Proposed Guidelines for the Management and Operation of Irrigation Systems with Diversified Cropping

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Introduction

Irrigation will remain as a critical factor in increasing food production in the Philippines. As such, it draws major fractions of the development investment resources of the country.

There are three approaches to help solve the problem of reduced economic return from irrigated rice lands: (1) increasing the economic yields of rice per unit area; (2) increasing the area served by irrigation systems through more effective and efficient irrigation management; and (3) introduction of higher value crops than rice.

The introduction of non-rice crops in irrigated rice areas may offer an opportunity to increase productivity, especially on areas which cannot support more than one rice cropping because of inadequate water supply. However, the introduction of non-rice crops in irrigation systems designed to irrigate rice complicates the existing irrigation systems operation and management procedures.

Improving irrigation systems management for rice and non-rice cultivation has been a major thrust of the International Irrigation Management Institute (IIMI), particularly in the Philippines where it has been implementing crop diversification studies since 1985 in collaboration with the National Irrigation Administration (NIA). Results of these and other related studies may now be used to modify existing NIA procedures not only for irrigated rice but also for diversified crops in rice-based areas.

The guidelines discussed herein will provide the basis for formulating procedures for water allocation and distribution for rice and non-rice crops especially during the dry season. It attempts to improve and supplement the procedures in the existing NIA Operations and Maintenance (O&M) plan and the Irrigation Management Information System for Monitoring and Evaluation (IMIS), particularly for irrigation systems suitable for diversified crops during the dry season. The guidelines focus primarily on how irrigation systems operation and management are planned and implemented, as well as the indicators used in monitoring and evaluating the system's physical performance and the analysis that will help in identifying the constraints and opportunities for improvement of the system.

Data from the Laoag Vintar River Irrigation System (LVRIS) were used to represent systems with distinct dry and wet seasons and from the Allah River Irrigation Project (ARIP) to represent systems with relatively evenly distributed rainfall pattern.

Adjustments will have to be made in the data used in the computation (i.e., seepage and percolation, rooting depth, crop growth duration, rainfall pattern, etc.), if this procedure is to be applied in other systems. These adjustments will hopefully enable the accommodation of location-specific information and data which will be used in making appropriate estimates of actual water use during the dry season.

It is expected that NIA will comment on the guidelines for further improvement and to adopt those appropriate and make them part of its operational procedures in managing irrigation systems for diversified cropping. The procedure will be tested during the 1988/89 dry season. However, testing during a full cropping year is most ideal.

Planning

Planning is an essential and critical stage in irrigation systems operation and management. It includes how much area will be irrigated, water scheduling, allocation and distribution, etc. Plans are primarily based on the predicted amount of available water supply and the amount that will be used or needed.

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Assessment of Available Water Supply.

The probable amount of water that will be available can be estimated from the analysis of river and rainfall data. The analysis should be done for both wet and dry cropping seasons. The dry season schedule is dependent on the completion of the wet season, and thus, cannot be planned independent of the wet season. However, details of the plans for the dry season will be made within and just before the harvest of the wet season crops.

River data. Data on streamflow are valuable when determining a river's characteristics. Using these data, the following guidelines can be used:

a. Maintain the present NIA practice of monthly discharge monitoring and yearly calibration.
b. In the absence of stochastic streamflow analysis, use the NIA procedure for averaging longest record of diverted flow into the system.
c. In cases of surface pump systems, the available river flow or streamflow records will be useful. The current NIA method of averaging the longest record of streamflow is still the only acceptable way of estimating available river flow.

If funds are available, it is recommended that NIA conducts with the National Water Resources Board (NWRB), the calibration and monitoring of streams which NIA systems are diverting water for irrigation.

Rainfall data. Most NIA systems are within the vicinity of rainfall stations with 20 or more years of records. Using these data, the probability of rainfall can be determined using the incomplete gamma function analysis. The present 5-year moving average method has a lesser degree of reliability on the weekly prediction compared with the 50% probability level of the incomplete gamma function (Serquina, C.M., 1977; Labios, L.C.T., 1979). The 5-year moving average overestimates the actual rainfall (see Figures I and 6). The rainfall records at Laoag City and Surallah, South Cotabato were used as examples in this assessment. A similar probability analysis can be made for other NIA systems.

The amount of effective rainfall should likewise be determined to have a more reliable estimate of available water supply. NIA's existing procedure may be used to compute this amount.

Estimating Irrigation Water Demand.

The demand for water is determined by the amount of water used by the crops throughout the growing period, the amount that is required in land preparation and other farming activities, and the amount that is lost through evaporation, seepage and percolation. The amounts of water used further depend on the kind of crops to be grown, soil characteristics, condition of the irrigation facilities, and other biophysical and agro-climatic factors.

Crop water requirement. In determining the amount of water needed by the crop(s), the following should be taken into consideration:

a. Each crop has its own water requirement or evapotranspiration (ET) demand. Rice is a crop with a relatively well established amount of water use at every growth stage. During the wet season, rice is the major crop. The NIA procedure for estimating the crop water demand of rice is acceptable, provided other values (e.g., seepage and percolation) are adjusted to suit local conditions.
b. The water demand of upland crops is less well known compared to rice. However, there are published and established values of crop water demand for various upland crops (Final Report, TA 654, IIMI, 1986; Philippines Recommends for Water Management for Upland Crops, PCARRD).
c. Upland crops are also sensitive to moisture deficits and water' excess. Waterlogging tolerance or sensitivity will have to be taken into consideration, particularly for leguminous crops at the early vegetative stage. Relative to rice, water demand of upland crops are more exacting. However, upland crops are also sensitive to moisture deficits especially at the reproductive stage.
d. After identifying the crops to be grown, a cropping pattern can be established using the crop characteristics and available water supply. Unless alternative cropping patterns have been introduced, cropping pattern are already established in most systems. New cropping patterns (e.g., cotton, wheat, tomato, peanut, etc. as second crop to rice) are also being tested in existing systems for adaptability.
e. Crop water demands are estimated with reference to surface water evaporation.

Thus, evaporation data are also important in estimating crop water demand (*see* Annex 1).

Soil water demand. The demand for water of the different soil types depends on their characteristics. The amount that will be required for land soaking and other land preparation activities depends on soil texture, infiltration characteristics and other soil properties. Losses due to seepage and percolation will likewise depend on these properties. Therefore, these properties are essential in estimating the amount of water that will be required by the soil to support crop growth.

For a specific soil type, values of seepage and percolation, saturation, residual moisture, etc., have to be estimated to arrive at the soil water demand and to determine conveyance losses in earth channels or unlined canals. In most NIA systems, the above values can be approximated depending on the type of soil (*see* Annex 1).

In a given area or irrigation system, it is useful to identify the soil types suitable for rice and upland crops. Their relative extent and distribution will facilitate the preparation of the plan. Mapping will facilitate identification (*see* Cablayan and Pascual, 1988). Sources of information or data base are diversifii land class maps, survey of existing land use and fanners' survey. Relevant maps may be available in other offices like the Provincial Development Staff (PDS), Municipal Development Council (MDC), the local Department of Agriculture (DA) offices, etc. There are a number of thematic maps prepared by the Bureau of Soils and Water Management. Although very gross and mostly province-wide in scope. these can be used to estimate soil suitability for various crops. Not all NIA systems have land evaluation maps. It is **recommended** that all of these systems be surveyed to have the appropriate maps.

Condition of irrigation facilities. The physical condition of the irrigation system (e.g., canals and ditches, turnout structures, etc.), will have a direct bearing on the amount of water that will be required, as it determines conveyance losses and consequently, efficiency of water delivery.

Yearly inventory and seasonal maintenance reports will provide the information on the physical capability of the system. High canal capacities to accommodate large intermittent flows are recommended for areas with coarse textured soils. Moreover, lined main farm ditches in these soils will have to be provided if large intermittent flows are to be delivered (*see* Annex 1).

Although lining of canals is expensive, it reduces conveyance losses, the lag time of water delivery to the different sections of the system, and time and resources spent for canal maintenance. Lining of channels is particularly important if water is **scarce** and earth channels are unstable and have coarse textural characteristics.

Conveyance losses are also reduced if turnouts, **canal intake structures (head gates of laterals)** and checking structures (cross regulators) are gated. Properly located turnouts will reduce the number of extra turnouts.

NIA's procedure in computing conveyance losses is acceptable (*see* Annex 1). However, it is recommended that inflow-outflow method to determine conveyance loss be instituted, particularly for unlined canals. With this method, a more accurate estimate of the actual conveyance loss can be obtained.

After determining the crop, soil and conveyance losses, the demand for crop to be planted can be assessed. In case of mixed cropping in a given turnout area, approximate requirement for both crops will be estimated. Waterlogging of upland crops will have to be considered in making the estimates and in the actual releases or implementation of these guideline.

WaferAllocation, Distribution and Scheduling

Program area determination. **Programming** the area which will be provided with irrigation water within the cropping season, based on the analysis of available water supply and the amount required, will help determine how water will be allocated, distributed and scheduled. NIA's present parcellary mapping program is commendable. Using parcellary maps, an accurate assessment of the actual area irrigated can be obtained. Accuracy of information is vital to optimally utilize the available water supply, particularly during the dry season

In determining the program area, water sup ply, crop demand and soil demand have to be considered. In most systems, however, areas nearest to water sources or areas in upstream portions are programmed for irrigation, especially during the dry season.

In system with an active irrigators' association (IA), program area determination is facilitated through the participation of the IA. However, NIA plans the program area first before the IA is consulted.

In most systems, an assessment is usually made based on the previous year's program area. This practice is acceptable provided a careful consideration of the water supply and accurate assessment of the demand is made. Furthermore, alternative crops will be considered, provided the farmers are able and willing to plant this crop.

When water supply is expected to be very Limited during the dry season, areas to he planted to rice will be confined to areas with heavy textured soils and close to the source or upstream portion of canals. However, the IA and the individual farmer's capacity to pay the irrigation service fee based on payment record are sometimes considered in determining the program area

Scheduling of *water distribution and delivery*. A schedule of water distribution and delivery is planned after the program area has been determined. This schedule is based on the availability of water supply (rainfall and river diversion discharge). A schedule is drafted, using data on water demand for the programmed area. Continuous or rotational water delivery schedule is proposed, depending on the availability of water. A continuous water delivery schedule is planned at the beginning of the dry season; rotational delivery is used when water becomes limited at mid-season up to the end of the dry season.

Implementation

Implementation includes the approval of the plan prepared by the NIA and its operational application. The plan passes through a series of meetings between farmers and NIA personnel before it is approved. In the field, monitoring is an important activity.

Meetings.

The plan is presented and discussed with the NIA field personnel, the IAs and the Provincial or Municipal Agricultural Coordinating Council.

