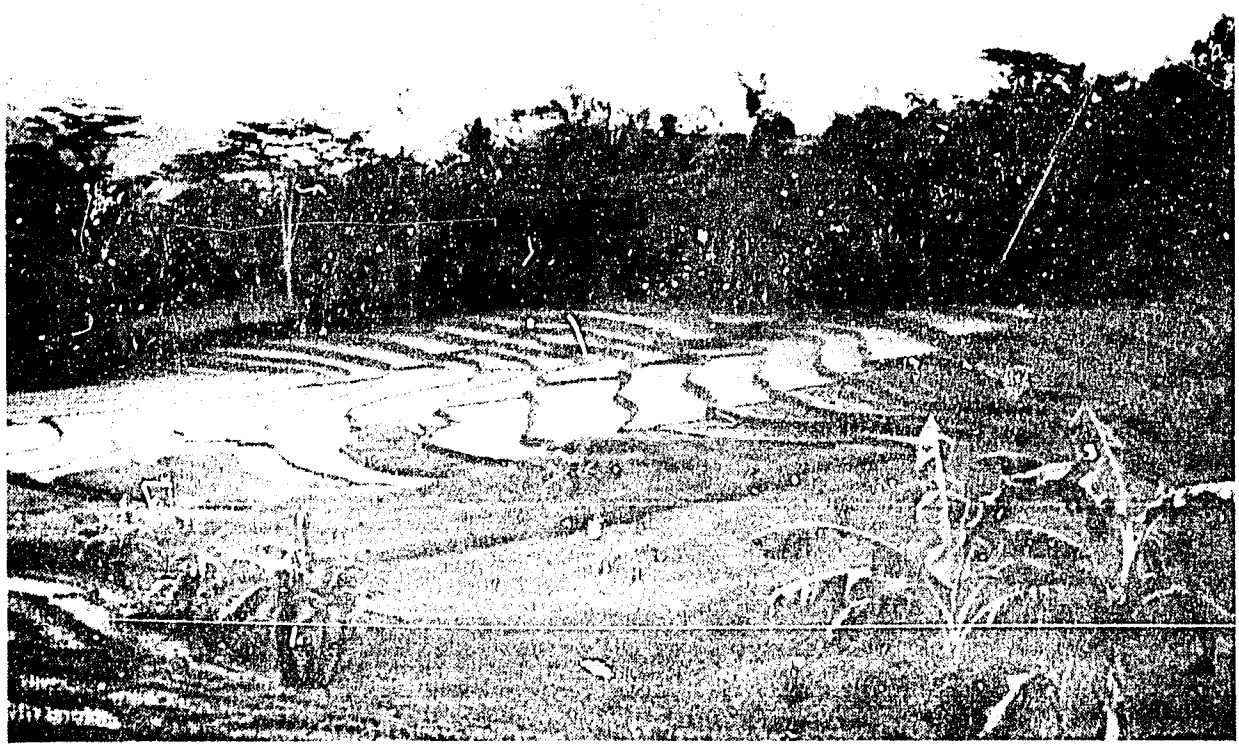
*the water management principles relevant to rice irrigation; and

*the influence of organizations and social customs on the operation and maintenance of a rice irrigation system.

WATER MANAGEMENT AND RICE AGRICULTURE

People recognize that water management can benefit farmers and crops in areas where water is scarce. Carefully conserving water and distributing it efficiently can mean that more farmers receive the amounts of water they need, when they need it. But what about rice, a crop generally grown in conditions of water abundance -- on land submerged under water?

During the rainy season, rice farmers may think more about flood control and drainage than water conservation. Improved water management in this instance may mean building and reinforcing the structures needed to control flooding and to drain away excess water. Thus, the farmer conserves his soil and fertilizers, a long-term benefit. But another reason irrigation system managers are looking at rice agriculture and the possibilities of improving water management is because the rice varieties, fertilizers and pesticides now available make it possible for farmers to grow rice during the dry season; but only if farmers have a reliable and adequate irrigation water supply.



