Management Arrangements for Diversifying Rice Irrigation Systems in Indonesia

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INTRODUCTION

THE CONTRIBUTION OF the irrigation Sector to agricultural development in Indonesia is significant. Irrigation does not merely stabilize and increase crop yield but also induces fanners to adopt improved cultural practices. Moreover, with sufficient water, farmers are able to use more production inputs, practice double cropping and crop diversification. Finn evidence of the impact of irrigation development on food production is shown in Table 1, (p. 38) Figure 1 and Figure 2.

With respect to the issue of crop diversification program in irrigated ricefields, technically it may not create a big problem to the existing irrigation systems. Irrigation systems in Indonesia have been planned, designed, and operated lo irrigate diversified crops since the colonization of the country. Therefore, the promotion of crop diversification is just like restoring the existing systems to their intended functions and operations (van der Elst 1924; Anonymous 1986).

In diversifying crops in irrigated ricefields, three benefits are expected from the irrigation aspect. First, the pressure on operation and maintenance (O&M) of the system during the dry season when water shortages commonly occur can be eliminated. Second, the implementation of the O&M program can be carried out according to a legal basis in any particular area. The last benefit is the prolonging of the functional life of structures, decreasing the burden on the government in providing O&M cost.

From the standpoint of the agricultural development program, crop diversification (both vertically and horizontally) has been chosen by the Department of Agriculture (the Directorate General of Food Crop Agriculture [DGFCA]) as one among four basic strategies to achieve the objectives of a) sustaining and improving food self-sufficiency; b) increasing the agricultural production in order to provide raw materials for industry and **export;** c) increasing farm productivity and value added of agricultural products; and d) increasing farmers' income as well as their welfare (Wardojo 1989).

Table 1. Areas harvested and lds of lowland rice, maize and soybean, 1983-88.

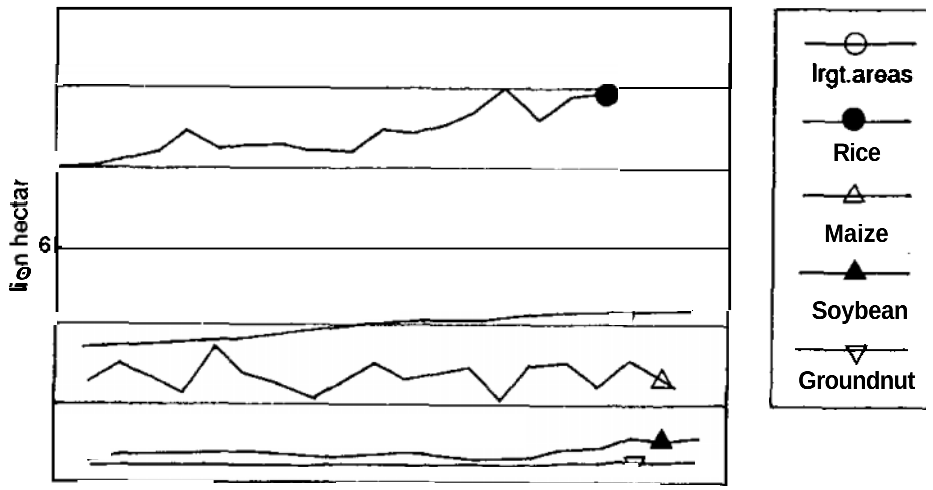
Year	IA ('000ha)	RCT (%)	Rice		Maize		Soybean	
			HA (ha)	Yield (t/ha)	HA (ha)	Yield (t/ha)	HA (ha)	Yield (t/ha)
1983	4,238	60.03	7,987	4.17	3,002	1.69	640	0.84
1984	4,322	69.91	8,547	4.21	3,086	1.71	859	0.90
1985	4,329	69.78	8,756	4.23	2,940	1.77	896	0.97
1986	4,335	69.10	8,888	4.25	3,143	1.88	1,254	0.98
1987	4,354	71.02	8,796	4.32	2,626	1.96	1,101	1.06
1988	4,388	71.62	a	4.33	3,406	1.95	1,177	1.08

