Review of the Water Management Systems in the Gujarat Medium Irrigation II Project

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REVIEWS OF THE WATER MANAGEMENT SYSTEMS

in the

Gujarat Medium Irrigation II Project
(Credit 1496-IN)

by Prof. R. Brouwer

August 1993

Communication nr.: 50
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1. INTRODUCTION

1.1 Terms of Reference

At the invitation of the World Bank a mission to the Gujarat Medium Irrigation II Project was undertaken by Prof. R. Brouwer, irrigation and water management expert.

The Terms of Reference agreed to are attached to this report as Annex 1. The tasks of the Expert included the review of World Bank documents and reports and studies relevant to the project, visits to some 7 Medium irrigation projects under construction and operational in the field, visits to the WALMI research institute and Gujarat State Department involved, to discuss the water management and operational procedures. Both operational management in the project areas, and the development and application of computer programmes used for water management were subject of the review.

The Expert arrived in Delhi on 25th July, 1993. After briefing and discussion on the scope of the review at the World Bank resident mission offices a field tour was undertaken by Prof. Brouwer accompanied by the World Bank Consultant Mr. G.M. Kathpalia. Apart from the Narmada and Water Resources Department of the Government of Gujarat in Gandhinagar and the Water and Land Management Institute (WALMI) at Anand the following projects were visited:

1. Karjan
2. Pigut
3. Baldeva
4. Dantiwada
5. Watrak
6. Demi II
7. Bhadar (M)
8. Uben

A detailed itinerary of the Mission is presented in Annex 2 and short notes on the field visit to the projects are presented in Annex 3.

After debriefing to Secretary N.B. Desai of the Narmada and Water Resources Department of Gujarat Government in Gandhinagar on August 7th, the Experts returned to Delhi on August 8th. Here the documents collected and the observations made were discussed with the World Bank staff and a short note on the field visit was prepared and submitted.

This present report presents the observations, conclusions and recommendations made.
1.2 Contents of this report

After this chapter 1 "Introduction" the theory and background on the Sheshpali, Warabandi and RWS water distribution methodologies are discussed in chapter 2.

In chapter 3 the actual water distribution methodology as presently practised in the Medium Irrigation II projects in Gujarat State is discussed.

In chapter 4 the involvement of the irrigating farmers in the operation and management of the water distribution system is discussed.

Design practices applied in the irrigation systems is described and commented on in chapter 5.

In chapter 6 the most important conclusions and recommendations made in the previous paragraphs are summarized.
2. FROM SHESHPALI TO RWS WATER DISTRIBUTION SYSTEM

2.1 Introduction

The Sheshpali water distribution methodology has been in use in the Gujarat irrigation practice for some time but was not giving the results desired by the Gujarat Government and the World Bank in the Medium Irrigation projects. For this reason it was decided to switch over to the "Rotational Water Supply" System (RWS); this RWS is an adaptation of the Warabandi type water distribution that has been successfully applied in the irrigation systems, a.o. in the Punjaab.

In the following paragraphs these water distribution methods will be discussed and their relative advantages and disadvantages described.

2.2 Sheshpali

The Sheshpali water distribution methodology as a form of water management widely practised in Gujarat and well documented [Seminar 1992; C.P. Sinha] [World Bank 1984].

The system can be classified as "prearranged" and is based on an "application" from the irrigating farmer for water supply for a specified crop and a "sanction" by the Irrigation Department of the water supply.

The whole system is designed for water shortage; even at full discharge only about 50% of the field water requirement of an irrigated area can be fulfilled.

The following steps can be distinguished in the water management [World Bank 1984]:

i. Farmers apply for water prior to the start of the irrigation season. Both crop and area to be cropped are specified.

ii. The Irrigation Department analyses the applications received and compares the total water volume required to fulfil them with the total water volume available for irrigation.

iii. Farmers receive a "sanction" from the ID to irrigate the area applied for, or a reduced area if total water demand exceeds total water supply.

iv. Based on the sanctions a water supply schedule is drawn and publicized indicating
   - which canals will flow in which weeks in the season
   - the turn of each farmer to draw water in each chak (tertiary unit)

The system is then operated by the ID down to the 40 ha chak level, maintaining a chak intake flow of 1 cusec (about 30 lps). The farmers rotate this discharge among themselves. Each farmer can use the full discharge until he is satisfied that his sanctioned cropped area is sufficiently irrigated, and then pass on the full discharge to the next farmer. The chak outlet is closed when all farmers have fulfilled their turn, till the next irrigation cycle begins.
The farmer has to pay water duties according to the sanctioned area, and this payment has to be made before he can get a sanction in the next irrigation season.

The Shesphali system has several advantages:

a) the water is supplied following an arrangement between the Farmer and ID for each season, the farmer can decide for himself what crop he wants to grow;

b) the supply and demand balance is prepared in advance of each season, ensuring optimal use of the available water;

c) if the farmers keep to the published schedule, an equitable water distribution is assured, and the timing is dependable.

In real life practice the system shows practical difficulties that make efficient irrigation problematic.

a) The paperwork for the application/sanction procedure is cumbersome and time consuming.

b) Operational water management is complex because gates to chaks have to be operated according to the sanctioned area in each chak with variable flowtimes per chak.

c) Rotation from one chak or canal to another can only be done after all farmers in the chak have completed irrigation of their sanctioned area. Because of the scarcity of water the farmers tend to overirrigate when it is their turn. This way
   - water is lost due to excessive seepage losses
   - the schedule of turns is upset and protracted, so that the next irrigation turn will come later than scheduled.

A vicious circle develops leading to wastage of water in the up-end chaks and infrequent or non-supply in tail end chaks. Some tail chaks had never seen water in more than 10 years.

d) Because of the complex operation schedule that is upset by the tendency of the farmers to irrigate longer than necessary, the causes and effects of faulty operation are not easily detected in the field.

For these reasons it was decided to implement a different water supply method that would allow for easier water management and more equitable water distribution.

2.3 Warabandi

The name "Warabandi" originates from two vernacular words "wara" and "bandi" meaning "turn" and "fixation" respectively. As such Warabandi literally means "fixation of turn" for the supply of water to the farmers [Seminar 1992, C.P. Sinha].

With this water distribution method the available irrigation discharge is equitably allocated (in proportion to the surface of the irrigated area) to all chaks (~ tertiary units) and each farmer has a fixed period of time in the week (day, hour, duration) during which he can use the total inflow into the chak. This fixed period of time
is proportional to his irrigable landholding in the chak; with minor compensations in the duration to make up for seepage losses and filling losses in the field channel between the chak intake up to his farm.

The Warabandi system is widely used in the large irrigation systems in the Punjab and other areas. Originally it was developed for "run of the river" supplied irrigation systems. The discharge taken from the source is proportionally distributed over the branch- and distributary canals and from the distributaries proportionally distributed to the chak offtakes.

In periods of low flow it was possible to close part of the distributary canals for the duration of one week. By rotating this "OFF" period is was possible to maintain a minimum of about 70% design discharge in the other running distributaries and chak outlets. By doing so the chak farm flows were maintained at a level of more than 20 lps (0.7 cusec) and tampering with canals and structures by farmers during very low flows was avoided.

The Warabandi system can be classified as an imposed irrigation method. The farmer has no influence on the discharge he will get. The day, time and duration that he is allowed to use the available water is fixed, and he gets the water that is then available.

The system is designed for water scarcity; even with full flow the water supplied will only cover a fraction of the water demand if a farm was to be cropped for a 100%.

Inside the chak the farmers are free to make arrangements with their neighbours on particular water distribution according to their needs, but their formal right to their own "fixed turn" will remain.

The Warabandi schedule has several advantages
- Equitable distribution of the available water is assured over the entire irrigable area on a proportional basis.
- The design for water shortage will create an incentive for efficient use of the available water.
- Operational water management is limited to proportional distribution of the available discharges over the distributaries, and in case of water shortage, to rotational operation of a limited number of gates on the main- and branch canals.

No operation of the chak-offtakes is necessary in principle, as these are all provided by proportional fixed intake and distribution structures.
- No procedures on application/sanctions are required.

The disadvantages of the Warabandi system are also clear:
- the supply is inflexible, each farmer gets water whether he needs it or not;
- the supply time is fixed but the discharge (in case of run-of the river projects) is variable and the farmer has to do as best as he can by adopting his cropped area to his experience of water supply in the past.
2.4 Rotational Water Supply (RWS)

The Medium Schemes in Gujarat have the great advantage that each has its own independent water source in the form of a Dam and a Reservoir.

This advantage made it possible to develop a modification to the Warabandi system for the Medium Irrigation schemes known as RWS system. (The name "Rotational Water Supply" is less aptly chosen as many different rotational supply systems are known in irrigation practice. In this report the term "RWS" will be used for the system proposed for the Gujarat Medium Irrigation II project.)