Terraced rice fields in Indonesia.

WHAT ARE THE BENEFITS OF IMPROVING WATER MANAGEMENT?

Farmers use water to prepare their land for planting, to germinate rice seed, to grow seedlings in nurseries, and to control weeds. Because water is important throughout the crop season, improved water management makes the following benefits possible:

*More farmers can have better water control and better access to adequate and reliable water supplies.

*Farmers can grow rice or other upland crops in the dry season.

*Farmers can have fewer conflicts with one another.

*Farmers can prepare land in less time.

*Plants can better use available nutrients and applied fertilizers, which helps make a farm more cost effective.

*Farmers can halt flooding, soil erosion, and fertilizer loss.

*The rice can grow more uniformly with better yields. Many of the new, drought-resistant rice varieties grow best when water depth is carefully controlled.

Some of these benefits improve the individual farmer's return on his investments. All of these benefits help to increase a country's rice production and can improve the farm family's welfare.

WHAT DOES RICE NEED TO GROW WELL?

Temperature, sunlight, water supply, and soil all influence rice growth, as do soil fertility, weeds, insects and disease. What are their effects and how do they shape a farmer's decisions?

THE RICE PLANT

Rice, a semiaquatic plant, grows successfully on submerged and unsubmerged land. Its ability to survive on submerged land makes it ideal where monsoon floods are common. Under wet rice cultivation, the land can absorb intensive use without losing soil fertility. Yet, the ability of rice to produce well when grown as an irrigated, upland crop promises a potential for further increasing production.

Rice plants in a Bangladesh field.

WATER SUPPLY

About 90 percent of all rice grows in the humid areas of Asia where rainfall is distributed in varying amounts from day to day and from place to place throughout the year. During the wet season, the farmer usually relies on the monsoon rains to raise his crops and diverts irrigation water to supplement the rain only if necessary. In the dry season, the farmer must irrigate because there is seldom enough rain to grow rice otherwise.

TEMPERATURE

In the tropics, temperatures favor rice growth all year. Low temperatures, 18-25°C, are necessary to germinate rice seed and for rice plants to root.

SUNLIGHT

Researchers in the Philippines have found that rice grows more tillers faster under high solar radiation. This means that although water is most abundant during the wet season, the monsoon clouds screen the plants from the sunlight, slowing their growth. It is possible for rice grown in the dry season to produce better yields than wet season rice because the plants receive more sunlight -- but only when adequate water and fertilizer are also provided.

SOIL

Clay soils are best for rice growth where water is limited or uncontrolled because farmers can make clay soils less pervious to water. If the water supply is dependable and is available in large quantities, farmers can grow rice in less clayey soils.

FERTILIZERS AND SOIL FERTILITY

Fertilizers can do more for a crop than any other production input besides water, yet their effects can vary greatly. Nitrogen is one essential nutrient for rice. How well the rice uses nitrogen fertilizers depends on several factors: the rice variety, the season, the soil, and the farmer's cultural practices. Fertilizers are often costly, and the farmer needs careful guidance on using fertilizers to make purchasing and applying them worthwhile.

A farmer broadcasts fertilizer by hand.

WEEDS, INSECTS AND DISEASE

Weeds, insects and disease can greatly reduce yields. Weeds directly reduce yields by competing with rice plants for nutrients, sunlight and space. Weeds also harbor insects and diseases that can severely damage the rice crop. Farmers need to learn the appropriate methods for eliminating weeds, insects and disease from their fields.

WHAT ARE THE FARMERS' CULTIVATION PRACTICES?

In many areas, farmers grow rice as it has been grown for centuries, and field layout, water flow and control, planting and harvesting are all woven into the social structure of the community.