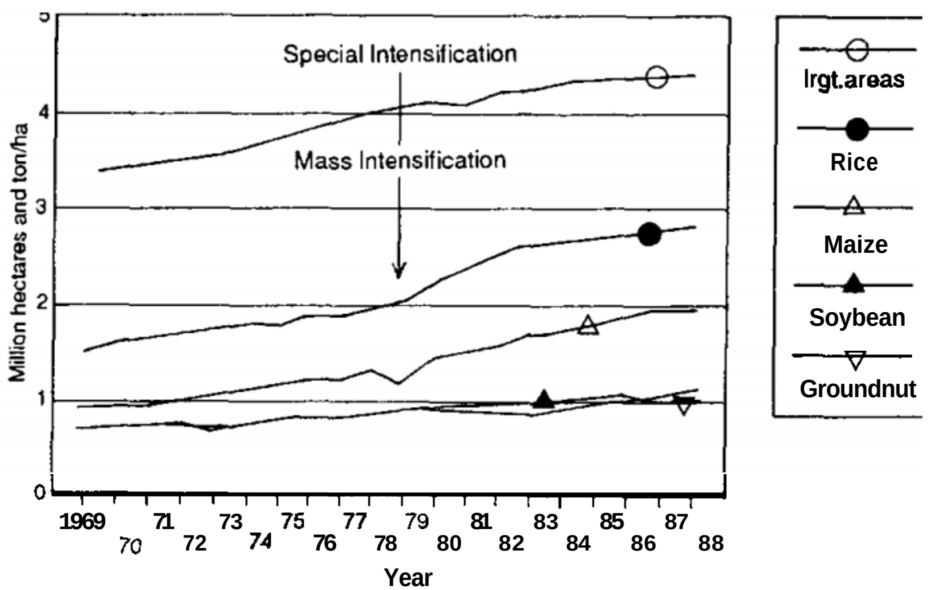
Notes: IA = Total irrigatedarea.
RCI = Percent of irrigated area with three rice crops/year.
HA = Harvested area.
a = No data available for harvested area of lowland rice.

Sources: **Statistical Yearbook of Indonesia, 1985, 1988; Directorate General of Food Crop Agriculture. 1990; Directorate General of Water Resources Development. 1990.**

Various initiatives have been made by the Department of Agriculture in an effort to promote the crop diversification program. Considering that unstable prices of food crop commodities (except thal of rice) became the main constraint in the promotion, a regulation on pricing policy for maize was drawn up in 1978. In the following year (1979), another pricing policy was drawn up for soybean, groundnut, and mungbean. To make the efforts more effective, 17 provinces have been designated as centers for the upland crops intensification program. Three provinces have adequate irrigation facilities. Within the province, the intensification area is decided every year by a decree from the Minister of Agriculture (Pabinru 1990). The total areas of upland crops for 198811989 cropping season were: 1,833,400 ha of corn, 716,000 ha of soybean, 338,000 ha of groundnut, and 136,700 ha of mungbean. Recently, because of their high economic values, shallot and onion were also included in the intensification program.

Figure 1. Development of irrigated and harvested areas (in M ha).





IRRIGATION PLANNING AND OPERATION FOR RICE-BASED SYSTEMS

Practices in Rice Irrigation Systems

Three basic principles are attached to all aspects of irrigation practices in Indonesia. These three principles are: a) the status of supplemental irrigation; b) sharing of responsibility between the government and the farmers (groups of farmers) as beneficiaries to ensure uninterrupted operation of irrigation networks, and operation and maintenance of the systems; and c) appropriateness of water utilization for the diversified crop. To ensure the application of the three principles in daily irrigation practices, a number of laws/instructions have been promulgated: a) Water Resources Development Law No. 11 of 1974; b) Government Regulation and Contribution for Operation and Maintenance Cost for Water Resource Development Infrastructure (No. 6 of 1981); c) Government Regulation on Water Management (No. 22 of 1984); d) Government Regulation on Irrigation (No. 23 of 1984); e) President Instruction on Implementation Guidance of Water Users' Association (P3A) and Management; and f) Decree, Letter, or Regulation issued by the Local Government.

