Irrigation Management for Diversified Crops: Opportunities for Learning and Improvement

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Abstract

The interim results of the study as conducted by the International Irrigation Management Institute (IIMI) is presented. Existing practices of farmers and the National Irrigation Administration (NIA) personnel in managing the available water supply are highlighted. These practices were analyzed for possible adoption in other NIA systems. The paper also presents opportunities for improvement to optimize land and water use during the dry season.

Limited water supply and suitable soils were the main physical factors that enabled farmers to effectively irrigate rice and non-rice crops during the dry season. The active involvement of the irrigators' association (IAs) in water allocation and distribution resulted in optimal or effective *use* of limited water supply. Further investigations into other factors, like the rice priority policy and other socio-economic incentives that will make irrigated crop diversification attractive and profitable to farmers were suggested.

Introduction

For the past **20** years, technological change has resulted in a gradual increase in the value of irrigation during the dry season. The main reason for this shift was the adoption of modern rice varieties whose yield potential **is** much higher during the dry season than during the wet season. The economic viabilities of farming and investments in irrigation systems are becoming more dependent on dry season cultivation. **As** a result, competition for limited water supply during the dry season has increased.

However, once self-sufficiency in rice **is** attained, there would be a comparative advantage in growing non-rice crops in irrigated areas during the dry season **(IFPRI,** 1984). Moreover, growing of irrigated non-rice crops during the dry season would also optimize the use of water and land which are ***not*** enough to support rice production. It takes almost twice as much water per hectare to grow rice than upland crops at the farm level. In some rice-based irrigation systems with limited water supply, the prevailing practice **is** to grow rice and non-rice crops during the dry season.

Practices and procedures in the production of irrigated non-rice crops have evolved through the years. However, it is only at the farm level where a headway was made in terms ofestablished practices (PCARRD-IIMI, 1988). Although there **is** a potential to increase production in irrigated areas during the dry season, factors that contribute to the success of growing non-rice crops have not been fully understood. Moreover, there are no established guidelines or procedures in irrigation management[2] of existing irrigation systems where mixed cropping is practiced during the dry season. This paper presents the interim results of a study[3] conducted by the International Irrigation Management Institute (IIMI). It determined irrigation management for mixed cropping **as** well **as** identified learning experiences and opportunities to

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[2]Irrigation management in this paper refers to the operation of the irrigation system to meet the objective of effectively providing adequate and timely water for optimum crop growth. Aside from water, other system components have to be managed including *information*, human *resources (farmers,* NIA *personnel, etc.,) and other inputs in crop production* revolving around water and its control (Keller, 1988).

[3]The results presented in this paper were taken from the Interim Report, Study on Irrigation Management for Diversified Crops, September 1988. Thin study was primarily supported by a grant from the Asian Development Rank (ADB) to the Goverment of the Philippines as TA No. 859.

improve these practices. The study was undertaken in collaboration with the National Irrigation Administration (NIA), Central Luzon State University (CLSU), Mariano Marcos State University (MMSU), University of Southern Mindanao (USM), Pampanga Agricultural College (PAC), University of the Philippines at Los Baños (UPLB) and the Department of Agriculture (DA).

The study sites were: the Laoag Vintar River Irrigation System (LVRIS) and the Bonga River Pump No. 2 Irrigation System (BP#2) in llocos Norte; the Upper Talavera River Irrigation System (IJTRIS) in Nueva Ecija; and the Allah River Irrigation Project (ARIP) and Banga River Irrigation System (BARIS) in South Cotabato.

Prevailing Irrigation Management Practices

Cropping Systems. Two main **sources of** irrigation water are available, in the study sites: rainfall and river flow. Shallow wells are used only for supplementary irrigation. Ilocos Norte and Nueva Ecija have similar rainfall (Figure I). The main crop or first crop is grown during the rainy months (May to September) and the second crop during the dry months (October to April). Rice **is** the main crop and a variety of crops follows.

In South Cotabato, rainfall is relatively evenly distributed throughout the year; with larger amounts from May to October and **lesser** during