Meeting with the NIA field personnel. The operational plan is presented to the NIA field personnel for comments and suggestions before the start of a cropping season. Possible reactions of the IA to the plan are also discussed. After modifications are made, the plan is presented to the IA.

Meeting between the NIA and the IA. A meeting between the NIA and the IA is held to discuss the program area and the schedule of water delivery. The projected available water supply is presented together with the plans for the coming season. Water allocation among farmers is also discussed. The programmed as well as the unprogrammed area is finalized during the meeting.

After an agreement between the NIA and the IA on the program area is reached, the schedule is discussed. The proposed schedule is presented for comments and suggestions to the IA members. Unless a substantial change in the plan is made, a consensus is sufficient to establish the agreement between the NIA and the IA; if not, a compromise schedule is drafted.

Presentation to the Provincial or Municipal Agricultural Coordinating Council. The schedule agreed upon by the NIA and the IA is then presented to the Provincial or Municipal Agricultural Coordinating Council. The council is composed of representatives from agencies concerned with agricultural production id the province or municipality like the NIA, the Philippine Crop Insurance Corporation (PCIC), the National Food Authority (NFA), the provincial and/ or municipal Department of Agriculture (DA), etc. The meeting is important to inform other government support agencies about the schedule of fanning activities in the area. Problems related to other support services such as availability of loans, crop insurance, seeds, fertilizers and other inputs are discussed.

Field Operations and Monitoring

The agreed upon schedule will have to be followed by the farmers and enforced by NIA. Any changes or deviations from this scheduk will have to be jointly acted upon by NIA and the IA.

Implementation of the schedule. The release or delivery of irrigation water will be in accordance with the agreed upon schedule and amounts. Adequacy of water supply will be quantitatively assessed. In most systems, NIA field personnel can estimate water adequacy by observing water elevation in the canals or intake structures. Although practical, these estimates should be calibrated every season by actual measurements to assure reliable estimates. Changes in the canal bed due to siltation makes these estimates of water elevations erroneous. If the agreed upon schedule is properly observed by the farmers and effectively enforced by NIA, conflicts and water distribution problems will be minimized.

Monitoring. Monitoring by the NIA field personnel is done to provide adequate irrigation water to the crops. Any extraneous record keeping activities by NIA will only result to fabricated records. Status of farming activities, flows or discharges at critical points and amount of rainfall are the key variables to be monitored. Farming activities should be noted on a weekly basis so as to provide enough data to base decisions on which sections of the system will need water. Flows on the critical points in the system, should likewise be used for making decisions and not for record keeping only.

Data or information should be considered important for making decisions pertaining to the management or operation of the system. Monitoring forms should be kept to a minimum, reflecting only those useful to the irrigation manager and his field staff. This system of monitoring is being piloted in several irrigation systems under the IMIS program.

A regular meeting between the IA and the NIA field staff during the cropping season is an effective means of monitoring the operations of the system. The meeting is expected to provide the feedback mechanism to make the schedule realistic and the opportunity to revise the schedule and settle conflicts in water distribution.

Evaluation

The evaluation mechanism should provide an objective assessment of the system's performance based on what had been planned. Evaluation of the actual accomplishments against what had been targeted will indicate how the system performed. Moreover, the assessment will provide information or explanation on why the system performed better or poorer than in previous years.

***Planned** target* versus *actual accomplishments.* The physical performance of a system can be assessed based on the area irrigated, area benefitted, equity of water distribution, and crop yield. Water distribution indicators will reflect the different demands of areas growing rice and non-rice, including areas with mixed cropping. Equity rather than equality is aimed for in systems with diversified crops.

The different indicators will be aggregated from the data or information monitored during the previous dry season. At this stage, the data on water flows will be utilized to determine shortfalls such that preventive measures or actions can be planned and instituted in the next dry season.

Process evaluation. While a comparison between the planned targets and the actual accomplishments provides indications of the performance of a system, it does not indicate why the system performed as such. This will be provided by process evaluation. Analysis of the causes of a system's success or failure will highlight the process or activities that led to the accomplishment.

An example of an indicator of improved performance of a system is the increased area irrigated or a third crop. An analysis of the factors that might have led to this accomplishment may serve as a guide in the coming seasons when similar conditions will be present.

Implementation of the schedule is another instance where shortfalls usually occur. Farmers and NIA field personnel's culpability will have to be assessed. Improvement of procedures to make farmers more responsive and to adhere to schedules should be looked into. Group pressure or sanction through the IA is recommended with NIA's concurrence. Whatever actions to be taken to prevent shortfalls and repeat excellent performance should be acceptable to the farmers and NIA field staff. These will then be instituted in the next season and likewise be evaluated to minimize shortfalls and increase excellent performance in the different activities.

IA-NIA meetings will have to be more functional to actually meet farmers' needs.

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Annex 1

Irrigation Management Procedures Under the Laoag- Vintar River Irrigation System

The Laoag-Vintar River Irrigation System (LVRIS) is a run-of-the-river type national irrigation system with a command area of 2,377 hectares in the province of Ilocos Norte. During the dry season, only 1,243 hectares or about 52% of the total command area is imgated with about one-half planted to non-rice crops, such as garlic, corn, tomato, mungbean, peanut, watermelon and other vegetable crops. The system consists of four watermasters divisions. The main canal of about 27.5 km draws water from Vintar River and branches out to seven laterals and five sub-laterals.

Assessment of Available Water Supply

The probable amount of water that will be available has been estimated from river discharge and rainfall data. Data on river discharge at the LVRIS damsite from 1980-87 were summarized on a monthly basis. The river flow is maximum in August with a mean of 25,000 Ips and minimum in April at 1,779 Ips (Table 1).

Rainfall data from 1965 to 1987 were summarized into weekly total rainfall. The incomplete gamma distribution function was used to analyze the weekly data. The 50% probable rainfall was compared with the mean rainfall (Figure 1). The figure shows that the probability of the mean rainfall is less than 50%. Higher weekly amounts of rainfall have lower probabilities.

Estimation of Water Demand

The irrigation water requirement can be estimated from crop and soil demand, and the irriga-

Table 1. Average monthly river discharge (Ips) of Vintar River at LVRIS Dam, 1980-1987.

Month	1980	1981	1982	1983	1984	1985	1986	1987	Mean
Jan		12670	9690	11452	3164	3240	3538	4770	6932
Feb		2879	7514	7500	1645	2440	2957	1843	3825
Mar		2810	3200	2610	1710	1622	2006	1570	2218
Apr	2270	2350	2550	1067	1675	1810	1460	1050	1779
May	2100	5540	5370	880	5113	1438	1520	820	2848
Jun	9130	15070	8830	1205	10800	46070	1520	5110	12217
Jul	19000	16600	24870	5645	10000	5350	5858	6000	11665
Aug	19000	16600	33840	26258	53290	18097	8153		25034
Sep	21330	16600	26900	17667	14400	8500	4500	54000	20487
Oct	21000	18880	23480	8067	11110	7806	5200		13649
Nov	21000	15430	25600	3980	6100	5000	5890		11857
Dec	17670	13000	12740	3990	3460	4265	12120		9606
Mean	14722	11536	15382	7527	10206	8803	4560	9395	6427

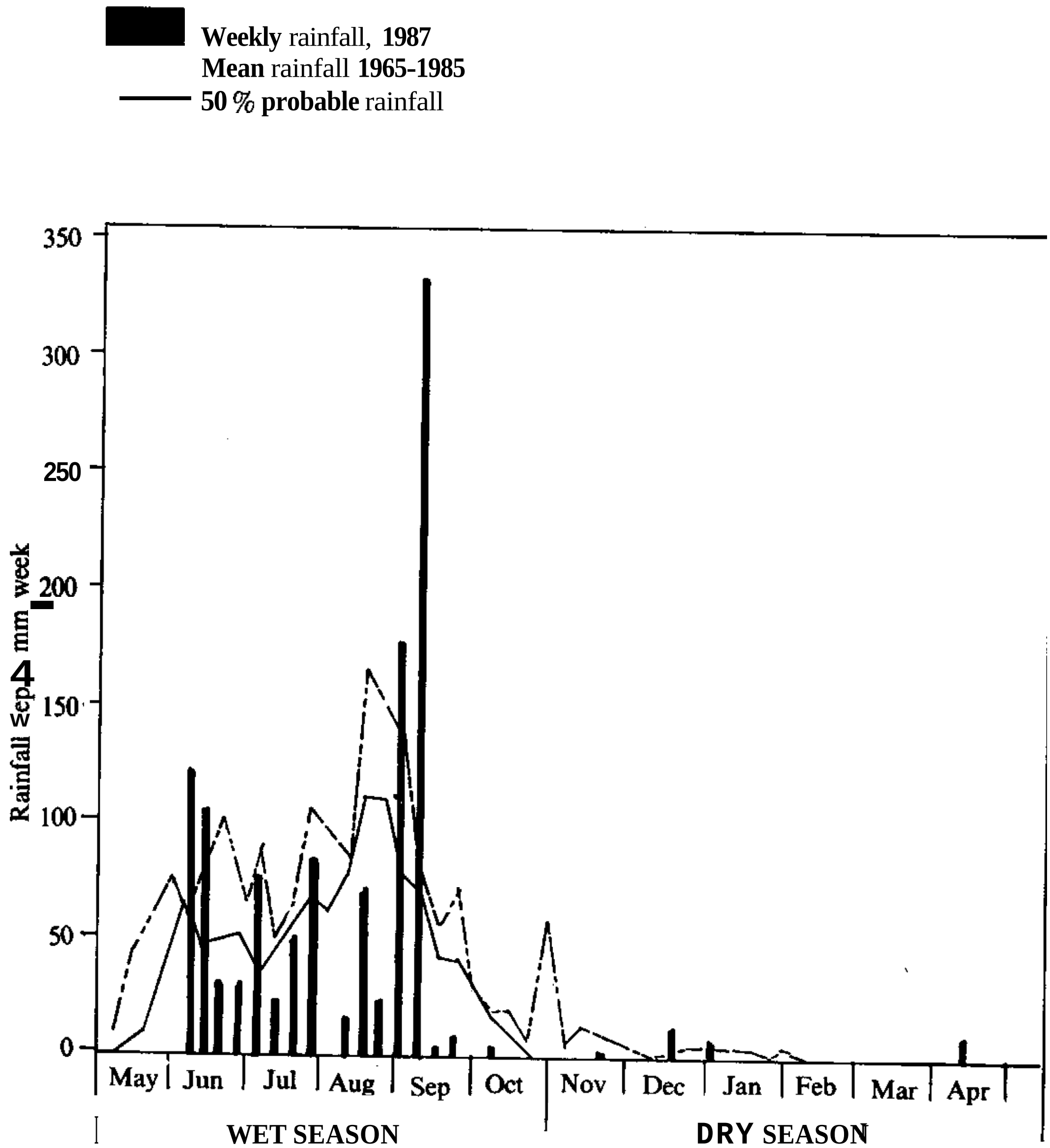

Figure 1. **Mean** rainfall, **1965-1985, 50 % probable rainfall computed using incomplete gamma distribution and** weekly rainfall, **1987.**

tion efficiency and canal capacities of the system. For lowland rice, seepage and percolation has a mean value of 4 mm/day for the entire system. Rice evapotranspiration (ET) was 5 mm/day during the wet season and 6 mm/day during the dry season. For the wet season, the soil saturation requirement was estimated at 91 mm, to be supplied in the first week of irrigation. For the dry season, the land soaking requirement was assumed to be zero, since the soil is still at saturation after the harvest of the wet season crop.