Planning for the cropping season

Planning for the cropping season is determined by Articles 7, 8, 10, 12 and 13 of Government Regulation (GR) No. 23/1984. These deal, among others, with the following:

1. Planning for cropping season and irrigation season which shall be done not later than one month before the beginning of cultivation season in every irrigation area.
2. Determining tertiary units which will receive water throughout the year (only in the rainy season), and those which will receive water only in the dry season: this includes their location, boundaries, and size specification of each village.
3. Assigning the area for a specific agricultural program, industrial crops, and 2 other specific uses corresponding to the assigned status of the area with respect to the irrigation plan.
4. Determining the time schedule of the partial irrigation for inspection and repair.
5. Establishing general rules of water allocation and distribution in case irrigation water is not sufficient to meet crop requirements.
6. Establishing water allocations for other uses, such as for sugarcane industry, domestic use, etc.

Planning for the cropping season in every region (province and district) is conducted by the corresponding Irrigation Committee, chaired by the Head of the Local Government. The representative of the Irrigation Agency in the respective areas is the treasurer of the Irrigation Committee, and all related agencies (especially Agricultural Food Crop Agency) involved in irrigation are the members. The plan is submitted by the Irrigation Committee to the Local

Government which promulgates the Local Government Regulation for cropping pattern. cropping season, and irrigation season in the respective areas.

The inputs used intheplanningare: weather data (especially rainfall) and river discharge after having been evaluated for their dependability, calculated irrigation requirement based on cropping panemmodel, calibration of measuring devices,and the calculated conveyance losses, and the irrigation schedule (Sutiyadi 1986). Other information on the government's policy on the changes of cropping areas and a o p priority, and the existing physical condition of the irrigation canal are also considered in the planning.

The plan is good for one year only. It is called the General Cropping Season Plan (GCSP). In the implementation of GCSP, various adjustments may have to be made to cope with the prevailing rainfall, the availability of water or river discharge, and the existing crop at the beginning of the cropping season. The degree of adjustment most likely depends on the accuracy of planning.

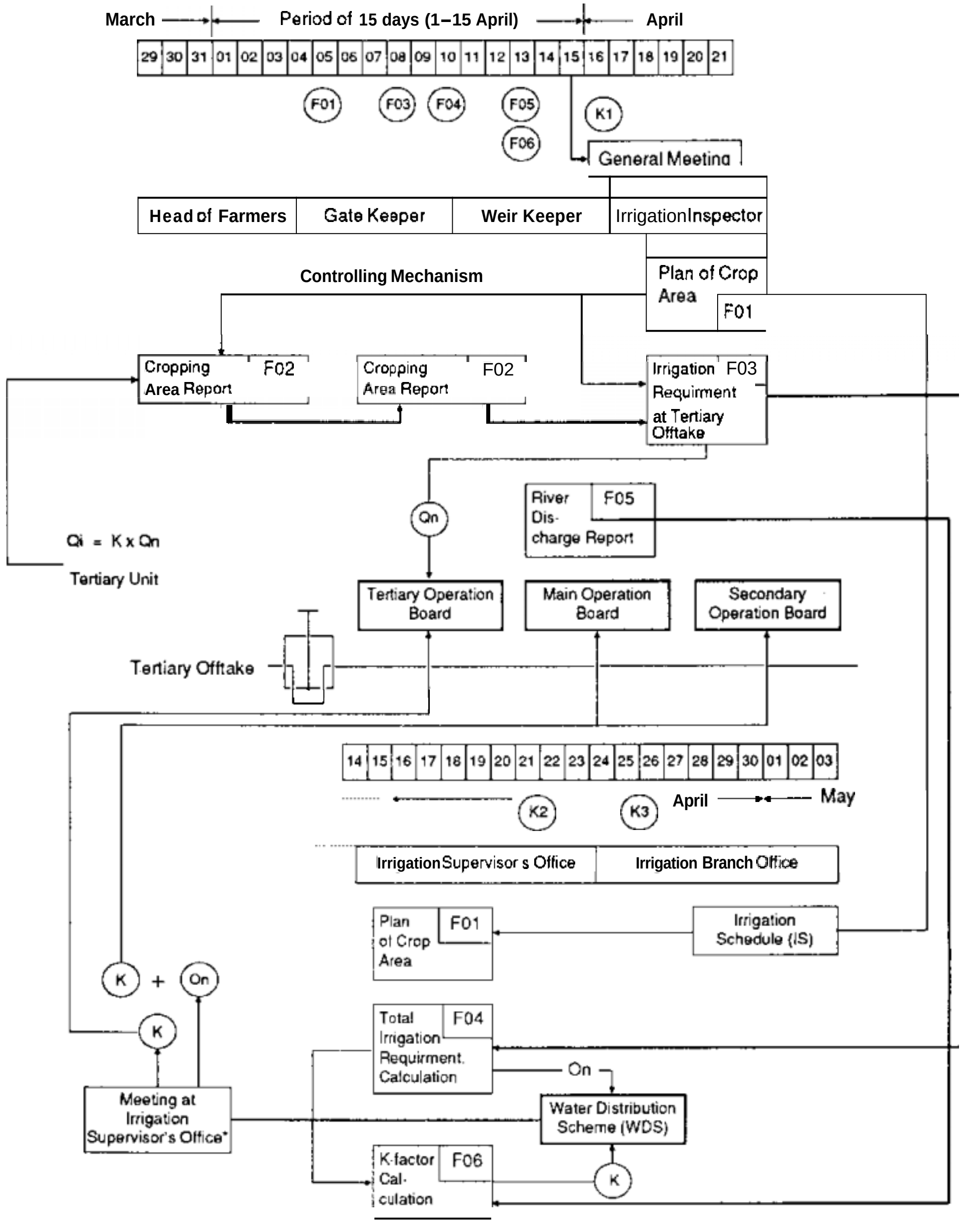
Assessing and matching water supply and demand