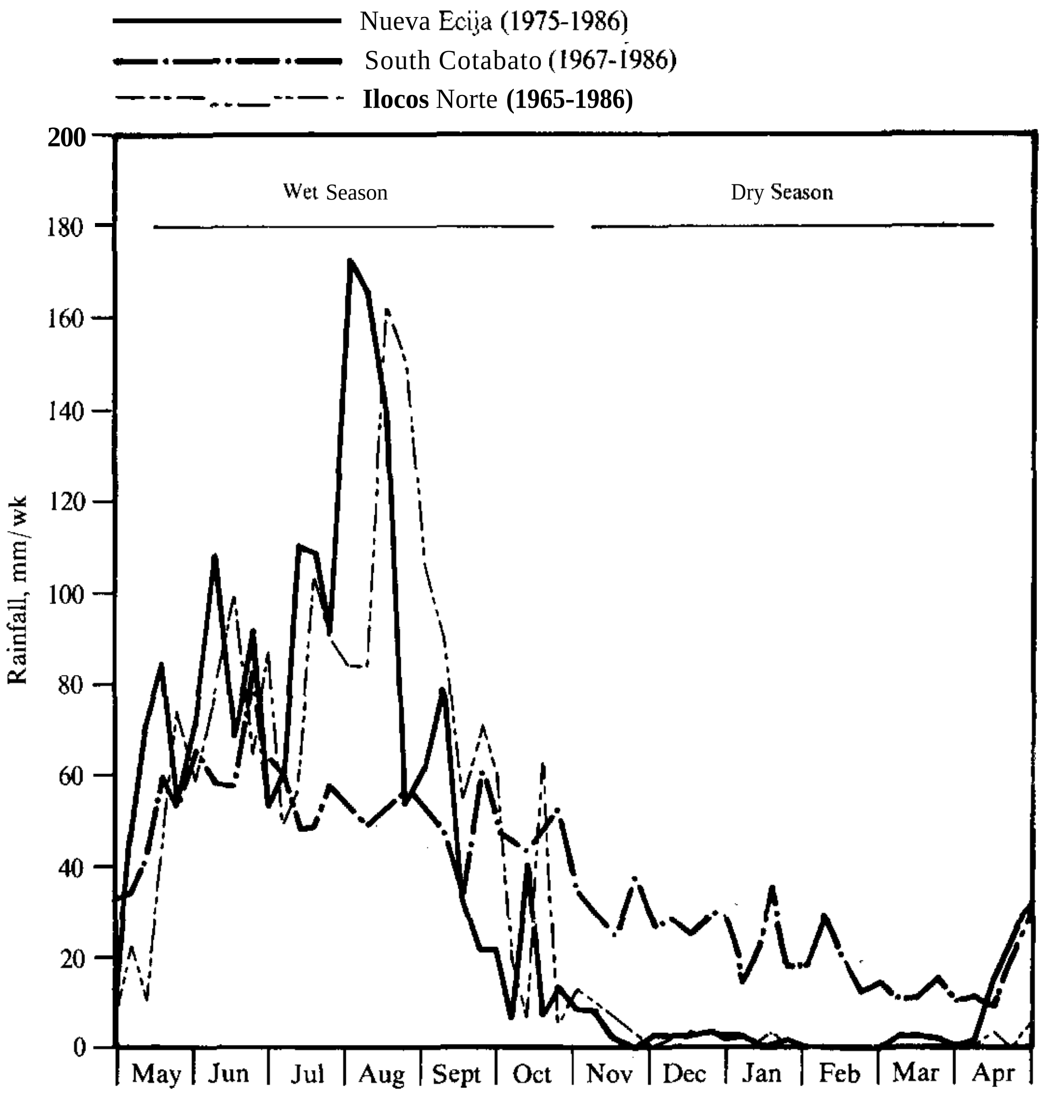

Figure 1. Mean Weekly Rainfall, South Cotabato, Nueva Ecija, & Ilocos Norte, Philippines.

the rest of the year (Figure 1). The main crop is grown during the rainy months while the second crop is grown when there is less rainfall, i.e., from November to March. Farmers especially in rainfed areas follow other cropping patterns. With abundant ranfall, mixed cropping is practiced during the dry and wet seasons. The main crops grown are rice and corn. Rice is usually irrigated during the dry season.

The limited water supply during the dry season resulted in less irrigated area in all of the sites than during the wet season (Table 1). Thus farmers practiced mixed cropping pattern. Limited water supply appears to be a necessary physical condition which makes irrigated diversified cropping persistent during the dry seasons.

Table 1. Irrigated areas and percent reduction in area served, crop year 1987188.

Location	Wet Season (ha)	Dry Season (ha)	Percent Reduction[1]
LVRIS	2220	1456	66
BP#2	375	213	57
UTRIS	3616	1395	38
ARIP	4668	3038	65
BARIS	1930	1750	91

[1] $\frac{\text{Wet Season Area} - \text{Dry Season Area}}{\text{Wet Season Area}} \times 100\%$

Water *Allocation.* At the onset of each cropping season, the irrigators' associations (IAs) and NIA meet to discuss the program area and water delivery schedules. The degree of farmers' participation depends on the level of involvement and functionality of the different IAs. Among the sites studied, the IAs under BARIS were found to have been very much involved and committed to the equitable sharing of water during the dry season.

Areas programmed for rice during the dry season were rotated on a yearly basis giving equal opportunities for all areas to be irrigated. Farmers in areas not programmed for rice were encouraged to plant corn and other upland crops. These areas were irrigated upon the farmers' request, a procedure needed to facilitate collection of irrigation fees. However, priority was given to areas programmed for rice.

Under LVRIS, the locationally favored (upstream) VINTAR IA was not interested in equitable sharing of water, especially during the dry season. Thus, only the LABASA IA was involved in water allocation activities. Areas near canals and those located at lower elevations are programmed for rice. Areas programmed for non-rice crops were located at the tail end of lateral and sub-lateral canals. Areas with coarse textured soil (as in some portions of Division I) were also programmed for non-rice crops. A third crop of mungbean was usually programmed, depending on the available water at the end of the dry season. Usually, two to four deliveries are available after the regular second crop.

Since BP#2 was partially turned over to the IA with no direct intervention from NIA, water allocation was simpler. Notwithstanding this arrangement, not all areas were irrigated for rice due to limited water supply. Farm location, soil suitability, and farmers' promptness to pay irrigation fees were the criteria used in allocating water for rice farms during the dry season. Non-rice crops, mostly garlic and watermelon, were also programmed.

At UTRIS, only upstream IAs were involved in water allocation. Nominal participation of other IAs are observed but farmers did not participate in actual group work activities or attend meetings. Farmers from the upstream IAs were found to be uncooperative resulting in the difficulties encountered in water allocation at the start of the season. Farmers were given the option to plant the crop of their choice. The NIA personnel, however, cautioned farmers that water was sufficient only in areas near the source. As a result, non-rice crops (mostly onions) were not programmed. Only rice areas were programmed for irrigation. Areas planted to rice and non-rice crops were billed accordingly. Under UTRIS, areas with medium textured soils which were located at the upper and middle portions of the service area wefe planted to non-rice crops.

Under ARIP, participation of the IAs in water allocation was at its early stage. The IAs of laterals A, B and C-extra were not convinced that their areas should be programmed for non-rice crops during the dry season. Most farmers in these areas preferred to plant rice even without being assured of irrigation water during the dry season. They thought that irrigation was synonymous to irrigated rice production because of the seeming abundance of irrigation water in irrigation canals and occassional rainfall during the dry season.

Water Disiribuiion. In all sites, a continuous method of water delivery was used for rice areas during the wet and dry seasons. However, water was delivered on a rotational schedule when supply became scarce. In the rotational schedule, irrigation of non-rice crops was included but priority was given to rice. For upland crops, an intermittent method of irrigation **or *flushing*** was applied.

During the **1987** wet season water was adequately supplied at LVRIS (Tables 2 and **3).** Water diverted to Division I was more than twice the amount diverted to the other three divisions downstream. Nonetheless, all the areas planted received adequate water supply. There was no cut-off of irrigation water delivery between the wet and dry seasons. During the dry season, a total of **1,456** hectares were irrigated consisting of **930** hectares planted to lowland rice and **536** hectares **(37%** of total area) planted to upland crops, mostly garlic. Rice was planted in Division I (laterals A to E) while the non-rice crops were planted downstream (Figure **2).** There was abundant water supply at the start of the dry season (Table **4)** because of residual river flow from a previous typhoon. Continuous deliveries, especially for rice areas, were made from November until mid-February. On the third week of February, a rotational schedule was implemented due to the abrupt decline in water supply from the river. Upstreamfarmers, however, did not follow the rotational schedule resulting in delayed and irregular water deliveries to the tail portions of the laterals. Unequal distribution of water occured because upstream fanners exceeded their schedule and because of the priority given to irrigating rice. However, estimated water use efficiency (WUE) indicated better distribution during the dry season (Table **2).** Moreover, there was no reduction in yield due to moisture deficit (Table 5).