For diversified crops, water requirements were computed using the crop coefficients (KC»s) gathered from available data. KC is the ratio of the actual FT to pan evaporation. The diversified crops grown in LVRIS are garlic, tomato, watermelon, mungbean and vegetables. For these crops, the maximum ET is at about 40 to 90 days after planting (Table 2). Other characteristics of these crops are also shown in Table 2.

Table 2. Characteristics of irrigated non-rice crops commonly grown at LVRIS.

Characteristic	Crop			
	Garlic	Watermelon	Tomato/Veg.	Mungbean
Growing Period	110	105	95	70
initial stage	0-20 DAT	0-20 DAT	0-20 DAT	0-10 DAT
crop development	21-45 DAT	21-55 DAT	21-50 DAT	16-40 DAT
mid-season	46-90 DAT	56-70 DAT	51-80 DAT	41-65 DAT
late season	91-110 DAT	71-105 DAT	81-95 DAT	66-70 DAT
Planting Dates	Nov - Dec	October	Dec - Jan	Feb - Mar
Rooting Depth (cm)	30-60	45-60	30-60	45-60
Crop Coefficient(Kc) DAT's				
0 - 10	0.15	0.20	0.28	0.30
10 - 20	0.22	0.24	0.28	0.42
20 - 30	0.35	0.48	0.50	0.82
30 - 40	0.55	0.72	0.73	1.00
40 - 50	0.66	0.95	1.01	1.00
50 - 60	0.84	0.95	1.05	1.00
60 - 70	0.93	0.95	1.05	0.90
70 - 80	0.93	0.95	1.05	0.72
80 - 90	0.87	0.85	0.80	0.65
90 - 100	0.72	0.65	0.44	0.55
100 - 110	0.68	0.50	0.30	0.40
Water Use/season,mm	360-400	400-600	460	210
Irrigation Method	Basin Flooding	Basin Flooding	Furrow Irrigation	Basin Flooding
Moisture Conservation practice	Mulching	Mulching		
Irrigation Frequency				
initial stage	Monthly	Monthly	Monthly	Monthly
crop development	Monthly	Monthly	Monthly	Monthly
mid-season	1-2 weeks	1-2 weeks	1-2 weeks	Monthly
late season	none	none	none	none

DAT - Days after transplanting/planting

Table 3. Conveyance losses and canal capacities. LVRIS, crop year 1987/88.

Station	Area served (ha)	Flow (lps) Maximum	Mean Dry Season	Mean Wet Season	Distribution Efficiency(%) Dry Season	Wet Season
Main Canal Headgate	2377	6088	2119	3897	61	71
Lateral A	82	617	196	297	67	72
Lateral B	64				83	86
Lateral E	25	70	30	36	65	66
Lateral F	653	1679	644	784	67	70
Lateral G	87	612	93	137	68	71
Lateral G-l	87	624	121	121	55	83
Lateral H	381	725	243	251	55	83

Canal capacities and irrigation efficiencies by season per lateral were summarized from previous records of the system (Table 3). The maximum capacity of the main canal is 6,088 lps with average discharges of 2,897 lps and 2,119 lps during the wet and dry seasons, respectively. Data for different sections of the main canal were also summarized but was not shown in the table. These data were used in the development of the proposed cropping schedule for the system.

Estimation of Irrigable Area and Cropping Schedule

From the above data, it was computed that the system could serve the whole irrigable area of 2,377 hectares for wet season lowland rice planting. The system could also irrigate 843 hectares of lowland rice and 834 hectares of diversified crops during the dry season. Based on canal capacities and available flow, the wet season operation should start on the first week of June. 'This is the usual start of system operation in previous years. The entire system could he land soaked for one month. Assuming rice with 120 days maturity is to be transplanted, transplanting could start by the first week of July and the area could be totally planted by the end of July. The wet season rice crop could be harvested by the middle of November (Figure 2).

Dry season rice cropped areas were assigned to areas already being programmed for this purpose in previous years. These areas are heavy textured and not suitable for diversified crops. Land preparation for these areas could be started by early November and rice transplanting could start in late November. These crops would be harvested by March (Figure 2).

Diversified cropped areas could be planted to garlic, tomato, vegetables and watermelon in November and planted to a third crop of mungbean in late February (Figure 3). This is already practiced in these areas. The second crop of diversified crops could be harvested by February in time for planting of a third crop of mungbean. The mungbean crop could be harvested by early May.

Computation of Irrigafion Diversion Reguiremenf

The irrigation diversion requirement (IDR) of the system was computed based on the proposed cropping schedule. This was done simultaneously with the computation of the progress of farming activities to ensure that canal capacities and available flow from the river are not exceeded. Also, IDR was computed separately for each lateral/section of the system to ensure that every structure in the system could handle the computed flows. However, only the whole system summary is presented in this report.

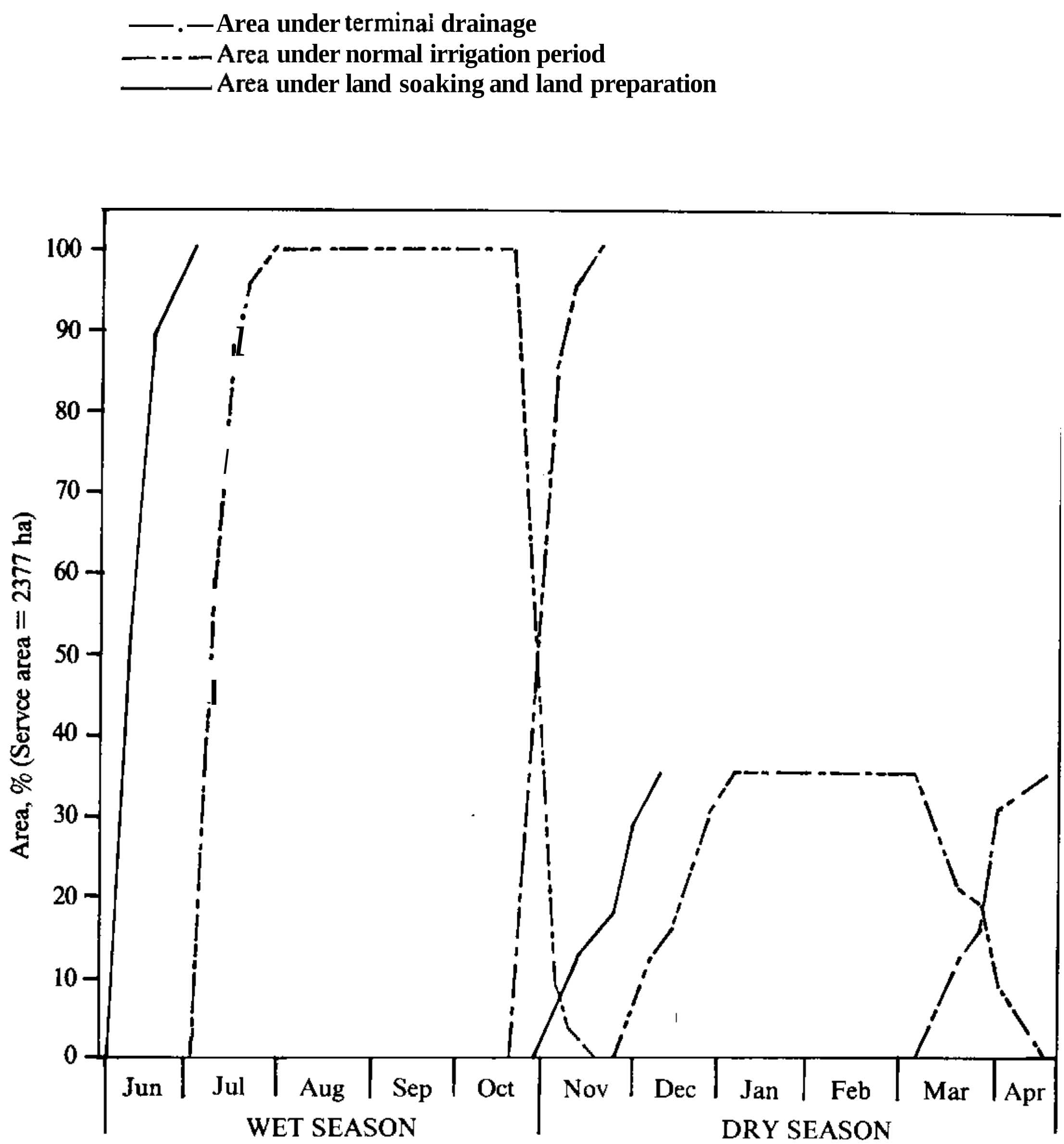

Figure 2. **Proposed weekly progress of farming activities, rice only, Laoag-Vintar River Irrigation System (Based on data for 1984-1988 and canal flow capacities).**

