Management Arrangements for Diversifying Rice Irrigation Systems in South India

R. Kulandaivelu
Professor and Joint Director (Training) Irrigation Management Training Institute (IMTI), Trichy, India

K. N. Raja Rao
Director (Engineering) Water and Land Management Training and Research Institute (WALAMTARI) Hyderabad, India

INTRODUCTION

WHEN INDIA ATTAINED independence in **1947** it was importing rice to meet its food requirements. In the early **1970s,** the country became self-sufficient in rice production. This was made possible by the introduction of new high-yielding and high fertilizer-responsive rice varieties and the rapid extension of irrigation facilities where rice was grown. The heavy investment in irrigation provided the controlled flood water environment to lake advantage of the full potential of the new high-yielding rice varieties. The success of this strategy, however, resulted in declining fanners' income from rice production. Growing of nonrice crops like sugarcane, banana, turmeric and cotton increased the benefit-cost-ratio besides increasing the income of the farmers. Hence, the farmers started diversifying the cropping system to nonrice crops.

Ricegrowingareas in Tamil Naduand Andhra Pradesh increased in the 1970s butstarted declining in the **1980s.** Rice was replaced by nonrice crops like sugarcane, banana, turmeric and cotton. The shift to nonrice crops has taken place in large and medium-size farm holdings where enough resources were available for investment. Small and marginal farmers could not allocate the available resources for raising commercial crops which require high capital investment. Wherever sugar factories are situated, even small fanners switched to sugarcane due **to** the available credit and other technical services.

Private sector installations like sugar factories and government agencies like the Agriculture Department and Agricultural Universities are mainly responsible for crop diversification to nonrice crops through their consistent promotion of crops which increase fanners' income and living standards.

IRRIGATION PLANNING AND OPERATION FOR RICE-BASED SYSTEMS

The basic principle in any case is simply to match as closely as possible the water supply available with the water demand or soil and crop requirements. The planning process observed can he very simple or complex, depending on the scope for manipulating supplies according to the demand. It can be as simple as the fanners being infonned by their association officers about the availability of water and the time of its distribution. Planning can mean estimating availability of the future water supply and the water deniand of thr expected cropping pattern, and then matching the supply to the demand. This procedure of matching the available water supply and demand is routinely done in all irrigation systems.

In estimating the future supply, the factors considered by the irrigatioii staff include anticipated rainfall distribution during the different seasons by using past records; type of water capture, diversion, and storage systems used; and reliability ofbydrologic and climatic data. The estimate often becomes pure gurss work in which future supply is variablr and unpredictablr, as in some run-of-the-river schemes.

The water demand is determined by estimating the cropping patterns, the cultivation extent, and irrigatioii efficiencies at the on-farm and main systems. Thr efficiencies used arr. assumed rather than measured in all irrigation projects. Based on past experience, tentative assumptions are made by the irrigation staff regarding the start of the cropping season, the crops to he grown, length of land preparation time, the start of normal irrigation and the end of the season. Once calculations of the supply and demand are completed, the appropriate allocation and distribution practices or other measures are considered to determine the target flows at various levels of the irrigation system. The final choice of distributioii method depends very much on the characteristics of the physical system in terms of capacity of tbe canal network, flow regulation available and the managerial capacity of the irrigationstaffand water users. Planning of the delivery schedule when done deliberately is normally tempered by experience gained through some form of monitoring of the results of previous cultivation seasons.

Before thr plan is finalized and operationalizcd, irrigation and other associated government officials meet with farmers or their representatives or both, to decide formally on: a) the start of the. season; b) areas and types of crops to be cultivated; c) length of land preparation period; d) the start of tbe normal irrigation: e) the end of the season; and f) distribution method. whether continuous or intermittent, and the maintenance schedule and responsibilities.

Although new tc: hnologies and practices which can increase productivity are available, adoption of these technologies by small-scale farmers is limited owing to the small extent of available land. Lack of incentives to invest in fanning, as it is a less profitable sector to invest when compared to industrial and other sectors, limits the possibilities for small-scale farmers to adopt new technologies.

CONSTRAINTS/OPPORTUNITIES IN THE MANAGEMENT CHANGES

Technical

Water control is more demanding in terms of supply and removal for nonrice crops due to their far stricter requirement of soil moisture. The intermittent delivery of limited and uncertain water supply during the dry season requires greater joint management effort and. in turn, effective communication between irrigation staff and the farmers.

