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IMPACT STUDY OF AN EXPERIMENTAL ROTATIONAL WATER DISTRIBUTION SCHEME AT THE FARM LEVEL IN THE MAHI-KADANA IRRIGATION PROJECT, GUJARAT STATE, INDIA

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SUMMARY

The controlled application of water, at suitably predetermined levels and on an assured basis, to the lands of all farmers in an outlet command is crucial to the optimum utilisation of irrigation supplies. This paper presents the results of an impact study on an experimental farm level rotational water distribution scheme which forms part of an Indian irrigation project. The farmers have welcomed the scheme because they are now able to obtain water in a very orderly manner and at appropriate intervals. Rotational water distribution is also a technological improvement resulting in increased production and greater efficiency.

INTRODUCTION

Efficient water management is the key to success of any surface irrigation project. It consists of providing infrastructural facilities below the last link in the distribution system; that is, the one cusec (cusec = cubic feet of water per second) capacity government outlet serving a block of not more than a hundred acres of farm land. These facilities include land levelling, field channels for the conveyance of water from the outlet to the farmers' fields and field drains for the removal of excess water.[1] Further, it is necessary to provide correct amounts of water, at appropriately predetermined intervals and on an assured basis, to the lands of all farmers in the outlet command. This is with a view to preventing the inefficiencies of over-irrigation which arise mainly from the prevalent practice of levying water charges on the basis of crop-acreage rather than on that of volume of water used, which invariably results in the wastage of water and damage to the soil.[2] It is also essential to ensure equity in distribution to each farmer's field, regardless of whether his land is situated on the upper reaches of the outlet or at the tail-end, whether or not he is economically or politically powerful and whether or not he belongs to a low or a higher caste.[3]

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The provision of infrastructural facilities has been tackled by the various command area development authorities set up in different irrigation projects in India since the mid 1970s in about 102 districts as part of the strategy to step up the rate of utilisation of the irrigation potential.[4] However, scientific rotational water distribution (RWD), based on crop-water requirements, has only very recently been introduced in certain command areas, although a kind of rotational distribution has been in vogue in the northern states of India for quite some time. Under the latter scheme, a farmer is provided with a share of the available water supply according to the number of acres he owns. He has no control, however, over the timing of supply and quantity of such water; he does not know when he will receive his share nor how much of his total share he will receive at any given time. Such a system of rotation, which does not give due consideration to crop-water requirements leads to a substantial degree of uncertainty regarding the supply of water which, in turn, gives rise to disappointing performance with respect to yields, projects and the utilisation of irrigation potential.[5]

The RWD scheme, introduced on a pilot scale in the Mahi-Kadana Irrigation Project in the Gujarat State in western India, is an improved one which takes crop-water requirements into consideration as well as assuring the quantity of water, on a per hectare-time basis, supplied at specified intervals to the farmer in the outlet block.

The objective of this paper is to evaluate the impact of an experimental rotational water distribution (RWD) scheme undertaken in the *rabi* (winter season) of 1978–79 in the Mahi-Kadana Irrigation Project in Gujarat, in western India. The paper is organised into three sections. The first outlines the mechanics of the RWD scheme, the second assesses the socio-economic impact of the scheme and the last section presents a summary listing some policy implications.

MECHANICS OF ROTATIONAL WATER DISTRIBUTION

Rotational water distribution (RWD) is adopted essentially for the *rabi* season when there is negligible precipitation and the cultivators in the command area of an irrigation project have to depend only upon surface irrigation. In the *kharif* (monsoon) season it is only when the monsoon fails or is erratic that surface irrigation assumes importance. For protecting water-intensive crops—for example, paddy—in the *kharif* the branches, minors and sub-minors of the canal distribution system are operated on a rotational basis. Apart from this, no attempt is made to introduce RWD at levels below those of the distributories in the *kharif*.