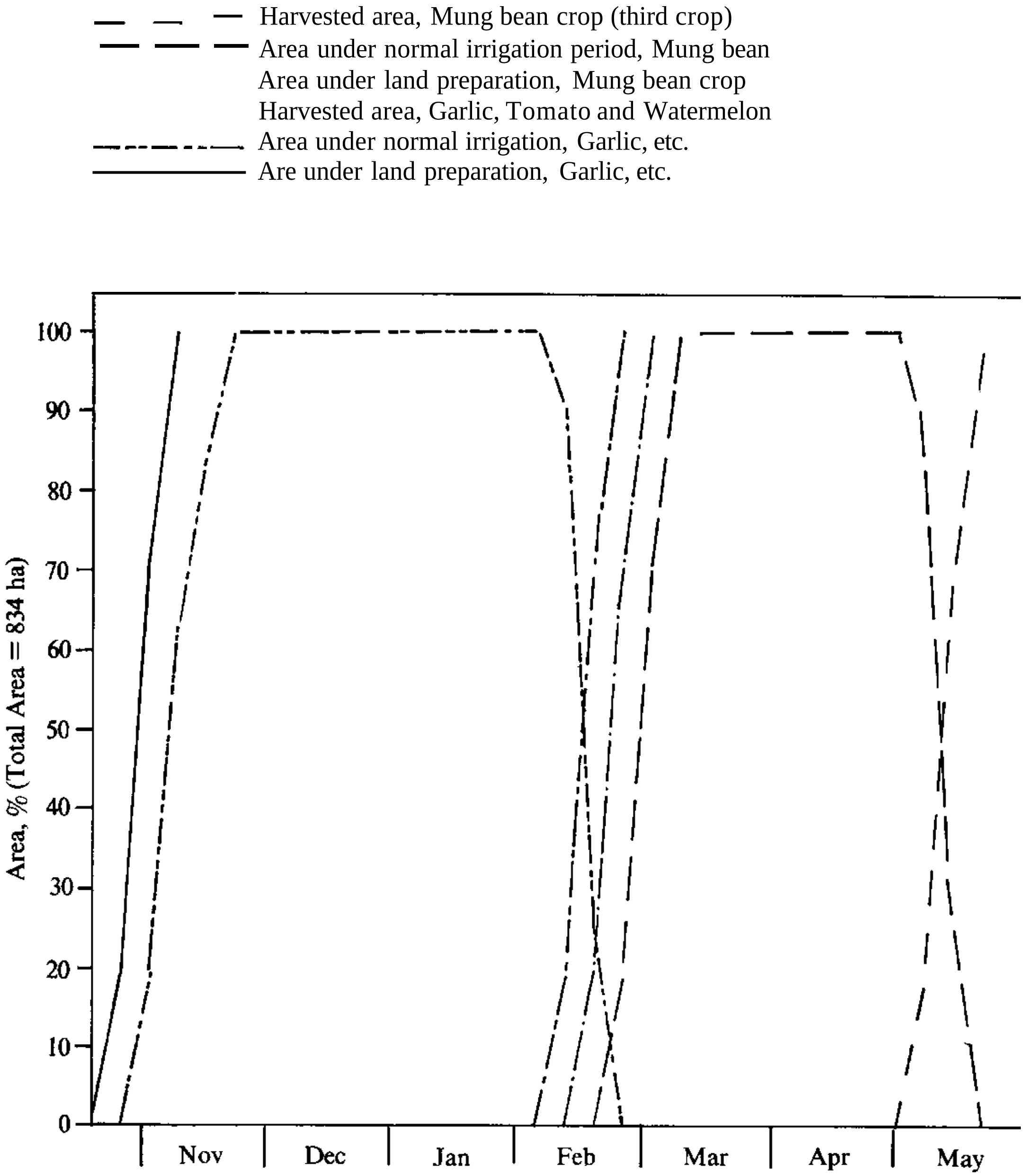

Figure 3. Proposed weekly progress of farming activities, diversified crop areas, Laoag-Vintar Irrigation System, (Based on data on cropped areas for 1984 to 1988 and Canal flow capacities)

Assuming zero rainfall, the system will have maximum IDR on the second week of operation. The irrigation will be about 30% of the mean river discharge for the entire wet season (Table 4 and Figure 4). If 50% probable rainfall is assumed, the IDR would be only 15% of the mean river discharge during the wet season.

Based on rainfall probabilities, rainfall is negligible during the dry season. Based on computations, critical water supply would be experienced in late January (Table 5 and Figure 4) and the system will not be able to fully imgate the third crop of mungbean. At present, the third crop of mungbean is being irrigated only once, depending on water availability. The first and second crops. however, could be fully irrigated.

Irrigation Management Procedures Under the Allah River Irrigation Project

Data were taken from the feasibility report of ARIP for the development of a feasible cropping schedule. The dependable flow data (Table 6), were reduced into weekly values for weekly irrigation scheduling. Only 60% of the dependable flow was assumed available. The rest will be used for flushing silt and for use by the lower dam. The

Table 4. Irrigation diversion requirements (IDR) for LVRIS, wet season rice crop based on cropped areas for 1984-87, canal capacities, and mean river discharge (river flow at damsite) from 1980-1987.

Week no.	Date	Rainfall: 50% Probable	Rainfall: 5-year mean	Irrigation Diversion Requirement (Ips) assuming Rainfall = 0	Irrigation Diversion Requirement (Ips) assuming Rainfall = 50% Probable	River Discharge (lps)
23	Jun 04-10	70	59	5061	3415	12217
24	Jun 11-17	44	76	6485	4462	12079
25	Jun 18-24	35	102	5806	3899	11941
26	Jun 25-Jul 01	52	65	5249	2226	11803
27	Jul 02-08	33	89	5423	3309	11665
28	Jul 09-15	45	50	4970	2401	15007
29	Jul 16-22	58	59	4970	1631	18350
30	Jul 23-29	68	108	4970	884	21692
31	Jul 30-Aug 05	62	99	4970	1240	25034
32	Aug 06-12	76	84	4970	459	24125
33	Aug 13-19	I13	165	4970	0	23215
34	Aug 20-26	I12	152	4970	0	22306
35	Aug 27-Sep 02	78	I36	4970	328	21396
36	Sep 0349	68	76	4970	927	20487
37	Sep 10-16	43	56	4970	2404	18778
38	Sep 17-23	40	73	4970	2574	17068
39	Sep 24-30	27	30	4970	3380	15359
40	Oct 01-07	16	20	4970	4044	I3649
41	Oct 08-14	9	19	4970	4418	13291
42	Oct 15-21	2	6	4970	4880	12932
43	Oct 22-28	0	59	2868	2868	12574
44	Oct 29-Nov 04	0	5	999	999	12215
45	Nov 05-11	I	13	225	225	11294
46	Nov 12-18	0	8	0	0	10731
47	Nov 19-25	0	7	0	0	10168
48	Nov 26-Dec 02	0	I	0	0	9606
	Mean	40	62	4103	1961	15730

- IDR's are sums of individual sections of the system
- Mean Rainfall 1975-1987
- 50% probable rainfall analyzed by the incomplete gamma function analysis.

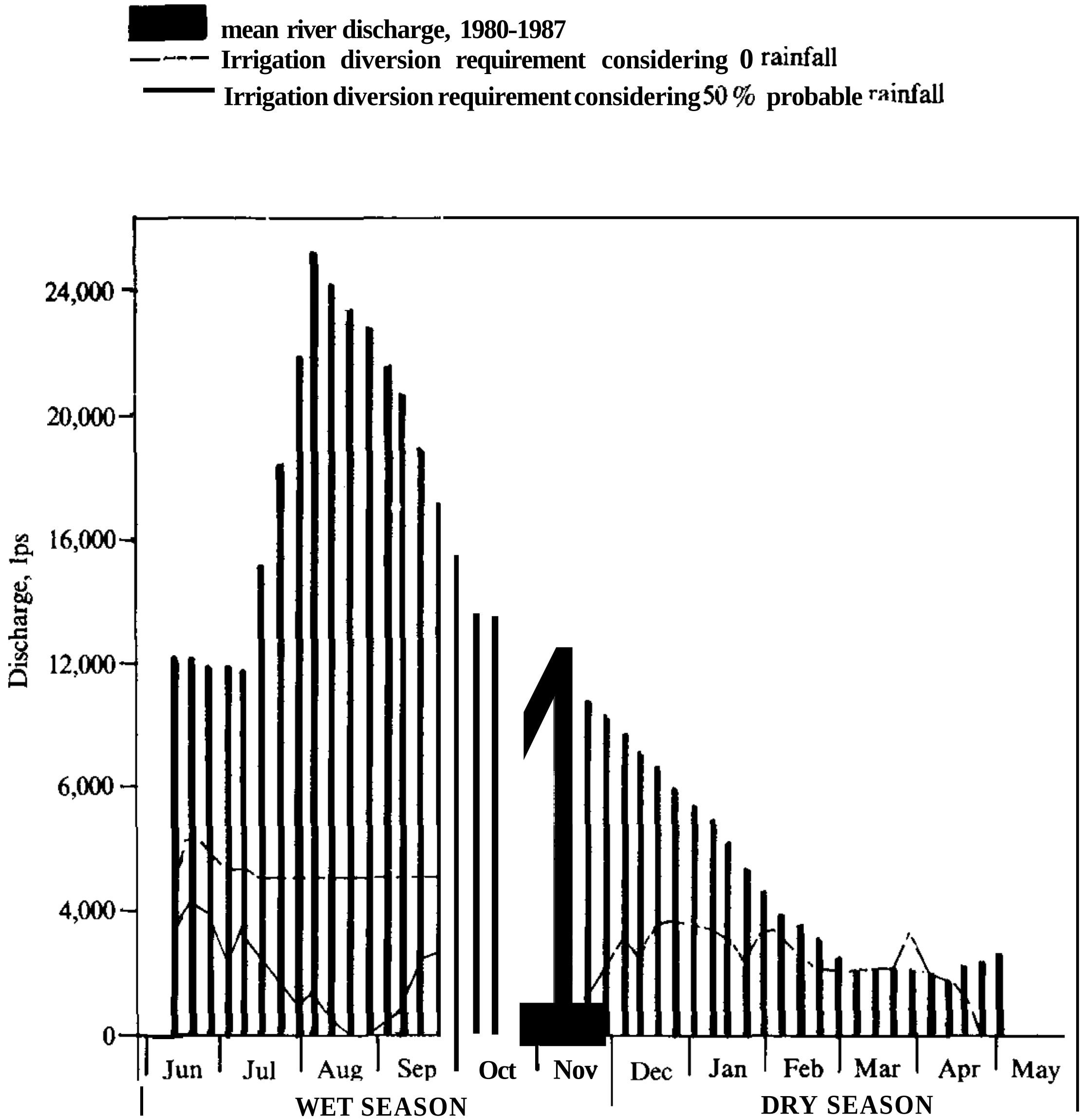

Figure 4. **Irrigation diversion requirements based on proposed progress of farming activities, and mean river discharge for Vintar River, 1980 to 1987, Laoag-Vintar River Irrigation**

Table 5. Irrigation Diversion Requirement (IDR) for the LVRIS, dry season crops (843 hectare - rice and 834 hectare - other crops), and mean river discharge from 1980-1987.