This makes it possible that pre-planning of the irrigation schedule on a project scale is possible, and that the weekly water supply can be stopped when it is not required.

Non requirement of water can occur
- when the interval between two irrigation farms or "waterings" is more than two weeks without significant stress to the crops;
- when rainfall in the command area make it possible to forego a scheduled "watering".

Rainfall is erratic but generally adequate in the rainy season (Kharif) and very low but not always negligible in the dry season (Rabi and Hot Weather).

The water distribution to the farmers is based on a Warabandi type schedule of a fixed turn (day, hour, duration) in a week when a watering is scheduled. Such a week the whole system is turned "ON" to run at 100% design discharge. In weeks when no watering is scheduled the whole system is turned OFF to zero discharge. In larger projects it is possible to stagger the ON and OFF periods over different Branch Canals or Distributary Canals to avoid excessive filling and depletion losses in the Main Canal.

The system is designed for water shortage, even at full discharge the water supply to a farm is insufficient to fulfil 100% of the field water requirement of the farm area.

The regulation or control of the water deliveries can be limited to opening and closing of the intake of a Distributary Canal; control structures downstream of the Distributary Offtake are of the proportional division type. These structures divide the oncoming flow of water in proportion to the downstream irrigable area to the different offtaking canals.

The advantages of the system are the same as for the original Warabandi system
- efficient use of water; because the water is the limiting factor;
- equitable supply; during the "ON" period 100% discharge is proportionally divided over the entire system down to the last tail end
- easy management because of the limited number of regulating structures
- no cumbersome bureaucratic application/sanction procedures.
In addition the RWS system in the Medium Schemes has the advantage of
- **adaptation to (dominant) crop water requirement** of the water scheduling
  because in the periods when no water is needed it can be conserved in the
  nearby reservoir.

The disadvantages of the RWS system are similar to the original Warabandi
system:
- **inflexible** towards the individual farmers *water requirement* because the weekly
  volume supplied is fixed for each "ON" week;
- **inflexible** towards the farmers *planting date* because during the "ON" period all
  farmers will get their water, whether they are ready for it or not;
- **night irrigation** with its inherent reduced efficiency is a must if large spill losses
  are to be avoided, because in the Gujarat systems no night storage reservoirs
  are present.
3. RWS MANAGEMENT FOR THE MEDIUM IRRIGATION II PROJECTS

3.1 Introduction

In the previous chapter the RWS methodology has been reviewed, with its advantages and disadvantages. In this chapter the application of the RWS in the Medium Irrigation II Projects, and the efforts to optimise the advantages and minimise the effects of the disadvantages is discussed.

3.2 Canal Scheduling and Reservoir Operation

3.2.1 Computer programme for command area water scheduling

The first step at the start of an irrigation season is to decide how much water can be made available and in what schedule it has to be released -within the constrictions of the RWS system- to derive the optimum benefits from the available water.

A water allocation and scheduling planning programme, based on crop-soil climate relations has been developed by research officers at WALMI. This programme does make use of a Lotus 123 spreadsheet package. Different files or modules are drawn up to calculate different aspects of the water scheduling, and these files are interrelated so that results of one calculation can be used in the next module.

The programme is oriented to the RWS water allocation concept and targets toward water delivery at the full discharge spread proportionally to all farmers in a weekly turn.

The full discharge from the reservoir is either "ON" and full or "OFF" zero. When the soil moisture is calculated to be still sufficient the whole system is "OFF" for one week or more weeks if this is possible. At the initial stage of crop growth when the crop is small and the water consumption limited it appears to be possible to have two consecutive weeks "OFF" after the first full irrigation supply or "Watering". (This is consistent with the experience that for wheat the critical second watering has to be given 3 weeks after the first watering at the sowing.)

The full supply discharge is insufficient to irrigate the full command area and thus the supply received by all the farmers will irrigate only a percentage of each irrigable field.

Crops that are not able to grow when one or two weeks no irrigation water is supplied, such as vegetables, are not considered. These have to be grown on areas additionally irrigated with groundwater from wells.

The steps followed in the WALMI Operation Scheduling is broadly as follows.

a) From data on the actual situation of the reservoir the total volume of water available for irrigation for the coming season is calculated, taking evaporation, seepage and dead storage into account.
b) The volume of water required for a full discharge running of the system during seven days is known from design discharges stated in the design/operation manuals, and from this and a) the number of times that the canal system can be run for a full week (number of "waterings") is calculated.

c) The volume of water supplied per ha to each farm during the full discharge during one week (equitably spread over all farms) is known from the design as in b) and thus the field application in mm/Ha is known in advance. Based on this knowledge and on the known number of waterings available the type of crop and the percentage of farmholding to be irrigated can be selected. Some crops require only 5 waterings, others a minimum of 7. The total crop water consumption is matched with the volume supplied by matching the area percentage to be planted. Crops with a high water consumption could for instance be grown on 30% of the irrigable area of the farms whereas crops with low water consumption could for instance be grown on 60% of the irrigable area. The unused area would remain fallow or with maturing crops that require no more irrigation.
(In case that for instance only 5 waterings can be given and as wheat requires 7 waterings, the farmers with access to groundwater may decide to plant wheat; they will use the first five waterings from the canal system and supply the last two from their well. Farmers without access to well water may decide to grow a crop that will mature on 5 waterings.)
This way a certain crop flexibility is possible within the constrictions of the RWS "ON""OFF" system and the Warabandi fixed return schedule.

d) Based on the above selection of most likely crop to be grown the soil-water balance in the root zone of this crop is simulated in timesteps of one week. In this simulation the crop evapotranspiration, water holding characteristics of the soil, eventual root depth of the crop and the application efficiency are taken into account. The simulation starts with one application of a water depth suitable for the crop considered (from this selected water depth the area to be planted can now be determined as the water volume supplied per watering is constant).
If after a timestep the soil moisture balance is found to be below the "Readily Available Water" content of the soil the canal system will be turned "ON" and the standard depth of mm water is added to the water balance in the soil. By judiciously putting the system "ON" the moisture content in the soil is kept between the "Total Available Water" and "Readily Available Water", and a schedule is found that will assure the efficient growth of the dominant crop.

It is possible to make refinements to this procedure e.g. by selecting an average cropping pattern instead of the dominant crops using that water requirement in the simulation.
There is however not much to gain by doing so since the RWS system will be run on rigid ON and OFF weekly supply schedule and no farmer can grow an average schedule efficiently.
Instead the extension officers and irrigation engineers discuss with the farmer the schedule proposed for the coming season and give advice on alternative crops and percentage of irrigated areas that will give good yields to the farmers.
In the hands of an experienced irrigation-agronomist this package is a very useful tool to establish the most suitable schedule of RWS supply from a given volume of reservoir water. For each project 20 typical operation schedules are prepared by the researchers at WALMI. Each schedule starts from different initial state parameters such as:
- volume of water available in the reservoir
- actual rainfall conditions in the Kharif season
and gives a detailed recommendation on the number and timings of the full supply runs to be made. The project water management officers and extension officers then use this as a guideline for the actual planning of the season at hand.

The programme has some characteristics to note

- The soil conditions and dominant crops are assumed homogeneous for the entire project area, whereas in reality there may be different soil types and related suitable crops distributed over the project area. If this is very pronounced for different Distributary Command Areas then for each area a separate schedule will have to be prepared. The Main and Branch canals would then be run to accommodate a staggered operation of the various distributaries.

- The programme does optimise the ON-OFF schedule for one dominant crop or cropping pattern. The irrigation of other crops in the area have to use the same schedule of water volume and timing and have to adapt the depth of supply in conjunction with the percentage area cropped to optimise the use of the water supplied. Crops which require frequent light applications can not be grown without additional groundwater irrigation, or without informal arrangements of the farmer with his neighbours in the (sub)chak for exchanging parts of their fixed-turn periods.

- The programme is fully oriented towards the RWS ON-OFF water operation system and can not be used for other types of rotation. This was the intention at the outset of the design of the programme and as such it serves its purpose well.