In the *rabi* season, three more levels of rotation can be visualised in addition to rotation at the distributory levels. The first of these is the rotation of the outlets along a continuous flowing minor, each outlet being opened once a week for a specific period. This is assuming that crops grown in the outlet area require a weekly rotation of water. Crops such as wheat may require a two-week—and those like tobacco a three-week—rotation. However, farmers find it convenient if water is delivered on the same day each week. For those crops requiring longer intervals, rotation can be carried out weekly. The second level of rotation is that among the farmers below the outlet. The third level of rotation is among the sub-groups of farmers within the group below the outlet. This paper seeks to examine the impact of RWD introduced simultaneously at the outlets and among farmers falling within the outlet blocks in a given minor.

The mechanics of rotational water distribution at and below the outlet level in the command area have been worked out on the basis of crop water requirements. (Details are given in Appendix A. Day and night irrigation are indicated without interruption in the flow in the land, branches and minors and only outlets are operated.)

Before introducing RWD one has to ensure farmers' acceptance of the programme. This is because autonomous decisions taken by a governmental agency in the interests of farmers are always suspect in their eyes. A good deal of promotion of the concept is required so that confidence in the irrigation supplies is established in the farmers' minds.[6] Secondly, the irrigation department, which will be the chief governmental agency to operate the RWD, has to restore the canal system to a good condition. Some preliminary construction work may also be required and this would consist of erecting flow regulators in minors. Further, below the outlet level, the field channels, whose maintenance is the responsibility of the cultivators, have to be cleared of weeds and silt and distribution boxes and drop structures may either have to be repaired or replaced altogether. It is also advisable to install measuring devices to determine whether water flow at the outlet is one cusec (cusec = cubic feet of water per second) or less. Experience has also proved the usefulness of lining the first 10 to 15 m of the channel. Appendix B lists the items of expenditure necessary for the introduction of RWD.

The expenditures above the outlet do not normally pose a problem from the point of view of financial sanctions since they come under the heading of distribution system maintenance expenditure which is usually borne by the Government. However, expenditure proposed below the outlet amounts to maintenance which is the responsibility of the cultivators. Apart from the replacement of damaged division boxes or inlets, there are some new investments such as the installation of measuring devices and initial lining. These essential expenditures are incurred by the Government as part of the scheme either with or without a tacit understanding that they may be recovered in the course of time through appropriate command area development surcharges or water rates.

In addition to the above expenditures for keeping the system both above and below the outlet level in good condition, some expenditure on additional staff may be necessary. This additional staff would be needed chiefly for system operations and would, for example, consist of canal inspectors and *chowkidars* to operate the minors and release water from outlets at a fixed time.

Operation of the scheme up to the outlet level thus clearly rests with the irrigation department. But below the outlet level farmers will be involved. Initially the working hours and days are worked out and details of days, times and survey numbers, together with the area and cultivators' names are displayed on the board fixed at the outlet. Sub-groups are also indicated so that the farmers are notified well in advance regarding the quantity of water in terms of hectare time. Although there will be no freedom to change the schedule within the outlet as a whole, the farmers within the sub-group have freedom to make adjustments amongst themselves, depending upon their convenience. This freedom is necessary since night and day irrigation are best observed if left to the cultivators themselves rather than insisted upon by official pressure. The members of a sub-group would constitute a committee with 100% membership and with an elected chairman. All the sub-group chairmen at the outlet level would form the group committee, the membership of which would not exceed three or four. They would elect a chairman from amongst their own number. At the minor level there will be a federating committee composed of all outlet group chairmen. Agricultural officers would be co-opted as members of these committees at the appropriate level to bring home the message of extension with regard to improved soil and water management practices.

Since quantities of water per hectare and time are to be fixed according to the availability of water, it is necessary to abolish the current practice of levying differential irrigation rates based on crops. A flat rate, regardless of the nature of the crops, on a per hectare basis would be more appropriate and would be payable whether the cultivator grows crops using irrigation supplies or not. He may go in for more individual efforts such as his own well or he may buy water-time from a neighbour growing relatively less water-intensive crops or one who might have kept his land fallow but who still has to pay the flat rate. Thus, water will, for the first time, be considered as a saleable commodity instead of the current practice of it being non-transactional and relatively free.