Week No.	Date	Irrigation Diversion Requirement (lps) Rice	O.C.	Total	River Discharge (lps)
44	Oct 22-28				
44	Oct 29-Nov 04	823	143	966	11857
45	Nov 05-11	1186	649	1835	11294
46	Nov 12-18	1052	0	1052	10731
47	Nov 19-25	1958	210	2168	10168
48	Nov 26-Dec 02	2126	904	3030	9606
49	Dec 03-09	2106	174	2280	9071
50	Dec 10-16	1832	1686	3518	8536
51	Dec 17-23	1832	1529	3361	8001
52	Dec 24-31	1832	1800	3632	7466
I	Jan 01-07	1832	1501	3333	6932
2	Jan 08-14	1832	1253	3085	6155
3	Jan 15-21	1832	418	2250	5378
4	Jan 22-28	1832	1627	3459	4601
5	Jan 29-Feb 04	1832	1514	3346	3825
6	Feb 05-11	I832	50I	2333	3423
7	Feb 11-18	1832	304	2136	3021
8	Feb 19-25	1832	331	2163	2619
9	Feb 26-Mar 04	1832	113	1945	2218
10	Mar 05-1I	1832	380	2212	2130
11	Mar 12-18	I493	656	2149	2042
12	Mar 19-25	1144	2242	3386	1954
13	Mar 26-Apr 01	994	953	1947	1866
14	Apr 02-08	533	962	1495	1779
15	Apr 09-15	192	I295	1487	2046
16	Apr 16-22		I56	I56	2313
17	Apr 22-28				2580
	Mean	1560	852	2349	5447

- Irrigation Diversion Requirement is the sum of all sections.
- Rainfall for dry season is 0 for all weeks.

water requirement of lowland rice based on different soil types was also considered (Table 7). The land soaking requirement was computed to be 90 mm and will be supplied during the first week of irrigation. Irrigated areas and canal capacities per lateral are summarized in Table 8.

Rainfall data from 1965 to 1985 were taken from the weather station at Norala, South Cotabato, which is within the service area. This data was summarized into weekly values, which were analyzed using the incomplete gamma distribution function. Figure 5 shows the weekly rainfall for South Cotabato. The mean rainfall has a probability of less than 50%. This means that the mean rainfall could not be expected once in two years.

The start of operation for the wet season was based on crop year 1987/88. During this season, the farmers clamored that the system should start operation in early April as water is already available and farmers are ready to start cropping. The area that could be land soaked weekly was computed based on the dependable flow and land soaking requirement, to come up with the weekly progress of farming activities (Table 9). The assumed operation was tail-first, which was already adopted by the system since it started operation in 1986. A 120-day rice variety was considered. During the wet season, the entire area of 7,300 hectares could be planted to rice. Figure 6 shows the resulting weekly progress of farming activities.

Table **6.** Smoothed dependable flow. ARIP Dam No. 1, (Taken from feasibility report of ARIP).

Period		Dependable flow, lps: lps/sq. km.	Dependable flow, lps: Total A = 483 ha	60% of Dependable Flow
Jan	1-10	19	9274	5564
	11-20	26	12365	7419
	21-31	24	11495	6897
Feb	1-10	23	10868	6521
	11-20	22	10771	6463
	21-28	21	10143	6086
Mar	1-10	20	9708	5825
	11-20	18	8549	5129
	21-31	16	7680	4608
Apr	1-10	16	7487	4492
	11-20	18	8549	5129
	21-30	19	9322	5593
May	1-10	20	9757	5854
	11-20	22	10433	6260
	21-31	26	12655	7593
Jun	1-10	36	17340	10404
	11-20	42	20189	12114
	21-30	41	19658	11795
Jul	1-10	35	17050	10230
	11-20	36	17388	10433
	21-31	38	18306	10983
Aug	1-10	36	17195	10317
	11-20	28	13717	8230
	21-31	26	12461	7477
Sep	1-10	31	14876	8926
	11-20	37	11774	10665
	21-30	38	18257	10954
Oct	1-10	38	18306	10983
	11-20	37	17919	10752
	21-31	39	18982	11389
Nov	1-10	39 40	18789	11273
	11-20		19513	11708
	21-30	40	19513	11708
Dec	1-10	41	19658	11795
	11-20	37	17968	10781
	21-31	34	16615	9969

It was also assumed that after harvest the areas could immediately start wet season operation. Considering transplanted rice, time from land preparation lo transplanting is **4** weeks. The whole system could be planted for the wet season toward the end of July (Figure **6).** The light soil areas of the **extra** laterals would be planted last. This would result in the harvest of the wet **season rice** crop in these areas by November which is a more acceptable time for fanners to plant corn.

Table **7.** Turnout water requirement (lps/ha) of different soil textures for lowland rice crop, ARIP, (Taken from feasibility Report, ARIP).

Soil Texture	**Dry** Season	Wet Season
Clay loam	1.30	1.16
Loam	1.45	1.30
Sandy Loam	2.02	1.88

Except for the extra laterals, all areas are programmed for lowland rice planting for the dry season. The extra laterals are programmed for corn. Planting would start by early December. The crops will be ready for harvest by late March assuming 105-day variety. Computations for the extra laterals for the progress of farming activities during the dry season was patterned on the simulation procedure used in Lateral A-Extra as reported in Final Report, TA 654 PHI (IIMI, 1986).

Based on the computed progress of farming activities, the IDR was computed. This was compared with the dependable flow (Tables 10 and 11 and Figure 7). Assuming zero rainfall, the system cannot will not be able to irrigate the entire area. Assuming 50% probable rainfall, the system would only need about 60% of the available flow for the whole crop year. Canal capacities were not to be exceeded even when rainfall does occur in these computations,

Table 8. Irrigable areas, ARIP.

Canal/Lateral	Canal Length (km)	Canal Capacity (lps)	Irrigable area (ha)
Main canal	20.13	14303	7311
Lateral A	7.98	4516	2192
Lateral A-I	7.08	1442	700
Lateral A-2	2.59	393	191
Lateral A-3	6.05	1730	840
Lateral A-3a	4.40	643	312
Lateral B	8.71	1669	810
Lateral C	7.84	1318	640
Lateral D	5.86	1374	667
Lateral E	3.50	976	474
Lateral A-Extra	4.80	391	296
Lateral B-Extra	3.65	475	360
Lateral C-Extra	3.71	486	368

Table 9. Progress of land soaking, wet season rice crop, ARIP.

Week No.		Increment area land soaked (ha)	Total area land soaked (ha)	Area covered
14	Apr 02-08		I209	MC TO's & Lateral D, C & E
15	Apr 09-15	790	1999	-do-
16	Apr 16-22	529	2528	-do-
17	Apr 23-29	422	2949	-do-
18	Apr SO-May 06	224	3173	MC TO's & Lateral B
19	May 07-13	180	3353	-do-
20	May 14-20	156	3509	-do-
21	May 21-27	448	3958	-do-
22	May 28-Jun 03	622	4580	Lateral A, A1, A2, A3 & A3a
23	Jun 04-10	761	5341	-do-
24	Jun 11-17	889	6230	-do-
25	Jun 18-24	312	6542	Lateral A-, B- & C-Extras
26	Jun 25-Jul 01	255	6797	-do-
27	Jul 02-08	255	7052	-do-
28	Jul 09-15	250	7302	- do
29	Jul 16-22			
30	Jul 23-29			

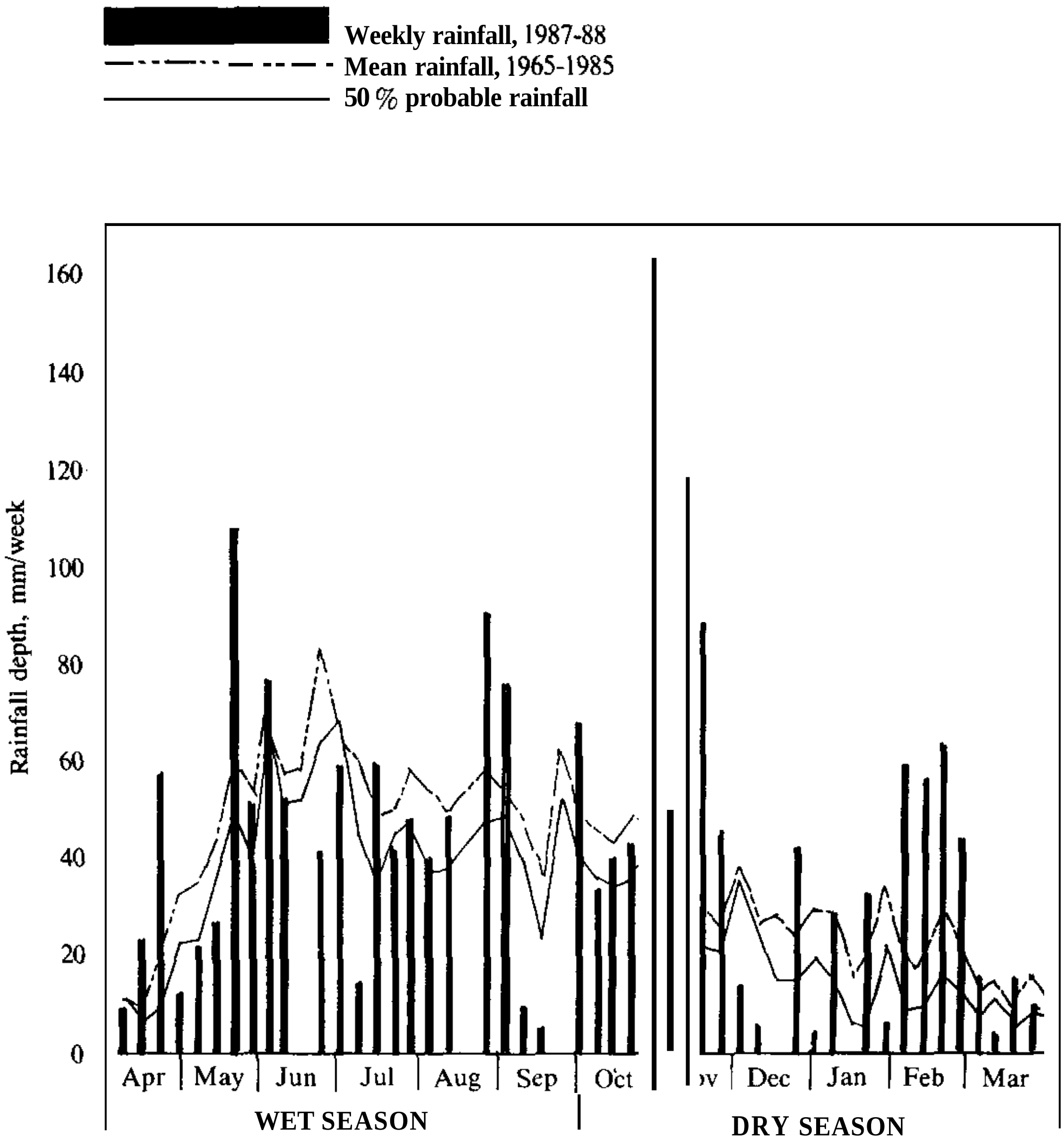

Figure 5. Mean rainfall, 1965-1985, 50 % probable rainfall computed using incomplete gamma distribution and weekly rainfall, 1987-88, South Cotabato, Philippines.