LAND PREPARATION

In the tropics, farmers usually divide their land into small basins (paddies) which they puddle, plow and approximately level. Puddling is working the soil and water into a slurry -- breaking up the normal soil structure and making the soil less pervious to water. Puddled fields lose less water through deep percolation. However, puddling requires large quantities of water -- more water than any other operation in the growing season (as much as 16-30% of the water used during the cropping season in Egypt and Indonesia).

The time farmers need to prepare land is partly related to the presence of adequate farm channels. During a study in the Philippines, farmers working in areas with good water distribution systems prepared their land within 19 days. Farmers in areas with less developed systems took 31 days. The extra days meant losses in time and water, plus the cost of hiring extra labor. Extended land preparation may also reduce crop yields because of fertilizer losses and water shortages later in the season.

A farmer in Bangladesh puddles the soil using bullocks.

LAND LEVELING

A farmer's ability to level the land is important to his management decisions, such as how large to make a paddy or an irrigation stream. His ability relates to the topography of his land and to the technology available to him. In the tropics, farmers usually build small basins on hillsides, and many farmers level and smooth the land with a wooden plank pulled by a bullock.

Farmers use water to indicate levelness -- to show up high spots and depressions. Then they smooth the bumps and fill the depressions in an attempt to make the land level. Yet, surface elevations still vary considerably from the degree of leveling needed for the most efficient water application. Because of this variation, water distributes itself unevenly and inefficiently in most fields. Proper leveling can greatly improve crop yields because water and fertilizers spread more evenly and efficiently. Unlevel fields often require over-irrigation which wastes water and can damage the crop.

A farmer levels his field using bullocks and a plank.

PLANTING THE RICE

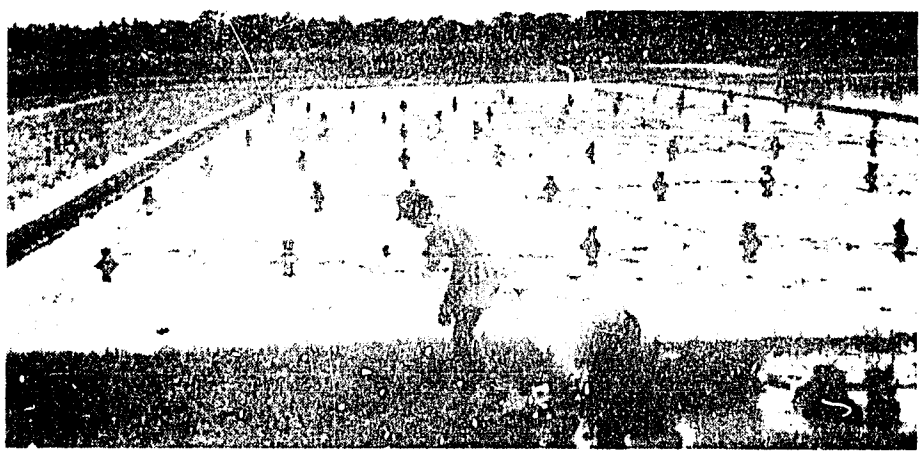
In much of southeast Asia, Bangladesh and Egypt, farmers usually transplant rice seedlings. In the United States, farmers seed it directly using a drill or by broadcasting from an airplane. In Pakistan, India and Sri Lanka, farmers directly seed using a drill, broadcast by hand, or transplant seedlings depending on the availability of water and labor.

Drilling and Broadcasting Seed

Before farmers drill or broadcast rice seed, they saturate the soil with water. Farmers irrigate the first time when the rice stands a few inches tall because the emerging rice plants will drown if the farmers submerge the land prior to this stage. Precision land leveling is critical to achieving uniform stands.