The discussion in the preceding paragraphs outlines some of the practices of RWD at an advanced level. But for those projects where RWD is being introduced for the first time, only essentials need to be followed. Fairly complex practices, such as a flat rate, may prove counter-productive in the initial stages.

The next section discusses the experimental RWD adopted in the Mahi-Kadana command area, on somewhat less simplified lines, in the last *rabi* season and presents the results of an impact study.

SOCIO-ECONOMIC IMPACT OF RWD

Rotational water distribution was introduced for the first time, purely as an experimental measure, in the Mahi-Kadana irrigation project in the *rabi* of 1978–79.

A small but compact area (206 ha) under the command of the Ravalapura sub-minor (9·5 cusecs) in the Anand taluka of the Kaira district was chosen for the purpose.

Figure 1 shows the details of the irrigation system with the network of watercourses and farm land under the command of each government outlet. The length of the water courses is 16·40 km and there were ten outlets before the introduction of RWD. The introduction of RWD necessitated some repairs to the distribution system, both above and below the government outlet levels. These consisted mainly of clearing off weeds, desilting and the replacement of damaged structures. No major investment, such as the installation of measuring devices or initial lining of the field channels, as described in the previous section, was undertaken. However, five more additional government outlets were provided to bring the existing area under irrigation a greater degree of assurance. This was found to be essential in order to create a sense of confidence amongst the project staff as well as trust on the part of the farmers in irrigation supplies, which greatly reduced the earlier uncertainties about irrigation. Details of expenditure are shown in Table 1, the per hectare expenditure working out at Rs.114·00 as compared with the estimated expenditure of Rs.333·00 under a more rigorous RWD scheme.

Although the objectives of the experimental RWD were not complied with, the procedure was far more relaxed. The objectives were: (a) to ensure that each farmer obtained an equal share of the available water volume per acre, based on the allotted time to his field, and (b) to ensure that losses accruing in the field channels are shared equally by the farmers. With regard to procedures, no night-time irrigation schedules were laid down and only day-time schedules were followed. Further, time schedules during the day were left to the farmers in the sub-groups to regulate amongst themselves without any enforcement from the irrigation department. The reasons for this were obvious. Farmers were not used to night irrigation and a disciplined rotational method of distribution in fixed turns was unknown. The large-scale introduction of RWD needs familiarisation in a painless manner and an experimental measure naturally required a relaxed atmosphere so that ultimate acceptance of RWD would be possible.

Despite the departures from the norms of RWD, results purely in terms of increased area irrigated under the experimental scheme were impressive, as is illustrated by Table 2. The farmers who did not normally go in for *rabi* cultivation in the earlier years, believing that they would not get an assured water supply, were encouraged by the irrigation department to grow crops. Secondly, the 'tail-enders' in each outlet command area were given a specific assurance that water distribution would be strictly according to schedule. Thirdly, as a result of RWD, over-irrigation was ended and the water in the distribution system of the Ravalapura minor saved as a result was utilised to irrigate an additional area by extending watercourses. Thus, the aggregate area irrigated went up by 13%.

A survey was conducted after the *rabi* season to assess the psychological impact of RWD on the farmers in the Ravalapura sub-minor. A questionnaire requiring the