The basis for the operation of irrigation systems in Indonesia is the monthly dependable rainfall and flow (80% probable). The assessment of water supply to match the demand is influenced (to some extent) by experience and intuition of the local Irrigation Committee or irrigation personnel. There is no fixed rule and regulation dealing with this matter. However, some guidelines are available: a) *A* rough comparison between the requirement of rice (lowland), sugarcane, and upland crops as 4 1 and 1/2:1; b) Some basic values of water requirement of rice for 1 1/2 months of land preparation (1.16 l/s), 2 1/2 months of flowering (1.00 l/s), and 1/2 month of ripening (0.62 l/s). Water requirement for sugarcane is calculated proportionally with the value for rice; c) Tertiary losses are 20-35 percent and main canal losses range from 10-15percent; d) Minimum areas which have to be reserved for the special program on crop intensification, or industrial crops (sugarcane and tobacco) (Sutiyadi 1986). When the irrigated area is quite large (5,000–10,000 ha), matching water supply at the beginning of the rainy season with peak demand for land preparation can be achieved by dividing the area into 3-4 blocks for irrigation. The establishment of an irrigation status in any particular area during one irrigation season, and prioritizing water utilization for the irrigating crop (Articles 10 and 11 of Government Regulation No. 23/1982) reflect the effort to match the potential supply and the demand for irrigation.

Allocation of water and land area

The allocation of water and land area under the current irrigation practice is rather complicated. Water allocation is updated after a certain period of time, normally 7 days (one week), or 10 days, or 15 days (two weeks). The time interval for updating water allocation is determined by the available flow discharge, the existing crops in the command area, and the adopted system in the irrigation scheme. *An* example of a 1s-day-basis water allocation practice is shown in Figure 3.

Figure 3. Operation of water allocation based on 15-day updating interval.



* This meeting is held on the 15th and the last day of every month and is attended by the Irrigation Supervisor/Staff Irrigation Inspector. Weir Keeper and Head of Farmers.

Figure 3 reflects the involvement of farmers in the decision-making process, although they only provide the cropping area for the different crops. Other data which are required in updating the water allocation plan are: a) planned crop area (FO1) data; b) river discharge report (FO5) data; c) the calculated crop water requirement at tertiary offtake (FO3); and d) the calculated K factor. The K factor is calculated as:

$$K = (Qa - Qb)/Qc \quad \text{...} \quad (1)$$

where Qa is the available discharge,
Qb is the sum of water losses and supplemental discharge, and
Qc is the discharge at the tertiary offtake.

Qa is calculated as:

$$Qa = (Q5 + Q10 + Q3)/3 - (Q13 - Q5)\ l/s \quad \text{...........................} \quad (2)$$

where Q5 is the average discharge from the 1st to the 5th day of operation,
Q10 is the average discharge from 1st to the 10th day of operation, and
Q13 is the discharge on the 13th day of operation.