- For use of the programme the user has to be conversant with PC operation, LOTUS 123 package, with the agro-hydrological principles of the field irrigation and with the (im)possibilities of canal scheduling. All these abilities are present with the WALMI officers working with this programme, but are lacking with most project water management officers. If in future the scheduling for RWS water management is to be decentralized to the Project Executive Engineers, then a user friendly and robust version of the programme would be needed. A RWS-module that uses the algorithms in the WALMI programme in the OMIS package that is presently under development for India in the INDO-DUTCH Training Production Management Unit would be an excellent solution for the future water management of the Medium II irrigation schemes. [OMIS, a computer model for irrigation management, 1992.]
For the implementation of the present schedules developed by WALMI, the water management officers can decide on the schedule of the water releases from the reservoir with the recommended crop pattern, based on the actual stage of the reservoir volume, at the start of the irrigation season. This schedule is then discussed with the representatives of the farmers in the command area, and modifications desired by the farmers can be made. Then the final schedule is drawn up and the days and timing of each farmer's irrigation turn in the coming season is made known both verbally through the karkoons/chaudikars and by putting up this schedule on announcement boards. Thereafter the canal runs can be made without further adaptation, unless (unexpected) rainfall does occur in the irrigation area; in this case the canal flow is stopped and resumed after the rainfall moisture is near depleted. A sample of the output of the WALMI spreadsheet programme is presented in Table 3.2-1.
Table 3.2-1  Typical sample of RWS water scheduling and canal operation

<table>
<thead>
<tr>
<th>BASIC INFORMATION OF AJI-II PROJECT (R.I.P.C.) FOR PLANNING CANAL OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROJECT PARAMETERS</strong></td>
</tr>
<tr>
<td><strong>GROSS STORAGE MCM</strong></td>
</tr>
<tr>
<td><strong>DEAD STORAGE MCM</strong></td>
</tr>
<tr>
<td><strong>LIVE STORAGE MCM</strong></td>
</tr>
<tr>
<td><strong>INFLOW</strong></td>
</tr>
</tbody>
</table>

| **NET UTILISABLE STORAGE WITHOUT INFLOW** | 13.56 |
| **NET UTILISABLE STORAGE WITH INFLOW** | 13.56 |

| **Reservoir at F.R.L + INFLOW SEASON (Ha) (%)** |
| **WATER ALLOCATION AT H.R. ON CCA in cm** | 56.88 56.88 KHALIF 2050 88.00 |
| **PHYSICAL EFFICIENCY (%) UPTO OUTLET** | 75.00 75.00 RABI 644 27.00 |
| **WATER ALLOCATION AT OUTLET ON CCA in cm** | 42.66 42.66 H.W. 0 0.00 |

Thus this project contemplates 56.88 cm. at H.R. and 42.66 cm. water depth at outlet and with inflow 56.88 cm. at H.R. and 42.66 cm. water depth at outlet of the project.

| **CALCULATION OF NUMBER OF WATERING** |
| **Service area = 2384.00 / 59.01 * (75.00 / 100)** | 53.87 Ha/CUSEC |
| **Number of HOURS in a WEEK (24 * 7)** | 168.00 Hr./WEEK |
| **DEPTH of water per Ha. per WEEK** | 3.12 cm / Ha |

| **Number of watering each of 7 days** |
| **Reservoir at F.R.L + INFLOW Weeks -->** | 13.42 13.42 |

Thus when the reservoir is at F.R.L. (20.39 MCM.), it can deliver 42.66 cm. and with inflow 42.66 cm. water over the whole 2384.00 CCA. To deliver 42.66 cm. without inflow / 42.66 cm. with inflow conditions at the rate 3.12 cm. allocation per Ha., canal is to be run for 13.42 weeks and 13.42 weeks respectively.

| **WATER APPLICATION INFORMATION** |
| **At OUTLET Ha. / Hr.** | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| **mm. / Ha.** | 60.00 | 70.00 | 80.00 | 90.00 | 100.00 | 110.00 | 120.00 |
| **AI/DC Ha. (24/Hr.)** | 4.00 | 3.43 | 3.00 | 2.87 | 2.40 | 2.18 | 2.00 |

| **COVERAGE OF AREA in Ha.** | **No. of Days * AI / DC** |
| **7 Days** | 28.00 | 24.00 | 21.00 | 18.87 | 16.80 | 15.27 | 14.00 |
| **14 Days** | 56.00 | 48.00 | 42.00 | 37.33 | 33.60 | 30.55 | 28.00 |
| **21 Days** | 84.00 | 72.00 | 63.00 | 56.00 | 50.40 | 45.82 | 42.00 |

| **IRRIGATION INTENSITY** |
| **(AI/DC * 7) * 100 / [SERVICE AREA (53.87 Ha.)]** |
| **7 Days** | 51.98 | 44.55 | 38.98 | 34.65 | 31.19 | 28.35 | 25.99 |
| **14 Days** | 103.95 | 89.10 | 77.97 | 69.30 | 62.37 | 55.70 | 51.98 |
| **21 Days** | 103.95 | 93.56 | 85.05 | 77.97 | | | |
According to this table with a proposed Al/DC and rotation, one can know the irrigation intensity possible to accomplish. For example, in order to accomplish a kharif irrigation intensity of 77.97%, the canal has to run for 14 days rotation and farmers have to be motivated to achieve Al/DC of 3 Hae. Irrigation intensity achievable in one week rotation (7 Days) with Al/DC of 3.00 would be 38.98%.

**QUANTITY OF WATER DRAWN IN ONE ROTATION (7 DAYS)**

<table>
<thead>
<tr>
<th>Canal Discharge</th>
<th>1.67 CUMEC (m³/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCM / DAY (1 CUMEC)</td>
<td>86400/1000000 = 0.0864</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second per Day</th>
<th>60 * 60 * 24 = 86400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours in week</td>
<td>24 * 7 = 168 HOURS</td>
</tr>
</tbody>
</table>

Thus in this project, the canal discharge of 1.67 CUMEC will draw 1.01 MCM of water in weekly rotation. If the canal is to be run for 5 rotations of 7 Days each, 5.05 MCM of water (1.01 * 5) will be needed.

**NUMBER OF WATERINGS REQUIRED FOR DIFFERENT CROP WATER REQUIREMENTS**

<table>
<thead>
<tr>
<th>HOURS PER HECTARE</th>
<th>CROP WATER REQUIREMENT (mm./Ha.)</th>
<th>WITH DIFFERENT HOURS AT OUTLET PER HECTARE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>9</td>
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<td>7</td>
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<td>11</td>
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<td>5</td>
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<tr>
<td>12</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Crops which required 500 mm. water at outlet (400 mm. or less at field) Two Seasonal after 15th October Cotton, Castor, RABI CROPS Raydo (Mustard), Jiru (Cumin), Mathi (Fenugreek), leebu, and other less leafy crops.

Crops which required 700 mm. water at outlet (500 mm. or less at field) RABI CROPS Wheat, Onion, Garlic.
### SCHEME OF OPERATION FOR AJI-II RESERVOIR

On the basis of net utilisable quantities of water available (excluding dead storage alternative have been worked out for operation of reservoir. These are as under.

<table>
<thead>
<tr>
<th>Case</th>
<th>Quantity Available</th>
<th>OPERATION PARTICULARS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POOR YEAR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.01</td>
<td>With the quantity of water available, only ONE WEEK canal can be run. Within one week rotation only 700.00 Ha area can be covered, so, supply water to the standing crop of GROUND-NUT at the time of peg initiation which occurs after 50 days of sowing (approximately third week of August) or after 21 days from last effective rain fall whichever earlier, if there is stress of moisture in the soil.</td>
<td>If there is no demand in kharif than run canal from 15th October as per farmers demand similar to case No. 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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<tr>
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<td></td>
<td>722.00 722.00</td>
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</tr>
<tr>
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<td>2.02</td>
<td>Same as one but continuous canal for TWO WEEKS and cover area of 1400 Ha. (G’Nutt 1431 + Beija 000 + Jower 000 + Other 000 + Cotton 000).</td>
<td>If there is no demand in kharif than run canal from 15th October as per farmers demand similar to case No. 7</td>
</tr>
<tr>
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<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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<tr>
<td></td>
<td></td>
<td>1444.00 1444.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3.03</td>
<td>Same as one but continuous canal for THREE WEEKS and cover area of 2100 Ha. (G’Nutt 1431 + Beija 238 + Jower 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.). but supply second irrigation after 21 Days to the Ground-nut (spreading) 722 Ha.</td>
<td>If there is no demand in kharif than run canal from 15th October at an interval of 28 Days similar to case No. 8</td>
</tr>
<tr>
<td></td>
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<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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<td>2000.00 100.00 2100.00</td>
<td>0.00 2100.00</td>
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<tr>
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<td>4.04</td>
<td>Same as one but continuous canal for THREE WEEKS and cover area of 2100 Ha. (G’Nutt 1431 + Beija 238 + Jower 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.). but supply second irrigation after 21 Days to the Ground-nut (spreading) 722 Ha.</td>
<td>If there is no demand in kharif than run canal from 15th October as per case No. 9 as shown in the annexure No.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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<td></td>
<td>2000.00 100.00 2100.00</td>
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<tr>
<td><strong>FAIR YEAR</strong></td>
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<td></td>
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<td>5.05</td>
<td>Same as one but continuous canal for THREE WEEKS and cover area of 2100 Ha. (G’Nutt 1431 + Beija 238 + Jower 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.). but supply second irrigation after 21 Days to the Ground-nut (spreading) 722 Ha. + Cotton 72 Ha. and T.S. Veg. 24 Ha. as shown in the annexure No. 5.5.3</td>
<td>If there is no demand in kharif than run canal from 15th October as per case No. 10 as shown in the annexure No.</td>
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<td>0.00 2100.00</td>
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<td>Same as one but continuous canal for THREE WEEKS and cover area of 2100 Ha. (G’Nutt 1431 + Beija 238 + Jower 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.). but supply second irrigation after 21 Days to the Ground-nut (spreading) 722 Ha. + Cotton 72 Ha. and T.S. Veg. 24 Ha. 1400 Ha. and after 15th October run canal as per farmers’ demand for Two Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. as shown in the annexure No. 5.5.3</td>
<td>If there is no demand in kharif than run canal from 15th October as per case No. 11 as shown in the annexure No.</td>
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<td>100.00 100.00 2200.00</td>
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<td>Same as one but continuous canal for THREE WEEKS and cover area of 2100 Ha. (G’Nutt 1431 + Beija 238 + Jower 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.). but supply second irrigation after 21 Days to the Ground-nut (spreading) 722 Ha. + Cotton 72 Ha. and T.S. Veg. 24 Ha. 1400 Ha. and after 15th October run canal for Two Weeks for Two Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Gram 600 Ha. as shown in the annexure No. 5.5.3</td>
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<td>600.00 100.00 700.00 2800.00</td>
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Table 3.2-1  Typical sample of RWS water scheduling and canal operation (cont’d)