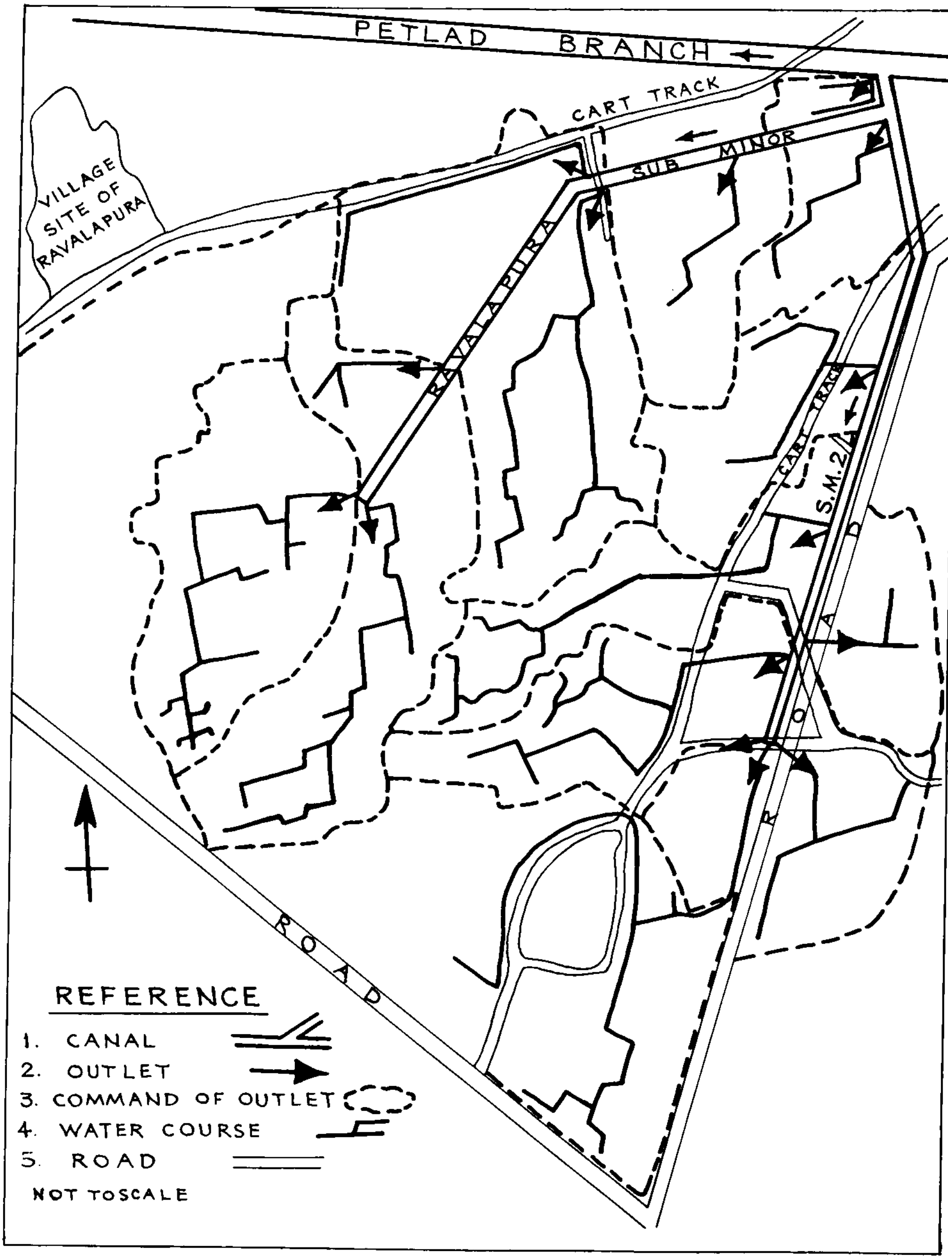

Fig. 1. The area under the command of Ravalapura sub-minor.

TABLE 1
EXPENDITURE INCURRED IN THE INTRODUCTION OF RWD IN RAVALAPURA IN THE *rabi* OF 1978–79

Area in hectares	*Expenditure in Rupees* New outlets	New structures	Repairs to canals	Repairs to field channels	Total expenditure	Total expenditure per hectare
206	5954	3000	4507	9984	23445	114·00

TABLE 2
AREA UNDER IRRIGATION BEFORE AND AFTER RWD

	Before RWD (*1977–78* rabi)	*After RWD* (*1978–79* rabi)	*Increase in percentage*
Number of farmers	289	315	9
Total area irrigated (ha)	168	190	13
Wheat	103	117	14
Tobacco	43	46	7
Vegetables	15	17	2
Others	7	10	43

farmers to indicate whether they approved of RWD or not, and, if they did, to six reasons why, was given to each farmer. Each was also asked to give details relating to the size of his land holding. Of 315 farmers sent the questionnaire, 207 responded. The respondent farmers were categorised into 36 small-scale and 171 large-scale farmers, the small-scale farmers being those with holdings no bigger than 2 ha and the large-scale farmers those with holdings larger than 2 ha.

