ICIWRM – 2000, Proceedings of International Conference on Integrated Water Resources Management for Sustainable Development, 19 – 21 December, 2000, New Delhi, India

Planning conjunctive use for controlling water table in a canal command area.

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Abstract
The major problem associated with canal irrigation projects are waterlogging, soil salinity and alkalinity. These ultimately leave bad impact on health and wealth through various means. The injudicious use of canal water causes the rise in water table which lead towards the above mentioned problems. In view of the above facts, one of the multipurpose irrigation projects has been selected for the purpose of study at river Narmada at Bargi in the state of M.P. (India). The study aimed to suggest preventive measures rather than remedial measures to control rising trend of water table in canal command area. The problem was tackled in two stages. The linear programming technique was adopted to allocate the existing resources of the study area in the first stage. The appropriate quantity of ground water that can be pumped out safely was worked out month wise in second stage after considering each component of water balance to control the rise in water table. The study reveals that the allocated crop plan utilizes maximum of the available resources and will increase the benefit- cost ratio from 1.49 to 1.99. It has been observed that the current supply of canal does not fulfill the water requirement of the allocated crop plan particularly in peak periods, which can be cover through the use of ground water in conjunction with canal water. The implementation of suggested measures would definitely keep the water table below the safe limits for rabi season.

INTRODUCTION

Large canal infrastructure network to provide irrigation has been the prime goal of the Government of India, since first five-year plan, which continued up to seventh five-year plan. This land marks in infrastructures development is still unbeaten. An ailment associated with fast growing activities has unnoticeably being ignored, which lead to the problem of the waterlogging salinity and alkalinity in limited to large patches in all the irrigation projects of the country. Karnal, M.P. and part of few other states are the examples to name a few. A symposium held in 1972 exercised a scientific churning of the causes and the remedial measures to strike off the problem. Many research workers (Micheal, 1982; Sondhi *et. al.*, 1982; Raghuwanshi *et. al.*, 1990) have focused the causes of water logging. The remedial measures to these have been suggested by (Raghunath, 1983; Tyagi and Agrawal, 1990; Murty, 1991; Tyagi *et. al.*, 1994) while (Khanna and Rai, 1991; Khan, 1992; Kale,1982; Naqvi, 1987; Ningombam, 1991 and Asrani, 1993) have demonstrated the measures and so consumerative effects. In fact literature shows legs in focusing the approach to arrest problems of water table rise before it approaches the dangerous or alarming situation. The situation necessitated to honor the thoughtful thinking mentioned above in one of the multipurpose irrigation projects launched in M.P. The aim of the study was to allocate the crop and land in the interest of the farmers for net benefit maximization. The irrigation needs for fulfilling crop water requirements to be satisfied by judicious utilization of available canal water in conjunction with ground water so as to keep the water level within the acceptable range.

MATERIAL AND METHODS

One of the seventh centrally sponsored project of Government of India, situated at river Narmada at Bargi(Jabalpur) in the state of M.P. (India), was the study area where, only a part i.e. Khulri minor, showing high water-table region was considered. On average basis, a rise in water table of the order of 2 cm per year was observed. Background information collected by previous research workers was critically investigated and the attempt was made to suggest arresting rise in water table through a two-stage approach, presented in Figure 1.

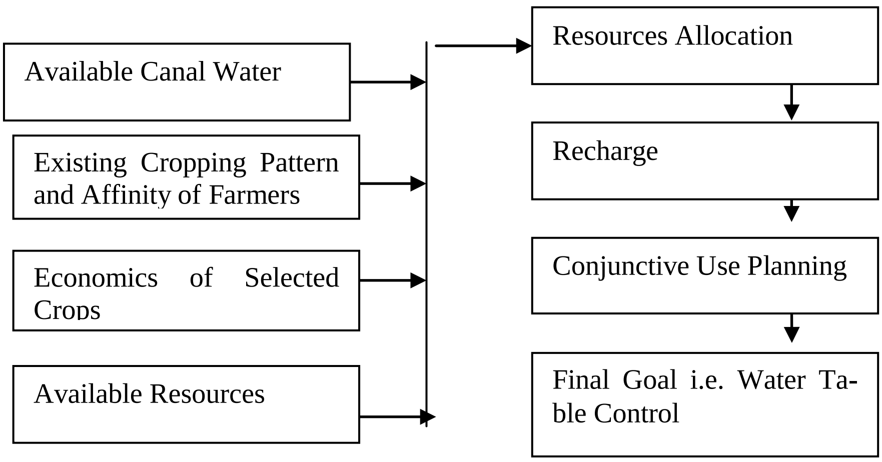

Figure 1. Flow Diagram Considered for Modelling.