At BP#2, only **58** hectares **(27%** of total area) out of **2 I3** hectares programmed for tne dry season were planted to non-rice crops. Other farmers within the service area planted non-rice crops using their own shallow pumps. The estimated WUE was **78%.** Lined canals and careful application of water contributed to the high WUE which was higher than at LVRIS (Table **7).**

At UTRIS, the **1987** wet season crop was delayed due to late rainfall. Downstream farmers who planted in June and July, augmented irrigation water by using shallow pumps. Adequate rainfall started in August when the monthly total rainfall exceeded **50** mm. Total area planted was **3,629** hectares. Estimated WUE **was** 53% (Table **8).**

During the **1987/88** dry **season**, a larger area was irrigated compared with the previous dry season. The total area irrigated was **927** hectares. Around ***465*** hectares (50% of the total **area)** were planted to non-rice crops, mostly onion. However, theestimated area planted exceeded 1,000 hectares. Areas with suitable soil were planted to non-rice crops (Figure **3).** Farmers in areas that were not programmed for irrigation took advantage of the seemingly abundant water supply in November and December and planted a second crop of rice. Water supply abruptly decreased in January resulting in its scarcity especially downstream. Shallow tubewells were again used to augment the limited water supply.

To enable all programmed areas to receive water, a rotational schedule was developed and was agreed upon during a meeting between NIA and the IA. However, this schedule was violated because some farmers diverted water to their fields even if it was not their turn. This usually happened during the night. Laxity of NIA field personnel in enforcing the schedule and lack of or poor state of control gates and structures aggravated the situation. Furthermore, scarcity of water **was** also attributed to the existence of a makeshift dam upstream (about 2-km from UTRIS dam) to irrigate approximately 60 hectares of onions. The resulting water scarcity contributed to the high WUE of **72%** for the system (Table **9).**

AT ARIP and BARIS, irrigated crop diversification was not an accepted practice. At ARIP, the total area irrigated was 3,100 hectares during the 1987/88 dry season. The WUE was **42, 37** and **57%**, for the upstream, midstream and downstream sections, respectively (Table 10). Use of drainage water from the upper sections by the downstream section, although not measured, contributed to this uneven distribution.

Suitable soil for non-rice crop were concentrated in laterals A, B, and C-extras (Figure **4).** These areas were programmed for non-rice crops and were intermittently irrigated by ***flushing.*** Before the 1988/**89** dry season, farmers from these areas were advised to plant non-rice crops. However, only farmers at lateral A-extra planted irrigated non-rice crops. Farmers a? laterals Band C-extras were more concerned on when to plant corn because their rice crop was harvested in September and if they were to plant corn in

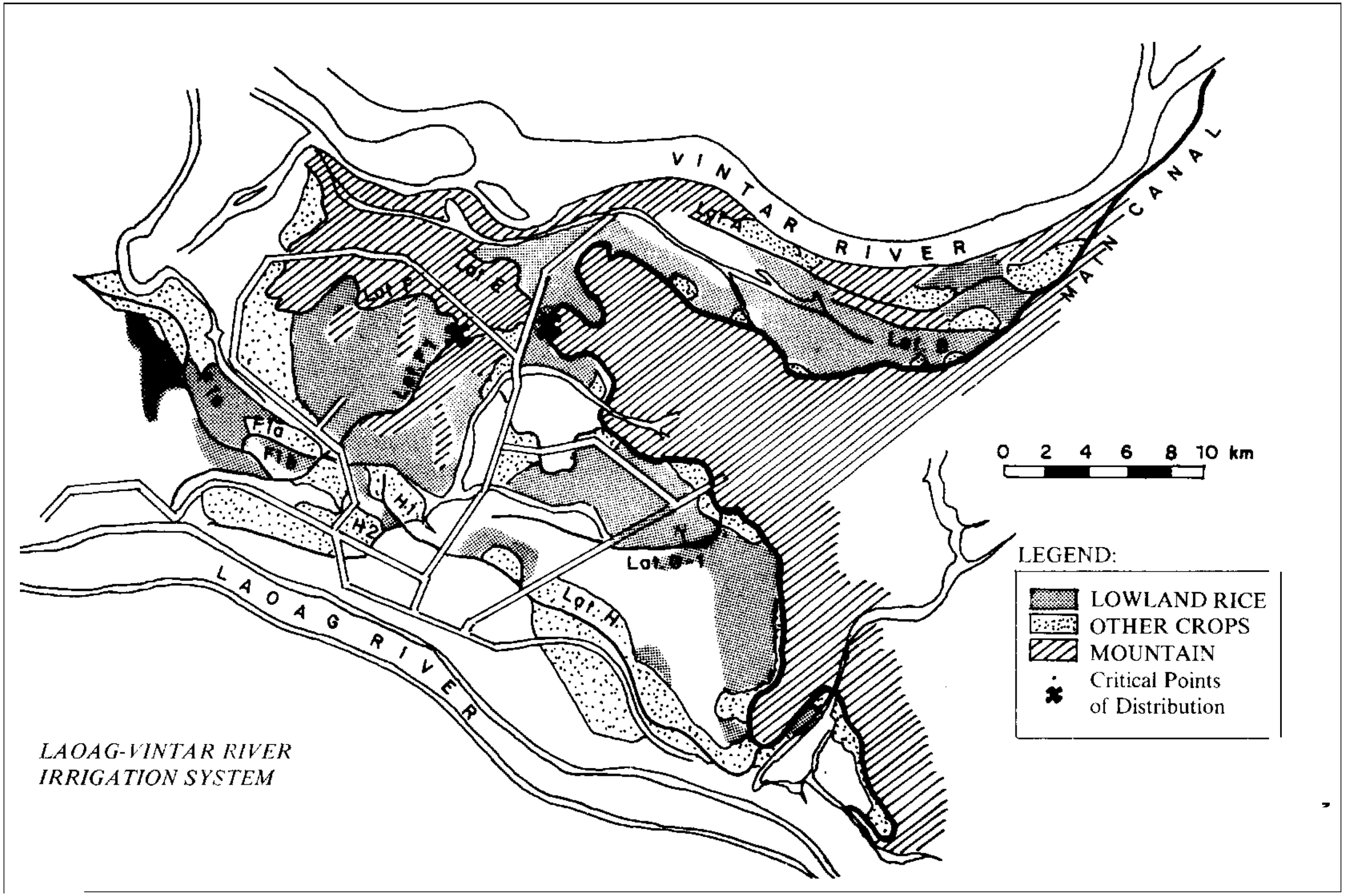

Figure 2. Map of the Laoag-Vintar River Irrigation System (LVRIS) in Ilocos Norte showing cropped **areas** for 1987/88 dry season and critical points **of** water distribution.