Tables 3 and 4 present the ranks assigned by small-scale and large-scale farmers, respectively whilst Table 5 presents the ranks assigned by farmers as a whole to the reasons referred to in the questionnaire. Each rank was given a score, the first rank 6, the second rank 5, the third rank 4, the fourth rank 3, the fifth rank 2 and the sixth rank 1. Total rank scores of each reason were computed by multiplying the frequency of farmers ranking it by respective scores and totalling up.

Farmers with large holdings preferred RWD primarily for the reason that they did not have to quarrel amongst themselves for access to irrigation supplies—unlike previous years—whereas the small-scale farmers ranked first the fact that they were able to obtain their water supply requirements on time. The large-scale farmers ranked this particular reason second. All the other reasons were ranked alike by both large-scale and small-scale farmers. These rankings point to the fact that both small-scale and large-scale farmers were assured of equitable water distribution regardless of the size of their land holdings and of the timeliness in supplies. The fact that RWD enabled them to plan their allocation of time for other work was given third preference and that they were able to undertake production plans in advance was

TABLE 3

REASONS FOR PREFERRING RWD: SMALL SCALE-FARMERS

Reasons	Ranks and frequency in each rank						Total number of farmers	Total score	Rank
	1	*2*	*3*	*4*	*5*	*6*			
1. This is the first *rabi* season when I have got water	1	—	1	2	7	—	27	46	VI
2. Although I got water in the last *rabi*, only now has timeliness been assured for the first time	19	2	1	3	2	—	27	141	I
3. Previously there were quarrels amongst farmers for water but during this *rabi* there has been no such quarrel	5	13	7	1	1	—	27	127	II
4. Since I know the time and day for my supply, I can plan my time for other work	—	10	10	6	—	1	27	109	III
5. Due to the assured supply of water, I can plan my production activities	1	1	7	14	4	—	27	89	IV
6. Under RWD I can go in for HYVs of crops	1	1	1	1	13	10	27	54	V
Total number of farmers	27	27	27	27	27	27			

TABLE 4

REASONS FOR PREFERRING RWD: LARGE-SCALE FARMERS

Reasons	Ranks and frequency in each rank						Total number of farmers	Total score	Rank
	1	*2*	*3*	*4*	*5*	*6*			
1. This is the first *rabi* season when I have got water	4	5	6	23	24	118	180	298	VI
2. Although I got water in the last *rabi* only now has timeliness been assured for the first time	84	36	13	13	28	6	180	838	II
3. Previously there were quarrels amongst farmers for water, but during this *rabi* there has been no such quarrel	61	75	23	20	1	—	180	885	I
4. Since I know the time and day for my supply, I can plan my time for other work	15	42	83	32	7	1	180	743	III
5. Due to the assured supply of water I can plan my production activities	16	8	46	67	37	6	180	601	IV
6. Under RWD, I can go in for HYVs of crops	—	14	9	25	83	49	180	396	V
Total number of farmers:	180	180	180	180	180	180			

TABLE 5

REASONS FOR PREFERRING RWD: ALL FARMERS

Reasons	*Ranks and frequency in each rank*						*Total number of farmers*	*Total score*	*Rank*
	1	*2*	*3*	*4*	*5*	*6*			
1. This is the first *rabi* season when I have got water	5	5	7	25	31	134	207	354	VI
2. Although I got water in the last *rabi* only now has timeliness been assured for the first time	103	38	14	16	30	6	207	978	II
3. Previously there were quarrels amongst farmers for water but during this *rabi* there has been no such quarrel	66	88	30	21	2	—	207	1023	I
4. Since I know the time and day for my supply, I can plan my time for other work	15	52	93	38	7	2	207	852	III
5. Due to the assured supply of water, I can plan my production activities	17	9	53	81	41	6	207	690	IV
6. Under RWD I can go in for HYVs of crops	1	15	10	26	96	59	207	450	V
Total number of farmers:	207	207	207	207	207	207			

ranked fourth. The choice of high yielding crop varieties made possible by RWD was ranked fifth whereas the fact that they were able to get water for the first time under RWD was ranked last.