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<td>2100 Ha. (G’Nut 1431 + Bajra 238 + Jawar 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.)</td>
<td>Continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground -</td>
</tr>
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<td>continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground- nut</td>
<td>T.S. Veg. 24 Ha.), 1400 Ha. and after 15th October run canal for Three Weeks for Two</td>
</tr>
<tr>
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<td></td>
<td>(spreading) 722 Ha. + Cotton 72 Ha. and T.S.Veg. 24 Ha.)</td>
<td>Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Gram 800 Ha. as shown in the annexure No. 5.5.3</td>
</tr>
<tr>
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<td>Same as one but continuous canal for THREE WEEKS and cover area of</td>
<td>2100 Ha. (G’Nut 1431 + Bajra 238 + Jawar 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.)</td>
<td>Continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground -</td>
</tr>
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<td>continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground- nut</td>
<td>T.S. Veg. 24 Ha.), 1400 Ha. and after 15th October run canal for Four Weeks for Two</td>
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<td>(spreading) 722 Ha. + Cotton 72 Ha. and T.S.Veg. 24 Ha.)</td>
<td>Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Gram 800 Ha. as shown in the annexure No. 5.5.3</td>
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<tr>
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<td>Same as one but continuous canal for THREE WEEKS and cover area of</td>
<td>2100 Ha. (G’Nut 1431 + Bajra 238 + Jawar 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.)</td>
<td>Continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground -</td>
</tr>
<tr>
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<td></td>
<td>continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground- nut</td>
<td>T.S. Veg. 24 Ha.), 1400 Ha. and after 15th October run canal for Five Weeks for Two</td>
</tr>
<tr>
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<td></td>
<td>(spreading) 722 Ha. + Cotton 72 Ha. and T.S.Veg. 24 Ha.)</td>
<td>Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Reyde 800 Ha. as shown in the annexure No. 5.5.3</td>
</tr>
<tr>
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<tr>
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<td></td>
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<tr>
<td>11</td>
<td>Same as one but continuous canal for THREE WEEKS and cover area of</td>
<td>2100 Ha. (G’Nut 1431 + Bajra 238 + Jawar 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.)</td>
<td>Continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground -</td>
</tr>
<tr>
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<td>continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground- nut</td>
<td>T.S. Veg. 24 Ha.), 1400 Ha. and after 15th October run canal for Six Weeks for Two</td>
</tr>
<tr>
<td></td>
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<td>(spreading) 722 Ha. + Cotton 72 Ha. and T.S.Veg. 24 Ha.)</td>
<td>Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Wheat 800 Ha. as shown in the annexure No. 5.5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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<tr>
<td></td>
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<tr>
<td>12</td>
<td>Same as one but continuous canal for THREE WEEKS and cover area of</td>
<td>2100 Ha. (G’Nut 1431 + Bajra 238 + Jawar 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.)</td>
<td>Continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground -</td>
</tr>
<tr>
<td></td>
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<td>continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground- nut</td>
<td>T.S. Veg. 24 Ha.), 1400 Ha. and after 15th October run canal for Seven Weeks for Two</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(spreading) 722 Ha. + Cotton 72 Ha. and T.S.Veg. 24 Ha.)</td>
<td>Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Wheat 800 Ha. as shown in the annexure No. 5.5.3</td>
</tr>
<tr>
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<td></td>
<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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</tr>
<tr>
<td></td>
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<td>2000.00 100.00 2100.00 600.00 100.00 700.00 2800.00</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Same as one but continuous canal for THREE WEEKS and cover area of</td>
<td>2100 Ha. (G’Nut 1431 + Bajra 238 + Jawar 187 + Other 120 + Cotton 72 and T.S. Veg. 24 Ha.)</td>
<td>Continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground -</td>
</tr>
<tr>
<td></td>
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<td>continuous canal for Two Weeks and supply second irrigation after 21 Days to the Ground- nut</td>
<td>T.S. Veg. 24 Ha.), 1400 Ha. and after 15th October run canal for Eight Weeks for Two</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(spreading) 722 Ha. + Cotton 72 Ha. and T.S.Veg. 24 Ha.)</td>
<td>Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Wheat 800 Ha. as shown in the annexure No. 5.5.3</td>
</tr>
<tr>
<td></td>
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<td>Kharif T.S. Total Rabi T.S. Total G.TOTAL</td>
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<td></td>
<td>2000.00 100.00 2100.00 600.00 100.00 700.00 2800.00</td>
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</table>
Table 3.2-1  Typical sample of RWS water scheduling and canal operation (cont’d)

VERY GOOD YEAR WHEN THERE IS NO DEMAND IN THE KHARIF
OR DEMAND IS MET FROM THE IN UNFLOW OF RIVER

14  9.09  Same as one but continue canal for THREE WEEKS and cover area of
2100 Ha. (G’Nut 1431 + Bajra 238 + Jowar 167 + Other 120 +
Cotton 72 and T.S. Veg. 24 Hs), continue canal for Two Weeks and
supply second irrigation after 21 Days to the Ground - nut,
and after 15th October run canal for Nine Weeks for Two
Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Wheat 800 Ha.
as shown in the annexure No. 5.5.3

Kharif  T.S.  Total  Rabi  T.S.  Total  G.TOTAL
2000.00  100.00  2100.00  800.00  100.00  700.00  2800.00

15  10.10  Same as one but continue canal for THREE WEEKS and cover area of
2100 Ha. (G’Nut 1431 + Bajra 238 + Jowar 167 + Other 120 +
Cotton 72 and T.S. Veg. 24 Hs), continue canal for Two Weeks and
supply second irrigation after 21 Days to the Ground - nut,
and after 15th October run canal for Three Weeks for Two
Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Gram 800 Ha.
and Seven Weeks for Wheat 700 Ha. as shown in the annexure
No. 5.5.3

Kharif  T.S.  Total  Rabi  T.S.  Total  G.TOTAL
2000.00  100.00  2100.00  800.00  100.00  1400.00  3600.00

16  11.11  Same as one but continue canal for THREE WEEKS and cover area of
2100 Ha. (G’Nut 1431 + Bajra 238 + Jowar 167 + Other 120 +
Cotton 72 and T.S. Veg. 24 Hs), continue canal for Two Weeks and
supply second irrigation after 21 Days to the Ground - nut,
and after 15th October run canal for Four Weeks for Two
Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Gram 800 Ha.
and Seven Weeks for Wheat 700 Ha. as shown in the annexure
No. 5.5.3

Kharif  T.S.  Total  Rabi  T.S.  Total  G.TOTAL
2000.00  100.00  2100.00  1300.00  100.00  1400.00  3500.00

17  12.12  Same as one but continue canal for THREE WEEKS and cover area of
2100 Ha. (G’Nut 1431 + Bajra 238 + Jowar 167 + Other 120 +
Cotton 72 and T.S. Veg. 24 Hs), continue canal for Two Weeks and
supply second irrigation after 21 Days to the Ground - nut,
and after 15th October run canal for Five Weeks for Two
Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Raydo 800 Ha.
and Seven Weeks for Wheat 700 Ha. as shown in the annexure
No. 5.5.3