To provide the necessary functional water control, regulating and measuring facilities have to be available to enable effective monitoring and feedback of the water supply.

Farmers who have grown only irrigated rice throughtout are unfamiliar with agronomic and irrigation practices for nonrice crops.

There are greater economic risks associated with nonrice crops than with rice. Cash and labor inputs can be 3 or 4 times higher for nonrice crops than for rice crops. Institutional credit is scarce while noninstitutional credit carries usurious interest rates.

Unlike for rice, unstable prices and lackoforgauizedmarketing fornourice crops increase the risks for farmers involved in their production.

Low light intensity, cloudy weather and low night temperature during the rice growing period pose a big constraint to diversified cropping in rice fields. Inadequate drainage systems prevent the use of rice fields for diversified winter crops.

Socioeconomic Constraints

There are some economic and social constraints other than the abovementioned technical and environmental constraints which influence farmers' decisions. One of these is the price incentives to grow nonrice crops.

The price of rice is unchanged for a long period, meaning it is relatively stable. To popularize the production of nonrice crops, price incentives should be provided. A major breakthrough in yield improvement of nonrice crops by introducing high-yielding varieties and proper cultural practices are needed lo realize the full technical and physical potential for growing nonrice crops.

Institutional Aspects

The major institutional strength for pursuing a crop diversification program is the presence of agricultural universities which deal with rice and nonrice crops and a number of crop-based research and extension institutions in the country. Foremost of these are the Indian Council of Agricultural Research (ICAR) and the Tamil Nadu Rice Research Institute. Furthermore, crop specificextension activities are alsoprovided by the Agriculture Department, the Oil Seeds Department, the Irrigation Management Training Institute

(IMTI), Trichy and Water and Land Management Training and Research Institute (WALAMTARI), Hyderabad, the last being the most organized institution engaged in irrigation development. Any crop diversification program needs fanners' cooperation and participation.

There are, however, shortcomings of these institutions which impede the diversificatioii of crops to a great extent.

STRATEGIES TO ADDRESS CONSTRAINTS/OPPORTUNITIES

Improvement of Irrigation Facilities

In recent years, there has been growing concern on how irrigation systems designed and operated for rice crops could be effectively utilized for production of irrigated dry crops.

Many people are of the opinion that the existing irrigation infrastructure is a major constraint to diversification from rice. Some agencies and authors have advocated improving the performance of the irrigation system by introducing the flexibility needed for large-scale crop diversificatioii within the irrigation system.

The performance of the irrigation system can be improved by:

1. Improving the physical structures (hardware improvements).
2. Improving the operational performance of the system through improved management (software improvements).
3. Augmenting the supply of water to the system.

There are three dimensions to achieving good performance of the irrigation system. The first and foremost requisite is the need fnr adequate water control and flow measuring structures in the main system. The second focuses on measurement at key points in the system and feedback for good control. The third aspect deals with adequate trained manpower and their commitment and attitude towards system operation.

Realizing the importance of manpower needs, the Government of India with the assistance of the. United States Agency for International Development (USAID) and the World Bank has set up Water and Land Management Institutes and Irrigation Management Training Institutes in 11 states for massive in-service training of professionals to improve irrigated agriculture. In addition, in three southern states, the World Bank has initiated a scheme titled National Water Management Project (NWMP) wherein in-service training of professionals and management staff of the system play a more dominant role than in creating physical infrastructure. These programs are in the right direction and are likely lo make visible impact on irrigated agriculture.

Innovative management will be needed to find ways to overcome bureaucratic inertia and vested interests in system operation. The technical deficiencies can be corrected through the use of technologies already known, although there are opportunities for high-tech applications in telecommunication and regulating arrangements in large canals.

Innovative management approaches will also be necessary to handle manpower training. There is an urgent need to make local organizations of project beneficiaries to assume responsibility for project activities. Compatible government policies for adequate recurrent cost financing for operation and maintenance are important for sustainability of benefits and of physical infrastructure.

Component research such as case studies of improved management performance could yield tangible benefits.