To sum up, although irrigation supplies of a kind were available before RWD, timeliness in supply and equitable access without quarrels were assured for the first time under RWD. Since water supply hours were fixed and made known, well in advance, to all, farmers were able to plan their time and production activities under conditions of greater certainty.

Since the introduction of RWD would amount to a technological improvement in the production function because of the controlled application of water, it was proposed to fit the production functions for two situations—one before and the other after RWD—for the *rabi* of 1977–78 and that of 1978–79. The assumption behind the approach is that the production function for any given crop would be recording an upward shift after the experimental RWD was introduced.

Data on production and inputs were collected for each farm and the crop chosen was wheat. Since the method of collection was the recall method and since it was found necessary to choose only those farms with the same high yielding variety of *Sonalika* wheat, both in the *rabis* of 1977–78 and 1978–79 for the sake of comparison, data for only 107 farms, complete in all output–input relationships, were utilised.

Before fitting a Cobb–Douglas production function for each of the two seasons, inter-correlation matrices of input variables were obtained and analysed. It was found that land, seed charges and bullock expenditure (draught power) were highly correlated with each other and hence it was decided to drop both seed charges and expenses on bullocks from the production function and only land and fertilisers (both chemical fertilisers and farm yard manure) as well as labour days (both family labour and hired labour) were retained. The functional forum for estimating the production function is given below:

$$\log Q = a + b \log LD + C \log F + d \log L + e$$

where Q = output in kilogrammes; LD = land in hectares; F = fertilisers and farm yard manure in Rupees; L = labour days; e is the error term.

The equations estimated by means of the OLS method are presented below:

1977–78 (*rabi*)

$$\log Q = \underset{(8{\cdot}74)}{2{\cdot}842} + \underset{(6{\cdot}25)}{0{\cdot}631} \log LD + \underset{(2{\cdot}81)}{0{\cdot}107} \log F + \underset{(1{\cdot}46)}{0{\cdot}107} \log L$$

$R^2 = 0{\cdot}942$ Degrees of freedom = 103

1978–79 (*rabi*)

$$\log Q = \underset{(9{\cdot}93)}{2{\cdot}719} + \underset{(3{\cdot}87)}{0{\cdot}799} \log LD + \underset{(2{\cdot}12)}{0{\cdot}164} \log F + \underset{(3{\cdot}26)}{0{\cdot}269} \log L$$

$R^2 = 0{\cdot}896$ Degrees of freedom = 103

(Figures in parentheses denoted computed t values)

In the estimated equation for the *rabi* of 1977–78, the coefficients of both land and fertilisers were significant but the coefficient of labour was not significant, the level of significance chosen being 5%. However, in the estimated equation for the *rabi* of 1978–79, the coefficients of all three variables were found to be significant at the 5% level.

Table 6 presents average and marginal products of the significant variables, calculated at their geometric means, together with their production elasticities. The average products of land, labour and fertilisers have gone up, although the rise in the average product of fertiliser is not substantial. Production elasticities of land and fertilisers have registered increases over the period. The returns to scale which were less than that before the introduction of RWD became equal to one after RWD. Since, of the three variables considered only the output elasticities of land and fertilisers were found to be significant both before and after RWD, only their marginal products are compared. Whilst the marginal product of land has substantially increased due to RWD, the marginal product of fertilisers has risen only very slightly. Evaluation by means of production function analysis reveals that