The interest of farming community lies in net benefit maximization was considered for the purpose of allocation of lands for different crops. The allocation of land for different crops were achieve s considering the constraints of availability of area for different crops within the command area, fertilizer, labour, and affinity to some extent by the way of vegetable, pulses etc. to keep the pace with balance nutrition for all the livelihood. At the last the most vital constraint i.e. available canal water were also considered. The allocation of areas for particular crop / vegetable were then subjected to the demands of crop / vegetable. While at the second stage, which had to apply the principle of water balancing, keeping in view the marginal water level for safe crop growth.

A traditional jargon for fitting in Simplex Methodology on linear variation was adapted to allocate the areas for particular crop / vegetable. The different component of water balancing viz. seepage in conveyance, ground water inflow and outflow, change in soil moisture storage, ground water draft, evaporation, evapo-transpiration, canal supply etc. were carefully estimated to calculate the net ground water recharge on monthly basis. The requirements of ground water were then calculated on monthly basis, to balance the deficit supply of canal water so as to arrest the water table rise.

RESULTS AND DISCUSSION

Total 214 hectare area lies in the command of selected Khulri minor was considered for the study, which covers three adjoining village (Barkhera, Khulri and Semra villages). The proposed length of the minor was 3 km, while the minor has been constructed up to 2 km. Out of the minor network, there are 30 open wells exist in the command area. The total 1150 people resides in the study area. The most of the population of the area depends on the agriculture. The total availability of the labour was worked out to be 27400 mandays during rabi season. The common rabi crops of the area was found as wheat and gram. It was observed that the cropping intensity of the area in rabi have been increased from 62 percent to 100 percent in three years period (i.e. 1991 to 1994) due to introduction of canal irrigation. The wheat and gram crops covered about 80 percent area of the total culturable command area. The total 26600 Kg Urea, 48570 Kg Single Super Phosphate and 12550 Kg of Potash were available in the command area during rabi season. The canal operation shows that on an average 51.4 ha-m water were diverted from main canal to minor, while it was worked out that only 40.43 ha-m remains available at field level. Most of the wells lies in the command area are not being used for irrigation. The result of the pumping and recovery test shows that the average specific capacity of the wells are 7.068 m^3/hr/m, draw-down and the average specific yield of these existing wells were worked out to be 21.204 m^3/hr. The most of the wells shows their recovery trend in such a way that the original level of water attains within 16 to 18 hrs after pumping, which were considered as the wells can be pumped once in a day. This consideration showed that one well is capable to supply 63.617 m^3 water in a day.

The economics of the existing cropping pattern and allocated crop plan for the area are presented in Table 1 and Table 2. The benefit cost ration of the existing cropping system was observed very poor, which appears to be 1.49. The existing system provides average net benefit of Rs.3778.00 per hectare, which found too low. It is clear from Table 1 that the existing system is not capable to utilize the existing resources of the study area. For example the availability of the fertilizer in command area are 26600 Kg Urea, 48570 Kg Single Super Phosphate and 12550 Kg of Potash whereas the existing system is utilizing only 13880 Kg of Urea, 7070 Kg of Single Super Phosphate and 4530 Kg of potash. This shows the big gap between availability and utilization. In view of the above facts a resources allocation plan has been developed to maximize the farmer's goal of net benefit maximization.

The allocation obtained for an area of 214 hectare was subjected to the water requirements keeping in view the availability of water through canal system needs to be supplemented. In order to have the crop allocation, six crops with different verities under irrigated and rainfed conditions were considered to incorporate the constraints of land, affinity, fertilizer, labour and the most crucial water constraint.

Table 1. Existing Economics of Cropping Patterns for Command area of Khulri Minor.

S. No	Crop Activity	Area	Fertilizers N	Fertilizers P	Fertilizers K	Labor (Man-days) @Rs35/-	Bullock (Bullock-days)	Over Head Charges (including irrigation charges)	Yield Grain	Yield Straw	Farming Cost	Gross Return	Net return	Total Production Grain	Total Production Straw	Total Labor Man-days	Total Investment	Total Benefit	Benefit Cost Ratio
		ha	Kg.	Kg.	Kg.			Rs/ha	qt/ha	qt/ha	Rs/ha	Rs/ha	Rs/ha	Qt.	Qt.		Rs.	Rs.	B/C
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Wheat	131.43	80	40	30	110	11	900	18	30	8155	11100	2945	2726	4543	16657	1234900	445958	1.36
2	Gram	20.78	30	30	-	75	11	800	12	15	5713	10875	5161	249	311	1558	118716	107245	1.90
3	Lentil	18.00	20	-	-	55	11	800	8	-	3835	8800	4965	144	-	990	69004	89375	2.29
4	Pea	6.70	30	-	-	70	10	800	8	-	4395	7200	2805	54	-	469	29446	18793	1.64
5	Vegetable and others	10.01	60	40	-	230	10	2000	5	-	12958	25000	12042	50	-	2302	129709	120540	1.93
Total			13880	7070	4530											21976	1581808	781911	1.49