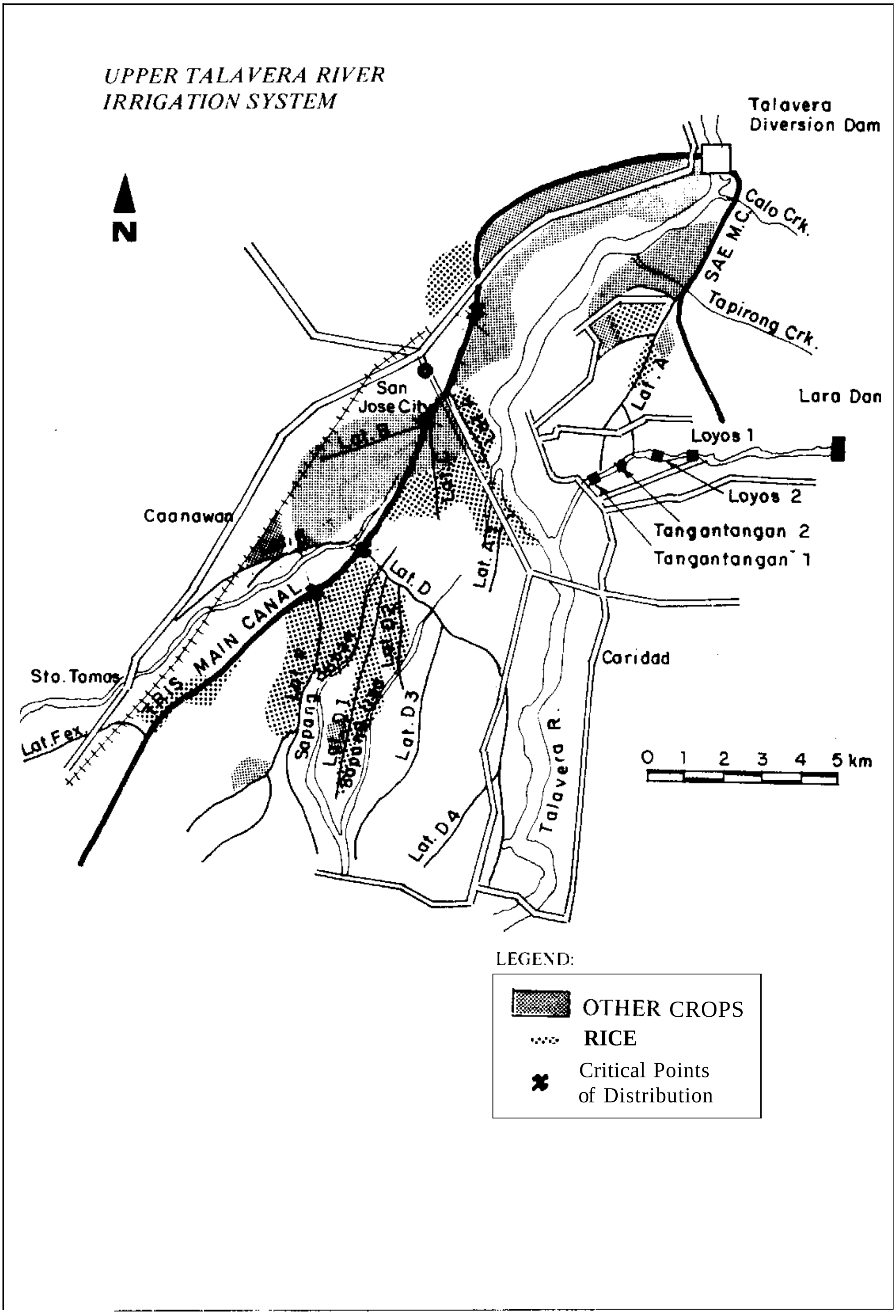

Figure 3. Map of the Upper Talavera River Irrigation System (UTRIS) in Nueva Ecija showing cropped areas for 1987/88 dry season **and** critical points of water distribution.

Table 2. Irrigated area. ha (IA), mean weekly actual irrigation diversion. mm/wk (AID), mean weekly relative water supply (RWS), and mean weekly water use efficiency, % (WUE), LVRIS, crop year 1987/88.

	Wet Season				Dry Season			
	IA	AID	RWS	WUE	IA	AID	RWS	WUE
Whole System	2220	143	2.1	60	1456	149	1.9	60
Division I	624	194	2.7	39	566	202	2.2	56
Division II	670	228	2.9	42	437	121	1.8	67
Division III	283	62	1.1	83	82	166	3.2	49
Division IV	643	87	1.5	75	437	110	1.9	59

***Table** 3.* Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), LVRIS. whole system. 1987 wet season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
19	May 07-13	0					
20	May 14-20	8					
21	May 21-27	53					
22	May 28-Jun 03	82					
23	Jun 04-10	213					
24	Jun 11-17	230					
25	Jun 18-24	556	121	31	377	3.4	30
26	Jun 25-Jul 01	908	120	28	279	2.5	39
27	Jul 02-08	1300	117	78	227	2.6	38
28	Jul 09-15	1924	113	22	133	1.4	100
29	Jul 16-22	2153	104	48	131	1.7	58
30	Jul 23-29	2179	99	87	137	2.3	44
31	Jul 30-Aug 05	2194	95	0	124	1.3	100
32	Aug 06-12	2204	93	16	117	1.4	70
33	Aug 13-19	2204	92	71	127	2.2	46
34	Aug 20-26	2222	91	24	123	1.6	62
35	Aug 27-Sep 02	2222	91	127	110	2.6	38
36	Sep 03-09	2222	91	348	95	4.9	21
37	Sep 10-16	2220	91	3	77	0.9	100
38	Sep 17-23	2220	91	6	121	1.4	72
39	Sep 24-30	2220	91	0	112	1.2	81
40	Oct 01-07	2220	91	4	128	1.5	69
41	Oct 08-14	2217	91	0	120	1.3	75
42	Oct 15-21	2139	91	0	144	1.6	63
43	Oct 22-28	1793	90	309	38	3.9	26
44	Oct 29-Nov 04	1484					
	Total	2220	1863	1204	2720		

WUE = (IDR/RF+AID)) X 100%
RWS = (RF+AID)/IDR
IDR values used are: Rice (land preparation) = 2.0 lps/ha
(normal irrigation) = 1.5 lps/ha

Table *4.* Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), LVRIS, whole system, 1987/88 dry season.