In most cases, in the allocation of water and land area the following factors are also considered: a) the acceptable level of irrigation efficiency; b) the maximum capacity of conveyance and distribution canals to supply water at peak demand; c) canal safety with respect to the possibility of having high sedimentation rate and canal bank protection from damages due to overdried condition; d) opportunity to grow more rice in the whole area; and e) the existing crop at the beginning of the cropping and irrigation seasons. The areas of a special agricultural program are given priority in land and water allocation.

In some irrigated areas where sugarcane is historically planted, the allocation of water' and land still follows the colonization rule. In these areas, one-third of the command area is assigned for sugarcane. The sugarcane area is rotated in the whole command. Consequently, the allocation of water and land area for sugarcane is more likely to be fixed. In an attempt to increase the cropping intensity of irrigated ricefields, the Government of Indonesia has started shifting the sugarcane cultivation to the upland (unirrigated area).

Coping with various water availability situations

The Government Regulation No. 23 of 1984 gives the general rules for coping with various water shortage situations. It states that:

1. The Local Government may establish the priority of irrigation water distribution in accordance with the local situation and condition (Article No. 13(2)).
2. To prevent crop failure, irrigation water shall be assured for already existing crops. When necessary, distribution of irrigation water may be reduced or rotated among tertiary units (Article No. 13(3)).
3. To meet the needs of industrial crops and food crops simultaneously, the water use may be regulated in rotation on the basis of the decision of the relevant Governor (Head of the Local Government) (Article No. 19(2)). Rotational irrigation will be carried out when the normal discharge (Qn) is less than 60 percent.

Modifiedpractices to accommodate nonrice crops

In principle, it may not be necessary to make major changes in the current irrigation practices to accommodate nonrice crops. If minor modifications would be required, they must be supported by a well-coordinated development program. The program should not only be concerned with the technical aspects of irrigation and agronomic practices, but also with the influence of the socioeconomic changes as affected by adopting the new technology. These minor adjustments of the irrigation system management in Indonesia may take a long time.

The most likely modifications or improvements required to provide a batter service for nonrice crop cultivation are: a) improving the drainage facilities, especially in the tertiary system; b) improving the accuracy of predicting the possible rainfall and river water discharge; and c) providing data on crop water requirements of upland craps.

CONSTRAINTS/OPPORTUNITIES IN IMPLEMENTING MANAGEMENT CHANGES

As mentioned earlier, the existing irrigation systems have been planned, designed, and operated to provide for diversified cropping. Accordingly, any necessary management changes in the irrigation system will require only minor adjustments. These minor management changes can be related to the following:

1. The degradation of the catchment area due to deforestation and improper land use. High fluctuation of Oow discharge between rainy and dry seasons causes either water excess or water shortage in the command area.
2. The adoption of high yielding varieties (HYV) with shorter growing periods. This allows farmers to harvest the second rice crop at the beginning of the dry season. As rainfall occurrence at this transition period is very uncertain, farmers tend to be more speculative as regards cultivating the third rice crop. This creates a highly diversified cropping pattern in the irrigated area and water in the field becomes very difficult to maintain at an optimum condition.
3. Rice being the staple food, it is grown by the subsistence farmers at every possible opportunity.
4. The difficulty in marketing food commodities other than rice influences the willingness of farmers to change the farming system from rice monoculture to diversified crops.

Other minor problems result from: a) insufficient facilities to carry out operation and maintenance (O&M) properly; b) insufficient irrigation personnel in terms of number and capability; and c) more time needed by farmers to adopt the new technology for profitable diversified cropping. The high economic value of nonrice crops during the last five years favored crop diversification. If this situation can be maintained, the minor changes in the irrigation management could easily be overcome.

STRATEGIES TO ADDRESS CONSTRAINTS/OPPORTUNITIES

Improvement of Irrigation Facilities

During the four consecutive Five-Year Development Programs (Pelita 1968/69-1987/88), the improvement of irrigation facilities has focused on the rehabilitation of the existing irrigationsystems and the developmentofnew irrigation schemes. Massive funds were spent for this program as shown in At the end of the Pelita IV (1983-1988), the Government shifted focus of irrigation development from construction to O&M. By focusing the program activity on O&M, the required funds for rehabilitation were reduced without adversely affecting maintenance and the service capability of the irrigation system. This policy of irrigation development has been continued in the Pelita V (1988/89/1993-94).

