IRRIGATED DIVERSIFIED CROPPING CONSTRAINTS IN THE PHILIPPINES: A PRELIMINARY STUDY

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In recent years, developing countries have become increasingly self-sufficient in irrigated rice. As an alternative strategy, many farmers in the Philippines produce non-rice crops under irrigation with highly variable results. The reasons for this are not well understood. Although all public irrigation systems were designed and built for wet season rice, these systems provide only enough water to irrigate a small portion of the full service area in the dry season.

A technological shift to adopt high yielding rice varieties in the past 20 years has increased the value of irrigation in the dry season. The economic viability of farming and of investing in irrigation development is increasingly dependent on dry season production. Competition for limited water in the dry season to produce rice has greatly increased. The need for alternatives has led to growing non-rice crops in suitable irrigated areas. However, the prospects for efficient and profitable production of these crops remain questionable. Agricultural and irrigation technologies, and economic and institutional factors that affect the performance of irrigated non-rice crops are not yet adequately understood.

STUDY OBJECTIVES

The overall objectives of the study were to identify the constraints to successful diversified cropping in irrigated areas and suggest ways to mitigate these constraints.[1] Constraints were grouped into irrigation, agronomic, economic, and institutional aspects of irrigated diversified cropping.

Study Sites

The study was conducted at three locations (Figure 1).

Allah Valley. In southern Mindanao, sites are: 1) the Allah Valley River Irrigation Project (ARIP), specifically the area served by lateral A-extra which is the Pilot Testing and Demonstration Farm Number 2 (PTDF#2) and which covers 277 hectares (ha); 2) the Banga River Irrigation System (BARIS), with an area of 2,300 ha; and 3) the Mani River Communal Irrigation System (MCIS), a farmer-managed system with an area of 732 ha.

Isabela. In northeastern Luzon, sites are part of the service area of the reservoir backed by the Magat River Integrated Irrigation System (MRIIS). Approximately 11,000 ha have soils in dual and diversified land classes. The area is served by lateral A of the Magat River Irrigation Systems (MARIS) --

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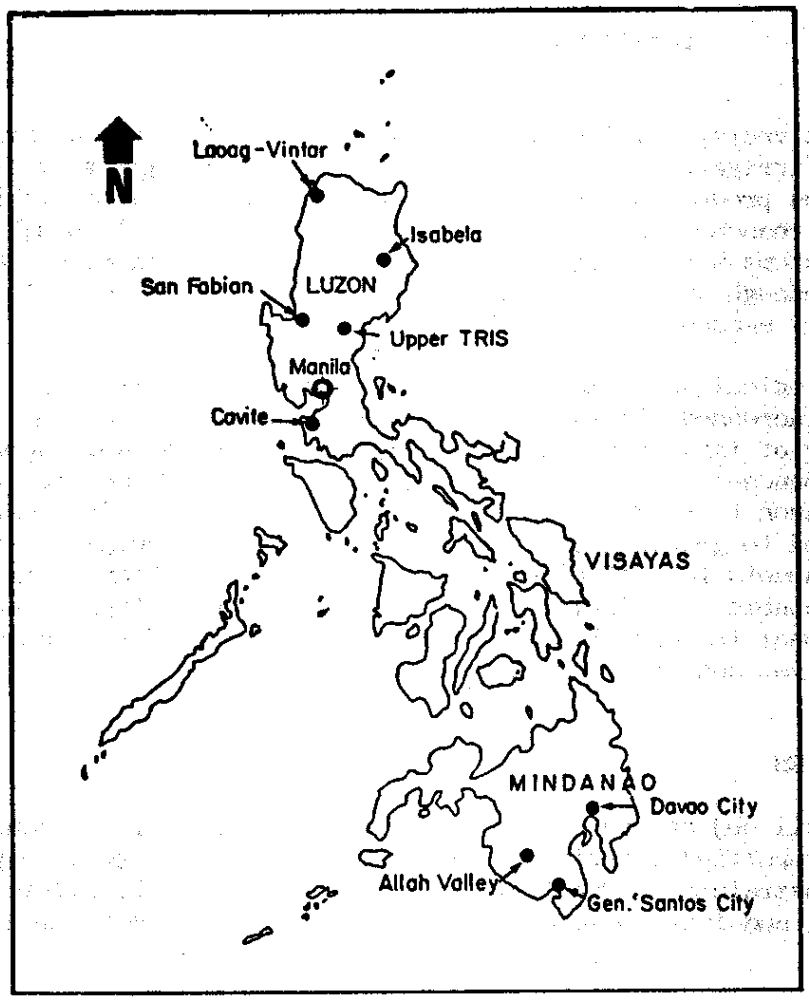
Figure 1. Map of the Philippines showing study sites.

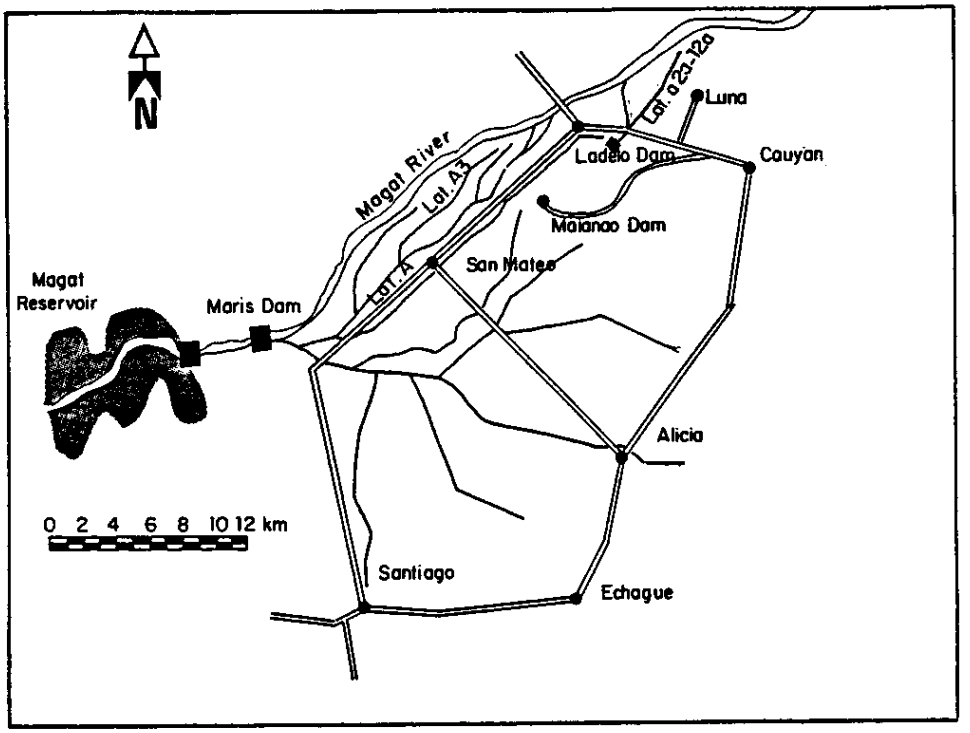


one of the two main systems comprising MRIIS. It is located near the banks of the Magat River and has a very high water duty if planted to lowland rice (Figure 2). It is classified as most adaptable for diversified crops. However with enough water, rice yields more than 5 tons/ha.

Cavite. In Central Luzon, the site is a part of the Second Laguna de Bay Irrigation Project (SLBIP). This project is expected to be completed in 1988 and will irrigate about 13,160 ha in the wet season and 9,600 ha in the dry. Approximately 2,500 ha is programmed for vegetable production in the dry season. Vegetable production is a logical choice for irrigated crop diversification due to the proximity of the project to Metro Manila.

Additional sites. In Luzon, four were added: the Upper Talavera River Irrigation System (Upper TRIS) in Nueva Ecija, the Agno River Irrigation System (Agno RIS) and the San Fabian River Irrigation System (SFRIS) both in Pangasinan, and the Laoag-Vintar Irrigation System (LVRIS) in Ilocos Norte.

Figure 2. Map of Magat River Irrigation System (MRIS) showing laterals.



Climate

Rainfall patterns can be categorized into four types (Hernandez 1975):

Type I. Two pronounced seasons. Dry from November to April and wet during the rest of the year. This type covers study sites in Ilocos Norte and Central Luzon.

Type II. No dry season with very pronounced maximum rainfall from November to January. This covers sites in Cavite.

Type III. Season not pronounced and relatively dry from November to April and wet during the rest of the year. This covers sites in Isabela.

Type IV. Rainfall more or less evenly distributed throughout the year. This covers the Allah Valley sites in southern and southwestern Mindanao.

METHODOLOGY

Study of Constraints to Diversified Cropping

Studies conducted at the main sites were: 1) system management, 2) evaluation of irrigation methods for corn, 3) crop testing of alternative non-rice crops, 4) economic aspects of irrigated/non-irrigated diversification, and 5) the role of irrigators' associations in operations and management.

Study 1. Stations were established in the sites to measure rainfall and evaporation. Canal flows were measured at strategic points to evaluate water availability and distribution equity. Planted areas under irrigation were monitored to estimate water demand.

Study 2. At the Allah Valley sites, furrow irrigation was compared with basin flooding for corn. At Isabela, double furrow and triple furrow methods were compared for corn. At Cavite, single furrow and double furrow irrigation for white beans were compared. In all studies, irrigation was applied when 50 per cent of the available soil moisture was depleted. Cut-throat flumes were used to measure irrigation flow. Duration of application, total water applied, and labor use were compared.

Study 3. Irrigated peanut, mungbean, and corn in Allah Valley were tested for adaptability. Researchers provided inputs and farmers provided land and labor. The farmers received the produce. At Isabela, irrigated peanut was compared with rainfed peanut under arrangements similar to those in the Allah Valley sites. Yields and farmer incomes were compared to those of farmers planting irrigated rice.

Studies 4 and 5. At least 10 per cent of the farmer population in the study areas were interviewed regarding cropping behaviors. At the additional sites, the study focused on the economics of irrigating non-rice crops and on farmer decision making related to irrigated crop diversification. Operations and maintenance procedures were also noted.

Crop Simulation Study

A crop simulation study was done for ARIP lateral A-extra to identify optimum irrigation scheduling for diversified crops. The cropping pattern was irrigated rice followed by irrigated corn. Weekly rainfall data from 1967-86 was used. However pan evaporation data was available only for 1980-85 and this 5-year mean was used for years without data. The flow chart for the simulation study is shown in Figure 3. Two simulations were done using the following:

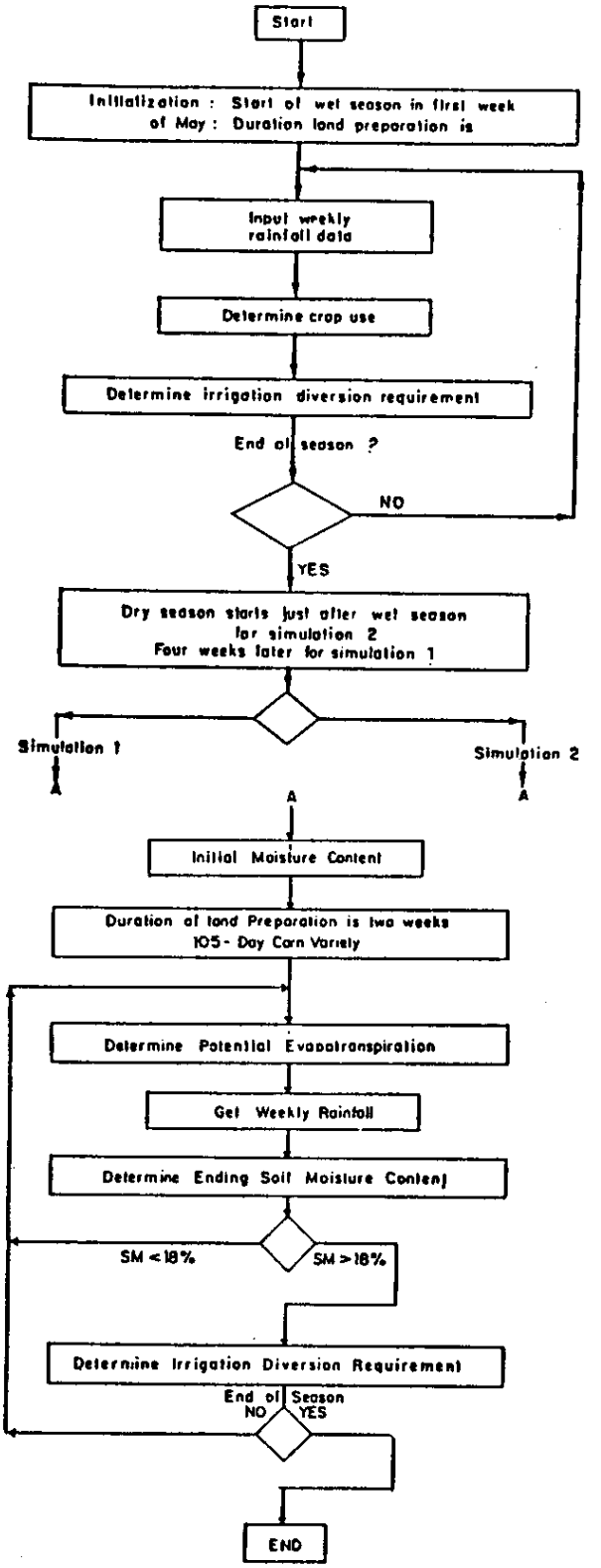
Simulation 1 (wet season):

1. Season started first week of May.
2. Land soaking was staggered to 4 weeks because of limited canal capacity.
3. Three weeks land preparation to coincide with seedling growth of transplanted rice.
4. Rice was 120-day variety.
5. Overall efficiency was 60 per cent.