Transplanting Seedlings

To transplant rice, farmers raise seedlings in nurseries where they saturate the soil to maintain the low temperatures needed for germination. Transplanting requires a considerable amount of labor, usually supplied by women. The women transplant the seedlings around the 20-25th day after germination, but the actual timing depends on the availability of labor and water. The women space the seedlings uniformly or randomly in soil that was saturated or flooded earlier. Though randomly spacing seedlings may save time early in the season, farmers can weed uniformly spaced plants more easily later on. Transplanting gives the farmer better control over plant density than does broadcasting seed.

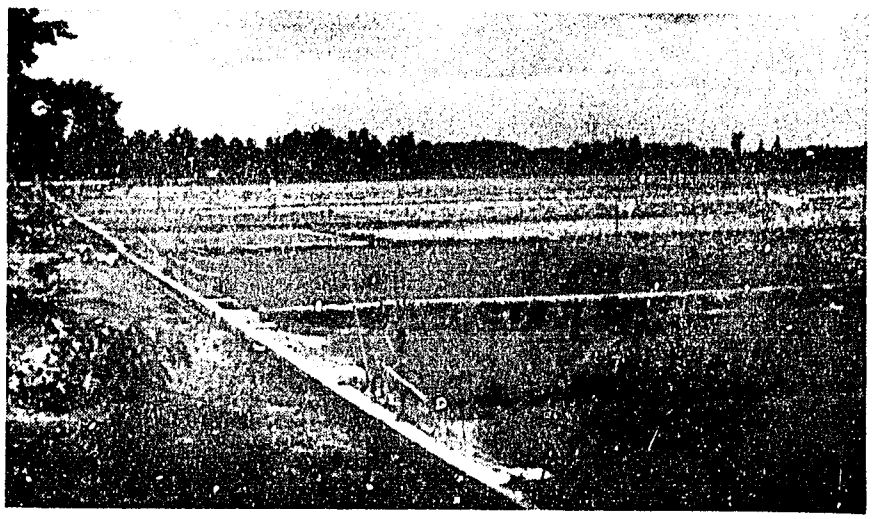


The farm workers gather the rice seedlings into bundles (foreground) which are placed in the field to prepare for transplanting (background.)

Water Management in Nurseries

In Asia, water management in nurseries often presents serious irrigation problems, particularly in the dry season. Commonly, water is delivered to individual, small nursery plots on each farmer's land. Such delivery is usually inefficient because the irrigation channels operate at higher flows than necessary to satisfy the seedlings' water needs. Thus, most of the water runs off at the tail end where farmers can no longer use it.

Water can be used more efficiently by encouraging the farmers within an irrigation unit to place a collective nursery near the head of their irrigation channel.



Where water is plentiful, farmers can afford to grow rice seedlings in individual nurseries.