Kharif  T.S.  Total  Rabi  T.S.  Total  G.TOTAL
2000.00  100.00  2100.00  1300.00  100.00  1400.00  3500.00

18  13.13  Same as one but continue canal for THREE WEEKS and cover area of
2100 Ha. (G’Nut 1431 + Bajra 238 + Jowar 167 + Other 120 +
Cotton 72 and T.S. Veg. 24 Hs), continue canal for Two Weeks and
supply second irrigation after 21 Days to the Ground - nut,
and after 15th October run canal for Six Weeks for Two
Seasonal (Cotton 72 + Veg. 24 Ha.) 100 Ha. and Raydo 800 Ha.
and Seven Weeks for Wheat 700 Ha. as shown in the annexure
No. 5.5.3

Kharif  T.S.  Total  Rabi  T.S.  Total  G.TOTAL
2000.00  100.00  2100.00  1300.00  100.00  1400.00  3500.00

FARMERS ARE FREE TO GROW AND IRRIGATE THEIR CHOICE CROPS

Crops and area shown in the operation plan is on the basis of the
following assumptions.

i) Crops and area shown to irrigate is as per Summary Appraisal Report
(name of crops are simply indicative).

ii) Availability of water

iii) Duration of crops

iv) Crop Water Requirement

v) Sowing time of rabi crops (e.g. Mustard, Gram etc. sown in
the month of October and mature in the month of January, hence there
less evaporation losses from the reservoir).

vi) Farmers are free to grow and irrigate their choice crops.

vii) Farmers will be given canal running schedule, they will not be
suggested any crops to grow but they will be provided information
which crops will be suited most to the given schedule.

viii) Area shown is also based on past irrigation performance.
Table 3.2-1  Typical sample of RWS water scheduling and canal operation (cont'd)
Irrigation Scheduling Based on Soil - Crop - CLIMATOLOGICAL Approach.

Table 3.2-1 Typical sample of RWS water scheduling and canal operation (cont'd)
3.2.2 Water Scheduling practice in the Project command areas

The above described principle of water scheduling are generally followed on all projects. The main deviation appears to be that not a strict RWS water delivery is made, but that in most projects the ID officers adapt the water delivered to the Water Courses or to the Field Offtakess according to the actual percentage of farmers that are "ready" to receive water. This is done by either
- limiting the number of days of supply to a particular Water Course, or
- limiting the discharge to a particular Water Course.

Because the structures have been converted for the RWS water supply method (100% discharge for 7 days consecutively; with only regulation of flow at the Distributary Canal or Minor Canal offtakes) this means that the Water Course and/or Field Channel outlets are manipulated with stones, sticks, sandbags and the like.

Strict adherence to the Warabandi "fixed-turn" time schedule has to be abandoned in these cases.

The concept that "the water will be running according to the "fixed-turn" schedule and the farmers are responsible for making the best possible use of it" has apparently not yet taken root.

The practice of water supply is in fact in many instances a modified Sheshpali type supply with improvised use of RWS structures. This could lead to abuse and deterioration of both the scheduling system, and the operation structures.

It appears that there is much uncertainty and ambiguity on the subject of the true application of the RWS methodology. Even in the recently developed Project Operation Manuals there is a detailed description of procedures and responsibilities for Sheshpali type water management but no such detailed description for RWS type management [POM, Dantiwada pages 7-25 and pages 10-2 and following].

At the Uben project the practice is nearest to the true RWS scheduling. Here those farmers that do not wish to participate in the season irrigation are not included in the Warabandi time schedule. The time that would have been allotted to them is shared proportionally by the other farmers in their sub-chak. This way the farmers who do irrigate get a higher irrigation percentage but the total irrigation percentage of the sub-chak run remains according to the overall planning. This way the Warabandi-time schedule prepared for that season can be maintained throughout, and no water is delivered to farmers who do not use it. For every season a new Warabandi-time schedule has to be prepared, according to the farmers who do and who do not participate. Furthermore a type of individual application/sanction procedure has to be maintained in order to get a correct "fixed-turn" schedule.
3.3 Farmers rotation in fixed turns

The system of calculating the fixed turns for each individual farmer is executed following the well established Warabandi methodology.

Compensations are made for transport/seepage losses and for transport/filling time in the length of Field Channel up to the individual farm Turnout.

To compensate for seepage loss generally 3% loss of discharge per 100 m Field Channel is taken and this is taken into account by increasing the actual farm area to a "notional area" inversely proportional to the percentage discharge loss.

To compensate for filling/transport time losses an additional irrigation period of 0.1 hr per 100 m Field Channel (from the outlet of the farm that had the preceding fixed turn) is taken.

The total time available for the total area irrigated is then:
(7 days x 24 hours) - (sum of time losses).

This available time is allocated to the farmers in proportion to their "notional area".

At WALMI a spreadsheet computer programme has been developed for this calculation. Once the data base with the farmers names, farm areas and field channel distances is completed, the calculation of the Warabandi-fixed turn schedule is a matter of minutes.

In the project offices no computer assistance is available and the calculations are done by hand; this takes then several days.

A sample of a spreadsheet RWS fixed-turn time schedule as prepared by WALMI, is presented in Table 3.3-1.
### Table 3.3-1 Typical fixed-turn calculation for RWS supply in a subchak area

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<th>Sr. No.</th>
<th>Chak No.</th>
<th>Name of farmer</th>
<th>Survey No.</th>
<th>Area in Ht.</th>
<th>Length of F.C. from T.O. in m</th>
<th>Distance to T.O. @ 3% per 100 m</th>
<th>Transport losses</th>
<th>Dividing factor</th>
<th>National Area Ht. in Col. 5</th>
<th>Transport time (TT) 0.1 hr</th>
<th>100 m for related distance Col. (7 + 8)x0.1</th>
<th>Time allocation 168 TT (12 + 13)</th>
<th>Final time</th>
<th>Final time x</th>
<th>Day &amp; Time</th>
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<td>Wed 4 22</td>
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**Table 3.3-1** Typical fixed-turn calculation for RWS supply in a subchak area
3.4 Operation of main canal system

Several of the Medium schemes are small in size and consist of one or two Distributary canals only. It is then relatively easy to follow the ON-OFF schedule without much loss of water, because the filling volume and filling time of the canal system is small.

For larger projects such as Dantiwada and in future the completed Karjan, the long main canal system will make ON-OFF operation difficult to execute without loss of irrigation water and fluctuations in the distributaries that disturb the equitability of the RWS schedule.

In Dantiwada the main canal is filled in steps of 200 cusecs until full flow is achieved.

There has been no research undertaken to establish the filling and closing programme that would achieve:
- guaranteed full delivery of full discharge to the farmers according to the fixed turn, without fluctuations
- minimal operational water losses from the canal system during the transition period.

Such research should also be used to find the best method of operation and the related best type of water control structures in the canal system for a design and for a rehabilitation redesign.

This type of canal operation research for design and for operation was not possible in the past because the complex hydrodynamic calculations are impossible to execute analytically and traditional stationary design procedures had to be followed. At present, however, hydrodynamic computer models exist that can calculate the behaviour and fluctuations in a canal system. [Schuurmans, 1991] [Brouwer, 1992].

Different operation scenarios can be tested for a given canal-control structure configuration to tend procedures with easy operation and minimal water loss. Different control structures can be tested as alternatives in a design or rehabilitation re-design.

It is strongly recommended that -given the large number of irrigation projects planned in Gujarat- the WALMI will start research of hydrodynamics of operation for improved systems design and improved systems operation.
3.5 Automation of the irrigation administration

The administration of the irrigation projects is now done manually, from field records of discharges supplied as noted by the chaukidars up to the financial and land tenure administration.

At WALMI attempts are made for automation of these administrative and accounting procedures. A dBase database package is used, and the information on irrigation projects such as names of farmers, cadastral data on the on the farms, irrigable areas, financial status on payments etc. are collected and processed.

This type of programme needs to be upgraded to a more powerful programme because the capacity of the database package is too limited for larger projects. Draft tender documents have been prepared, but the specifications of the programme required are not fully clear and definite.

It is recommended to follow a two step approach:

1. Prepare a "Definition Study" of the specifications of the programme required, with the assistance of a professional (paid) software systems analyst in cooperation with the WALMI subject experts.

2. Have a programme prepared according to the specifications laid down in the Definition Study by a reputable software engineering firm.

3.6 Conclusions on RWS water management system

From the analyses presented in the previous paragraphs the following conclusions can be drawn:

1) It is possible to have a water-efficient reservoir operation and canal scheduling for the Medium Irrigation projects. The operation and canal scheduling programme prepared by WALMI will give good results within the constraints imposed by the pre-arranged rotational water supply methodology of the RWS.