TABLE 6
OUTPUT ELASTICITIES, AVERAGE AND MARGINAL PRODUCTS OF LAND, LABOUR AND FERTILISERS BEFORE AND AFTER RWD

	Before RWD *1977–78* (rabi)	*After RWD* *1978–79* (rabi)
Geometric Means		
Output (in kilogrammes)	902·801	986·972
Land (in hectares)	0·314	0·303
Fertiliser (in Rupees)	203·655	220·700
Labour (in man-days)	25·443	21·098
Production Elasticities		
Land	0·631*	0·799*
Fertilisers	0·107*	0·164*
Labour	0·107****	0·269*
Sum of elasticities	0·738**	1·012***
Average Products		
Land (in kilogrammes per hectare)	2875·162	3257·332
Fertiliser (in kilogrammes per Rupee)	4·433	4·472
Labour (in kilogrammes per man-day)	35·483	46·781
Marginal Products		
Land (in kilogrammes per hectare)	1814·227*	2602·608*
Fertiliser (in kilogrammes per Rupee)	0·474*	0·733*
Labour (in kilogrammes per Rupee)	—	12·583*

* Significant at 0·05 level.
** Significantly different from unity.
*** Not significantly different from unity.
**** Not significant at the 0·05 level.

RWD has certainly led to an upward shift in the production function and that the marginal and average products of land and fertilisers have recorded increases and the contribution of labour has also become significant.

However, a caveat is in order. The introduction of RWD in the Ravalapura minor in the *rabi* of 1978–79 was an unusual event in the history of the irrigation project. Apart from improvements in the distribution system, both above and below the government outlet, substantial extension efforts to promote irrigated agriculture were undertaken. Thus RWD also represented an unprecedented application of technical and human resources of a fairly high intensity, in addition to the controlled administration of water to crops. The contribution of these two elements cannot be easily captured in a conventional production function analysis.

CONCLUSIONS

An experimental RWD introduced in the Mahi-Kadana irrigation project in Gujarat, India, during the *rabi* of 1978–79 in a very limited area under a sub-minor has evoked a very favourable response both from small-scale and large-scale farmers. This is because the farmers were able to obtain irrigation supplies in appropriate amounts, worked out on the basis of scientifically determined crop water requirements and at predetermined intervals on a per hectare-time basis, and no longer had to quarrel amongst themselves for access to water supplies since each farmer's turn was fixed and made known to everyone well in advance.

Apart from the social impact of the RWD, economic gains are also impressive. These gains flow from: (a) an increase in the irrigated area under the outlets due to an assured pattern of distribution; (b) an increase in the profitability of production through the increased application of inputs such as high yielding variety seeds and fertilisers under conditions of certainty in irrigation supplies and (c) an increase in area of irrigation outside the original command area due to saving in water use through watercourse extension.

Because the controlled application of water avoids over-irrigation, average and marginal products of land and fertilisers in the production of a specific crop, wheat, whose production functions before and after RWD were fitted and compared, registered increases over the period.

The experimental RWD did not, however, follow the strict norms such as flat irrigation water charges, regardless of crops grown, or night irrigation. Further, no investments such as measuring devices and initial lining of field channels were undertaken. As the scheme was tried only to discover the farmers' response to an entirely new pattern of water distribution, rigorous observance of norms was not found to be necessary. Thus, expenditures were kept to a minimum and were not recovered from the farmers.

On the other hand, RWD on rigorous lines requires investments of a higher magnitude below the government outlet. However, there exists a legitimate case for recovering the investment costs and operational expenditure, either through an appropriate flat rate on water use, regardless of the nature of the crops grown and whether a farmer raises crops or not, or through a special command area development surcharge, since the gains arising out of RWD are too obvious.

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APPENDIX A: DETAILS OF A HYPOTHETICAL RWD SCHEME

For working out the rotational schedule of irrigation, the following crop water requirements, based upon the results of research studies conducted by the Gujarat Agricultural University, are assumed:

(a)	Wheat	Seven irrigations, each 3 in = 533 mm
(b)	Tobacco	Four irrigations, each 3 in = 305 mm
(c)	Vegetables	Seven irrigations, each 3 in = 533 mm
(d)	Others	Seven irrigations, each 3 in = 533 mm

It is also assumed that there are losses in transmissions: (a) losses in the field channel system (25 %) and (b) losses in field application (10 %). Thus, total losses amount to 35 %.