On-Farm Development Works

On-farm development works like constructing field channels are being done through the Command Area Development (CAD) program. In rice irrigation schemes, they are not maintained by farmers since they are able to get water from their neighboring field due to field-to-field flow. But if nonrice crops are grown, farmers will have to use the field channels constructed by the CAD program, and a few more channels could be constructed by government agencies or group of farmers if properly motivated. This will develop in phases over years if rice cultivation is stopped in the dry season in any irrigation command. However, some patches affected by seepage from canals may have rice crops because of the saturated condition of the soil throughout the growing season.

Improvement in Procedures and Practices

System Characterization and Mapping

First, it is necessary lo know the individual nature of the system itself. No two systems are exactly alike. They exhibit individual traits. These individualities which are unique to the particular system must he taken into account when planning.

The delivery system for rice crop or nonrice crop remains the same. But for the rice crop, water flows continuously in all sections of the distribution system. Nonrice crops need intermittent irrigation as excess water will severely damage the crops. Depending on the soil type and climatic requirements of crops, the frequency of irrigation can be decided. Minor branch canals can flow continuously. while rotational water delivery schedule must be done in minors and sub-minors. Operating the smaller canals can be practiced perfectly if the operating staff are trained in the aspects of irrigation scheduling.

Rice irrigation systems do not have appropriate in-field water application systems to favor nonrice crops. Small field-channel drains at ridges and furrows or beds are examples of requirements of in-field systems for irrigated nonrice crops. These on-farm facilities can be dismantled during land preparation for Kharif rice production.

More accurate method of prediction

Prediction of the behavior of the monsoon is difficult and beyond human control. In spite of the scientific advances made and the large efforts in the collection of weather data, weather remains as unpredictable as ever. Over a short range of 3 to 7 days perhaps, the prediction may be reliable but not beyond that. This will not be helpful for irrigation. There must be an indication whether the precipitation through the monsoon is normal, or above normal or below normal even as the cropping season starts. However, since monsoon failure is to be anticipated and droughts are felt in cycles of years, there is need to plan ahead.

In such conditions, Systems Engineering can be applied in an organized manner so that the best or optimum solution is determined. The advantages of the systems engineering approach are:

1. It is systematic and organized.
2. It is focused on the overall problem and the interactions between all parts of the system.
3. It is interdisciplinary and promotes communication among all disciplines needed for the project.
4. It promotes creativity and innovative solutions.
5. It gives the sensitivity of selected solutions to uncertainties.

Simulation modeling

The two most general types of models used in systems engineering are simulation models and optimization models. The simulation model is used to predict the outputs of various designs and operation policies. The uses of simulation models are to: a) predict; b) store data; c) identify physical and institutional relationships needed in research; d) identify system objectives; and e) help in training.

Since simulation is an extremely useful technique in systems analysis, it can be applied for prediction of water supply for different crops. The simulation technique was introduced in Periyar-Vaigai Project, Madurai, Tamil Nadn and it is functioning well without any problem.

Simulation allows the prediction of impacts of decisions. In other words, simulation provides answers lo "what it" questions before a project is implemented or an operational policy is changed. By testing potential decision with simulation, one can measure the impacts both qualitatively and quantitatively. The big advantage of simulation modeling is that it allows the user to gain a lot of insight or experience with a system in a short period of time.

With the advantage of simulation modeling, rice-bascd systems can be successfully diversified with crops of different water requirements.

Participation of farmers

The farmers have been responsive to irrigation development and are quite conscious of the benefits from well-managed irrigation systems. However, they are poorly informed about the actual resources and the manner in which these resources have to be managed to minimize the failure in irrigated crop production. They also seem to be afraid to accept a change unless they are assured of the benefits they will receive. A system should be evolved by which organizations are created at the field level with enough freedom to function in their best interest.

It is time that every attempt is made to increase the level of income of the fanning community. The farmers can be easily benefited by crop diversification. A study on the impact of some socioeconomic factors influencing the adoption of crop diversification by fanners has shown that it is fanners with larger landholdings who were more interested in crop diversification. Small and marginal fanners grow mainly rice for family consumption while the big fanners are interested in growing nonrice crops to obtain more profits.

The caste system has had no effect on the adoption of crop diversification. Education was found to influence the adoption behavior of the farmers attracting them to crop diversification. Cosmopolitan and social participation was found to have an impact on fanners in adopting diversified cropping patterns in irrigated areas.