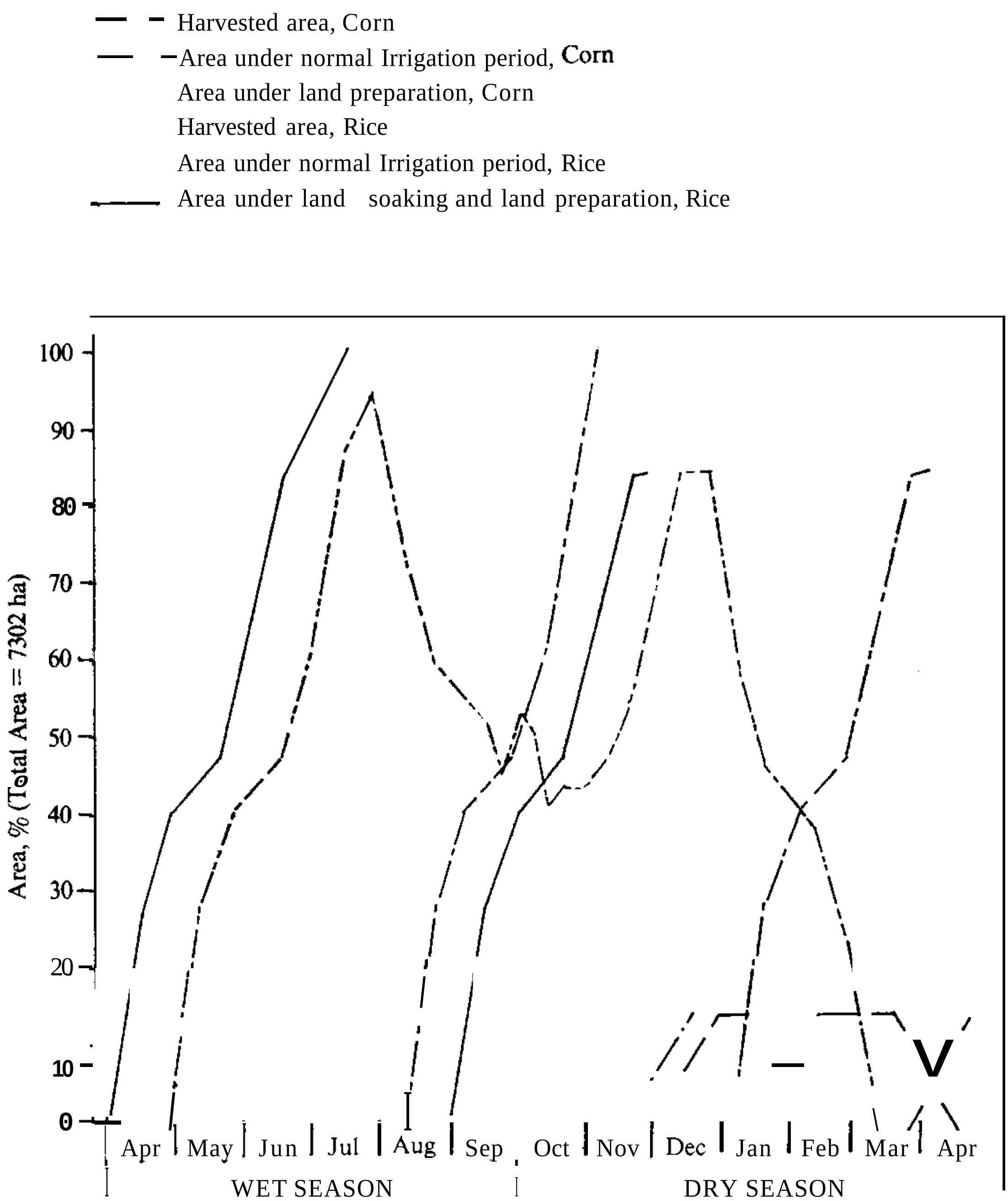

***Figure* 6.** Proposed weekly progress of farming activities, Allah River Irrigation Project, (Based on 60 % of dependable **flow** at Allah River).

Table 10. Dependable flow, rainfall, assumed progress of farming activities, area under land soaking and land preparation (LS/LP), area under normal irrigation period (AUNIP), area harvested (AH), irrigation diversion requirement assuming 0 rainfall (*), and assuming 50 % probable rainfall (**), wet season, ARIP.

Week no.	Date	60% of Dependable flow (lps)	Rainfall (mm)	LS/LP (ha)	AUNI (ha)	AH (ha)	Irrigation diversion requirement (lps) *	**
14	Apr 02-08	4492	11	1209			4492	4274
15	Apr 09-15	4811	5	1999			4811	4639
16	Apr 16-22	5129	9	2528			5129	4762
17	Apr 23-29	5593	22	2949			5593	4515
18	Apr 30-May 06	5854	22	3173	I209		5854	4689
19	May 07-13	6057	34	3353	1999		6057	4161
20	May 14-20	6260	49	3509	2528		6260	3434
21	May 21-27	7593	39	3958	2951		7593	5054
22	May 28-Jun 03	8998	70	4580	3177		8998	3690
23	Jun 04-10	10404	51	5341	3353		10404	5892
24	Jun 11-17	12114	52	6230	3509		12114	6768
25	Jun 18-24	11795	63	6542	3958		12197	5339
26	Jun 25-Jul 01	11012	69	6797	4580		I2796	5031
27	Jul 02-08	10230	44	7052	5341		13396	8219
28	Jul 09-15	10433	35	7302	6485		13976	9750
29	Jul 16-22	10708	45		6797		13604	8195
30	Jul 23-29	10983	48		7052		13604	7784
31	Jul 30-Aug 05	10317	37		6093		11447	7679
32	Aug 06-12	9274	38		5303		10037	6670
33	Aug 13-19	8230	43		4774	I209	9094	5738
34	Aug 20-26	7477	48		4353	1999	8341	4915
35	Aug 27-Sep 02	8201	49		4129	2528	7942	4583
36	Sep 03-09	8926	39		3949	2949	7620	5048
37	Sep 10-16	10665	24		3793	3173	7342	5862
38	Sep 17-23	10810	52		3344	3353	6542	3677
39	Sep 24-30	10954	40		2722	3509	5431	3617
40	Oct 01-07	10983	35		1706	3958	3475	2484
41	Oct 08-14	10868	34		505	4580	1187	900
42	Oct 15-21	10752	36		250	5596	588	440
43	Oct 22-28	11389	41			6740		
44	On 29-Nov 04	11331	40			7052		
45	Nov 05-11	11273	27			7302		
46	Nov 12-18	11708	22			6287		
	Mean	9261	39				8135	5097

Table 11. Dependable **flow.** rainfall, assumed area under normal irrigation (AUNI) for rice and corn areas, and irrigationdiversion requirement for rice and cornareas, and total for system assuming0 rainfall('), and assuming 50% probable rainfall **(**)**, dry season, ARIP.

Week no.	Date	60% of Dependable Flow (lps)	Rainfall (mm)	AUNI (ha) Rice	AUNI (ha) Corn	Irrigation Diversion Requirement (lps) Rice	Irrigation Diversion Requirement (lps) Corn	Total *	Total **
36	Sep 03-09	8926	39			1964		1964	1177
37	Sep 10-16	10665	24			3248		3248	2468
38	Sep 17-23	10810	52			4107		4107	1942
39	Sep 24-30	10954	40	1209		4792		4792	2827
40	Oct 01-07	10983	35	1999		5156		5156	3315
41	Oct 08-14	10868	34	2528		5449		5449	3542
42	Oct 15-21	10752	36	2949		5702		5702	3631
43	Oct 22-28	11389	41	3173		6431		6431	3748
44	Oct 29-Nov 04	11331	40	3353		7443		7443	4436
45	Nov 05-11	11273	27	3509		8678		8678	6321
46	Nov 12-18	11708	22	3958		10123		10123	7878
47	Nov 19-25	11708	21	4580		10216	0	10216	8023
48	Nov 26-Dec 02	11708	36	5341		10216	1224	11440	7129
49	Dec 03-09	11795	24	6230	259	10216	1340	11556	9103
50	Dec 10-16	12737	14	6287	513	10216	1340	11556	10080
51	Dec 17-23	13679	14	6287	763	10216	1340	11556	10101
52	Dec 24-31	12867	19	5078	997	8252	0	8252	6657
1	Jan 01-07	5564	15	4288	997	6968	1340	8308	7238
2	Jan 08-14	7419	7	3759	997	6109	1340	7449	7045
3	Jan 15-21	7158	4	3338	997	5424	1340	6764	6527
4	Jan 22-28	6897	21	3114	997	5060	1340	**6400**	5304
5	Jan 29-Feb 04	6521	8	2934	991	4767	1340	6107	5729
6	Feb 05-11	6492	9	2778	997	4514	1340	5854	5441
7	Feb 12-18	6463	17	2329	997	3785	390	4175	3536
8	Feb 19-25	6086	11	1707	997	2374	1340	4114	3798
9	Feb 26-Mar 04	5955	7	946	997	1538	1340	2878	2775
10	Mar 05-11	5825	11	57	997	93	390	483	473
11	Mar 12-18	5129	5		997		1340	1340	1340
12	Mar 19-25	4869	8		738				
13	Mar 26-Apr 01	460R	7		484				
14	Apr 02-08	4492	11		234				
	Mean	8956	**21**			6054	1064	6484	5078