2) The RWS methodology of fixed-turn schedule is not in fact practised in the projects. Applications/sanctions are still being practised and the concept that "water will be supplied to the farm turnout as prearranged irrespective of the farmers actual demand" has not taken root. This will become an impediment to water management by farmers associations and to the development of informal exchange of water turns between farmers inside one (sub)chak.

3) In most projects the RWS proportional division structures are misused for Sheshpali type on demand/pre-arranged water scheduling by improvised means of sticks, stones and sandbags. This could be a prelude to unofficial tampering with the control structures.

4) It appears that a decision has to be made to implement the RWS system fully, to avoid a hybrid operation system that has all the disadvantages of the
Shesphali system, with applications, sanctions, field monitoring of cropped areas to establish water charges and so on.

Clear operational guidelines are necessary to train both ID water operators and farmers in the RWS methodology. These guidelines should give unambiguous instructions on
- no (or simplified Uben type) applications;
- strict adherence to the fixed turn scheduling;
- administrative and financial procedures to be followed with RWS scheduling, giving water to a fixed schedule against a fixed prescheduled water charge.

It is advised to prepare these guidelines as an appendix to the POM’s and concentrate therein on the type of water operation and administration that has to be aimed at with true RWS methodology, and avoid confusion by mixing in old references to the Sheshpali. This appendix should be prepared by experts experienced in Warabandi type water management in cooperation with field engineers form the Medium Irrigation projects and WALMI researchers.

5) Operation and design of the main canal system needs to be upgraded by using hydrodynamic flow calculations (using a computer package) to identify the optimum operation of existing control structures and optimum types of control structures in newly designed or rehabilitated irrigation systems. This type of development should start at WALMI as early as possible.

6) For future development of water management decisions in the field offices of the projects development of computer based tools that are robust and user friendly is recommended. This concerns:
- OMIS type water scheduling programme with an RWS scheduling module as developed at WALMI incorporated;
- Administrative database and information processing programme.

As much as possible these type of programmes should have communical/exchangeable files on common data such as farmers names, farm areas, project characteristics and so on.
4. FARMERS COOPERATION IN WATER MANAGEMENT

4.1 Introduction

Efforts are being made at various Government and Project levels to get more active involvement of farmers in the operation of the water management and in the maintenance of the irrigation system infrastructure.

Farmers involvement is proposed on different management levels in RWS projects. [Moench, 1993]

- Village Service Area Committee (VSAC)
  These are not necessarily based on village boundaries but more likely on hydraulic boundaries of the irrigation system on the level of Section Engineers jurisdiction.
  Their function would be to monitor (and propose adaptations to) water delivery schedules, assist in water charges recovery, promote Water Users Associations at the minor canal of chak level.

- Water Management Committee (WMC)
  These would be a concentration of VSAC representatives on the level of a Deputy Engineer with roughly the same responsibilities on a higher hierarchical level.

- Project Level Water Management Committees (PLWMC)
  These would function at the level of the Executive Engineer.

All committees would consist of representatives from the irrigating farmers and the ID staff concerned at their respective levels.

The objective is to achieve the daily operation and water management by farmers Water Users Associations. A Water Users Association would then eventually operate, maintain and administrate the irrigation of 200 Ha - 400 Ha areas under the guidance and assistance from the ID.

The advantages of the shift of responsibilities in operation and maintenance on the chak-level towards the farmers themselves are extensively debated. [Seminar 1992, Kathpalia]

These advantages are:
- equitable distribution of water over the entire area;
- more cost effective maintenance of the chak level irrigation and drainage system;
- reduction of costs at the ID;
- general emancipation of the farmers toward more self management and responsibility.

4.2 Functioning of Farmers Associations

At the projects visited only the Pigut and Baldeva farmers expressed enthusiasm for the concept of farmers responsibility in operation and maintenance.

These are two projects where the farmers had to form an association in order to
participate in the completion of their irrigation system. In all other projects the irrigation system was constructed and operated by the ID without any initial participation of the farmers. These farmers apparently see no reason why they should take on additional responsibilities now.

These observations are corroborated by the reports of [Moench 1993, paragraphs 6, 7, 8] and [Bagadion 1993] Both reports conclude that farmers participation will only succeed if there is an incentive or motivation for the farmers to participate; and give recommendations how to reach this objective.

At present in most of the Medium Irrigation II projects the attention focused on the (problematic) transfer to RWS water scheduling has increased the reliability of the water supply in such a measure, that there appears no motive for the farmers to take over the responsibility for operation.

The Pigut and Baldeva farmers who have been involved from the beginning are satisfied with the result of their participation and would like to take on more responsibilities.

4.3 Conclusions

If the farmers participation process is to be advanced further the following steps seem to be necessary from the water management point of view.

1. Make the water operation more simple by adhering to the strict RWS-fixed turn concept (possibly modified according to the Uben concept described in paragraph 3.2.2). It is advised to engage resident consultants, who are experienced in rotational water scheduling, for several seasons at the projects, to assist the ID staff in full change over. When the water scheduling is simplified and understood without hesitations by all ID staff and all farmers the transfer of responsibility can be made more easily and without confusion.

2. Create incentives for the farmers for take over of the water management and maintenance. Financial incentives in water charges and maintenance costs have to be identified.

3. Draft and institutionalize the necessary by-laws and regulations to give the farmers associations the necessary executive and financial powers. These regulations and powers should be consisted with the operational guidelines proposed in guidelines in paragraph 3.6.(4).
5. DESIGN

5.1 Operation as design criteria

The design procedures are executed following the traditional practice of civil engineering.

The designs are prepared following standard traditional design criteria and after the construction is completed the possible method of water operation is studied and operation rules are established and put to practice.

With use of modern computer models it is possible to execute simulations of the operation in the design stage. The hydrodynamic effects of the operation actions on timelag, spillage, supply fluctuations and the like can be compared. Different designs and different operation strategies can be compared and used as an input for the design.

This way the operation of the system becomes a design criteria as it should be. It is recommended that this type of research is to be taken up at WALMI at the earliest.

5.2 Design Reports

For none of the projects visited a design report was available. In its place a Plan for Operation and Maintenance was prepared several years after the completion of the main elements of the projects.

These POM's are valuable documents as they contain information on the irrigation system that is needed by the offices in charge of operating and maintaining the system.

However, it is recommended that the design practice is amended and that a design report is completed before the tenders for construction are prepared.

In this design report not only the hydrology and hydraulic design criteria are to be presented, but the future operation of the irrigation system has to be described. In systems with long canals to be operated with ON/OFF scheduling for various distributaries the hydrodynamic performance of the main canals should be tested in computer simulations and the suitability of the canal and control system proposed for the future operation should be demonstrated.

5.3 Metric system/cusecs

India has converted to the Metric System but in the design of the irrigation projects the use of cusecs and other remnants of the Imperial System are still common.

This does lead to incompatibility of calculations and can create confusion, as Hectare [Ha] and Litres per Second [l/s] are mixed with Cubic foot per second [cusec].

The main reason for this persistance of the cusecs seems to be the concept of "service Area"
The SA is defined as the area that can he served by one cusec at outlet at peak demand in H/cusec [CDO, 1989; page 24], and this concept is further used in planning and design of the distribution and micro canal network.

It appears that the concept of "Service Area" should and can be abolished and be replaced with the "Basic Discharge Coefficient".

This BDC is defined as the basic discharge at the Outlet of a chak or subchak in lps/Ha. [CDO, 1989; page 8]. This BDO is in fact the Metric System inversion of the Imperial System Service Area concept, and this carries exactly the same information, when used in conjunction with the practice that a farmers flow should be between 20 lps and 45 lps for practical reasons.

It is recommended to abolish the SA and all calculations involving cusecs in the planning and design and to revise the Guidelines for Planning and Design accordingly.

5.4 Design of proportional structures RWS

The design manuals and three dimensional models used at WALMI for training and design of the proportional division structures for RWS are based on sound hydraulic engineering.

Less experienced design officers sometimes try to save money and in rehabilitation do combine pipe outlets and overflow weirs in one division complex. This means that the discharge division will not be proportional when the oncoming discharge is not exactly 100% design flow. It is recommended to use structures with the same type of flow regulators, that will achieve proportional distribution with all discharges.

5.5 Non-designed pump offtakes

When pump offtakes to areas above command level are allowed, then the pumps should not draw their water from the canal directly, but through a sump with a regular offtake, that can be fed or closed according to the RWS schedule of the other offtakes by the canal operators.