Simulation 1 (dry season):

1. Season started four weeks after rice harvest. Irrigation began when the available moisture in the upper 60 centimeters (cm) of soil fell below 50 per cent.
2. Corn was 105-day variety.
3. Overall efficiency was 40 per cent.

Figure 3. Flow chart for simulation studies



Simulation 2: All the above hold except that the dry season started immediately after rice harvest. The following were also used:

1. Seepage and percolation = 10 millimeters (mm)/day.
2. Soil moisture saturation = 30 per cent by weight.
3. Apparent soil specific gravity = 1.5.
4. Depth of root zone for corn = 60 cm.
5. Soil field capacity = 15 per cent by weight.
6. Permanent wilting point = 7.5 per cent by weight.

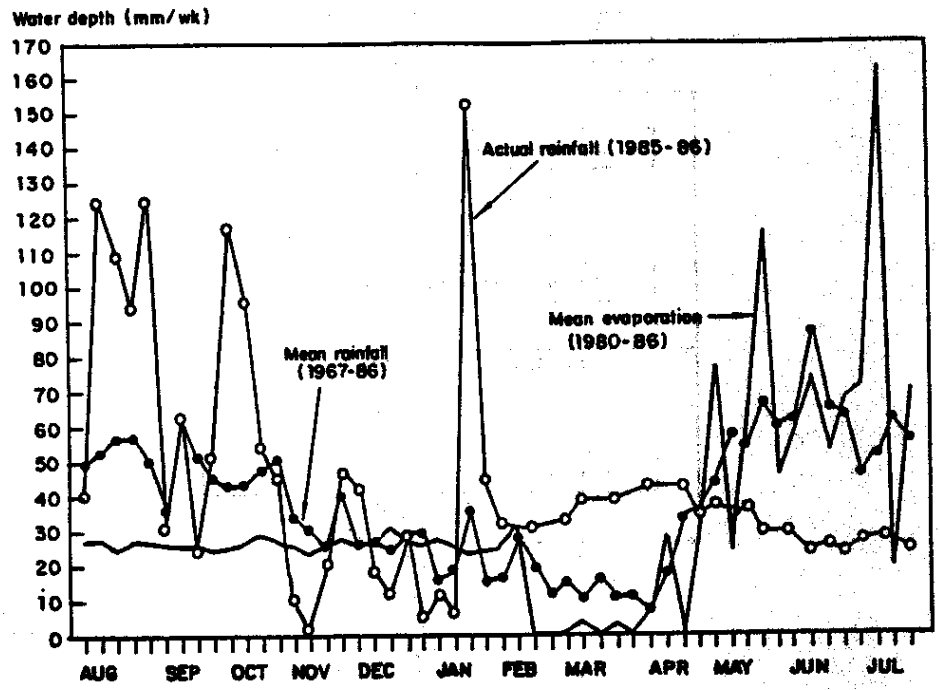
Crop coefficient for corn, which is multiplied by pan evaporation to obtain potential evapotranspiration, ranged from 0.3-1.2 from land preparation to grain formation. Rainfall data was analyzed using the incomplete gamma distribution.

RESULTS AND DISCUSSION

The Allah Valley Sites

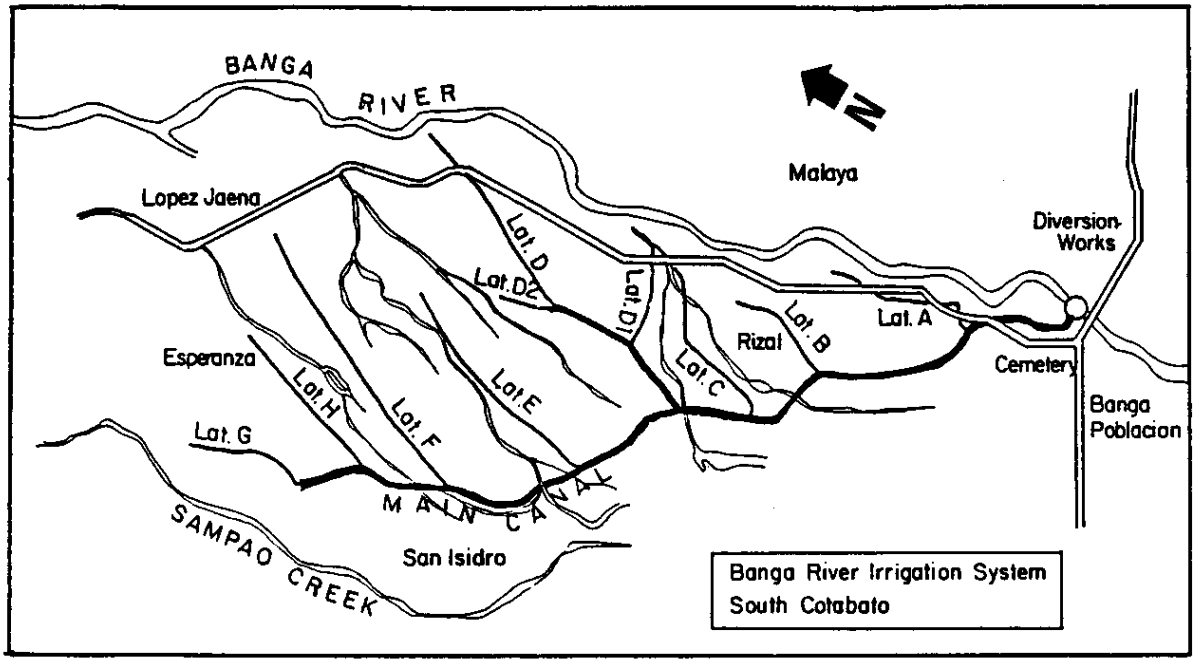
The rainfall pattern is type IV. Evaporation averages 4 mm/day from June to January, and 6 mm/day for the rest of the year (Figure 4). Moisture deficit occurs only from late December to April in an average year. Crop water use averaged 4 mm/day in evapotranspiration and 13 mm/day in seepage and percolation (S&P). The soils are mostly sandy loam. There is a sandstone-like layer 100-120 cm deep which restricts downward water flow.

Figure 4. Mean weekly rainfall (1976-86), mean evaporation (1980-86), and actual rainfall (1985-86), Surallah, South Cotabato.



Banga River Irrigation System (BARIS). This run-off-the-river system commands 2,300 ha. A major problem is the large amount of silt that limits the amount of water that can be diverted into the canals. The service area, headed by an Assistant Irrigation Superintendent, is divided into three water masters' divisions into six hydrological sectors (Figure 5).

Figure 5. Map of the Banga River Irrigation System (BARIS).



The irrigable area has been reduced to 1,930 ha because of limited water supply. However, when planted to rice, the system can only irrigate 1,600 ha in the wet season and 1,300 ha in the dry. This system has nine irrigators' associations (IA) integrated into one federation. To plan the water delivery schedule, IA, federation, and barangay (smallest political unit in the Philippines) officials meet with representatives of the government and private agencies concerned with agriculture in the area one month before the start of each season. They decide which to irrigate. Farmers are encouraged to plant excluded areas with corn or other diversified crops but the land is not irrigated. However, if there is enough water left after irrigating the programmed rice areas, excluded areas may be given water.

Irrigation is rotated by providing each sector with water for a specified number of days on a weekly schedule. The National Irrigation Administration (NIA) field staff implement the schedule but cannot alter it without consulting farmers. Water supply data is shown in Table 1. Flow measuring devices were installed in August 1985, which was in the middle of the wet season. To prevent unscheduled deliveries, unauthorized checks are removed

Table 1. Irrigation diversion (ID), rainfall, and relative water supply (RWS*; in millimeters per week) by division for BARIS during the wet and dry seasons, 1985-86.

Wk	Season & date	Rain fall	Total ID	Total RWS	Div A ID	Div A RWS	Div B ID	Div B RWS	Div C ID	Div C RWS
35	Wet Aug 27-Sep 2	80	46	1.6	60	1.6	29	1.2	52	1.9
36	3-9	140	46	2.3	24	2.0	47	2.1	58	2.7
37	10-16	69	20	1.1	22	1.1	16	1.0	35	1.3
38	17-23	34	59	1.1	37	0.9	15	0.6	67	1.2
39	24-30	38	46	1.0	110	1.8	16	0.6	38	0.9
40	Oct 1-7	34	49	1.0	118	1.8	40	0.9	16	0.5
41	8-14	63	52	1.6	104	2.4	31	1.2	38	1.2
42	15-21	87	47	2.1	178	4.5	17	1.6	24	1.5
43	22-28	38	35	1.2	160	3.8	8	0.8	27	0.9
44	29-Nov 4	16	103	1.5	1735	23.5	41	0.8	76	1.2
45	Dry Nov 5-11	0	104	1.1	262	2.9	83	0.9	29	0.3
46	12-18	11	74	0.9	187	2.2	59	0.8	22	0.4
47	19-25	30	54	0.9	159	2.1	32	0.7	14	0.5
48	26-Dec 2	3	65	0.7	143	1.6	39	0.5	42	0.5
49	Dec 3-9	28	76	1.1	139	1.8	99	1.4	72	1.1
50	10-16	121	60	2.0	89	2.3	80	2.2	73	2.1
51	17-23	11	65	0.8	45	0.6	73	0.9	84	1.1
52	24-31	10	95	1.1	78	1.0	70	0.9	133	1.6
1	Jan 1-7	2	81	0.9	65	0.7	113	1.3	63	0.7
2	8-14	12	92	1.1	126	1.5	91	1.1	74	0.9
3	15-21	31	101	1.4	148	2.0	136	1.8	85	1.3
4	22-28	36	57	1.0	59	1.0	63	1.1	52	1.0
5	29-Feb 4	23	44	0.7	82	1.2	25	0.5	38	0.7
6	Feb 5-11	5	63	0.8	75	0.9	90	1.1	60	0.7
7	12-18	11	71	0.9	149	1.8	107	1.4	101	1.3
8	19-25	3	85	1.0	250	2.8	217	2.5	152	1.8
9	26-Mar 4	2	139	1.6	784	8.7	475	5.3	213	2.4
10	Mar 5-11	9	95	1.2	0	-	0	-	0	5.0
11	12-18	0	162	1.8	0	-	0	-	0	3.3
12	19-25	0	534	5.7	0	-	0	-	0	11.7
Wet season mean		65	45	1.4	90	2.2	24	1.1	40	1.3
Dry season mean		21		1.0		1.6		1.2		1.0
Overall mean		37		1.2		1.8		1.2		1.1

*RWS = (rainfall + irrigation)/crop water requirement; means do not include weeks 44 and 9-12 due large amounts of water diverted and small areas under irrigation at the end of the season.

by NIA staff. Areas not scheduled have their gates closed. Division A is upstream and laterals are closed when water is not scheduled; checks in the main canals are removed. Division B, served by lateral D, has one supply point. Divisions A, C, and D include many turnouts directly served by the

main canal. Division C, the tail end, uses return flows into the main canal, thus receiving more water in the wet season than Division B. Dry season flows were minimal. There were many weeks where the relative water supply (RWS) was less than one. The means show maldistribution: Division A received twice as much water as Division C and three times that of Division B. Crop water stress was not observed.