Week	Date	IA (ha)	IDR (mm)	KF (mm)	AID (mm)	RWS	WUE (%)
45	Nov 05-11	933					
46	Nov 12-18	703					
47	Nov 19-25	749					
48	Nov 26-Dec 02	760					
49	Dec 0349	943					
50	Dec 10-16	1168	87	12	270	3.3	31
51	Dec 17-23	1221	85	2	258	3.1	33
52	Dec 24-31	1363	85	0	231	2.7	37
1	Jan 01-07	1359	73	10	181	2.6	38
2	Jan 08-14	1393	70	0	236	3.4	30
3	Jan 15-21	1396	70	1	209	3.0	33
4	Jan 22-28	1396	70	0	72	1.0	98
5	Jan 29-Feb 04	1407	70	0	85	1.2	82
6	Feb 05-11	1438	70	0	80	1.2	87
7	Feb 12-18	1456	69	1	84	1.2	81
8	Feb 19-25	1427	68	0	116	1.7	59
9	Feb 26-Mar 04	1246	67	0	116	1.7	57
10	Mar 05-11	1167	66	0	13	1.1	90
11	Mar 12-18	1033	68	0	75	1.1	90
12	Mar 19-25	1061					
13	Mar 26-Apr 01	905					
	Total	1456	1018	26	2086		
	Mean		73	2	149	1.9	60

WUE =(IDR/RF+AID)) X 100%
RWS =(RF+AID)/IDR
IDR values used are: Rice (land preparation) = 1.5 lps/ha
(normal irrigation) = 1.0 lps/ha

October, their field will be waterlogged due to heavy rainfall. Moreover, farms will remain idle for two months if farmers will plant corn in December. Thus they opted to plant a second crop of rice. At such time, NIA did not **assure** them of sufficient irrigation water but compromised to provide irrigation until the end of December instead of the scheduled cut-off on 31 October. However, a few farmers who planted late obtained reduced crop yields due to moisture deficit.

At BARIS, WUE was 85% during the 1987/88 dry season (Table 11). Area planted to irrigated rice was 1,750 hectares, which was larger than the irrigated area during the previous dry season. A staggered water delivery schedule was implemented to accommodate this larger area. Moreover, the high WUE indicated the successful implementation of water delivery schedules. Similar values were obtained in previous dry seasons. The schedule was revised on a monthly basis to adjust to the current needs of the different sections of the system, particularly the downstream portion. The high efficiency can be attributed to the unmeasured inflows into the main canal from ARIP and also due to the effort of NIA personnel and IAs to optimize the use of available water. In addition, approximately 52 hectares were planted to irrigated corn. Technically, the corn was irrigated since they subsisted on seepage water from adjacent rice paddies and occassional rainfall. Without seepage water from adjacent paddy fields, the corn crop would have suffered moisture deficit **as** was demonstrated in 1984 when rainfall was not enough to support the crop *so* that farmers requested *flushing* or irrigation.

A third crop of corn was planted in the upstream portion of the system. This was possible due to the staggered planting schedule adopted

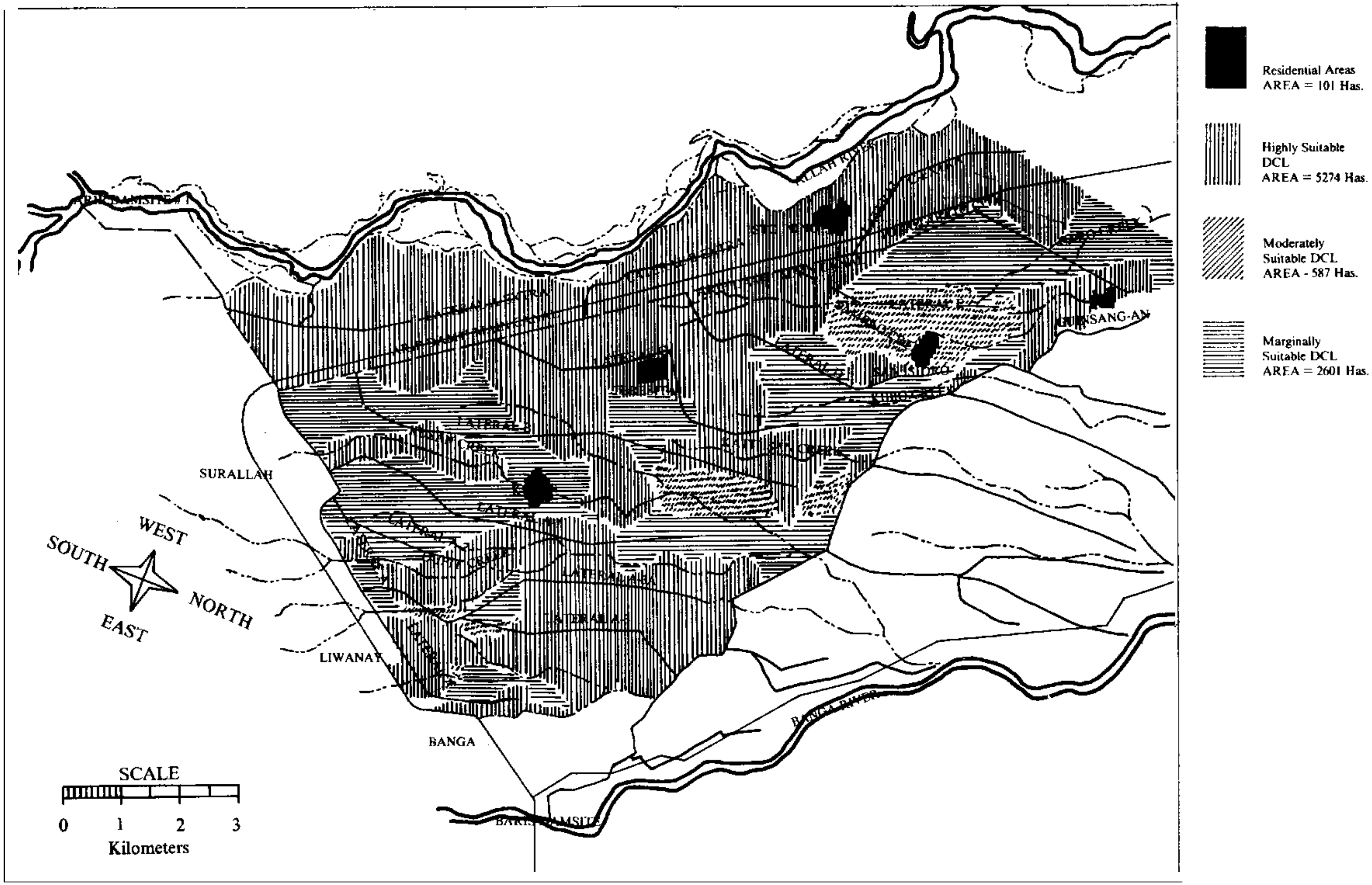

Figure 4. Suitability Map to Irrigated Diversified Crops during the Dry Season [illegible] River Irrigation Project, South Cotabato, Philippines.

Table 5. Mean water use efficiencies (WUE) and yields **by** section of systems, **1987/88** dry season.