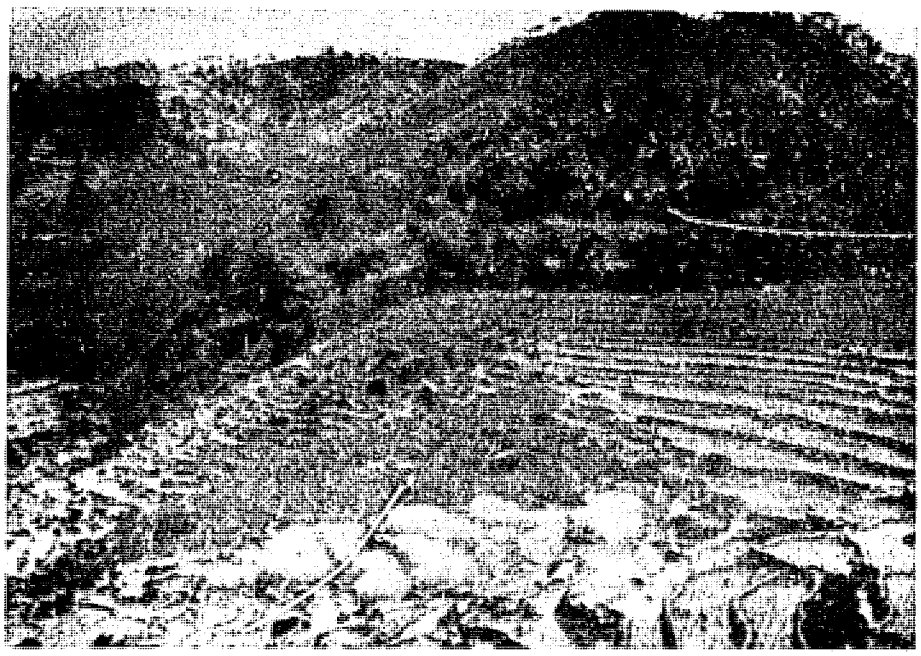
LABOR

The number of laborers a farmer employs depends on how he prepares his land and on how much cash he has for hiring outside the family. Few farmers use mechanical tools in most of south and southeast Asia. Instead, they use animals to plow and puddle the flooded soil. When operating with scarce water supplies, farmers must often turn the soil using spades.

Farmers do not need to flood rice fields continuously to produce maximum yields, but farmers often substitute water for labor. Keeping water ponded in a field kills most weeds, which decreases labor requirements for weeding.

WATER APPLICATION

To irrigate rice in Asia, usually a farmer releases water into a basin adjoining a field ditch. From there, the water spills from basin to basin (paddy-to-paddy flow). Asian farmers build basins to capture as much rainfall as possible and to keep water on the fields as long as possible. Basin flooding considerably alleviates the risk of undependable water supplies, whether from rainfall or from the irrigation system.



The steep hillsides in Indonesia are terraced with many basins that capture rainfall or water flow from above and make full use of the available land.

Paddy-to-Paddy Flow During the Wet Season

During the wet season, paddy-to-paddy flow can flood downstream farms and erode the soil on upstream farms, especially if soils are not heavy clay. Retaining walls often slough where water spills from one basin to the next through hand-dug cuts. Erosion usually prevails where farmers irrigate with a large stream and use graded borders instead of level basins. The lack of drainage facilities in most areas compounds flood damage.

Paddy-to-Paddy Flow During the Dry Season

Although growing populations are making dry season rice cultivation a necessity, the absence of an adequate farm channel system makes crop diversity and equitable water distribution difficult. In northeast Thailand, farmers think the lack of farm channels limits dry season cultivation more than any other factor, as well as causing conflict because not all farmers have equal access to the available water.

Though a farmer may want to grow a cash crop like tobacco or sugar cane as an alternative to rice, it may not be possible. Only with a direct connection to an irrigation ditch can all farmers get the water control they need to diversify their crops. Lacking direct access, many farmers avoid conflict with their neighbors by refusing to adopt more productive practices.

With an efficient, responsive irrigation system, paddy-to-paddy flow is no longer necessary. Direct access to water for all farmers can increase production, reduce conflict, and give farmers the option of diversifying their crops by giving them control over an equitable, adequate and dependable water supply.

A farmer can grow more rice when he has control over a dependable water supply.

Paddy-to-Paddy Flow and Land Use

Most farmers attempt to put as much land into production as possible. They feel that less land is out of production using paddy-to-paddy flow than if channels that supplied water to every field occupied the land. For farmers with direct access to the water supply or fields close to the head of the system, this may be true. However, for farmers whose fields lie farther away, a more dependable water supply balances any loss of productive land. Many of these farmers already have unproductive fields because of inadequate water supplies. For some, a year of little rain means that a field at the tail end of a paddy system may receive little or no water. These lands often represent more area than the land used to build an irrigation system that could supply water to each field directly.

In many areas, farmers at the head of the system resist changes to the system because they feel they will lose some of their productive land to irrigation channels while gaining few substantial benefits. To gain farmers' cooperation, the government could teach them about the benefits of having direct outlets to channels and could consider subsidizing them for the land used to build ditches.

HOW DOES ORGANIZATION INFLUENCE WATER MANAGEMENT?