The large area served by the main canal made it necessary for NIA staff to gather data by division and not by sector; water flows were measured up to the sector level. In order to compare sectors, these flows were converted into values by using a water duty of 1.5 liters per second/ha (lps/ha) or 13 mm/day. As an alternative method of analyzing equity in water distribution, the area in each sector programmed for water deliveries became the basis against which actual irrigation was compared for every rotation. Weeks when the irrigated area is greater than the programmed area are "excess" weeks, while the opposite are "deficit" weeks. Maldistribution is evident with Sector I having fewer deficit weeks (Table 2). Sectors III and IV were not scheduled for irrigation in the dry season; the wet season was extended for 1.5 months for Sector III and 2 months for Sector IV.

More deficit weeks appear in Table 2 than in Table 1 (as shown by an RWS less than one) because actual irrigated area, used in Table 1, exceeds the programmed area, used in Table 2. Although the rotation scheme gave equal opportunity for all farmers to receive a share of water, even during periods of water scarcity thus preventing serious crop damage, there was not enough water to irrigate the system. About 1,500 ha of rice was irrigated in the wet season and 1,200 ha in the dry. Irrigated corn was not included in the program due to farmers' preference for rice.

Including corn in the program would mean a probable loss of revenue for the NIA because of the difficulty in collecting irrigation service fees. Farmer groups scheduled to plant irrigated rice in the wet season tend to request extended water deliveries into their dry season schedule. By doing so, soil moisture may become sufficient to support dry season rice. Such requests are usually granted to compensate farmers for not planting rice in the next wet season. In areas scheduled for rice irrigation, some farmers tend to plant corn adjacent to rice paddies where the corn can be irrigated by seepage. These farmers cannot be billed for irrigation service because the corn is not directly served. Although there is a large area of corn planted adjacent to rice in BARIS, farmers are under the misconception that corn does not normally need irrigation. However, during droughts in 1983 and 1984 dry seasons, farmers requested irrigation for corn and were made to sign promissory notes to pay their irrigation service fees.

Mani Communal Irrigation System (MCIS). This farmer-managed system serves 732 ha and gets water from a concrete diversion dam across the Mani River at Esperanza, South Cotabato. The system was rehabilitated through a NIA loan which farmers are amortizing. Managed by an Irrigators' Association (IA), the system is divided into five sectors, each having a leader. A hired canal tender oversees water distribution and a hired gate keeper tends the dam's main diversion point. Before each season the IA decides which sectors will be irrigated, and schedules deliveries and cut-off dates. There

Table 2. Water availability and equity by sectors as a function of comparing "Excess" (E) and "Deficit" (D) weeks, BARIS, wet and dry seasons, 1985-86.

Week	Season & date	Total*	Sectors I	II	III	IV	V	VI
35	Wet Aug 27-Sep 2	E	E	E	D	E	D	E
36	3-9	E	E	E	E	E	E	E
37	10-16	D	D	D	E	E	E	E
38	17-23	D	E	D	D	E	D	E
39	24-30	D	E	D	D	D	D	D
40	Oct 1-7	D	E	D	E	D	D	D
41	8-14	E	E	D	E	E	D	E
42	15-21	E	E	E	E	E	E	E
43	22-28	D	E	D	D	D	D	D
44	29-Nov 4	D	E	D	D	D	D	D
Programmed area (ha)		1930	250	400	360	300	350	270
Excess weeks		4	9	3	5	6	3	6
Deficit weeks		6	1	7	5	4	7	4
45	Dry Nov 5-11	D	E	D	D	D	D	D
46	12-18	D	E	D	D	D	D	D
47	19-25	D	E	D	D	E	D	D
48	26-Dec 2	D	E	D	D	E	D	D
49	Dec 3-9	D	E	D	D	D	D	D
50	10-16	E	E	E	E	E	E	E
51	17-23	D	D	D		D	D	D
52	24-31	D	D	D		D	E	E
1	Jan 1-7	D	D	D			D	D
2	8-14	E	E	D			D	D
3	15-21	E	E	D			D	E
4	22-28	D	E	D			D	E
5	29-Feb 4	D	E	D			D	D
6	Feb 5-11	D	D	D			D	D
7	12-18	D	D	D			D	D
8	19-25	D	D	D			D	D
9	26-Mar 4	E	E	D			D	E
10	Mar 5-11			D			D	D
11	12-18			D			D	D
12	19-25			D			D	E
Programmed area (ha)		1277	207	509	235	248	309	252
Excess weeks		4	11	1	1	3	2	6
Deficit weeks		13	6	19	5	5	18	14

*Programmed areas were reduced to 150, 36, and 114 ha for the Total, Section A, and lateral B, respectively, from week 1-8.

are monthly meetings in each sector. Instruments to measure canal flows were installed in August; Table 3 shows total water supply. The area was divided

into two parts: sector A (300 ha), served by the main canal, and sector B (432 ha), served by lateral B (Figure 6).

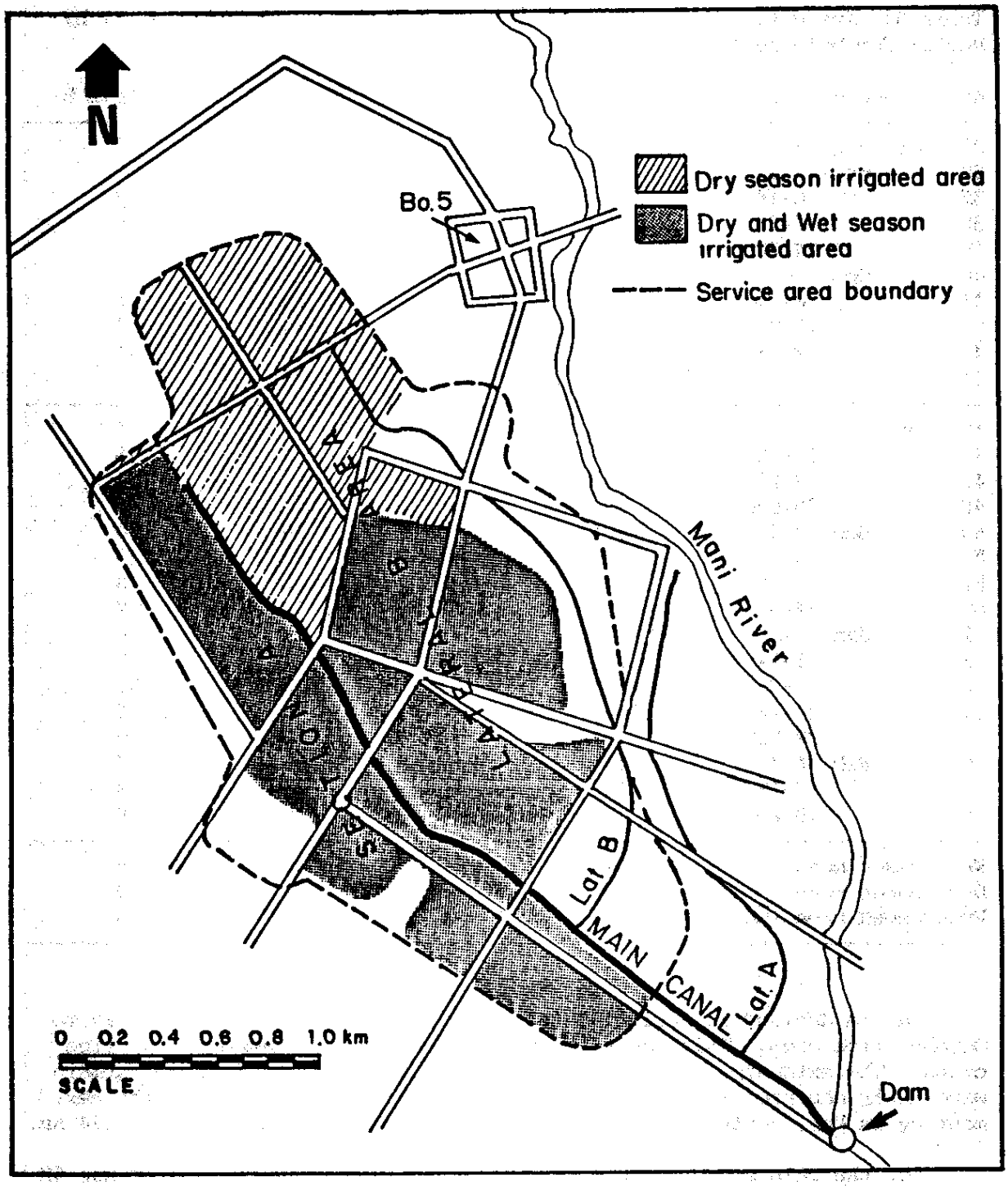
Table 3. Irrigation diversion and rainfall (in millimeters per week) by sector for MCIS during the wet and dry seasons, 1985-86.

Wk	Season & date		Rainfall	Total	Sector A	Lateral B
35	Wet	Aug 27-Sep 2	31	59	61	56
36		Sep 3-9	33	71	55	91
37		10-16	31	58	56	59
38		17-23	33	80	83	76
39		24-30	31	68	58	79
40		Oct 1-7	33	81	82	81
41		8-14	31	70	65	75
42		15-21	33	72	84	57
43		22-28	31	63	82	41
44		29-Nov 4	33	54	64	42
45	Dry	Nov 5-11	2	75	68	84
46		12-18	1	90	52	135
47		19-25	14	103	102	104
48		26-Dec 2	14	16	29	0
49		Dec 3-9	40	89	56	130
50		10-16	6	85	53	125
51		17-23	36	43	17	73
52		24-31	5	96	79	117
1		Jan 1-7	3	65	48	84
2		8-14	27	73	21	136
3		15-21	29	21	9	35
4		22-28	148	0	0	0
5		29-Feb 4	7	0	0	0
6		Feb 5-11	15	80	56	67
7		12-18	11	97	28	88
8		19-25	11	65	8	118
Wet season mean			32	67	69	66
Dry season mean			20	63	51	80
Programmed area (ha)				240	132	108

The IA decided in April 1985 to program the area for a single May to October rice crop. This was extended to January to accommodate two rice crops. The extension helped the tail end area of lateral B whose farmers were newly accepted members of the IA. From February 1986 until the next meeting in May, sector A was programmed for 36 ha and lateral B for 114 ha.

For the main season, the mean irrigation supply for the system was 62 mm/week. Sector A had 53 and lateral B had 73 mm/week. This shows maldistribution in favor of lateral B. Most areas served by sector A got their

Figure 6. Map of the Mani Communal Irrigation System (MCIS).



water after the head gate of lateral B. The IA president has a farm served by this lateral and the ditch tender responsible for water distribution is his son. In the extra cropping season, the mean water supply for the whole system was 72 mm/week (sector A had 69 mm/week and lateral B, 82 mm/week). The data shows maldistribution favoring the upstream farmers.

Farmers in MCIS irrigate a smaller rice area in the dry season and take advantage of seepage for adjacent corn. Farmers don't directly irrigate corn, even during drought periods unless corn planted away from the rice fields exhibit moisture stress. However, these corn fields are located far from water sources in higher elevations. As in BARIS, the area not planted to rice is rotated to give equal opportunity to all farmers.

Institutional Observations at BARIS and MCIS. Members of the IAs formally organized by NIA in ARIP and BARIS, and members of the communal irrigation association at MCIS, were interviewed in order to compare the NIA and communal systems.

The results in Table 4 show a discrepancy between the farmers' perceptions of their responsibilities for operations and maintenance and actual practice. This discrepancy is also apparent in the system level management studies at BARIS and MCIS. At BARIS and MCIS, water delivery schedules agreed to between NIA and IAs were seldom adhered to, particularly by the upstream farmers, which resulted in maldistribution. Seasonal decisions were ignored, which made it hard to implement regular rotations and cropping schedules. In order to reduce farmers' uncertainty, the IAs need to communicate to farmers the dates of deliberate suspensions of delivery due to activities such as dam desilting and repair of main canals. Poor communication and implementation of policies appear to be the major constraints that limit effective operation of IAs in BARIS and MCIS. Responses showed that sufficient water and increased income were the dominant benefits perceived by farmers. This implies that an IA's viability is dependent on the irrigation needs of the farmers. The results also indicate that the communal system does no better than the NIA system in terms of actual operational effectiveness.