As regards crop diversification, irrigation development activity will be concentrated in the selected production centers identified by the Department of Agriculture, especially in Java. The reasons for selecting Java as a priority for irrigation development are: a) crop diversification needs more fertile soil than the monoculture rice crop; b) farmers are already accustomed to crop diversification in the ricefield areas: c) presence of better marketing facilities: and d) most irrigation systems were established a long time ago.

Table 2. Irrigation development pı ram, 1983/84-1986/87.

Subject	Y r			
	1983/84	1984/85	1985/86	1986/87
Irrigation development		Rp x 109		
Foreign assistance	587.4	658.3	529.6	394.2
Local funds	203.3	285.9	209.1	227.6
O&M funds	(32.9)	(46.7)	(46.4)	(40.6)
Physical development		1000 ha		
New irrigation schemes	34.6	60.2	124	24.7
Groundwater development	43.1	49.1	41.4	43.7
Rehabilitation work	146.1	208.9	114.1	
Tertiary development	157.3	83.0	26.9	34.1
Swampy area development	46.4	48.0	54.4	4.8
Total	428.1	449.2	309.8	107.3

Source: World Bank Report (February 1989).

Strengthening Institutional and Managerial Capability

Aside from the physical improvement of irrigation facilities, the government launched several measures for improving the institutional aspects of O&M (DPU 1987). These improvements include: a) strengthening the organization of Water Resources Public Work Service (WRPWS - Dinas Pekerjaan Umum Pengairan) to enable a more effective, efficient and uniform implementation of the O&M plan; b) clarifying the right, authority, and responsibility of the agencies involved in the implementation of O&M; and c) enforcing the implementation of President Instruction No. 211984 on sharing of responsibility for O&M between the government and Water Users' Associations, and the Government Regulation No. 2311982 on strengthening the function of the Irrigation Committee. Improving personnel management, developing a management information system (MIS) and a system for monitoring and evaluation of O&M are also relevant efforts on institutional improvement.

Improvement of Procedures and Practices

Various efforts have been made to improve irrigation management procedures and practices in diversified ricefield areas. Among these are:

System characterization and mapping

To implement the improvement program on the physical facilities of the irrigation system and to strengthen irrigation management, reliable system characterization and mapping are needed. These will show the physical characteristics of a system as regards the topography, hydrology, and soils, among others. Furthermore, the structural density and variability and the network pattern could be easily identified. In Indonesia, only the physical characteristics of the tertiary system have been intensively studied so far (Pusposutardjo 1989).

The irrigation system can be characterized according to its performance in distributing and supplying water over the command area. Sukirno (1989) characterized irrigation system performance in distributing water based on the water status of the command area. The water status at any particular time was classified as: a) suitable for lowland rice only; b) suitable for upland crops (nonrice crops) but needs irrigation for rice; and c) insufficient for growing any crop. The changes of water status with respect to time and area were monitored from the depth of the table. Theoretically, the method is able lo characterize system capability especially in the coastal area. However, large-scale trials are still needed.

Improvement of the accuracy ofplanning

Studies have been conducted to improve the accuracy of planning for the cropping season and irrigation season. The studies covered the hydrological aspect of rainfall and the estimation of crop water requirement.

Hydrological studies of rainfall include the determination of the minimum number of rain gauges per unit area, and the prediction of the start of the rainy and dry seasons. Masruki (1987) and Hadiani (1989) concluded that one rain gauge was sufficient to cover one tertiary block with an accuracy of 90-95 percent (area of a tertiary block ranges from 100 ha to 150 ha). For hilly areas or in inland areas, the accuracy would slightly decrease especially during the transition seasons.

Another study related to rainfall showed that 300-400 nun of cumulative rainfall accounted for the driest days at the beginning of the rainy season could be used as the time of the beginning of the cropping season (Anonymous 1986). Provided 15 years of serial rainfall data are available, this cumulative rainfall could be predicted by extrapolating its variogram value (Hadiani 1989).

Studies on crop water requirement have been conducted in several irrigation schemes, from areas of 700-800 m elevation down to coastal areas. In addition to estimating crop water requirements of different H W of rice and nonrice crops, the assessment of suitable methods for estimating crop water requirement under limited available data was also done. Results from these studies were compiled by Pusposutardjo (1986) and submitted to the Directorate General for Water Resources Development (DGWRD) for use in irrigation practice. Other studies on crop water requirement were also conducted by Syamsiah and Fagi (1986) for mungbean. Sukirno et al. (1986) for rice, corn, mungbean and peanut, Hermantoro (1985) and Syamsuddin (1985) for stringbean and red pepper. Studies on crop water requirement of other crops are still continuing.