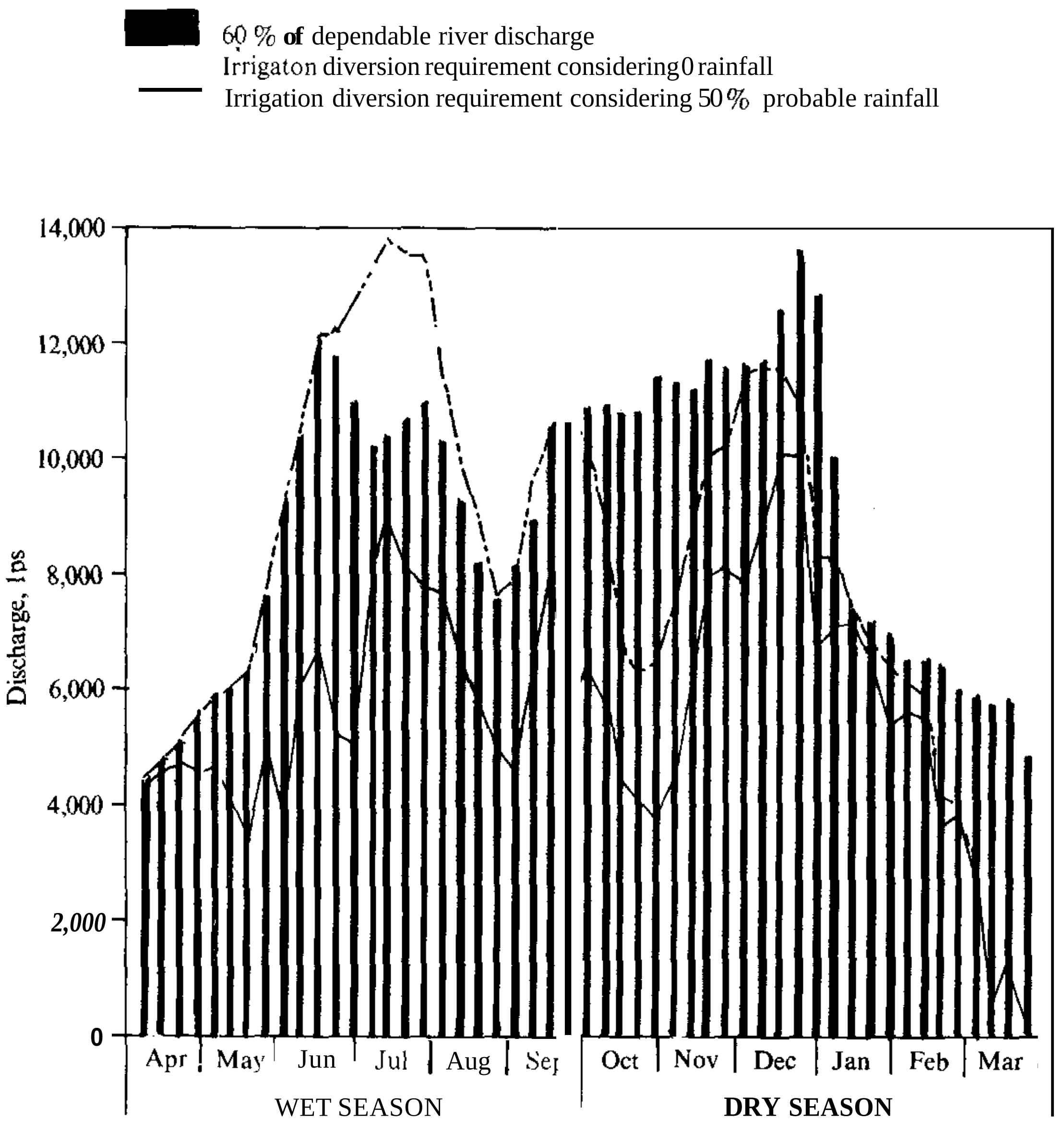

Figure 7. Irrigation diversion requirements based on proposed progress of farming activities, and 60 % dependable flow of Allah River at damsite, Allah River Irrigation Project.

Computational Procedures

Laoag-Vintar River Irrigation System.

Rice crop.

a. Basic data.

Seepage & percolation rate, (S&P)	= 4 mm/day
Residual soil moisture at start of wet season volumetric bask, (RM)	= 15%
Soil moisture at saturation, volumetric basis, **(SM)**	= 45%
Evapotranspiration. (ET)	
Wet season	= 5 mm/day
Dry season	= 6 mm/day
Soil bulk density	= 1.5 g/cc
Depth of soil to be saturated, (D)	= 300 mm
Farm waste, percent of requirement, (L)	= 30%

b. Computed water requirements.

Saturation requirement, (SR)
$$= [SM - RM] \times D/100$$
$$= [45 - 15] \times 300/100$$
$$= 90 \text{ mm}$$

Field land soaking requirement (assuming that land soaking requirement will be supplied in one week), (FSR)
$$= SR + ET + S\&P$$
$$= 90/7 + 5 + 4$$
$$= 22 \text{ mm/day}$$
$$= 2.53 \text{ lps/ha}$$

Turnout land soaking requirement, (TSR)
$$= FSR + \text{farm losses}$$
$$= 2.53 \times 1.3$$
$$= 3.27 \text{ lps/ha}$$

Field normal irrigation requirement, (FIR)
$$= ET + S\&P$$

Wet Season
$$= 5 + 4$$
$$= 9 \text{ mm/day}$$
$$= 1.04 \text{ lps/ha}$$

Dry **Season**
$$= 6 + 4$$
$$= 10 \text{ mm/day}$$
$$= 1.16 \text{ lps/ha}$$

Turnout normal irrigation requirement, (TIR)
$$= FIR + \text{farm losses}$$

Wet Season
$$= 1.04 \times 1.3$$
$$= 1.35 \text{ lps/ha}$$

Dry Season
$$= 1.16 \times 1.3$$
$$= 1.5 \text{ lps/ha}$$

c. Computation for area that can be land soaked.

For a certain canal, its maximum capacity is considered. Maximum canal capacity is divided by the canal distribution efficiency to obtain the net flow that will enter the turnouts. The result is divided by the turnout land soaking requirement to obtain the area that can be land soaked during the first week. If the total command of the canal is not land soaked during the first week, the procedure is repeated considering that the land snaked area will require an amount equivalent to the normal irrigation requirement. The procedure is repeated until all areas are land soaked.

Example: Lateral E

Area, (A)	= 25 ha
Canal capacity, (C)	= 70 Ips
Canal distribution efficiency, (E)	= 66 %
Turnout land soaking, requirement (TSR)	= 3.27 lps/ha
Turnout normal irrigation requirement, (TIR)	= 1.35 lps/ha

First Week

Available water at turnouts, (AW)	= C×E/100 = 70×66/100 = 46 lps
Area to he land soaked, (A2)	= AW / TSR = 46 / 3.21 = 14 ha

Second Week:

Area land soaked, (Al)	= 14 ha
Available water at turnouts, (AW)	= 46 Ips
Normal water requirement for land soaked area, (WRI)	= A1×TIR = 14X1.35 = 19 Ips
Available water for land snaking, (AW1)	= AW - WRI = 46 - 19 = 27 Ips
Area to he land soaked, (A2)	= AW1 / TSR = 21 / 3.21 = 8 ha

Third Week:

Area land soaked, (Al)	= 22 ha
Available water at turnouts, (AW)	= 46 Ips
Normal water requirement for land soaked area, (WR1)	= A1×TIR = 22x1.35 = 30 Ips
Available water for land soaking, (AWI)	= AW - WRI = 46 - 30 = 16 Ips
Area to he land soaked, (A2)	= AW1 / TSR = 16 / 3.27 = 5 ha

The remaining area to be land soaked on the third week is only 3 ha. Therefore the whole area can be land soaked within three weeks. The resulting progress of farming activities will be:

Week no.	Area under land soaking and land nreoaration	Area under normal irrigation	Harvested area
1	14		
2	22		
3	25		
4	19	14	
5	3	22	
6		25	
17			
18		25	
19		19	
20		3	
21		0	14
22			22
			25

The other assumptions are: the area will be transplanted on the fourth week of land preparation; rice will be harvested 105 days after transplanting; and rice will be terminally drained two weeks before harvest.

d. Computation of irrigation diversion requirement (IDR).

The complete progress of farming activities is computed based on the progress of land soaked areas. It is assumed that an area is planted 4 weeks after land soaking. A 120-day rice variety is also assumed. Based on this progress of farming activities, the IDR for each week are computed. The IDR for a particular week is equal to the IDR for land soaking multiplied by the area programmed for land soaking plus the IDR for normal irrigation multiplied by the area programmed for normal irrigation. Terminal drainage is assumed at two weeks before harvest.

Example: Lateral E

First week:

Canal distribution efficiency	= 66%
Area to be land soaked (A1)	= 14 ha
Area land soaked **(A)**	= 0 ha
Turnout land soaking requirement, (TSR)	= 3.27 lps/ha
Turnout normal irrigation requirement, (TIR)	= 1.35 lps/ha
Total land soaking water requirement, (TSWR)	= A1×TSR = 14X3.27 = **46** lps
Total normal irrigation requirement, (TNWR)	= A2×TIR = 0×1.35 = 0 lps
Lateral irrigation diversion requirement, (IDR)	= [TSWR+TNWR]/E×100 = [46 + 0] / 66×100 = 70 lps

Second week:

Area to he land soaked, (A1)	= 8 ha
Area land soaked, (A2)	= 14 ha

Total land soaking water requirement, (TSWR) = A1XTSR
= 8X3.27
= 26 lps

Total normal irrigation requirement, (TNWR) = A2XTIR
= 14X1.35
= 19 lps

Lateral irrigation diversion requirement (IDR) = [TSWR+TNWR]/ EX100
= [26 + 19] / 66X100
= 68 lps

Third week:

Area to be land soaked, (A1) = 3 ha

Area land soaked, (A2) = 22 ha

Total land soaking water requirement, (TSWR) = A1XTSR
= 3X3.27
= 10 lps

Total normal irrigation requirement, (TNWR) = A2XTIR
= 22X1.35
= 30 lps

Lateral irrigation diversion requirement, (IDR) = [TSWR+TNWR]/ EX100
= [10 + 30] / 66X100
= 61 lps

Fourth week, etc.

Area to be land soaked, (A1) = 0 ha

Area land soaked, (A2) = 25 ha

Total land soaking water requirement, (TSWR) = A1XTSR
= 0X3.27
= 0 lps

Total normal irrigation requirement, (TNWR) = A2XTIR
= 25X1.35
= 34 lps

Lateral irrigation diversion requirement, (IDR) = [TSWR+TNWR]/EX100
= [0 + 34]/66X100
= 52 lps

Diversified crops.

a. Basic data.

Field capacity, volumetric basis = 40%

Soil Moisture at which irrigation is needed, volumetric basis (based on on-farm irrigation study) = 27%

b. Irrigation requirement computation.

At planting, it is assumed that the field is at field capacity. A soil moisture balance is then computed daily. Soil moisture depletion is equal to ET multiplied by the crop coefficient based on crop growth stage. When the soil moisture is depleted to 27%, irrigation is applied to bring back soil moisture content to field capacity. The same farm losses as in rice irrigation were considered since the same method of irrigation will be used (basin irrigation). This is done separately for each lateral. An example of this method is shown for Lateral A-Extra of ARIP (see Final Report, TA 654 PHI). Irrigation is stopped at two weeks before harvest.