Site	Section	Yield. kg/ha			WUE. %
LVRIS		Rice	Garlic	Mungbean	
	Whole System	n.a.	**756**	**536**	**60**
	Division I		**774**	**470**	**56**
	Division II		**855**	**300**	**67**
	Division III		**687**	**545**	**49**
	Division IV	**656**	**523**	**59**	
UTRIS		Rice	Onion		
	Whole System	**3129**	**3925**		**72**
	Upstream Area	**3225**	**4038**		**64**
	Downstream Area	**2558**	**3197**		**89**
ARIP		Rice	Hybrid corn	Native corn	
	Whole System	**3926**	**3544**	**2355**	**41**
	Upstream Area	**3734**	**3544**	**2355**	**42**
	Midstream Area	**4203**			***31***
	Downstream Area	**4101**			**57**
BARIS		Rice	Hybrid corn		
	Whole System	**3828**	**4038**		**85**
	Division A	**4192**	**4038**		**60**
	Division B	**3641**			**85**
	Division C	**3393**			**83**

n.a. -not available

which enabled upstream farmers to harvest their crop earlier than other farmers. the second rice crop **was** harvested in February. IA leaders requested NIA to arrange for credit of hybrid corn seeds from local dealers. About 160 hectares were planted to corn **as** third crop. NIA did not assure irrigation water but *flushing* was considered a possibility in case rainfall would not he sufficient. However, sufficient rain sustained the corn crop throughout its growing period.

The viability of irrigated corn during the dry season at BARIS can only he attained through the observed method whereby seepage from adjacent paddy fields and rainfall will sustain the crop. On the average, 60 hectares were planted to corn in this manner during the previous dry seasons. Farmers preferred to plant irrigated rice. It has been a practice among farmers to irrigate corn only when drought occurs, like during the **1984** dry season. Irrigation is viewed as a last resort to save a standing crop.

Lessons Learned

Irrigation practices at the farm level. The development of irrigated crop diversification at LVRIS, BP#2 and UTRIS can be attributed to two physical factors, namely, limited water supply to grow rice during the dry season and suitable soil for upland crops. LVRIS, BP#2 and UTRIS are found in Luzon where the rainfall pattern is ideal for upland crop production. In Mindanao, farmers resorted to irrigation of upland crops in times of drought.

No major land or field movement was needed to irrigate upland crops in rice-based areas. The existing paddy dikes were retained and the upland crops were planted within these paddies during the dry season. These practices are shown by studies on irrigation of garlic and mungbean at LVRIS (Pascual, **1988)** and onion at UTRIS (Agulto, **1988** and Aragon, **1988).**

Irrigation management at the system level. Other lessons learned based on prevailing practices in these sites was the role that the IAs played in water allocation and distribution during the dry season. An active or effective **IA** enhances the

Table 6. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), Bonga Pump No. 2, whole system, 1987 wet season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
27	Jul 02-08	0					
28	Jul 09-15	10					
29	Jul 16-22	257	I20	66	190	2.1	47
30	Jul 23-29	297	102	43	107	1.5	68
31	Jul 30-Aug 05	375	97	0	111	1.1	88
32	Aug 06-12	375	93	7	95	1.1	91
33	Aug 13-19	375	92	46	110	I.7	59
34	Aug 20-26	375	91	14	194	2.3	44
35	Aug 27-Sep 02	375	91	101	76	2.0	51
36	Sep 03-09	375	91	205	0	5.4	19
37	Sep 10-16	375	91	10	0	0.1	100
38	Sep 17-23	375	91	13	0	0.1	100
39	Sep 24-30	367	91	0	61	0.7	100
40	Oct 01-07	363	91	9	67	0.8	100
41	Oct OX-I4	315	91	0	117	1.3	78
42	Oct 15-21	262	91	0	101	1.1	90
43	Oct 22-28	153	91	205	0	3.5	29
44	Oct 29-Nov 04	51					
	Total	375	1414	719	1229		
	Mean		94	48	R2	1.7	71

WUE = (IDR/RF+AID)) × 100%
RWS = (RF+AID)/IDR
IDR values used are: Rice (land preparation) = 2.0 lps/ha
(normal irrigation)= 1.5 lps/ha

optimum use of limited irrigation water as shown at BARIS. The initiative of the IAs coupled with responsive NIA personnel and favorable rainfall pattern resulted in a high WUE and a chance to plant a third crop of corn.

At ARIP, farmers will not readily adopt irrigated crop diversification. The abundance of irrigation water and rainfall, together with unfavorable socio-economic factors (e.g., low price of corn) inhibit farmers from planting irrigated upland crop during the dry season. Studies (Caluya and Acosta, 1988; Marzan, 1988; Bayacag, 1988; Reyes and Reyes, 1988; Intal and Valera, 1988) have shown other socio-economic factors that make irrigated upland crop production a profitable alternative during the dry season.

Studies on irrigation management under LVRIS, BP#2, UTRIS, ARIP and BARIS found some irrigation practices which can serve as basis for formulating guidelines on irrigated crop diversification during the dry season. The following practices were considered effective in irrigation management for upland crops: planning with accurate records of river flow; rainfall, and irrigation facilities; parcellary mapping; meetings and farmers' participation on water allocation and distribution; and strict implementation of rotational schedule as agreed upon by the IAs and NIA. These practices were found to be effective in all sites and were made part of the proposed guidelines for irrigation management for diversified crops (Valera, et al., 1988). Another aspect in irrigation management which must be reckoned with is the priority given to rice. Because of a national policy, second priority is given to upland crops in the dry season irrigation operation. A study on the policy implications of irrigated crop diversification is also being conducted (Adriano, 1988).

Improvement Opportunities

Irrigation facilities restoration/modification. Most irrigation systems in the Philippines were

Table 7. Irrigated area (IA). irrigation diversion requirement (IDR). rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), Bonea Pump No. 2. whole system, 1987/88 dry season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
45	Nov 05-11	30					
46	Nov 12-18	30					
47	Nov 19-25	0					
48	Nov 26-Dec 02	0					
49	Dec 03-09	0					
50	Dec 10-16	0					
51	Dec 17-23	1					
52	Dec 24-31	1					
1	Jan 01-07	8	110	9	205	4.1	24
2	Jan 08-14	13	111	0	205	3.9	26
3	Jan 15-21	64	119	0	126	1.1	94
4	Jan 22-28	83	119	0	86	0.7	100
5	Jan 29-Feb 04	150	115	0	124	1.1	93
6	Feh 05-11	184	106	0	148	1.4	71
7	Feh 12-18	190	95	2	64	0.7	100
8	Feh 19-25	192	92	0	84	0.9	100
9	Feh 26-Mar 04	180	85	0	95	1.1	90
10	Mar 05-11	213	76	0	90	1.2	84
11	Mar 12-18	213	76	0	151	2.0	50
12	Mar 19-25	213	76	2	86	1.2	86
13	Mar 26-Apr 01	213	76	0	87	1.2	87
14	Apr 02-08	213	76	0	130	1.7	58
15	Apr 09-15	203	78	0	65	0.8	100
16	Apr 16-22	I88	81	0	I37	1.7	59
17	Apr 23-29	I62	84	0	22	0.3	100
	Total		1575	13	1905		
	Mean	213	95	1	112	1.5	78

WUE = (IDR/RF+AID)) X 100%
RWS = (RF+AID)/IDR
IDR values used are: Rice (normal irrigation) = 1.5 lps/ha
Other crops = 1.0 lps/ha

designed to irrigate rice. Using rice irrigation facilities to irrigate upland crops entails some modifications, i.e., additional control structures and facilities. Inspite of the demanding nature of upland crops compared with rice, existing rice imgation facilities have been modified or have been used to provide imgation for upland crops. Adjustments and modifications have been made in LVRIS, BP#2 and UTRIS to make these systems capable of providing imgation water for both rice and upland crops during the dry season.