Simulation and modeling

Taking advantage of the availability of computers, several crop yield-water use models have beendeveloped. Three models have been tested for their application in planning the cropping season and in predicting the effect of water shortage in the command area. These models are:

1. CRPSM (Crop Yield Simulation Model) developed by DAE/GMU in 1982. This model is continuously being improved and at present has the capability to handle a crop yield-water userelationship of 11upland (nonrice) crops (Pusposutardjo 1990). RADYM (Random Simulation Model) developed from CRPSM has the capability to simulate the most possible planting date of crop, with minimum water requirement.
2. AGWAT (Agricultural Water Demand) developed by the Institute of Hydraulic Engineering, DGWRD (Suryadi et al. 1989). The model was developed to predict agricultural water demand in a large area of a water resources development project. By integrating AGWAT model with another model (RIBASIM) it could be used to study the impact of actual water supply on agriculture in the Cisadane-Cinamuk Integrated Water Resources Development Project (Hatmoko et al. 1990).
3. The latest model, the Rice Yield Model as Affected by Excessive Water developed by Arif (1989). This model is still new and intended for irrigated rice in areas with potential excess water problem. With a little modification this model might also be used for other crops.

Farmer participation

A pilot project on irrigation development using the farmer participatory approach was carried out in Madiun Irrigation project from 1983184 to 1987/88. The objective of the projectwas to study the farmer participation process in irrigationdevelopment. Lessons from the project would be very useful in developing a strategy for involving farmers in irrigation development programs. The involvement of farmers in irrigation development enhances their sense of belonging which could result in a smooth turnover of the system to them.

DIRECTION OF IRRIGATION MANAGEMENT FOR CROP DIVERSIFICATION

Research and Development

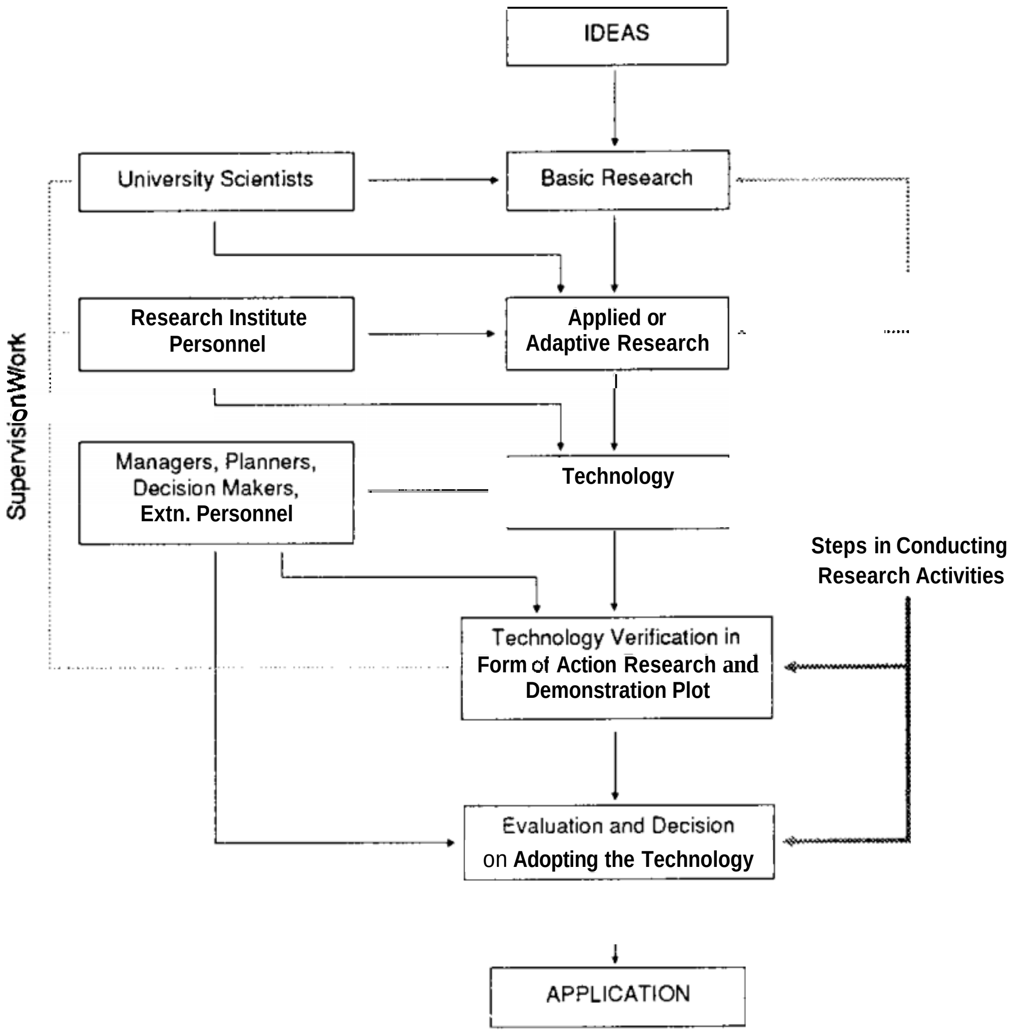
Minor problems in irrigation management for crop diversification can be considered as associated problems in the technology transfer process of farming and irrigation practices. In this case, technology transfer means a process of translating ideas into action. The process comprises a series of activities, which are interconnected and represent the contribution of agencies involved in the process (Holt 1988).