Irrigation organizations, whether community- or government-based, operate and maintain the physical structure of the irrigation system. Effective water management requires well-developed communication channels between farmers and management personnel and a technology that allows flexible and fast response to requests for water.

Population pressures have led governments in much of Asia to divide farmland into small holdings that are farmed at high intensities. Here, organizations greatly affect water distribution and water use. For an irrigation system to succeed, an appropriate physical technology must support the organizational rules, and water managers must be able to respond quickly to changes in water supply.

WATER SUPPLY AND ALLOCATION

Asian countries have few reservoirs to store water, a circumstance which has helped prevent water supplies from being reliable and predictable. Most irrigation water is diverted from rivers through weirs to the supplying channels. In some mountainous areas, members of the farm communities make and maintain small, usually temporary, diversion weirs. The community controls the water from the source to the place of use and can respond quickly to farmer demand.

In the lowlands, government agencies make and maintain larger, permanent weirs that include control gates and water measuring devices in the structure. The agency may allocate water to several villages, finding it difficult to well match water supply and water demand because the users do not participate in controlling the water supply.

During the rainy season in southeast Asia, irrigation channels usually receive water continually, and the farmers take water freely as they need it. Irrigation institutions are inactive as minimizing control on the system reduces operational costs.

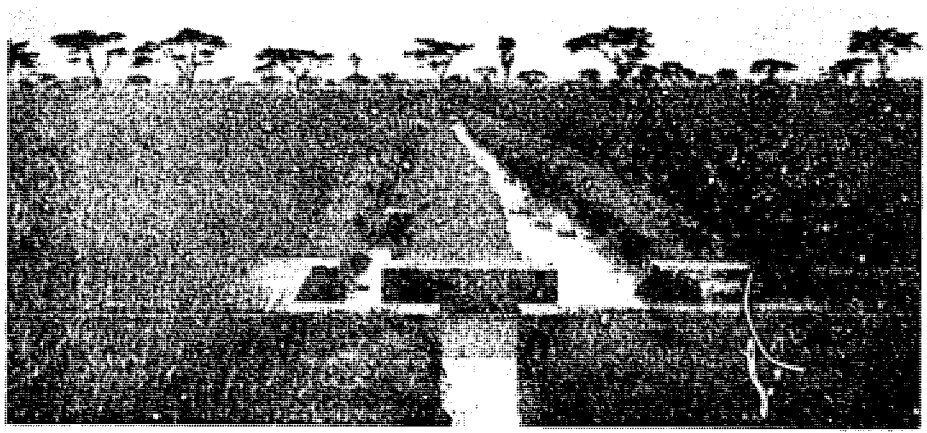
In the dry season, water control shifts to various irrigation institutions including water users' associations in some areas. These institutions monitor the water to reduce water waste and to control demand. Farmers have less flexibility because supervisors often supply the water on rotation.

Problems in water management can arise in water control and channel maintenance when financing construction and maintenance, when setting organizational rules, and when lacking farmer involvement. Although these factors are treated separately here, in reality they are interrelated, and solutions to problems should be approached with that in mind.

Water Control

Where fields do not border a water channel (the field receives water from another field), few opportunities exist for the farmer to make flexible management decisions. Farmers cannot diversify their crops or stagger their cultivation activities to reduce peak demands for water without direct access to an irrigation channel. Farmers have little control over the water, and the potential for conflict among farmers is high. Communities attempt to substitute for the lack of physical control by emphasizing cultural norms and values to distribute water equitably.

Unequal access has made farmers and system managers more interested in building field channels to give every farmer direct access to irrigation water. The need may not be physical, but socio-organizational -- to form farm units of smaller size and give each farm physical identity. This makes enforcing operational rules easier and reduces conflict within the community.



A channel that supplies water directly to individual farmers' fields runs alongside a small distributary channel in Indonesia.