The responses of the farmers indicate ambivalence in their willingness to shift from rice to non-rice crops (Table 5). However, the popular choice of non-rice crops are corn and mungbean. Particularly at BARIS and MCIS, the testing of alternative non-rice crops might have convinced farmers of the profitability of mungbean production at these two sites.

Isabela Site

The Magat River Integrated Irrigation Systems (MRIIS) service area has a Type III rainfall pattern. Average evaporation is 4 mm/day in cold months, and 6 mm/day in hot months (March-July). Moisture deficits occur from December to April (Figure 7). Corn and tobacco, usually planted October to November, were the main dry season crops before irrigation was introduced. The mean 10-year weekly rainfall shows that such deep-rooted crops may not need irrigation in the early growth stages. This is why farmers believe that such crops do not need irrigation.

Table 4. Percentage responses to questions about perceived problems affecting the Irrigators' Association (IA), responsibilities of the IA members, actual activities of IA members, and perceived benefits of IA membership at ARIP, BARIS, and MCIS, 1985-86.

	ARIP	BARIS	MCIS
Perceived problems affecting IAs			
Members lack interest in IA activities	22.0	25.5	16.4
Inadequate supply, unequal distribution	23.7	25.5	61.8
Poor Irrigation fee collection	1.7	0.0	1.8
Poor management, weak leadership	1.7	0.0	7.3
Marketing problems lack of drainage, no funding	3.4	4.3	1.8
Insufficient & bad farm roads, poor drainage	25.4	0.0	0.0
Did not answer	22.4	44.7	10.9
Total responses	59	47	55
Responsibilities of IA members			
Attending meetings	41.5	7.9	23.4
Maintaining and repairing canals	5.7	14.3	11.7
Paying irrigation fees and financing the IA	40.2	25.4	46.8
Cooperating with IA policies and plans	12.6	49.2	16.9
Helping plan, decide, and solve IA problems	0.0	3.2	1.2
Total responses	51	56	54
Actual activities of IA members			
Maintaining and repairing canals	98.0	64.3	98.1
Cooperating with IA policies and plans	0.0	16.1	0.0
Helping in building IA center	0.0	17.9	0.0
Did not answer	2.0	1.7	1.9
Total responses	51	56	54
Perceived benefits of IA membership			
Increased income and production	35.3	27.7	34.9
Improved standard of living	6.8	1.1	22.1
Sufficient water	54.5	27.6	39.5
Personality development, human relations	0.0	18.4	0.0
Facilitated farm operation	0.0	5.7	0.0
Additional knowledge and technology	1.1	18.4	0.0
Others (request is easier, inputs/financing aid)	0.0	1.1	0.0
Did not answer	2.3	0.0	2.3
Total responses	88	87	86

Note: Respondents gave more than one answer.

Table 5. Percentage responses to questions asking if farmers would consider planting alternative crops to rice during the dry season at ARIP, BARIS, and MCIS, 1985-86.

	ARIP	BARIS	MCIS
1. Are you willing to plant alternative crops to rice during the dry season?			
Yes	84.3	50.0	85.2
No	15.7	50.0	14.8
Total responses	51	46	54
2. If yes, which crop would you prefer?			
Corn	63.6	32.7	44.4
Mungbean	19.7	23.6	30.3
Peanut	4.5	0.0	4.0
Cotton	0.0	0.0	7.1
Eggplant, watermelon, sweet potato, cassava	12.2	41.9	8.1
Total responses	66	55	99
3. If no, what are your reasons?			
Used to planting rice and its our staple	0.0	6.3	0.0
Farm is not suitable for upland crops	13.7	25.4	3.7
Poor drainage	2.0	12.7	11.1
Limited water during the dry season	0.0	1.6	0.0
Not applicable	84.3	38.0	85.2
Total responses	51	63	54

Note: Respondents gave more than one answer.

The Magat River Integrated Irrigation System (MRIIS). This is a 97,400 ha reservoir-supported system that covers the Magat River Irrigation System (MRIS) and the Siffu River Irrigation System (SFRIS). MRIS includes 11,000 ha classified as diversified crop land which is served by lateral A. These areas have light soils and very high water requirements if rice is grown in the dry season. The mean water duties in lateral A areas are: 59 mm/day for land soaking, 27 mm/day for land preparation, 29 mm/day for vegetative stage, and 30 mm/day for reproductive stage.

Two sub-laterals in lateral A were used for growing irrigated diversified crops in past years, specifically corn. Sub-lateral 3a is under the SIBESTER irrigators' association, and sub-lateral A2-a12-a1 is under the CPPL irrigators' association. These two IAs are active and assist NIA with water distribution in their respective areas. NIA has contracted them to clean the canals and participate in irrigation service fee collection.

Figure 7. Mean weekly rainfall (1975-85), evaporation (1985-86) and actual rainfall (1985-86) in millimeters per week for Luna, Isabela.

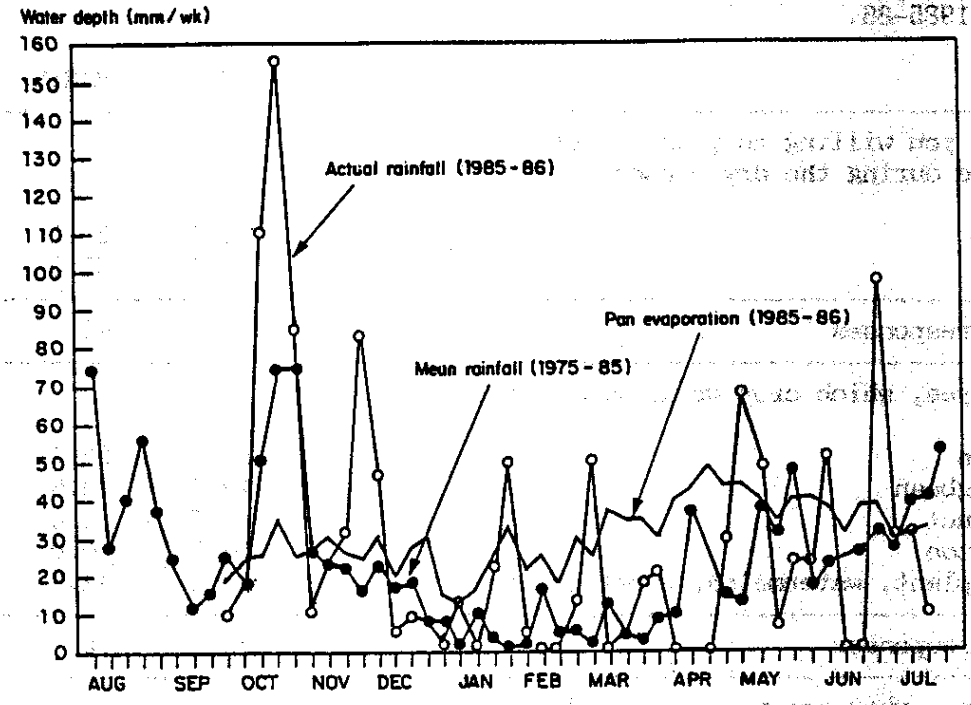
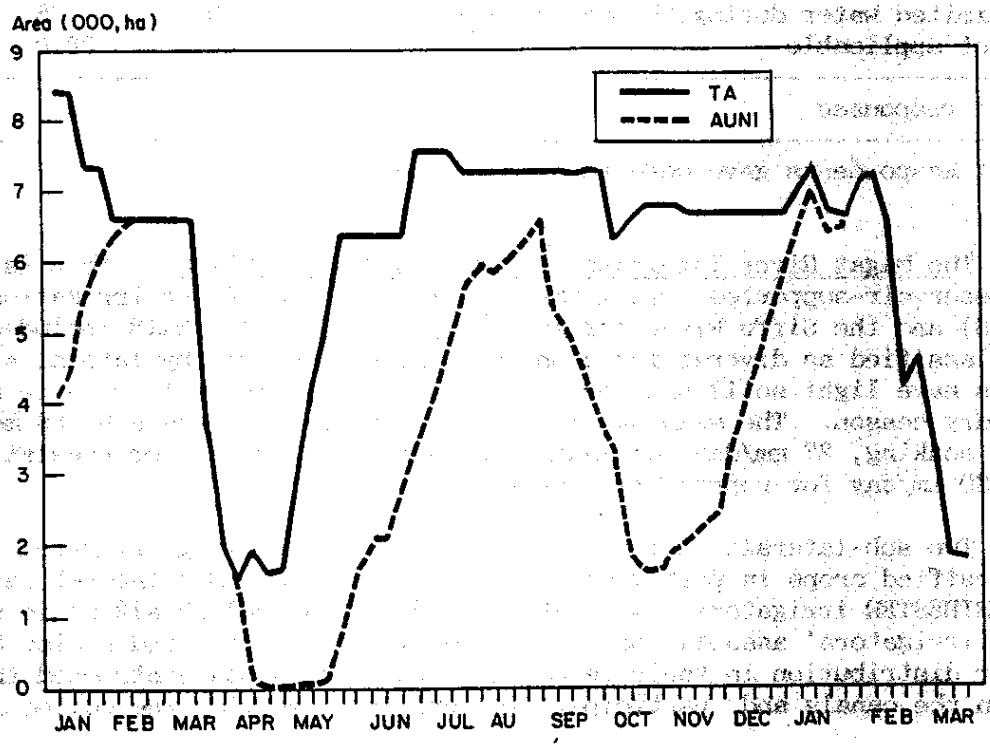


Figure 8. Weekly irrigated areas under normal irrigation (AUNI - covering the period between transplanting and terminal drainage), and total irrigated area (TA = AUNI plus other areas under land soaking and land preparation), for rice, lateral A, MRIS, January 1985 to March 1986.



Although in MRIS there is continuous cropping in lateral A (Figure 8), water is cut-off in April. Rainfall enables some farmers to start farming activities earlier. Some have a standing crop by the start of water delivery in early June. They can often grow three crops during the two-crop season specified by the irrigation plan for MRIS. The cropping schedule planned for the area is not followed by some farmers.

The start and end of each cropping season is not distinct. Usually beginning in November, in some areas dry season begins in mid-October when land preparation has already started. Farmers try to grow three crops of rice in a year if they are located nearer the water source and served by the main lateral or upstream sub-laterals. Planting activities in the tail end sub-laterals are delayed for a month longer, causing maldistribution favoring those who plant early. This practice is not conducive to introducing crop diversification. Although these tail end areas are more adaptable to diversified crops, farmers can hardly grow two crops of irrigated rice.

Figure 9 shows that the total water supplied in MRIS (rainfall plus irrigation) is greater than the irrigation diversion requirement (IDR) during most weeks. The resulting relative water supply averaged 1.5 for the whole duration of the observation (Table 6). There is sufficient water in the system to support lowland rice even in areas where the water duty is high. Farmers feel no need to change crops for efficient use of water. When the MRIIS service area is fully developed, it will serve a large area and there will be a need to efficiently use the available water to irrigated all areas.

Figure 9. Actual irrigation supplied (IS), irrigation diversion requirement (IDR), and rainfall (RF), lateral A, MRIS, October 1985 to March 1986.