To properly irrigate upland crops, control structures and facilities will have to be provided. UTRIS and BARIS need restoration. Other systems are either new (e.g., ARIP) or recently rehabilitated (e.g., LVRIS). Absence of gates at the main canal structures (cross-regulators), headgates of laterals and turnouts at UTRIS and BARIS posed as obstacles in controlling water deliveries. In spite of these obstacles, the NIA personnel at BARIS were still able to deliver adequate amounts of water to the farms. Improvements in water delivery such as reliability of deliveries and reduction in losses will eventually increase irrigated area.

Farm level facilities will also have to be restored or modified to effectively irrigate upland crops. The density of farm dicthes and optimum size of turnout service area have evolved in some of the sites particularly at LVRIS and UTRIS. A study to determine the optimum farmditchdensity in order that appropriate farm level facilities and

Table 8. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), UTRIS, whole system, 1987 wet season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
20	May 14-20						
21	May 21-27						
22	May 28-Jun 03	5					
23	Jun 04-10	37					
24	Jun 11-17	103					
25	Jun 18-24	277					
26	Jun 25-Jul 01	537	121	19	575	4.9	20
27	Jul 02-08	739	120	64	258	2.7	37
28	Jul 09-15	1124	119	0	195	1.6	61
29	Jul 16-22	1472	116	5	111	1.0	100
30	Jul 23-29	1737	112	123	171	2.6	38
31	Jul 30-Aug 05	2122	110	20	130	1.4	74
32	Aug 06-12	2687	108	13	65	0.7	100
33	Aug 13-19	3060	107	109	137	2.3	43
34	Aug 20-26	3516	106	163	109	2.6	39
35	Aug 26-Sep 02	3601	103	98	144	2.3	43
36	Sep 03-09	3616	99	86	163	2.5	40
37	Sep 10-16	3611	96	26	146	1.8	56
38	Sep 17-23	3585	89	161	134	3.3	30
39	Sep 24-30	3531	91	40	137	2.0	51
40	Oct 01-07	3474	91	17	154	1.9	54
41	Oct 08-14	3327	91	58	142	2.2	46
42	Oct 15-21	3041	91	1	133	1.5	68
43	Oct 22-28	2810	91	12	148	1.8	57
44	Oct 29-Nov 04	2565	91	34	184	2.4	42
	Mean	3616	103	55	170	2.2	53

RWS = (AID+RF) / IDR

WUE = IDR / (AID + RF) X 100%

IDR values used are: Rice (land preparation) = 2.0 lps/ha

(normal irrigation) = 1.5 lps/ha

canal structures will be provided was conducted in these sites (Pascual et al., 1988). The study is expected to provide appropriate values that can serve as a guide in either rehabilitation or design of systems that will accommodate both rice and upland crops during the dry season. Improvement of existing irrigation methods at ARIP and BARIS is necessary if imgated upland crop production will be pursued. Furrow irrigation of corn has been found to be more effective in terms of water use and duration of irrigation compared with the traditional practice of basin flooding (IIMI, 1988).

Improvement in procedures and practices. Irrigation practices and procedures used by NIA were designed only for rice. Improvements or modifications of these procedures will provide NIA with a set of guidelines to effectively irrigate both rice and non-rice or mixed cropping in systems where irrigated diversified cropping is viable. Moreover, existing procedures which are actually being practiced but not recorded have to be incorporated. The following suggested improvements focus on existing planning, monitoring, implementation and evaluation procedures of NIA: 1) A computer aided mapping program as a tool for identifying parts of systems suitable for irrigated non-rice crop production is proposed (Cablayan and Pascual, 1988) to help improve the planning procedure in allocating water for rice and non-rice crop areas. 2) In determining water availability from the river and rainfall, a more frequent assessment of river flow and a more powerful rainfall probability method are suggested.

Table 9. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), water use efficiency (WUE), and relative water supply (RWS), UTRIS, whole system, 1987/88 dry season.

Week	Inclusive	Rice		Onion		Total				
		IA	IDR	IA	IDR	IDR	RF	AID		WUE
no.	Dates	(ha)	(mm)	(ha)	(mm)	(mm)	(mm)	(mm)	RWS	(%)
45	Nov 05-11	2286								
46	Nov 12-18	1888								
47	Nov 19-25	1557								
48	Nov 26-Dec 02	1305								
49	Dec 03-09	1183								
50	Dec 10-16	1176								
51	Dec 17-23	1261	91	205	61	87	5	170	2.0	50
52	Dec 24-31	1394	91	251	61	87	13	129	1.6	61
1	Jan 01-07	1453	91	276	61	86	4	135	1.6	62
2	Jan 08-14	1418	91	348	61	85	0	104	1.2	82
3	Jan 15-21	1395	91	378	61	85	1	96	1.2	87
4	Jan 22-28	1378	91	384	61	85	0	91	1.1	93
5	Jan 29-Feb 04	1373	91	384	61	85	5	74	0.9	100
6	Feb 05-11	1304	91	382	61	84	0	75	0.9	100
7	Feb 12-18	1161	91	372	61	84	1	92	1.1	90
8	Feb 19-25	1003	91	330	61	84	13	104	1.4	72
9	Feb 26-Mar 04	869	91	158	61	87	0	122	1.4	71
10	Mar 05-11	809	91	142	61	87	0	146	1.7	59
11	Mar 12-18	631	91	125	61	86	0	153	1.8	56
12	Mar 19-25	537	91	111	61	86	0	157	1.8	55
13	Mar 26-Apr 01	454	91	91	0	216	2.4	42		
14	Apr 02-08	384								
15	Apr 09-15	289								
16	Apr 16-22	233								
17	Apr 23-29	143								
18	Apr 30-May 06	37								
	Mean	1395	91	384	61	86	4	124	1.5	72

RWS = (RF+AID)/IDR
WUE = IDR/(RF+AID) X 100%
IDR values used are: Rice (land preparation) = 1.5 lps/ha
(normal irrigation) = 1.0 lps/ha

If a weekly assessment is to be used in predicting rainfall, the incomplete gamma function analysis which is more accurate than the five-year average currently being used is recommended provided a 20-year or longer rainfall record is available. 3) Regular annual inventory of irrigation facilities will provide an accurate assessment of the capability of the system in providing timely and adequate water to the farms. This is an existing practice that should be continued. 4) The effort exerted by NIA field personnel in soliciting IA participation in water allocation and distribution should be continued. The enthusiasm of the farmers to organize and to participate and of the NIA personnel to carry out these suggested practices must co-exist in order to attain the suggested improvement.