Adopting the concept of technology transfer, the basic strategy to solve the minor problems in water management for crop diversification by a) defining the steps for achieving the objectives; b) the responsibility of each agency and its expected role in every step of the process; and c) the linkage between agencies. At present, the settlement of minor problems in irrigation management for crop diversification is far removed from the basic strategy of technology transfer. Most personnel in the agencies involved in the crop diversification programs and irrigation management do not realize that these minor problems are deeply rooted in the complicated interaction between technical, economic, and social aspects of the farming system as a whole. The diagram of technology transfer is shown in Figure 4.

Observations on research activities dealing with irrigation management improvement indicate that the linkage mechanism between researchers, researchers and the agencies as interested parties and between the involved agencies, is the weakest line in technology transfer. Because of the poor linkage, many research findings in irrigation management seemed unutilized.

Garret (1985) and Hess (1985) pointed out several benefits from good linkage with research. These are: a) avoiding the possible conflict of interest (in tenns of financial, material, academic status, promotion, or prestige); b) having the same perception on the importance of the problems and their expected contribution in solving the problem; and c) effective and efficient use of the available resource. Technology transfer shows that a close linkage among agencies should not only be in the implementation of the program planned, but should start from the earliest step in the planning process.

Figure 4. Framework of technology transfer in irrigation management.



——— These steps of activities are Still missing.

Considering that problems in irrigation management for crop diversification cover various technical, economic, and social issues, the suggested steps lo address the problems could be as follows:

1. Establishing the framework of technology transfer process in irrigation management improvement, starting from basic research until the utilization of the new technology.
2. Establishing the institutional linkages on a basis which can accommodate partnership and cooperation.
3. Establishing a definite workplan covering at least a 3-5-year program.

An initial research activity could be a one-year program on the inventory, review, and documentation of the previous research. If time allows, the activity can pursue the screening of promising research finding. In the second year, a coordinated research program on the various steps of technology transfer could be started.

Funding

Funds available for conducting research in irrigation management improvement are very limited. Without a well-planned program, and well-structured implementation. it may be difficult to achieve the objectives of the research. Based on similarities in irrigation management practices and problems, a regional collaboration would be helpful to address the funding problem. In conjunction with this, international sponsorship is required.

SUMMARY

Irrigation management problems of crop diversificatioii in Indonesia are considered minor, because the existing irrigation systems have been developed and operated for diversified crops in ricefield areas. Although the problems are considered minor, they are very complicated in nature. These problems are deeply rooted in technical-socioeconomics interaction between irrigation management practice and the crop diversification farming system.

Great opportunities for developing crop diversification and improving irrigation management practice can be gained by having a well-planned program and well-structured implementation of research. An integrated approach in technology transfer is suggested for adoption. International sponsorship of regional collaboration in irrigation management development programs is required to address the funding problems.

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