Maintenance

Proper maintenance of channel banks reduces water loss and lessens the number of access points where farmers can draw water. In many areas, the responsibility for maintaining the main and distributary channels belongs to the government, farm channels to the village, and field channels to the farmers who receive water from them. Maintenance of farm channels falls to all households whether they farm or not because most households use the channels for sanitation, washing and bathing.

A group of farmers use ropes to pull out a large rock to increase the capacity of the channel.

On field channels, the farmer using the channel must maintain it. To motivate farmers to maintain the channels in Indonesia, the government requires farmers on some systems to clean the channel section that passes the plot of the farmer immediately upstream.

Construction and Maintenance Financing

Charging farmers the full cost of providing irrigation structures is not politically possible in many areas. Farmers often already pay taxes assessed on their income from agricultural land, and irrigated lands often are taxed more than rain-fed lands. Farmers also pay for the village watermaster where such officers receive a salary instead of farming community land in exchange for their services.

Farmers could be charged a water levy based on the cost of operating and maintaining the system per hectare or by volume. The farmers should use less water and use it more efficiently if charged volumetrically. However, someone must carefully monitor and measure the volume. Since an infrastructure to support such accurate measurement does not exist in most irrigation systems today, volume charge remains a long-term goal. Also, volumetric charge may not be appropriate in all areas. This system can penalize farmers who farm soils that lose a lot of water through percolation.

Farmer Involvement

In most government-controlled systems, farmers do not maintain their channels because they have not developed a sense of ownership or a commitment to organize. Often, the government has not demonstrated that the water supplies will be reasonably adequate, reliable, and controllable. Thus, the farmers feel no need or desire to become involved in the initial decisions about layout and construction of irrigation structures.

Government officials could encourage farmers to participate by having them work together within the framework of a water user's association and by using the farmers' knowledge of micro-topography in planning and the rural residents' skills in construction. Unfortunately, water users' associations have not succeeded in many areas. When water is managed by a team of irrigation specialists, new roles are created in the community which the water users must support. This often places a heavy economic burden on the farmers if they must pay for the services of the team as well as the village watermaster. Many farmers would rather contribute their own labor than pay others to work on the irrigation system. Therefore, organizers should integrate water users' associations with indigenous institutions wherever possible to lessen the number of people the farmers must support.

Organizational Rules

With scarce water supplies, the influential farmers often pay irrigation staff to give them more water than they should receive. Resisting farmer requests makes the staff unpopular while complying can bring the staff substantial financial rewards.

Therefore, the following points should be considered when organizing the operation of an irrigation system:

*The appropriate department should make clear rules about water allocation and distribution based on cropping patterns, soil and crop water requirements, and cultural norms and values of the community.

*Farmers and field staff should fully understand the rules.

*The rules should demand no more than the physical system provides, and the physical system must allow the rules to be implemented.

*The appropriate department should motivate the staff with rewards and sanctions, and farmers should pressure the staff to apply the rules.

*There should be effective legislation for punishing managers and farmers who break the rules.

Some other problems are unequal access to land, absentee ownership and ineffective administration at the local and village levels. Agricultural officials cannot separate water management from the socio-economic problems facing agriculture in most developing countries.

CONCLUSION

Today, increasing production and distributing water equitably are important agricultural issues in developing countries. This is particularly true for dry season cultivation of rice because the lack of irrigation systems that provide equitable and efficient water distribution and the absence of institutions to supervise water distribution seriously hinders most attempts to tap the potential for increased production that dry season cultivation offers.

In Asian rice agricultural systems, most improvement will have to come through better organization -- of the physical farm system, of government management and communications, and of farmer institutions. The keys to better organization are creating a responsive and responsible management system and encouraging farmer involvement. By structuring the physical system so that it can respond to changing agricultural needs, and by developing good relationships and communications between government representatives and farmers, developing countries can unlock the productive potential of rice, the land, and their people.

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