Example: A 25 ha diversified cropped area (Garlic)

Planting date is on week 1.	
Potential evapotranspiration (PET)	= 6 mm/day
Field Capacity volumetric basis, (FC)	= 40%
Soil Moisture at which imgation is required, volumetric basis, (SMI)	= 21%

First week:

Crop Coefficient, (CC)	= 0.1
Starling moisture content, (SM) (field capacity)	= 40%
Effective root depth, (D)	= 100 mm
Available soil moisture for crop maintenance, (AW1)	= (SM-SMI)x D/100%
	= (40 - 27)×100/ 100
	= 13 mm
Moisture depletion, (MD)	= 7×PET×CC
	= 7×6×0.1
	= 4.2 mm
Available soil moisture at the end of the week, (AW2)	= AWI - MD
	= 13 - 4.2
	= 8.8 mm

Second Week

Available moisture at the start of the week, (AW1)	= 8.8 mm
Crop coefficient, (CC)	= 0.15
Moisture depletion, (MD)	= 7×PET×CC
	= 7×6×0.15
	= 6.3 mm
Available soil moisture at the end of week the, (AW2)	= AWI - MD
	= 8.8 - 6.3
	= 2.5 mm

Third Week

It is apparent that on the third week, irrigation is needed.	
From the first week the needed replenishment	= 13 - 2.5
	= 10.5 mm
	= 1.2 lps/ha
Field distribution efficiency	= 80%
Turnout water delivery requirement	= 1.2 / 80×100%
	= 1.5 lps/ha

Lateral distribution efficiency = 60%

Lateral water delivery requirement = 1.5×25/60×100%
= 62.5 Ips

If irrigation will be delivered in 8 hours then:

New lateral water delivery requirement = 62.5 / 8×24
= 188 Ips

Suppose the lateral has a capacity of 200 Ips, then irrigation can be completed in one day.

After irrigation:

Soil moisture at start of week (at field capacity), (SM) = 40%
Effective root zone depth, (D) = 200 mm
Crop coefficient, (CC) = 0.22

Available soil moisture, (AWI) = (SM - SMI)×D/ 100%
= (40 - 27)×200/100
= 26 mm

Moisture depletion, (MD) = 7×PET×CC
= 7×6×0.22
= 9.2 mm

Available soil moisture at the end of the week, (AW2) = AW1 - MD
= 26 - 9.2
= 16.8 mm

Fourth Week:

Available soil moisture at start of week, (AWI) = 16.8 mm
Crop coefficient, (CC) = 0.35

Moisture depletion, (MD) = 7×PET×CC
= 7×6×0.35
= 14.7 mm

Available soil moisture at the end of the week, (AW2) = AW1 - MD
= 16.8 - 14.1
= 2.1 mm

Fifth week

It is apparent that irrigation is needed:

Needed irrigation = 26 - 2.1
= 23.9 mm
= 2.8 lps/ha

Field distribution efficiency = 80%
Turnout water delivery requirement = 2.8 / 80×100%
= 3.5 lps/ha

Lateral distribution efficiency = 60%

Lateral water delivery requirement $= 25 \times 3.5 / 60 \times 100\%$
$= 146$ lps

If irrigation will be delivered in 8 hours

New lateral water delivery requirement $= 146 \times 24 / 8$
$= 437$ lps

Lateral capacity $= 200$ lps

The lateral will operate on the first day for 8 hours at 200 lps and on the second day for 10 hrs at 200 lps

After irrigation:

Soil moisture is at field capacity., (SM) $= 40\%$
Effective rooting depth, (D) $= 300$ mm
Crop coefficient, (CC) $= 0.42$

Available soil moisture, (AW1) $= (SM - SMI) \times D / 100\%$
$= (40 - 27) \times 300 / 100$
$= 39$ mm

Soil moisture depletion, (MD) $= 7 \times PET \times CC$
$= 7 \times 6 \times 0.42$
$= 17.6$ mm

Available soil moisture at the end of the week, (AW2) $= AW1 - MD$
$= 39 - 17.6$
$= 21.4$ mm

Sixth Week
Available soil moisture at the start of the week, (AW1) $= 21.4$ mm
Crop coefficient, (CC) $= 0.55$

Moisture depletion, (MD) $= 7 \times PET \times CC$
$= 7 \times 6 \times 0.55$
$= 23.1$ mm

Available soil moisture at the end of the week, (AW2) $= AW1 - MD$
$= 21.4 - 23.1$
$= -1.7$ mm

Seventh week:
Irrigation is needed:
Needed irrigation $= 39 + 1.7$
$= 40.7$ mm
$= 4.7$ lps/ha

Field distribution efficiency $= 80\%$
Turnout water delivery requirement $= 4.7 / 80 \times 100\%$
$= 5.9$ lps/ha

Lateral distribution efficiency $= 60\%$

Lateral water delivery requirement $= 5.9 \times 25 / 60 \times 100\%$
$= 246$ lps

The lateral will operate for 3.5 days at 200 lps (8 hours operation to irrigate the 25 ha)

The process is continued until the whole season is completed.

The ***Allah River Irrigation Project.***

Rice.

a. Basic data

Seepage and percolation, (S&P)

- Clay loam areas = 4 mm/day
- Loam areas = 5 mm/day
- Sandy areas = 10 mm/day

Residual soil moisture at start of wet season, volumetric basis, (RM) = 15%

Soil moisture at saturation, volumetric basis, (SM) = 45%

Evapotranspiration, (ET)

- Wet Season = 4 mm/day
- Dry Season = 5 mm/day

Soil bulk density = 1.5 g/cc
Depth of soil to be saturated, (D) = 300 mm
Farm waste, percent of requirement, (L) = 25%

b. Computed water requirements

Saturation requirement, (SR) $= [SM - RM] \times D / 100$
$= [40 - 15] \times 300 / 100$
$= 90$ mm

Field land soaking requirement (assuming that land soaking requirement will be supplied in one week), **(FSR)** $= SR + ET + S\&P$

Clay loam areas $= 90 / 7 + 4 + 4$
$= 21$ mm/day
$= 2.4$ lps/ha

Loam areas $= 90 / 7 + 4 + 5$
$= 22$ mm/day
$= 2.5$ lps/ha

Sandy areas $= 90 / 7 + 4 + 10$
$= 27$ mm/day
$= 3.1$ lps/ha

Turnout land soaking requirement $= FSR + \text{farm losses}$

Clay loam areas	$= 2.4 \times 1.25$ $= 3$ lps/ha
Loam areas	$= 2.5 \times 1.25$ $= 3.1$ lps/ha
Sandy areas	$= 3.1 \times 1.25$ $= 3.9$ lps/ha
Field normal irrigation requirement, (FIR)	= ET + S&P
Wet Season	
Clay loam areas	$= 4 + 4$ $= 8$ mm/day $= 0.92$ lps/ha
Loam areas	$= 4 + 5$ $= 9$ mm/day $= 1.04$ lps/ha
Sandy areas	$= 4 + 10$ $= 14$ mm/day $= 1.6$ lps/ha
Dry Season	
Clay loam areas	$= 5 + 4$ $= 9$ mm/day $= 1.04$ lps/ha
Loam areas	$= 5 + 5$ $= 10$ mm/day $= 1.16$ lps/ha
Sandy areas	$= 5 + 10$ $= 15$ mm/day $= 1.7$ lps/ha
Turnout normal irrigation requirement, (TIR)	= FIR + losses
Wet Season	
Clay loam areas	$= 0.92 \times 1.25$ $= 1.16$ lps/ha
Loam areas	$= 1.04 \times 1.25$ $= 1.3$ lps/ha
Sandy areas	$= 1.6 \times 1.25$ $= 2.0$ lps/ha
Dry Season	

Clay loam areas $= 1.04 \times 1.25$
$= 1.3$ lps/ha

Loam areas $= 1.16 \times 1.25$
$= 1.45$ lps/ha

Sandy areas $= 1.7 \times 1.25$
$= 2.13$ lps/ha

c. Computation of area that can be land soaked.

For a certain week, the available flow from the dam **is** considered. The available flow is divided by the canal distribution efficiency to obtain the net flow that will enter the turnouts. The result is divided by the turnout land soaking requirement to obtain the area that can be land soaked during the first week. The capacity of the canal is considered to program the area that can be land soaked. If the total command of the canal **is** not land soaked during the first week, the procedure **is** repeated considering that the land soaked area will require an amount equivalent to the normal irrigation requirement. The procedure is repeated until all areas are land soaked (see example for LVRIS).

d. Computation of irrigation diversion requirement (IDR).

The complete progress of farming activities **is** computed based on the progress of land soaked areas. It is assumed that an area is planted four weeks after land soaking. **A** 120-day rice variety is also assumed. Based on the progress of farming activities the **IDR** for each week are computed. The IDR for a particular week is equal to the IDR for land soaking multiplied by the area programmed for land soaking plus the **IDR** for normal irrigation multiplied by the area programmed for normal irrigation. Terminal drainage **is** assumed at two weeks before harvest (see example for **LVRIS).**

Diversified ***crops,*** (extra laterals only)

a. Basic data.

Field capacity, volumetric basis $= 25\%$
Soil moisture at which irrigation is needed, volumetric basis $= 15\%$
(based on on-farm irrigation study)

b. Irrigation requirement computation.

At planting, it is assumed that the field is at field capacity. **A** soil moisture balance **is** then computed daily. Soil moisture depletion **is** equal to ET multiplied by the crop coefficient based on the crop growth stage. When the soil moisture is depleted to 27%, irrigation is applied to bring back soil moisture content to field capacity. The same farm losses as in rice irrigation were considered since the same method of irrigation will be used (basin irrigation). This **is** done separately for each lateral. An example of this is method is shown for Lateral A-Extra **of ARIP** (see Final Report, **TA** 654 PHI). Irrigation isstopped at two weeks before harvest (see example for **LVRIS).**

Dependable Rainfall

The incomplete-gamma distribution function **(IGDF) is** a 'hydrologic frequency analysis tool which is appropriate for analyzingdaily, weeklyor 10-day rainfall data. In irrigation planning, the IGDF produces a more reliable data than arithmetic means. Suppose that you have a five year rainfall data for a certain week. For four years the rainfall was zero; for the remaining year the rainfall was 50 mm; arithmetic mean will say that you can expect 10 mm of rainfall while IGDF will say that you can expect zero rainfall once in four years, which best describes the data.

The procedural analysis of IGDF **is** complex and requires a good background of statistics and hydrology. For the purpose of the study, a computer program has been developed to handle the analysis. Minimum instruction is needed for a computer user to be able to run the program. For the purpose of **NIA,** training Irrigation Superintendents (IS) to be able to analyze rainfall data using IGDF **is** not an easy task. It **is** proposed that the computer program for **IGDF** be given to the System Management Department (SMD) of **NIA** and for a user to be instructed on how to use it.

Each IS will be required to submit at least a 20-year record of daily or weekly rainfall. The rainfall record could be taken from weather stations of **PAGASA. SMD** would analyze the data and provide the weekly dependable rainfall to the **IS,** which will be used for irrigation planning. The data could be updated every five years using additional data gathered.