Water augmentation

In many irrigation commands where there is scarcity of surface water, conjunctive use of surface water and groundwater is taking place at a rapid pace. With the introduction of high yielding varieties, with more exacting water requirements and sensitivity to water shortages, adequate and reliable water supply has become critical. Conjunctive use of surface water and groundwater helps to meet the water requirements of crops with respect to both time and quantity.

Table 1 shows the results of an adaptive research conducted by Anna University on the comparative crop yields obtained from the fields on Padianallaur tank irrigation system which were served by wells as supplementary sources of irrigation and from those fields which did not have this facility.

Table 1. Rice area cultivated, water diverted, and crop yield in Padianallur tank command (1984-85).

	Farmers owning wells	Farmers who purchased water	Fanners with no access to well water
Area cultivated	8.27	4.05	3.09
Number of land holdings	7	21	12
Effective rainfall (cm)	1.46	1.46	1.46
Water actually released through sluices (cm)	42.34	64.46	65.66
Well water used (cm)	57.04	21.16	–
Number of irrigations from wells	4 to 9	1 to 6	–
Total water used (cm)	100.84	87.08	67.12
Crop yield (kg/ha)	3705 to 4817	962 to 3385[a]	741 to 1853

[a]One fanner who purchased water and irrigated only twice got 962 kg/ha.

Also shown are the crop yields from the fields which utilized well water on a limited scale through purchase from neighboring well owners. The difference in the total amount of water used by owners of wells and those who purchased water was 13.76 cm. Crop yields from fields which did not use supplemental well water were very much lower than those which used well water. Farmers were quick to see the importance of having wells, and during 1983-86, 9 additional wells were constructed. Considering the potential of groundwater resources, additional wells at appropriate spacing will be helpful to address water scarcity experienced during certain periods of the year.

The conjunctive use of water in canal commands is exemplified in the Lower Bhavani Project command, where zonal irrigationwith year to year rotation was followed. Under the zonal system, the command area is divided into two zones (Turn I and Turn II) and water is made available to each zone in alternate years for raising one wet crop and one dry crop. In the first year, "Turn I" areas were allowed to raise wet crops from 15th August to 15th December with continuous water supply.

From 16th December to 15th April, the same sluices were operated for only irrigated dry crops with 10 days on, and 10 days off. This is similarly done in the second year for "Turn II" areas.

The uncertain and unreliable supply of canal water, particularly in the dry season (December-April), generally compelled the farmers to supplement the canal water with well water. The present method of giving water in alternate years to farmers based on odd and even turn systems also induced the farmers to exploit groundwater to irrigate the crops mainly in the non-turn year, when the canal supply is not available at all. Instead of depending on the rainfall to take one rain-fed crop, farmers switched to dry crops irrigated with well water.

Crop scheduling

The soil characteristics. the traditional agronomic practices, the seasonal conditions and the price structures in the market mainly decide the cropping pattern in a command.

Farmers usually give priority to growing their own food and only thereafter think of other crops for marketing. Many cases in the South have shown that farmers resort to rice cropping whether the soil is suitable or not once they are assured of irrigation. This upsets the design parameters of many irrigation schemes where irrigated dry crops were proposed resulting in modifications in the water scheduling. The Lower Bhavani Project and the Parambikulam Aliyar Project in Tamil Nadu State are examples of these schemes.

In the Lower Bhavani Project Command area, water is released in alternate years to a rice crop and a peanut crop. When there is no water, farmers with groundwater resources opt for sugarcane, turmeric, cotton and other crops.

A study conducted at the Agricultural Research Station, Bhavanisagar on four cropping sequences in a red sandy loam soil during 198485, showed that a rice-based sequence with sesame, pearl millet, turmeric, and cotton gave the highest net profit (US$2,998) with a cost benefit ratio of 1:15 (Table 2). This sequence could increase productivity in the region by 174 percent. It would reduce water use for the 2-year period from 482 cm to 411 cm.

Table 2. Two-year rice-based cropping system yield, water consumption and net return, Bhavanisagar. India. 1984-85.