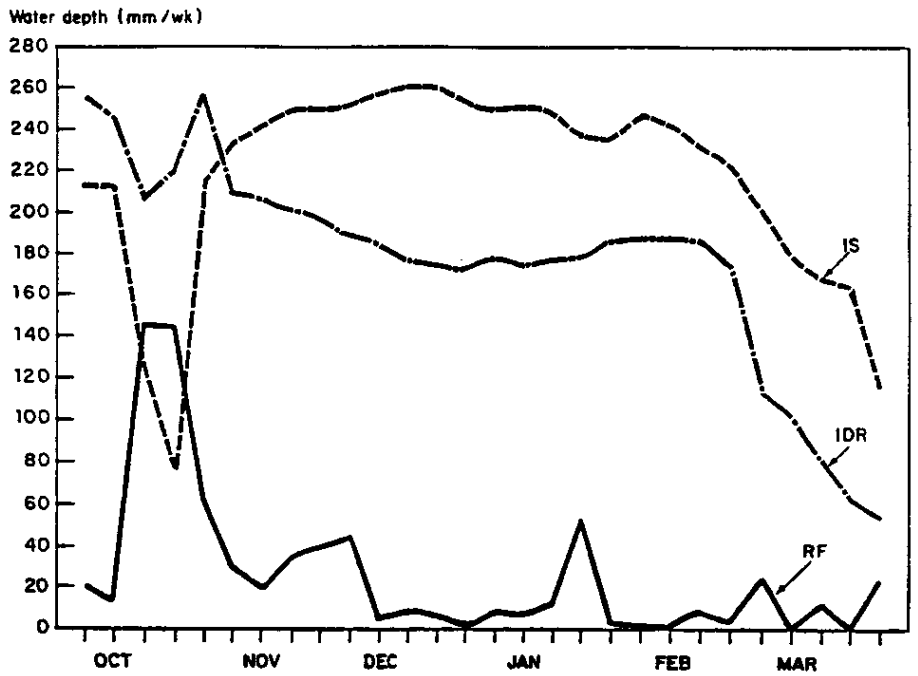


Table 6. Weekly irrigation diversion requirement (IDR), actual irrigation water supplied (IR), and rainfall (RF) in millimeters per week, and relative water supply (RWS), MRIS, District II, lateral A, dry season 1985-86.

Wk	Date	IDR	IR	RF	RWS*
40	Oct 1-6	256	213	21	0.9
41	7-13	244	213	13	0.9
42	14-20	206	124	146	1.3
43	21-27	220	75	145	1.0
44	28-Nov 3	257	214	63	1.1
45	Nov 4-10	209	234	30	1.3
46	11-17	207	244	20	1.3
47	18-24	201	251	34	1.4
48	25-Dec 1	198	249	41	1.5
49	Dec 2-8	188	250	44	1.6
50	9-15	185	257	5	1.4
51	16-22	176	260	9	1.5
52	23-29	174	261	7	1.5
1	30-Jan 5	172	255	1	1.5
2	Jan 6-12	179	248	8	1.4
3	13-19	173	252	7	1.5
4	20-26	178	249	12	1.5
5	77-Feb 2	178	236	52	1.6
6	Feb 3-9	186	234	3	1.3
7	10-16	187	248	2	1.3
8	17-23	187	243	0	1.3
9	24-Mar 2	187	231	3	1.3
10	Mar 3-9	173	223	3	1.3
11	10-16	114	201	24	2.0
12	17-23	102	177	0	1.7
13	24-30	79	167	12	2.3
14	31-Apr 6	60	163	0	2.7
15	Apr 7-13	52	116	23	2.7
Mean		175	217	26	1.5

*RWS = (IR + RF)/IDR

Flow measurements were neglected in MRIS. However, inflows equivalent to 10,000 ha sections were measured. Flows into and within each water master's division (750 ha) should be measured to improve distribution. Because flows are not measured, upstream farmers cannot be detected getting more than their share, which causes shortages downstream while excess water upstream goes to the drains. Some downstream farmers reuse the drainage water.

Institutional observations at the Isabela site. Two IAs were studied: SIBESTER and CPPL. The former had more active participation in meetings and group work (maintaining or cleaning canals). The latter was beset with problems caused mainly by ineffective leadership. Other causes included dependence on NIA and structural defects in the irrigation facilities.

Crop diversification at the Isabela site was unanimously perceived as feasible at both IAs if the market price of corn and other non-rice crops were attractive and stable enough to warrant a shift from rice. The abundance of irrigation water for rice exacerbates the economic constraints as reflected in the unfavorable market price of corn.

Additional Sites

Ilocos Norte and Nueva Ecija belong to rainfall Type I. In the wet season, rainfall peaks at a mean of 500 mm/month in August. This enables farmers to grow rainfed lowland rice. There is very minimal rainfall in the dry season and diversified crops cannot grow unless provided with irrigation (Figure 10 & 11). Farmers adopt irrigated diversified crops which need less water. Although irrigation systems in Northern and Central Luzon have areas planted to irrigated diversified crops in the dry season, in Ilocos, it is necessary to grow crops all-year round because of the small land holdings (less than a hectare) if the farmer is to survive financially. When water is available, the preferred crop is lowland rice (Layaoen 1982).

Figure 10. Rainfall pattern (1965-1976) and cropping seasons. Ilocos Norte, Philippines (taken from Ilocos Agriculture, Vol.1, No.1, January to March 1982.

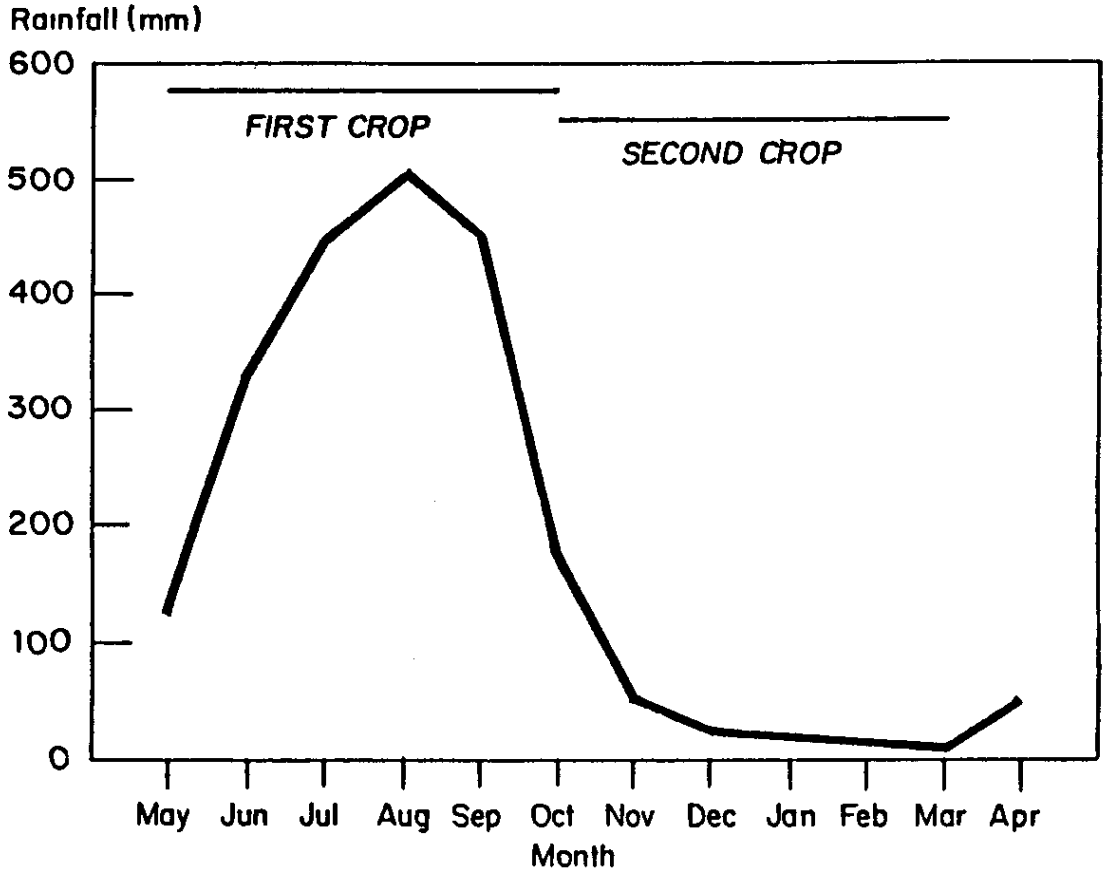
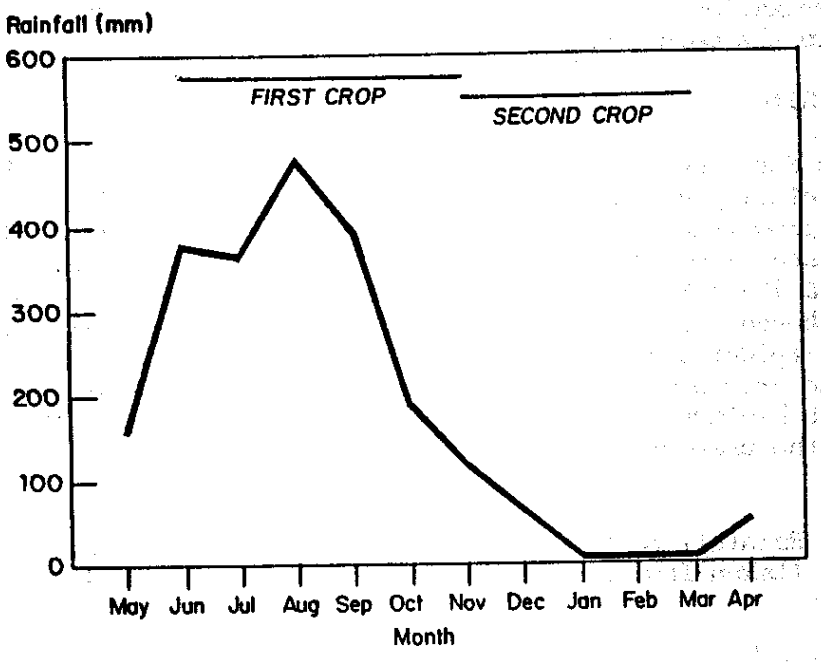


Figure 11. Rainfall pattern (1948-1970) and cropping seasons. San Jose, Nueva Ecija (ECI-EDCOP 1975).



Upper Talavera River Irrigation System (Upper TRIS). Although the entire dry season service area (500 ha) was scheduled for irrigated diversified crops, some farmers persisted with rice in the upstream and low areas. In most years, only 50-60 per cent (about 200-300 ha) of the programmed area was actually planted. Continuous irrigation is generally practiced but, during water shortages, non-rice crops receive priority on a rotational schedule. Because there are few control structures and few guidelines to operate the system for diversified crops, farmers have evolved a basin-flush-flooding method. The paddy dikes are retained from the previous rice crop to impound the water which is later drained into the next paddy in a form of paddy-to-paddy irrigation. Onion and garlic are grown in either mulched plots or raised beds. For the former, ditches are constructed on the inside edges of the paddies, and used as perimeter ditches for flooding and draining. For the raised beds (1.0-1.5 meters wide), ditches are made between beds for both flooding and draining. NIA provides water to the turnouts and enforces rotational schedules when water is scarce.

Agno River Irrigation System (Agno RIS). Only 20 per cent of the service area is programmed for crops, such as mungbean, cotton, tomato, and tobacco. The latter two are contracted with commercial firms which are assured water because they guarantee payment of irrigation fees. Crops are planted in upstream areas. Tobacco and corn are planted sparingly in elevated portions adjacent to rice, while mungbean (about 200 ha) is located at the tail end of the system. When water is short, rotations are by sections of the main and lateral canals. Because the canals have no control gates, farmers provide their own checks to raise water elevation. The mungbean area is dependent on additional water being diverted into the Agno River from the

hydroelectric dams at Ambuklao and Binga. Because there is no reliable schedule for water releases, farmers use the basin method to irrigate mungbean.

San Fabian River Irrigation System (SFRIS). Here the yearly dry season water supply determines the actual irrigated area. NIA staff schedule irrigation and inform the farmers when collecting fees. For heavy soils, water duty is computed at 1.5 lps/ha; for coarser soils at 2.5 lps/ha. Of 1,383 ha in the dry season, about 884 ha was planted to tobacco and the rest to rice. Continuous irrigation is practiced in the wet season. However, a rotational schedule by laterals or sections of the main canal is implemented in the dry season due to limited water. The measurement gauges at the main canal and lateral head gates are rarely calibrated, and flow duration proportional to the area and crop grown is estimated by the NIA staff for a weekly rotation. As in other systems, control gates in the main and lateral canals are absent. Checking is done ad hoc by farmers using debris. Tobacco is irrigated using the basin-flush-flooding method. In flatter areas and in larger paddies, additional farm ditches are constructed and openings are made in the paddy dikes to hasten irrigation delivery and drain excess water to other paddies.

Laoag-Vintar Irrigation System (LVIS). This system is divided into an upstream portion serving the Vintar area with irrigated rice during both seasons, and a downstream portion serving the Laoag-Bacarra-Sarrat (LABASA) area with irrigated rice in the wet season and irrigated diversified crops in the dry. Only 1,800 ha is irrigated in the dry season due to limited water; of this, about 700 ha is planted to diversified crops and the rest to rice.