5.6 Surface drains

There appears to be no surface drain system designed nor constructed. This hampers operation (fear of field damage if farmer does not take his water in time) and does make for difficult drainage after heavy rainstorms. Each farmer's field should have an outlet to a field drain and each field channel and water course should have a tail-end escape into a field drain.
5.7 Buried pipe distribution channels

The application of buried pipes instead of concrete lined canals should be encouraged for all water courses, minor- and distributary canals. Also, if the water velocity would be below the non-silting velocity, these pipes could be preferred because the "floating ball" silt flushing would prevent clogging of the pipes. The main advantages are:

a. no land acquisition for canals; and

b. less maintenance of removing silt fallen from embankments or weeds growing in the canals.
6. SUMMARY OF CONCLUSIONS

6.1 General

Different activities are ongoing in the Medium Irrigation II project simultaneously. These are:
- emancipation of farmers through their involvement in the operation and management;
- change over from Sheshpali type water management to RWS type water management;
- design and construction of remaining parts in some of the projects.

Training of farmers by extension workers and training of irrigation staff at WALMI form an integrated part of these activities.

The experience gained at the Medium Irrigation projects will serve Gujarat State also at future irrigation developments now in the planning stage.

6.2 RWS Water Management

The RWS methodology of fixed turn irrigation water supply is not fully implemented in the projects.

The main causes appear to be:
- Project officers are not certain on the way to implement this in practice and on the legality of supplying water and charging for it without the prescribed Sheshpali application/sanction method.
- The POM do not give unambiguous guidelines how to implement and administer the RWS methodology.
- Farmers have been accustomed to be supplied after discussions with the chaukdar and have not been accustomed to the idea that they will receive water automatically following the fixed-turn schedule.

It will be necessary to take action on Government level to avoid the development of a hybrid type operation, different in all projects, with possible misuse or destruction of the control structures.

It is recommended to take the following actions:

1) Prepare an unambiguous RWS manual as appendix to the existing POM's. This manual should describe the method of operation and of the administration of the RWS water management, with detailed description of the procedures to be followed and the responsibility of the ID officers and the irrigating farmers.

Any reference to old Sheshpali procedures should be avoided.

2) Assist the Project staff by making a Resident Consultant available to them for several seasons. This resident consultant should be experienced in fixed-turn type water supply and its administrative procedures.
6.3 Irrigation System Operation and Design

At the design stage of an irrigation project a complete design report should be prepared that describes fully all the natural conditions, design considerations, physical features, and the operation method of the planned irrigation project. The operation of the irrigation water supply system should be clearly described and should be treated as a design criterion for the design of the canals and control structure.

In larger projects the water operation should be simulated with a hydrodynamic computer programme to demonstrate that the proposed operation method will perform well and that the water losses will be minimal.

6.4 Farmers Cooperation in Water Management

Farmers Cooperation appears to be successful only where the farmers are motivated by incentives to participate. In most projects these incentives are not obvious. The recommendations in this respect of [Bagadion, 1993] and [Moench, 1993] are clear and should be implemented.

6.5 Computer Programmes for Irrigation Management

Three types of computer programmes have been discussed and all three merit further development.

These are:

1. **Administrative Database and Information**

   This type of programme will be useful both for the Medium Irrigation projects as well as for other projects in Gujarat. Further development as discussed in paragraph 3.5 is recommended.

2. **Water Scheduling Programme**

   The programmes developed at WALMI for canal scheduling and fixed-turn are useful. It is recommended to develop the water supply scheduling programmes further toward a user-friendly and robust programme that can in future be used at the project offices. It is recommended to explore the possibility to implement the WALMI-RWS scheduling into the OMIS programme that is presently being developed for application in India by the Indo-Dutch Training Production Management of the Ministry of Water Resources.
3. Hydrodynamic analysis of canals and operational structures

Some of the Medium Irrigation projects have long canals that will require complex operation in the transitions in ON-OFF scheduling.

At present no research is ongoing to test the hydrodynamic behaviour of gradual varied flow waves in controlled canal systems. This type of research would be beneficial both for analysis of operation in existing projects, and even more as a design tool for new projects.

The results would not only be beneficial to the Medium Irrigation projects but also give valuable experience and design tools for new irrigation projects and canal systems such as the Narmada developments. It is recommended to start this type of research at WALMI.
ITINERARY

July 25, 1993  (Sunday)  - Travel from Nijmegen (The Netherlands) to New Delhi via Amsterdam

July 26  (Monday)  - Briefing at World Bank office at Jorbagh, New Delhi by Mr. J.-P. Baudelaire, Mr. G.N. Kathpalia and Mr. R.K. Malhotra

July 27  (Tuesday)  - Reading of project documentation and discussions at WB, Delhi

July 28  (Wednesday)  - Early morning flight Delhi-Ahmedabad.
 - By car to Gandhinagar.
 - Discussions with Mr. Buch and Mr. Mandavia;
   Meeting with Secretary Desai.
 - Travel by car to WALMI at Anand.

July 29  (Thursday)  - Detailed discussion on RWS scheduling with Mr. Patel, Mr. Joshi and computer programmes at WALMI.
 - Demonstrations by Mr. Patel, Mr. Shukla and Mr. Joshi of Crop Water allocation programmes and RWS scheduling programmes.
 - Late afternoon travel to Rajpipla.

July 30  (Friday)  - Field visits in Rajpipla.
 - Morning: Karjan Scheme, farmers in field meeting place
 - Afternoon: Pigut and Baldeva, farmers in meeting room of darly cooperative office.

July 31  (Saturday)  - Early morning discussion field officers of Karjan.
 - Start Rajpipla (9.00 - Ahmedabad).
 - Start discussion with the consultants/authors of the POM.
 - Ahmedabad - Dantiwada.
 - Brief introduction to officers in charge.
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| August 1     | - Early morning discussion on O&M of Dantiwada at damsite; visit farmers group of D6 and inspection of irrigation system.  
| (Sunday)     | - After lunch discussion.  
|              | - Departure to Ahmedabad. |
| August 2     | - Visit to Watrak irrigation project; return to Ahmedabad. |
| (Monday)     |                                                                 |
| August 3     | - Visit to Demi II project.  
| (Tuesday)    | - Onward travel to Rajkot. |
| August 4     | - Morning visit to Bhadar (Modernised) system.  
| (Wednesday)  | - Afternoon visit to Uben system.  
|              | - Return to Rajkot. |
| August 5     | - Morning discussions on outstanding issues with officers from Demi II, Uben and Rajkot.  
| (Thursday)   | - Travel to WALMI at Anand. |
| August 6     | - Discussions on outstanding issues with officers from WALMI and Dantiwada. |
| (Friday)     |                                                                 |
| August 7     | - Final discussions at WALMI.  
| (Saturday)   | - Afternoon travel too Ahmedabad.  
|              | - Debriefing session at Gandhinagar with Secretary N.B. Desai; C.E. and Joint Secr. Mr. Kirit Patel and with officers from Gandhinagar and from projects visited. |
| August 8     | - Travel to Delhi.  
| Sunday)      | - Study of documents. |
| August 9     | - Discussions at World Bank.  
| (Monday)     | - Reading of Project Documents.  
| to           | - Preparation of short note. |
| August 12    |                                                                 |
| (Thursday)   |                                                                 |
| August 13    | - Travel to Nijmegen, The Netherlands. |
| (Friday)     |
SHORT NOTES ON FIELD VISIT

1. Karjan Project

Irrigation infrastructure
- This is a Medium Project of 40,000 ha of which as yet only 7,000 ha is under irrigation. Dam and reservoir are fully operational.
- Distributary Canal is provided with flat gate cross regulator and offtakes that are proportional when the water level is at FSL mark.
- No gauges are present at offtakes.
- Chak outlets are supplied with proportional long vested weirs; and there is a proportional long crested weir in the ongoing Minor Canal.
- Minor canal tile lining is only 2 years old but already damaged at joints.

Comments from farmers
- The water supply is sufficient.
- Remaining wishes:
  * more frequent supply in the hot season
  * government should level their fields
  * access road to market in Rajpipla
- Farmers understand that water is now abundantly available to them because only 7,000 ha out of 40,000 ha is now operational.
- Farmers are not keen to take over operation and maintenance of Minor Canals/Water Courses/Field Channels. They are satisfied to have the ID do this for them.

Water operation
- Field records show that the discharges are always noted as 100% Full Supply; there are no gauges in the field to note and calculate deviations in the actual discharge.
- More frequent water releases and of longer duration have been implemented than the programme of water scheduling (according WALMI system) indicated. The reason given was:
  * there were more perennial crops (bananas) that require more water;
  * there is plenty of water available in the reservoir for the limited irrigation command area completed.