Nominally, all NIA systems have organized IAs that can participate in water allocation and distribution. However, there are ineffective IAs which can be made to contribute in terms of adhering to water delivery schedules and other activities that will reduce water losses. The NIA personnel should provide the necessary support in making these IAs effective. Studies have been conducted regarding IAs or organizations in irrigation. However, considering the present lethargy of IAs, what is needed are studies and resulting plans of action that will make these IAs more responsive and effective. There are practices that can be

Table 10. Irrigated area, ha (IA), mean weekly actual irrigation delivery, mm/wk (AID), mean weekly relative water supply (RWS), mean weekly water use efficiency (WUE), ARIP, crop year 1987/88.

	Wet Season				Dry Season			
	IA	AID	RWS	WUE	IA	AID	RWS	WUE
Whole System	4668	219	2.7	40	3038	202	2.6	41
Upstream Area	1857	233	3.0	35	1109	207	2.7	42
Midstream Area	1363	296	3.8	30	1208	242	3.1	31
Downstream Area	1448	93	1.3	80	721	152	2.1	57
Lateral A	1367	262	3.2	34	670	261	3.4	31
Upstream Area	606	292	3.7	30	415	280	3.8	28
Downstream Area	761	220	2.8	38	255	228	3.0	38
Lateral A-I	359	260	3.1	37	300	234	3.0	39
Lateral A-2	211	302	4.2	28	115	406	5.2	24
Lateral A-3	492	215	2.7	39	not served			
Lateral B	532	244	3.1	37	532	214	2.7	42
Lateral	467	200	2.6	47	467	218	2.7	41
Latera	354	171	2.3	54	not served			
Lateral E	370	126	1.7	71	330	89	1.4	76
Lateral A-Extra	130	259	1.2	83	89	105	1.0	88
Main Canal turnouts	1257	228	3.1	36	958	169	2.3	
Upstream	569	314	4.1	27	569	190	2.6	51
Downstream	688	39	0.8	93	389	154	2.1	53

emulated with appropriate modifications to suit the specific needs of the target group of farmers or ineffective IAs.

Implications and Conclusions

There are lessons to be learned in the practices and procedures employed by farmers in irrigating crops and in their participation for water allocation and delivery. NIA personnel on the other hand, have adopted existing procedures to accommodate the needs of non-rice crops while giving piiority to the irrigation of rice. Under LVRIS, BP#2 and UTRIS, the practice of irrigating rice and non-rice crop during the dry season have evolved and developed through the years. This was brought about by the combination of physical and socio-economic factors which made the production of irrigated non-rice crops the prevailing practice in these systems. Among the physical factors affecting irrigated mixed crop production during the dry season were limited water supply and suitable soils for upland crop production.

The abundance or relative availability of water during the dry season prompted farmers under ARIP and BARIS not to practice irrigated non-rice or corn production. Although limited, corn crops under BARIS were irrigated during the dry season through seepage from adjacent rice paddies. Farmers irrigate corn only in times of drought. Thus, limited water supply is a necessary but not a sufficient condition for farmers to practice irrigated non-rice crop production.

Farmers under ARIP, in spite of suitability of the soil and limited water supply, still prefer

Table 11. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), BARIS, whole system, 1987188 dry season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
40	Oct 0147	1500	88	71	0	0.8	100
41	Oct 08-14	1495	88	57	0	0.6	100
42	Oct 15-21	'588	88	35	50	1.0	100
43	Oct 22-28	1620	88	69	84	1.7	58
44	Oct 29-Nov 04	1547	88	68	83	1.7	58
45	Nov 05-11	1503	88	71	83	1.7	57
46	Nov 12-18	1521	88	41	40	0.9	100
47	Nov 19-25	1531	88	19	82	1.1	87
48	Nov 26-Dec 02	1339	88	0	113	1.3	78
49	Dec 03-09	1520	88	0	93	1.1	94
50	Dec 10-16	1610	88	60	89	1.7	59
51	Dec 17-23	1750	88	36	75	1.3	79
52	Dec 24-31	1750	88	76	60	1.5	65
1	Jan 01-07	1750	88	0	49	0.6	100
2	Jan 08-14	1750	88	0	62	0.7	100
3	Jan 15-21	1750	88	12	54	0.7	100
4	Jan 22-28	1750	88	2	61	0.7	100
5	Jan 29-Feb 04	1700	88	5	58	0.7	100
6	Feb 05-11	1600	88	39	58	1.1	91
7	Feb 12-18	1500	88		65	1.0	100
8	Feb 19-25	1302	88	4	86	1.0	97
9	Feb 26-Mar 04	1135	88	0	60	0.7	100
10	Mar 05-11	950	88	7	73	0.9	100
11	Mar 12-18	875	88	9	102	1.3	79
I2	Mar 19-25	800	88	0	109	1.2	81
13	Mar 26-Apr 01	725	88	90	149	2.7	37
	Total		2288	791	1838		
	Mean	1750	88	30	71	1.1	85

RWS = (RF+AID)/IDR

WUE = IDR / (RF+AID)) X 100%

IDR values used are: Rice (land preparation)= 2.0 lps/ha
(normal irrigation)= 1.5 lps/ha

imgated rice production during the dry season. Alternative non-rice crops aside from corn were tested and found suitable. However, other support services must be provided to enhance farmers to practice irrigated non-rice crop production.

Changes in the rice priority policy have to be considered, if production of irrigated non-rice crop is to increase. Existing irrigation technologies and some suggested areas for improvements are deemed necessary to help optimize the use available water supply in most irrigation systems in the country especially during the dry season.

The proposed guidelines for irrigation management for diversified crops and the results of the component studies are expected to be useful, particularly to NIA. The Diversified Crop Irrigation Training Center is expected to make valuable use of the outputs of this study.

Table 10. Irrigated area, ha (IA), mean weekly actual irrigation delivery, mm/wk (AID), mean weekly cumulative water supply (RWS), mean weekly water use efficiency (WUE), ARIP, crop

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