The Vintar IA is not functional. The LABASA IA is active because farmers need to cooperate to effectively use the scarce water. The LABASA area is divided into two zones, each managed by one water master, and each zone is sub-divided into districts. Irrigation is planned jointly by the LABASA IA and NIA staff two weeks before the start of the season. In the dry season, areas for irrigated rice and diversified crops are based on land classification. About 90 per cent of the land is planted to garlic, mungbean, and other vegetables. Weekly irrigation water is supplied for coarse soils and every other week for clay. When there is acute water shortage, priorities are decided by the district officers in cooperation with the NIA field staff. Gauges at major canal points are rarely calibrated and farmers have evolved ad hoc irrigation practices. For diversified crops, water is impounded in paddies and basin flooding is practiced. The mean farm ditch density is 108 meters/ha. The undulating topography (mean slope of one per cent) allows water to flow from paddy to paddy. The small farm size (0.5 ha) enables, in some cases, a 300 per cent cropping intensity.

Simulation Studies

Allah Valley River Irrigation Project Pilot Testing and Demonstration Farm No. 2 (ARIP PTDF#2). Results of the simulation showed that the seasonal water requirement for the rice crop would be 1,700-2,300 mm. After considering rainfall, the seasonal irrigation diversion requirement (IDR) ranges from 900-1,800 mm, with a mean of 1,300 mm. In an average year, the daily IDR will not exceed the 2 lps/ha design of the system. Table 7 shows results of the simulation studies.

Table 7. Total evapotranspiration (ET), water requirement (WR), and irrigation diversion requirement (IDR) in millimeters from crop simulation studies for an irrigated rice-corn cropping pattern in South Cotabato, 1968-85.

	Total	ET	WR	IDR
Irrigated rice, planted 1st week of May				
Mean	1274	612	2498	1363
Probable rainfall - 20%	550	717	2619	2069
- 50%	1051	717	2619	1568
- 80%	1766	717	2619	856
Irrigated corn, early planting (early November)				
Mean	514	631	514	100
Probable rainfall - 20%	150	595	493	165
- 50%	398	595	493	93
- 80%	697	595	493	44
Irrigated corn, late planting (early December)				
Mean	457	672	560	134
Probable rainfall - 20%	100	633	534	228
- 50%	319	633	534	107
- 80%	571	633	534	82

With probable rainfall of 20 per cent, the IDR would be 2,069 mm (2.5 lps/ha), which is higher than ARIP's design capacity (Table 7). At 50 and 80 per cent probable rainfall, IDRs are 1.9 and 1.1 lps/ha, respectively. For irrigated corn planted in late December and assuming land preparation starts 4 weeks after rice harvest, the mean seasonal IDR is 134 mm. The minimum is 73 mm in 2 applications, and the maximum is 231 mm divided among 6 applications. For 20 per cent probable rainfall, the IDR is 228 mm, divided into 6 applications with one made every 2 weeks (Figure 12). For the 50 per cent probable rainfall, 3 applications are needed, totalling 107 mm (Figure 13). For the 80 per cent probable rainfall, two applications are needed with a total of 82 mm (Figure 14). Simulation 1 shows that throughout the year irrigation is needed for a corn crop planted in early November to maintain the soil moisture above stress levels.

For simulation 2 (assuming land preparation for early planting starts first week of November, just after rice harvest), the mean seasonal IDR is 100 mm, with a maximum of 183 mm over 5 applications and a minimum of 46 mm in one. There is no year where irrigation is not needed. For 20 per cent probable rainfall, the seasonal IDR is 165 mm distributed in 4 applications (Figure 12); 50 per cent, 2 applications totalling 93 mm (Figure 13); and 80 per cent, 1 application of 44 mm (Figure 14). Earlier planting thus reduces the amount of irrigation needed for corn because of rainfall.

Figure 12. Results of simulation study 2 with probable weekly rainfall (PR) at 20 per cent giving potential evapotranspiration (PET) and weekly irrigation water requirement (IWR) for irrigated corn planted early (e) and late (l) in the dry season, South Cotabato.

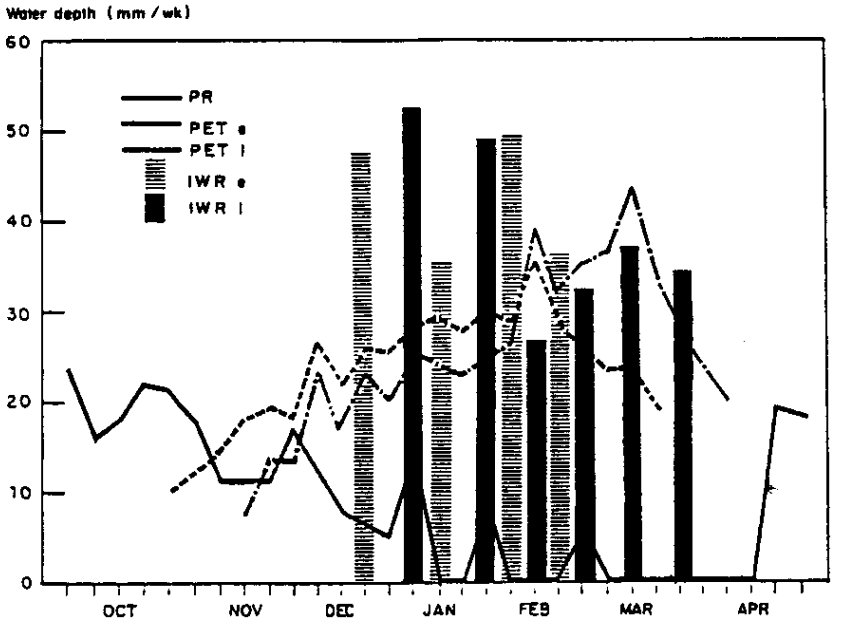


Figure 13. Results of simulation study 2 with probable weekly rainfall (PR) at 50 per cent giving potential evapotranspiration (PET) and weekly irrigation water requirement (IWR) for irrigated corn planted early (e) and late (l) in the dry season, South Cotabato.

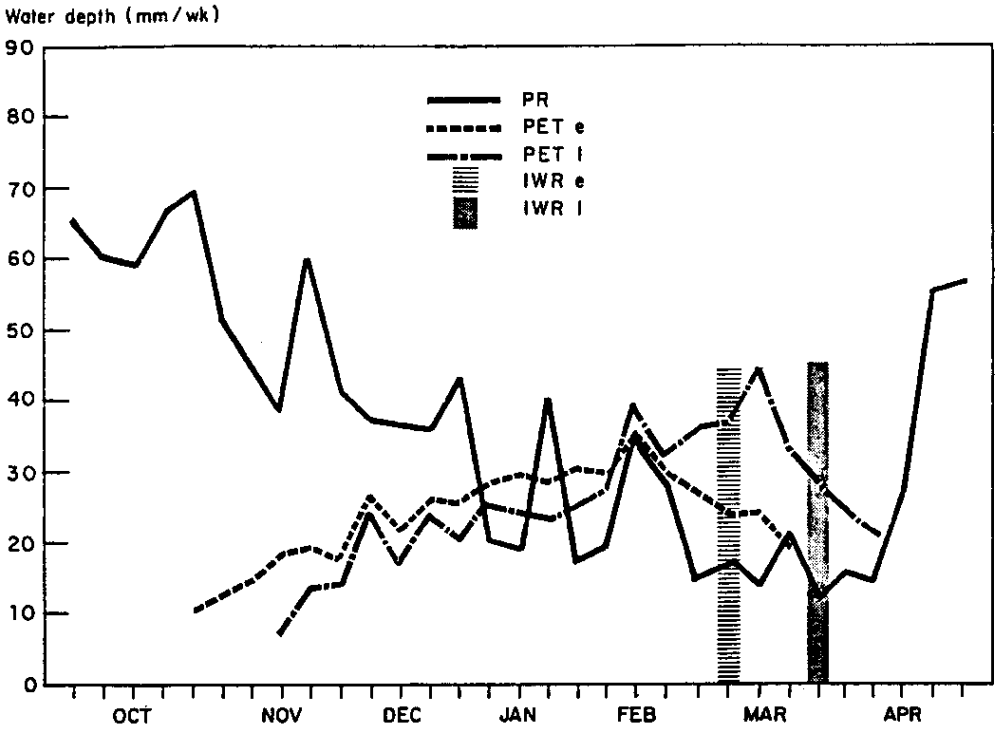
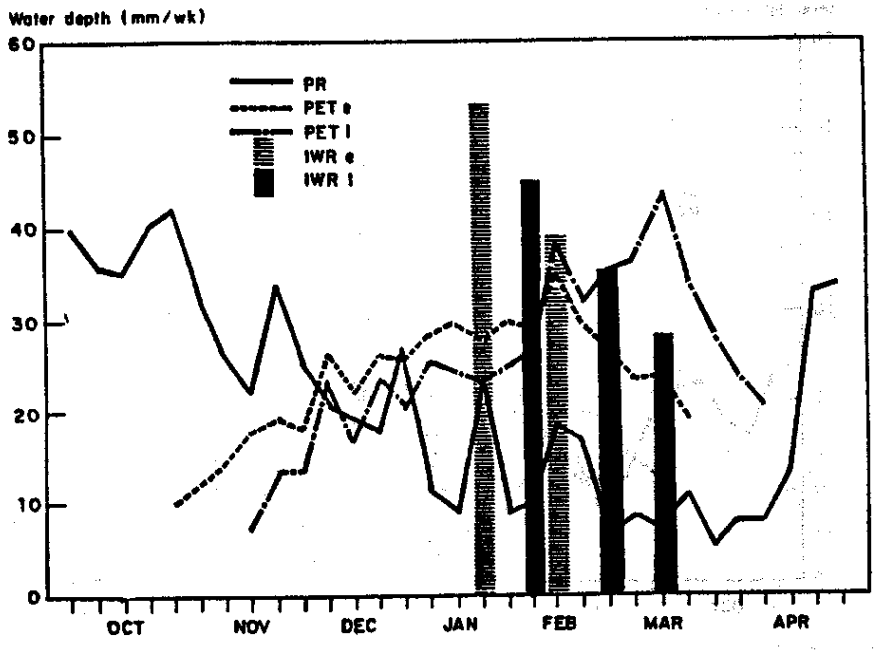


Figure 14. Results of simulation study 2 with probable weekly rainfall (PR) at 80 per cent giving potential evapotranspiration (PET) and weekly irrigation water requirement (IWR) for irrigated corn planted early (e) and late (l) in the dry season, South Cotabato.



The simulation shows that irrigated corn will need less water than lowland rice seasonally. Such volume should be delivered in a short time at a high discharge rate. If irrigation is to be applied at 50 per cent available soil moisture, the actual irrigation required could be computed as :

$$IR = [0.5\ (FC - PWP) \times SG \times RZD]\ /\ 100$$

IR = irrigation water required to bring soil moisture to field capacity (mm)
FC = field capacity (%)
PWP = permanent wilting point (%)
SG = specific gravity of the soil
RZD = root zone depth (mm)

Using the data from PTDF#2 and a RZD of 600 mm, IR will be 67.5 mm. If a field application efficiency of 60 per cent is assumed, the required depth will be 112.5 mm. At the turnout, the daily demand will be 22.5 mm for 5 days. Assuming 10 hours of operation, the design capacities of facilities would be 6.25 lps/ha; for 7-days at 10 hrs/day, 4.5 lps/ha. The design capacity on the main canals and laterals will be less. Even if there is no rainfall, diversified crops will only need irrigation once every 2 weeks and every week only 50 per cent of the service area will need to be irrigated. For a 5-day operation, main system canal capacities should be designed at 3.13 lps/ha; for 7-days, design capacity should be 2.25 lps/ha.

A simulation on ARIP PTDF#2, lateral A-extra, dam 1 was made to find out if a system designed for rice could accommodate diversified crops. Because canal capacity did not allow crops to be planted simultaneously in all areas,

the tail enders planted their corn the first week of November. The upstream group planted the first week of December. The 50 per cent probable rainfall was used to calculate the IWR. Assumed efficiencies for field application was 60 per cent and for conveyance was 75 per cent due to unlined main farm ditches. The overall efficiency was 40 per cent. The irrigation delivery schedule was adjusted to conform to a turnout capacity of 75 lps/ha. The capacity of the lateral was the design value of 390 lps. The lateral would only operate for 38 days for the entire dry season. The maximum delivery was to 383 lps and the minimum was 208 lps (Table 8).