2. Pigut and Baldeva

Irrigation infrastructure
- These two projects were completed upon the request of Farmers groups, when the original construction and development program had failed to be completed. Designs and supervision were executed by the ID, and farmers groups have contributed in kind and in money.
- Several Water Courses are executed as buried pipeline systems. Reportedly this is cheaper than open channel systems because of irregular topography and because no land purchase for the right of way is required.
- Systems are fully designed and built for RWS proportional distribution.
Comments from farmers:
- Farmers are very enthusiastic about the support received from the ID Rajpipla and from WALMI.
- Further wishes:
  * more influence in the design
    (farmers now are consulted and can make suggestions on the draft layout, based on their detailed knowledge of field topography etc.)
  * more say in the construction supervision
    (farmers now are allowed to assist in the supervision of the construction work of contractors and report their findings to the ID)
  * more say in water scheduling
    (at present chaukidars are working toward transfer of daily operation of Water courses to the farmers; reportedly it is not yet possible to hand over full operation responsibility)
  * farmers are not keen on night irrigation
- The Water Users Associations were here formed to organise the request for, and the participation in, the completion of the development by the farmers. The farmers are enthusiastic about these WUA because they find this leads to:
  * less quarrels about water distribution
  * more collegial cooperation in water scheduling to avoid crop damage to fellow members of the WUA, change of schedules can be executed by chaukidar upon request of WUA.

Water operation
- The irrigation officers report no problem with the water operation. RWS schedule is followed and adaptations are made according request from WUA.

4. Dantiwada

Irrigation infrastructure
- The Dantiwada project is the largest project, fully completed with more than 40,000 ha irrigable developed, with a few outstanding works for the RWS system.
- Dam and reservoir are fully operational.
- Measuring Weir is not present at Dam outlet.
- Drainage system is not developed. Farms drain on each other and finally into the natural Nallah’s.
  Emergency outfall drains were observed to be clogged with eroded soil material. Erosion on farmlands ins reportedly limited and repaired by farmers themselves.
- Main Division Works is a flat gated cross regulator structure supplied with gauges to have proportional division of water; unsubmerged flow downstream.
- If the Main Canal is not at full discharge, the direct outlets can not be supplied with water proportionally.

Farmers comments
- The Warabandi system is welcomed because of its benefits:
  * more assured timing of supply
  * better spread of the water over the entire area.
- Farmers are not keen to start a WUA and take over O&M responsibilities. They would like to visit an operational WUA first to understand the benefits.
- If a WUA is to be formed, then in the opinion expressed by the farmers it should give benefits to its members such as
  * increase of water supply
  * priority of water supply to the WUA
  * assurance that water supply to the WUA will be guaranteed always.

**Water operation**
- The weekly ON/OF schedule is implemented according to the WALMI schedule, but discharges may be reduced according to the area of land irrigated known from applications and field monitoring.
- The main canal is run on a continuous supply base, with rotation over the Distributaries. The WALMI has not yet prepared detailed schedules for this type operation.
- Rotation in sub-chaks according to Warabandi schedule is abandoned when small discharges are available if some farmers do not require water and a limited number did put in an application.
- Liaison with WALMI is only at the start of the season. Further feedback on experience with the implementation of the schedules is needed and planned.
- Before the start of an irrigation season the water scheduling is discussed with the farmers representative and extension officers. The final schedules are then released and also posted on announcement boards in the villages.
- The operation of the water courses with reduced discharges is more according to the shespali - semi demand system than according to the RWS fixed turn system. The proportional structures are now regulated with improvised means.
- The full "application and sanction" methodology is maintained. The final supply schedule implemented, differs markedly from the original RWS schedule.
- The water management officers do not see how they can bring a strict RWS-Warabandi system to come about; long term assistance from a consultant experienced in this type of operation would be required and welcomed.

5. **Watrak**

**Irrigation infrastructure**
- The project is almost fully completed with original proportional division weirs for RWS water distribution.
- Discharges are measured at the Minor Canal offtake, all downstream distribution is proportional division without regulation.

**Farmers comments**
- Farmers state that they do not believe in WUA for water management and canal maintenance. They think their internal quarrels will lead to mis-management.
- They prefer the Government to continue the maintenance and the water operation.
Water Management
- The WALMI RWS schedule is not followed. Instead water is delivered upon application by the operation officers.

The reasons given are:
* farmers are not ready simultaneously to start irrigation;
* officers are reluctant to supply water without application;
* legality of supply without application/sanction and the possibility to charge water duties in that case, is not clear;
* the method of receiving water charges when there is no application is not clear;
* supply when there is no application could lead to waste, and to damage in fields and field channels (because there is no drain system);
* farmers do not like night shifts and so disturb the RWS schedule;
* farmers insist to be supplied according to their crop grown and not according fixed schedule;
* after payment of a yearly lump sum for an electric pump, the electricity is free, and then farmers will prefer to use pumped ground water if they have a well, instead of paying for surface water charges.

Watrak reservoir has ample water, ground water is available in many areas, thus there is no incentive to farmers to adhere to a strict schedule.

- The automatic proportional division of the structures is circumvented by using sandbags to stop the flow to water courses when not required. Upstream intake will be regulated accordingly.

The RWS infrastructure is in fact used for Shespali operation.

- The officers agree that this mixed system can lead to confusion and damaging of the canals and structures.

In order to have a full switch to the RWS operation it will be required to:
* train the farmers to RSW water supply on a fixed day for a fixed duration without application;
* have clear government instructions on procedures with regards to sanctions and water charges.

6. Demi II

Irrigation infrastructure
- No escape to drains at the end of Field Channels is present;
- Water courses have still the gates from the original Shespali design.

Farmers comments
- Farmers met in the field, feel that a system operated by themselves will not work as they will find it difficult too accept orders from their fellow villagers.
- They would require the right "to use a stick" before attempting to accept responsibility for water management.

Water management
- The WALMI schedule was followed, but one week early at the request of the farmers.
- First supply and last supply were at a reduced rate of about 90% full discharge, because there was a reduced demand.
Some Water courses were closed using existing gates from original design.
- No applications are taken, water releases started according schedule but the discharges are reduced when water is not used in some fields.
- If full discharge continues to flow and nobody is using the water the lower fields could be damaged, or crops that need no more water could start rotting.
- Required reductions in the release are telephoned from the Section Office (inside the Command Area) to the Dam outlet without delay.
- There is a very high (> 90%) recovery of water charges.
- If a water shortage is known in advance and a limited number of waterings is scheduled, then only those farmers with access to well-water will grow wheat; the other farmers will grow a short maturing crop.

7. Bhadar(m)

Irrigation infrastructure
- For this project the dam and reservoir are fully operational but the irrigation area development is only about halfway completed.
- Design and construction is on-going. Designs of layouts and canals are prepared first in the I.D. design office. At the project office the structures are designed within the limits of the fixed alignments, levels and discharges.
- Progress is slow because of land acquisition problems.
- Buried pipelines are not applied because of the mild slopes that cannot make "non silting velocities" possible.
- Water is supplied both for irrigation and for municipal water supply to nearby towns.
  Outlets are provided directly from the dam as well as from the Main Canal.
- Measuring weir in the Main Canal was broken down as it obstructed flow at low reservoir levels.

Farmers comments
- Farmers met in the field confirmed to get water when it was available from the reservoir.

Water management
- Actual operation deviates from WALMI RWS schedules; because only half the irrigation area is completed a continuous reduced discharge is supplied during the irrigation season from the dam.
- The discharges delivered to the Distributaries is decided on the base of applications received.
- The telephone system is out of order, Section officers make a daily round to check the situation.
- Records on flows are kept, monitoring 3 x per day.
  Flows are calculated from the gauges read.
  After initial fluctuations on the first day, the discharges stabilize around the intended value.
- Discharges required are calculated form the applications received (in ha crop) and the water requirement per ha crop experienced in the previous years.
8. Uben

Irrigation infrastructure
- This is a small irrigation system (2,500 ha) completed with its own dam and reservoir fully operational.
- Measuring weirs are installed complete with gauges in lps and in cusecs.

Water management
- The water scheduling system of WALMI is successfully implemented.
- Applications are invited and the share of water not applied for in a chak is proportionally distributed over those farmers in the chak who did fill an application.
  Thus the original irrigation intensity for the chak is maintained but the farmers who want to irrigate get a higher intensity.
  The farmers take the extra water willingly.
- The Warabandi schedule for the farmers who have applied is then strictly followed.
- There are no problems with absent farmers or with refusal of night shifts.
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Photo 1
Meeting with group of farmers

Photo 2
Informal discussion with farmers in the field
Photo 3
Proportional division structure with compatible all-overflow weirs

Photo 4
Proportional division structure with combination of overflow weir and submerged pipes
Photo 5
Buried pipe of private well irrigation crossing surface distributary canal

Photo 6
Measuring weir in disuse on main canal
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