Crop sequence and yield (t/ha)	Net return (US$)	Cost benefit ratio	Water consumption (cm)
1. Rice(3.6) Peanut (1.52) Sesame (0.07) Rice (3.4) Peanut(1.59) Sesamum (0.58)	1095	0.54	482
2. Rice(3.6) Sugarcane (105.9) Sesame (0.58) Peanut (1.52)	1192	0.60	409
3. Rice(3.4) Sesame (0.71) Pearl Millet (2.78) Turmeric (16.76) Peanut (1.56)	2393	1.07	404
4. Rice (3.6) Sesame (0.72) Pearl millet (2.86) Turmeric (15.76) Cotton (2.15)	2998	1.15	411

DIRECTION OF RESEARCH AND DEVELOPMENT ON CROP DIVERSIFICATION

Numerous research projects related lo crop diversification are already being conducted at institutions like the Indian Council for Agricultural Research (ICAR), and agricultural universities. However, there is no coordination between these institutions and the irrigation management authorities to implement the research findings. The universities and research institutes should be involved in irrigated crop diversification research which should be multidisciplinary and drawing inputs from engineers, crop scientists, soil scientists and socioeconomists.

The multidisciplinary teams that are formed at different institutes may fonn a national network of crop diversification research with a coordination committee composed of representatives from the individual research teams as well as from government implementing agencies. National and international agencies may fund the research.

Multidisciplinary teams in selected command areas under each agroclimatic zone should undertake a detailed diagnostic analysis to be able to define and prioritize the problems. This is possible through the coordinated effort of the staff of the agricultural universities. The Irrigation Management Training Institute could coordinate and guide the entire process. Research should include action research, adaptive trials, and systematic programs for technology transfer. The selection of crops, which could he suitable substitutes in rice-based irrigation systems, can he done on the basis of a) agroclimatic requirements; h) higher efficiency of irrigation; c) increased returns per unit of land and water; d) marketing facilities; and e) availability and future prospects of allied agro-industries.

Action and adaptive researches may be conducted in demoustration farms and farmers' fields. The research may he conducted for 5 years. Funding required to carry out the research has to he calculated after its scope is defined in inure detail. This will depend on the location, alternate crops and cropping systems, number and size of demonstration sites, etc. To meet the recurring expenditure, agencies like USAID, World Bank, etc., may he tapped in addition to the existing funding agencies.

SUMMARY

India attained self-sufficiency in rice during the early 1970s with the introduction of high yielding varieties and extension of irrigation facilities. This success, however. resulted in declining farmers' incomes and heiice they started diversifying their cropping systems to nonrice crops, which required changes in planning, watrr allocation, operation and maintenance. The management changes need consideration of water control, agronomic and irrigation practices, economic risks, inputs, climatic requirements. socioeconomic constraints and institutional strengths. In order to address the ahove factors, strategies will have lo he identified by undertaking research on policy changes, implementation and technical solutions to specific constraints hy ICAR institutions, agricultural universities and water and laud management institutes in the country. For carrying out the research, necessary funding may he sought from agencies like USAID, World Bank, ctc.

References

International Irrigation Management Institute. 1989. Research network on irrigation management for diversified cropping in rice-based systems. Proceedings of the Organizational and Planning Workshop held at Asian Institute of Technology. Bangkok, Thailand. 30 November to 3 December. 1988.

Irrigation Management Training Institute (IMTI). 1989. Diversification of crop in Delta. Background material. Tamil Nadu: IMTI.

Miranda, Senen M. 1989. Irrigation Management for Crop Diversification in Indonesia, the Philippines and Sri Lanka: A synthesis of IIMI's Research. Sri Lanka: International Irrigation Management Institute.

Sakthivadivel, R. 1988-89. Lecture notes of Sixth Training of Trainers Course, conducted by Centre for Water Resources, Anna University, Madras, Tamil Nadu, India.

Selvaraj, K.V.; R. Kulandaivelu; B. Rajkannan and P. Muthuvel. 1988. Rice-based cropping system in LBP areas in Tamil Nadu, India. IRRN, 13:3. p.49.

Sivanappan, R.K. 1986. Research and development in agricultural water management

Water and Land Management Institute (WALMI). 1989. National seminar on constraints and prospects of productivity in rice-based cropping system under irrigated agriculturc. Orissa: WALMI.

World Bank. 1988. Draft paper on diversification in Asian Agriculture. Washington D.C., USA: World Bank.