The simulation shows that for an average year a rice-based system can accommodate irrigated diversified crops by adjusting water schedules. In dry years, this may not be the case because the flows are already near the design capacity. In this system, capacity can be increased by lining the main farm ditches. If this were done and capacity increased to 150 lps, the conveyance efficiency could be assumed to be 100 per cent and the overall efficiency, 60 per cent. With these adjustments, the lateral would operate in the dry season for 18 days at an average of 3 days/week with mean flows of 340 lps. The system could then accommodate diversified crops even in a dry year.

Table 8. Irrigation requirements (IR, in liters per second) at 40 and 60 per cent efficiency and schedule given rainfall (RF) and evapotranspiration (ET) in millimeters per week: simulation study 2 for corn on ARIP lateral A-extra, dam 1, South Cotabato.

Wk	Season and date	RF	ET	IR (40%)	Days	IR (60%)	Days
42	dry Oct 15-21	35	27				
43	22-28	40	29				
44	29-Nov 4	42	33				
45	5-11	32	25				
46	12-18	26	24				
47	Nov 19-25	22	26				
48	26-Dec 2	34	28				
49	Dec 3-9	25	22				
50	10-16	21	33				
51	17-23	19	24	340	7	344	3
52	24-31	18	29	289	7	381	5
1	Jan 1-7	27	25				
2	8-14	11	28	244	7		
3	15-21	11	27	231	6	344	4
4	22-28	24	23	208	4	343	3
5	29-Feb 4	9	25	383	7	293	3
6	Feb 5-11	10	24				
7	12-18	19	32				
8	19-25	17	27				
9	26-Mar 4	6	29				
10	Mar 5-11	9	33				
11	12-18	7	40				
12	19-25	11	40				

Farm-Level Study Results

Table 9 compares corn irrigation practices at the Allah Valley sites. Farmers at BARIS irrigate one hectare fields for three days using the basin method due to the low volume water flows necessary to prevent farm ditch erosion and the minimal field slopes. The corresponding furrow slopes range from 0.8-1.0 per cent. By comparison, the double and triple row irrigation methods at Isabela showed no significant differences in yield, total water, or labor (Table 10). However, there was a significant difference in labor at CPPL, where more was required to irrigate double row furrows. Differences between sites were to some extent due to differences in soil characteristics.

Table 9. Irrigation method, soil type, flow (in liters per second), total water applied (in millimeters), and mean duration of flow (in hours) at ARIP-PTDF#2, BARIS, and MCIS, dry season 1986.

Site	Irrigation method	Soil type	Critical flow	Total water	Duration of flow*	Difference
ARIP PTDF#2	Basin	Sandy	10	380	3.2	0.8
	Furrow			242	2.4	
BARIS	Basin	Sandy	15	520	6.2	1.8
	Furrow	Clay loam		384	4.4	
MCIS	Basin	Sandy loam	15	381	6.1	2.1**
	Furrow			242	4	

*Mean duration to irrigate 0.25 ha of corn; **significant at 10 per cent.

Table 10. Mean yield (in tons/hectare), water use (in millimeters), and labor use (man-days/hectare) for double-row and triple-row furrow irrigation methods for corn at CPPL and SIBESTER sites, Isabela, dry season 1986.

Site	Method	Yield	Water use	Labor use
SIBESTER	Double-row	4.79	43	3.47
	Triple-row	4.61	39	2.00
CPPL	Double-row	4.84	131	2.15
	Triple-row	4.46	120	1.23

Furrow and basin methods for irrigating white beans were compared at the Cavite site. Labor use was much higher for the furrow method (Table 11) due to the labor needed to direct water into the furrows. Furthermore, with basin flooding, pre-planting irrigation is applied prior to seeding in order to suppress weed growth. For the furrow method, the first irrigation is applied after planting and fields require weeding.

Table 11. Total water supplied and stored (in millimeters), water application efficiency (EFF, in per cent), mean yield (in tons/hectare), labor use (in man-days/hectare), and field slope (in per cent) for for basin and furrow methods to irrigate white beans, SLBIP, Cavite, dry season 1986.

Irrigation method	Supply*	Stored	EFF	Yield	Labor	Slope
Basin flooding	161.8	152.3	94.1	0.99	0.5	0.00
Single-furrow	132.6	109.0	82.2	0.89	4.5	0.25
Double-furrow	94.3	77.1	81.8	1.18	4.0	0.25

*For basin method, 7 mm of rainfall was stored; none for the other methods.
EFF = (Stored/supplied) x 100; does not account for losses from percolation.

Although the furrow method requires more frequent applications, this can be an advantage at bean formation when pods touch the ground and may rot in contact with water from the basin method. Most diversified crops need hilling up for weed control. The furrow constructed by such operations can serve as a water conveyance to prevent water logging. All the irrigation methods need ditches within the field plots to drain excess water. The additional labor needed for land preparation can be reduced by double or triple furrows.

Agronomic Study Results

A preliminary assessment of agronomic constraints for alternative crops to irrigated rice was conducted at the study sites to determine actual field production potential and adaptability in an irrigated environment.

Allah Valley sites. At these sites early maturing improved open-pollinated yellow corn, mungbean, and peanut were planted at PTDF#2 lateral A-extra, BARIS, and MCIS. Each crop was planted on a 0.25 ha plot to simulate actual field conditions. Table 12 shows yields and profitability.

BARIS had the lowest yields (excluding PTDF#2 where excess water was inadvertently applied by the farmer and, due to water logging which induced disease, low or no yield was obtained for corn and mungbean). Late planting at all sites contributed to pest and disease infestation. Thus, corn yields were not impressive. The open-pollinated corn was relatively unresponsive to irrigation. Low soil fertility did not affect the peanut crop much but proper timing of planting made a big difference in yield. Both peanut and mungbean encountered marketing problems. Problems with farmer cooperation at BARIS resulted in a delay in planting the test crops.

Isabela site. Comparative testing between irrigated and rainfed peanut production used two methods: raised bed and furrow. The sites were at San Mateo and Luna. Four field plots were planted at San Mateo: one rainfed plot with sandy loam soil was planted in November 1985; and three irrigated plots with soils ranging from clay loam to loamy sand were planted in January 1986. Three plots were planted at Luna: two rainfed field plots, one with sandy loam soil and the other with clay loam soil, were planted in December 1985; and one irrigated plot with silty clay loam soil was planted in January 1986.

Table 12. Summary of yields (kilograms per hectare) and costs and returns (in Philippine pesos) of selected diversified crops at the Allah Valley sites, dry season, 1985-86.

Crop	Site	Yield	Gross returns	Costs[1]	Net returns
Corn	PTDF#2	588[2]	1586	2924	-1338
(shelled)	BARIS	2240	6048	3596	2452
	MCIS	2660	7182	3728	3454
Peanut	PTDF#2	1988	14200	5708	8492
	BARIS	1120	8000	4933	3067
	MCIS	1400	10000	5183	5817
Mungbean	PTDF#2	0[3]	0	1249	-1249
(shelled)	BARIS	1320	6600	4979	1621
	MCIS	1742	8710	5330	3380

Pesos 20.00 = US$1.00; [1]production costs do not include land rent; [2]low yield due to pest and disease infestation, and low organic content of soil; and [3]no yield due to water-logging inducing nematode and virus infestation.

Table 13 shows that the mean yields for the irrigated plots were consistently higher than those for the rainfed plots, and irrigated plots at San Mateo were higher than those at Luna. These differences in yield can be attributed to soil moisture availability and earlier planting of the irrigated plots. Results indicate that irrigated peanut should be planted in January, and preferably in sandy loam and clay loam soil.

Table 13. Mean yields of bean and pod yields of peanut (in tons per hectare) planted at San Mateo and Luna, Isabela, dry season 1986.

	Bean yield		Pod yield, peanut		Number of pods/plant	
Site	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
San Mateo	1.52	1.08	2.28	1.65	20	10
Luna	1.00	0.70	1.52	0.90	18	16

Cavite site. Irrigated white bean production was introduced with NIA MAF credit incentives to encourage production, and marketing was assured by a commercial company. Only 21 ha were planted out of 100 ha targeted. However, not all farmers who joined the program made a profit (Table 14). The reluctance of farmers to join can be attributed to unfamiliarity with the production technology despite the training provided. This was exacerbated by the limited credit for inputs finally provided. Farmers who did not strictly follow the planting, fertilizer and pesticide schedule obtained low yields. White bean is sensitive to high temperature especially during pod formation. The recommended planting period is from early November to mid-December so pod

Table 14. Sample area (in hectares), yields (in kilograms), and costs of production and net returns (in Philippine pesos) to produce white beans in 13 sample farms in Cavite, dry season, 1985-86.

Farm	area	Yield	Gross returns	Costs	Net returns
1.	0.4	686	8924	3071	5853
2.	0.5	506	6578	3445	3133
3.	0.4	404	5252	2774	2478
4.	0.3	296	3835	2735	1100
5.	0.2	181	2353	1688	665
6.	0.2	157	2041	1512	529
7.	0.2	127	1651	1151	500
8.	0.4	228	2957	2523	434
9.	0.3	73	949	1703	-754
10.	0.2	106	1372	2306	-935
11.	0.5	225	2925	3904	-979
12.	0.3	25	325	1613	-1288
13.	0.5	148	1924	3341	-1417

Pesos 20.00 = US$1.00

formation will occur in the cooler periods of January and February. Proper applications of fertilizers and pesticides to control bean fly and root rot are necessary for optimum production of the white bean. Successful farmers were from the area where white bean had been pilot tested the year before and this experience, and the continued incentives, contributed to the farmers' adoption of white bean in the following year. Irrigated crop diversification can succeed where the farmer is familiar with the cropping technology.

Economic Study Results

At the Allah Valley and Isabela sites a study was undertaken of economic aspects of cultivating rainfed crops and irrigated rice and non-rice crops.

Allah Valley site. Particularly at BARIS and MCIS, profitability and labor use were assessed across rice-rice, rice-rice/corn, and rice-corn irrigated cropping patterns. The results showed that irrigated rice-rice gave the highest profitability. A further analysis of irrigated and rainfed hybrid and open-pollinated corn showed significant differences between irrigated rice and irrigated hybrid corn (Table 15). Except for fertilizer, seeds, and returns to family labor, all other items were higher for irrigated rice. The non-significant difference in returns to family resources can be attributed to the significantly higher production costs of irrigated rice. The study also showed that the higher costs of seeds and fertilizer for hybrid corn inhibit farmers from growing corn. This is consistent with the farmers' responses on production problems encountered (high input cash costs) as indicated in the survey at BARIS.

Differences between irrigated and rainfed hybrid yellow corn were not statistically significant (Table 165). The non-significant difference in

Table 15. Comparison of yields and costs of production of irrigated rice and hybrid corn at BARIS, dry season 1985-1986.

	Rice	Corn	Difference
Number of samples	77	15	
Average farm area (ha)	1.41	1.13	
Yield (kg/ha)	4199.41	3673.93	525.48 ns
Price (Pesos)	2.52	2.26	0.26
Output value (P/ha)	10585.73	8234.12	2351.61 **
Inputs: Fertilizer (P/ha)	843.77	1369.56	-525.79 **
Pesticides	359.21	35.38	323.83 **
Seeds	516.08	773.34	-257.26 **
Equipment rental	1045.20	631.84	413.36 **
Other cash outlay	27.78	10.72	17.06 ns
Total farm inputs	3002.52	2802.84	181.68 ns
Hired labor cost	1396.87	964.37	432.50 **
Land rental payments	1208.93	463.38	470.63 ns
Irrigation fee	540.09	0.00	540.09 **
Total family labor	1561.50	1090.87	470.63 ns
Total production cost	7709.93	5339.75	2370.18 **
Return to family resources (P/ha)	2875.81	2894.37	-18.56 ns
Return before labor (P/ha)	4437.31	3985.24	452.07 ns

Pesos 20.00 = US$1.00; ** = significant at 1 per cent, ns = not significant.

Table 16. Comparison of yields and production costs of irrigated hybrid and open-pollinated (OP) and rainfed hybrid corn at BARIS, dry season 1985-86.