Suppose there are four outlets in a group, all served by a sub-minor. The areas under the outlets are given below:

	Acres	*Hectares*
Outlet A	28	11·34
Outlet B	20	8·10
Outlet C	30	12·15
Outlet D	29	11·74
	107	43·33

If the cropping pattern is such that 80 % of the area is under wheat, 10 % under tobacco and another 10 % under vegetables, crop water requirements on a per hectare basis are as presented in Table A.

TABLE A
CROP WATER REQUIREMENTS PER HECTARE

Crops	*Area (%)*	*Water requirement (mm)*	*Requirement per hectare (m^3)*
Wheat	80	533	4260
Tobacco	10	305	305
Vegetables	10	533	533
Total			5098

Suppose the average length of the growth period for the crops is 120 days. The flow per second per hectare is worked out as follows:

$$\frac{(5098\,\text{m}^3\text{ per hectare})(1000\text{ litres/s})}{(120\text{ days})(24\text{ hours})(3600\text{ s})} = 0{\cdot}49\text{ litres/s/ha.}$$

If the transmission losses are taken into account, the flow rate per second per hectare should be:

$$(0{\cdot}49)(1{\cdot}35) = 0{\cdot}66\text{ litres/s/ha}$$

Since a cusec equals 28·3 litres/s, the area that could be irrigated is 42·8 ha (= 28·3/0·66).

Since the flow in the distribution system is continuous, 168 h a week would be available for irrigation. Thus, the total flow per hectare is 168/43·33 = 3·88 h/ha/week.

Since there are four outlets in the group, they have the time allocations worked out in Table B.

TABLE B
TIME AND DAY SCHEDULES FOR ALL OUTLETS

Outlet	*Area (ha)*	*Hours per week*	*Schedule*
A	11·34	44	Monday 05.00 hours to Wednesday 01.00 hours
B	8·10	31	Wednesday 01.00 hours to Thursday 08.00 hours
C	12.15	47	Thursday 08.00 hours to Saturday 07.00 hours
D	11·74	46	Saturday 07.00 hours to Monday 05.00 hours

Since each outlet is going to be divided into sub-groups for irrigation purposes with a view to protecting the 'tail-enders', the adjusted time, allowing for line losses, which is worked out for outlet A is given in Table C.

TABLE C
TIME AND DAY SCHEDULE FOR OUTLET A

Sub-group	*Area (ha)*	*Distance from outlet*	*Base time (h)*	*Adjusted field channel losses (Percentage)*	*Adjusted time (h)*	*Time schedule*
1	3·24	1000	13	−20	10	Monday 05.00 hours to 15.00 hours
2	4·46	3000	17	+0	17	Monday 15.00 hours to Tuesday 08.00 hours
3	3·64	5000	14	+20	17	Tuesday 08.00 hours to Wednesday 01.00 hours
			44		44	

APPENDIX B: MINIMUM IMPROVEMENTS/REPAIRS/REMODELLING REQUIRED FOR THE INTRODUCTION OF RWD IN MAHI-KADANA RIGHT BANK

	Rupees/ha
1. Increasing the capacity by widening or lining of the canal below 20 cusecs and up to government outlet	100·00
2. (a) Measuring devices in network up to government outlet (b) Measuring devices at outlet	36·00
3. Additional cross regulators throughout system	10·00
4. Additional outlets and extension of canal system to reduce outlet size	23·00
	8·00
5. Improvement to service roads and inspection path	21·00
6. Radio telephone network limited to light equipment for facility of regulating distribution in the service area	10·00
7. Community works consisting of the remodelling of field channels	95·00
8. Remedial measures for existing structures throughout the system to bring them to a satisfactory condition	30·00
	333·00

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