	Irrigated hybrid	Rainfed hybrid	Irrigated OP
Number of samples	15	13	10
Average farm area (ha)	1.13	1.38	1.05
Yield (kg/ha)	3673.93	2926.23	2122.00
Price (Pesos)	2.36	2.32	2.18
Output value (P/ha)	8234.12	6765.13	605.48
Inputs: Fertilizer (P/ha)	1369.56	1412.18	493.45
Pesticides	35.38	30.77	8.68
Seeds	773.34	766.67	61.78
Equipment rental	631.84	599.34	220.12
Other cash outlay	10.72	15.38	75.00
Total farm inputs	2820.84	2824.34	859.02
Hired labor cost	964.37	973.62	596.74
Land rental payments	463.38	853.36	466.51
Irrigation fee	0.00	0.00	0.00
Total family labor	1090.87	932.77	1324.10
Total production cost	5339.75	5584.09	3246.37
Returns to family resources (P/ha)	2894.37	1181.04	1359.10
Return before labor (P/ha)	3985.24	2113.81	2683.20

yield can be attributed to rainfall in the dry season which masked the effects of irrigation on hybrid corn yield.

Another factor is the higher costs of corn production relative to gross income or yield compared to irrigated rice production (Table 17). Despite lower total labor costs of irrigated upland crop production, the study also showed higher profitability of irrigated rice production, which in turn explains farmers' preference for irrigated rice over corn in the dry season.

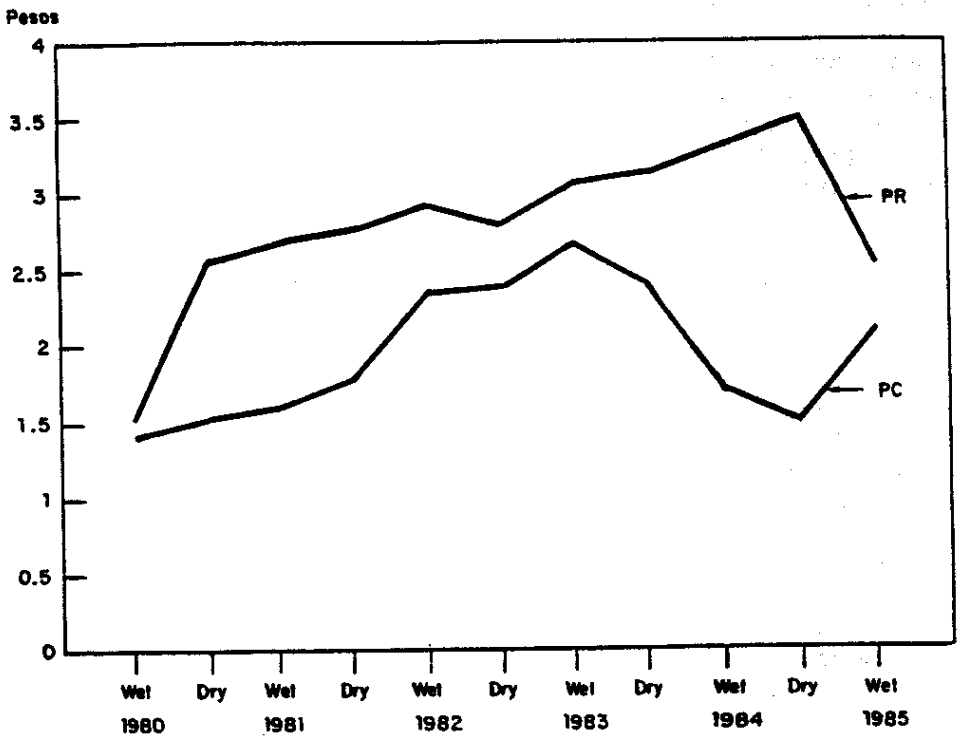
Table 17. Comparison of yields and costs of production of irrigated rice and corn at SIBESTER Irrigators' Association area, Isabela, dry season 1985-86.

	Rice	Corn
Number of samples	11	5
Average farm area (ha)	0.69	0.6
Average yield (kg/ha)	5015	10826 (unshelled)
Total receipts (P/ha)	12689	12018
Total cash inputs (P/ha)	4400	3767
Fertilizer	1175	1338
Pesticides	473	715
Seeds	445	740
Hired labor	2307	974
Land rental payments	1246	-
Irrigation fee	572	-
H/T share	963	-
Creditor's share	1474	-
Others	655	751
Family labor	1072	344
Exchange labor	386	-
Total production cost	10769	4862
Returns to family resources (P/ha)	1920	7150

Isabela site. Results, particularly for the SIBESTER IA, showed that irrigated corn production was more profitable than rice (Table 16) due to the optimum yields and high market price. However, only a few farmers planted corn, and practically none at the CPPL IA, which can be attributed to the low market price of corn compared to rice (Figure 15). This low market price at the start of the dry season discouraged farmers.

Moreover, production costs for irrigated corn were lower than rice, no irrigation fee was charged for corn as long as the previous fee was paid for rice, and there were no land rental charges for corn. Landowners do not normally charge land rental for corn due to its low income as long as the income from rice is shared. The responsiveness of farmers to market price for non-rice crops indicate the fragmented market structure existing at Isabela. Incentives which reduce irrigation fees and land rental help promote irrigated crop diversification.

Figure 15. Seasonal price of rice (PR), and corn (PC), Isabela, 1980-85.



Farmer's Decision Making Processes

Six case studies were conducted to identify conditions that are conducive to the successful adoption of diversified cropping in the dry season. Tobacco, cotton, mungbean, tomato, onion, and garlic were selected as alternative non-rice crops. The sites for this study were at SFRIS for tobacco; Agno RIS for cotton, tomato, and mungbean; Upper TRIS for onion; and LVRIS for garlic. Forty respondents for each crop were interviewed. The results revealed the following conditions that promote crop diversification:

1. Water is limited for rice.

2. Other sources provide low income opportunities.

3. Farmer observes profitability of neighboring diversified farm.

4. Family's rice consumption requirement has been met for the year from the wet season cropping.

5. The crop is perceived as technically feasible to grow (suitable soil, topography, familiarity with crop technology, and water availability).

6. Seeds are available.

7. The crop is perceived as economically feasible (availability of market, sources of credit if needed, and labor).

8. The farmer is convinced that the crop will significantly provide higher returns than rice, and the market price is assured or relatively stable.

9. The persistence of diversified cropping at these sites can be attributed to the trend of positive net returns.

Table 18 shows that higher cash outlays were required for diversified crops compared to rice. The labor demands, particularly family labor, were significantly higher than rice. Net farm incomes after deducting family labor indicated low returns. The implications are that diversified cropping is more viable for small farms, and that there is no "real opportunity cost" for family labor, at least not in the sites for this study.

Table 18. Mean of rice production costs and returns, and input-output ratios for non-rice/rice patterns.

	Rice*	Tob/R	C/R	Tom/R	M/R	O/R	G/R
Total cash costs	7507	1.22	1.39	1.26	0.39	3.22	1.94
Hired labor	2842	0.60	0.78	0.53	0.22	2.56	1.39
Seeds	435	0.00	0.00	1.15	1.79	9.84	29.17
Fertilizer	1243	1.82	1.51	1.95	.00	.00	1.25
Pesticides	290	5.60	8.57	9.15	2.00	3.72	1.78
Labor & non-cash costs	1911	4.80	2.58	3.07	0.37	7.08	11.78
Gross return	11035	1.86	1.89	0.62	0.25	3.70	2.19
Net return	3528	3.48	2.59	-	-	4.77	2.69
Net farm income	1617	-	2.59	-	-	3.75	-

* mean values in Philippine pesos/ha for all sites P20.00 = US$1.00; R = rice; Tob = tobacco, C = cotton, Tom = tomato, M = mungbean, O = onion, G = garlic; - = negative return for non-rice crop.

CONCLUSIONS

These results are preliminary due to only one dry season observation. A second phase is being developed to capitalize on the following:

Irrigation Factors

Four constraints to crop diversification were identified: dry season rainfall, availability of irrigation water for rice, limited irrigation management, and inappropriate on-farm irrigation and drainage facilities.

At Allah Valley, and to some extent at Isabela, rain was sufficiently frequent to grow upland crops without irrigation. Irrigation under rainfall conditions discourages non-rice cropping because of water logging. There is little or no dry season rainfall in Pangasinan, Nueva Ecija, and Ilocos Norte where crop diversification has been successful. However, there were years in which rainfall was not sufficient to sustain dry season corn. Further study is necessary to demonstrate optimum production and profitability levels.

In the Allah Valley and Isabela sites, crop diversification was to a large extent discouraged by the continuous supply of irrigation water. In Isabela, water is currently delivered at two to three times the design rates, encouraging farmers to grow rice rather than other crops. This is prevalent where seepage affects corn planted adjacent to rice fields. Results from all sites show that irrigation is continuous in the main system, and management techniques have not yet been developed to allow precise control of flows. Design capacities of lateral canals should be increased in order to accommodate large and intermittent flows. Results at PTDF#2 and surveys of existing canal capacities show that a design capacity of 2.25 lps/ha can be accommodated provided appropriate control and scheduling are undertaken.

On-farm irrigation facilities, especially where continuous flows on heavy soils result in water logging, require modifications to provide optimal water conditions for diversified crops. Turnout capacities should be raised to 3.0 lps/ha and deliveries rescheduled to speed up irrigation from three days to one day per hectare. This will require additional research to determine the optimal ditch density and to develop less erodible channels. Farmers should consider adopting furrow rather than basin irrigation to speed up and provide more uniform water applications to their crops.

Agronomic Factors

Farmers are unfamiliar with producing non-rice crops under irrigation. In Allah Valley and Isabela, most non-rice crops are grown under rainfed conditions or by utilizing seepage water from adjacent rice fields. Where dry season rainfall is adequate farmers are unwilling to risk water logging non-rice crops with excess irrigation. Thus yields do not reach their full potential. In drier areas, acceptance of crop diversification and improved agronomic practices are evident. In areas where rainfall is prevalent in the dry season, the correct timing of irrigation relative to crop growth stages should be demonstrated. The results from Cavite demonstrate that agronomic constraints to crop diversification can be overcome.

Economic Factors

For diversified crops, prices are generally unfavorable compared with rice, and costs are higher. Where market prices are stable compared to rice, there is evidence that crop diversification can be achieved. The results at Cavite show that most farmers who have grown white beans successfully once will grow them again. At Isabela, farmers cite the unstable farm gate price of corn as a constrainst to diversifying in the dry season. Markets and post-harvest facilities should be investigated, incentives should be considered for stable pricing of non-rice crops, and indirect incentives, such as reduction of irrigation fees for non-rice crops, should be further studied.

At all sites, the cash input costs before harvest for non-rice crops are higher than for rice and labor requirements are less. Removing the agronomic constraints would raise the profitability of diversified cropping. Support for input costs, as in the Cavite case, would reduce risks and encourage farmers to shift away from rice in the dry season. This was undertaken at Cavite to guarantee supplies to the bean processing industry.

Institutional Factors

Irrigation schedules need to be better communicated between the IAs and NIA to reduce uncertainty over water scheduling. At sites with continuous irrigation for rice, ways to improve water delivery schedules are needed if diversified crops are to be grown. The intermittent and large volume flows needed for diversified crops require better communication between farmers and system operators. The preliminary study indicated that the viability of the IAs depends on the benefits derived by the farmer members and the foremost benefit identified is adequate irrigation water supply. Studies to improve joint management of irrigation facilities by IAs and NIA are needed.

ACKNOWLEDGEMENT

The authors thank Mr. G. Simbahan, IIMI research assistant, and Ms. N. Llemit, media coordinator, PCARRD, for assistance in preparing this paper.

NOTES

1. This study was conducted in support of the International Food Policy Research Institute and the International Rice Research Institute (IFPRI-IRRI) joint study. The objective among others was to assess the potential of irrigated crop diversification in the Philippines. The Asian Development Bank (ADB) in collaboration with the International Irrigation Management Institute (IIMI) financed the study to assess technical and socio-economic constraints to irrigated crop diversification. Component studies were jointly conducted with the University of Southern Mindanao, Isabela State University, and the University of the Philippines at Los Banos. These universities are under the research consortia of the Philippine Council for Agriculture and Resources Research and Development (PCARRD). The lead agency collaborating with IIMI in the study was the National Irrigation Administration (NIA).

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