Table 2: Land Allocation and Resource Utilization with Crop Plan Economics for the Proposed Plan

S. No	Crop Activity	Area	Fertilizers N	Fertilizers P	Fertilizers K	Labor (Man-days) @Rs35/-	Bullock (Bullock-days)	Over Head Charges (including irrigation charges)	Yield Grain	Yield Straw	Farming Cost	Gross Return	Net return	Total Production Grain	Total Production Straw	Total Labour Man-days	Total Investment	Total Benefit	Benefit cost Ratio
		ha	Kg.	Kg.	Kg.			Rs/ha	qt/ha	qt/ha	Rs/ha	Rs/ha	Rs/ha	Qt.	Qt.		Rs.	Rs.	B/C
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Wheat HYV-I (WH 147)	80.00	100	50	50	110	10	953	30	35	11194	20000	8806	2400	2800	8800	895520	704480	1.79
2	Gram HYV-II (JG 221)	4.55	20	60	-	75	11	827	22	24	9714	19500	9786	100	109	241	44221	44549	2.00
3	Vegetable (Tomato)	40.00	110	80	80	200	10	1492	80	-	17401	40000	22599	3520	-	8800	765644	994356	2.29
4	Pea-I (T 19)	44.45	20	50	-	70	10	741	20	-	8641	18000	9359	889	-	3111	384075	415989	2.08

Table 3: Monthly Ground Water Balancing

S. No.	Particulars	Months								
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	Seepage from Canal, (ha-m)	0.0000	4.0275	8.3200	8.3200	7.5180	8.3200	4.0275	0.0000	0.0000
2	Seepage from Minor,(ha-m)	0.0000	0.3504	0.9346	0.7243	0.6075	0.7243	0.1869	0.0000	0.0000
3	Seepage from Water Course, (ha-m)	0.0000	0.8669	2.3110	1.7917	1.5027	1.7117	0.4624	0.0000	0.0000
4	Ground Water Inflow (ha-m)	0.6998	0.3002	0.6311	0.5170	0.5343	0.6208	0.2289	0.6982	0.5459
5	Ground Water Outflow (ha-m)	0.5692	0.2747	0.4358	0.5025	0.2677	0.4319	0.2713	0.3181	0.3520
6	Change in Soil Moisture Storage, (ha-m)	-6.4467	4.0200	-1.0500	-0.8400	-0.8400	-1.0500	-5.1570	-3.8680	-5.1573
7	Ground Water Draft, (ha-m)	0.7735	0.7485	0.7734	0.7734	0.6986	0.7734	0.7485	0.7734	0.7485
8	Evapotranspiration from Rainfed Crops and Uncultivated Area, (ha-m)	8.7483	11.3500	15.6708	15.3591	7.7525	6.5968	9.5540	4.0430	0.7445
9	Evapotranspiration from Irrigated Crops, (mm/ha)	-	42.2318	78.9270	79.5580	31.9810	6.4976	-	-	-
10	Canal Water Supply, (mm/ha)	-	34.8900	64.4400	44.0290	35.4852	34.3340	27.1570	-	-
11	a. Excess canal Supply, (mm/ha)	-	- -	-	-	3.5042	27.8364	27.1570	-	-
	b. Deficit Canal Supply, (mm/ha)	-	7.3418	15.4870	35.5290	-	-	-	-	-
12	Net Recharge, (ha-m) (1+2+3+4+9-5±6-7-8)	-15.8379	3.0889	4.9898	1.3190	6.6007	8.4071	-6.2355	-8.3043	-7.0006
13	Calculated Fluctuation	-1.2283	0.2395	0.3870	0.1023	0.5119	0.6520	-0.4836	-0.6440	-0.3430
14	Estimated Water Table Depth because of Recharge, (m)	2.7383	2.2751	1.8881	1.7881	1.2762	0.6242	1.1078	1.7518	2.0940
15	Required Ground Water to compensate Deficit Canal Supply, (ha-m)	-	1.2400	2.6170	6.0040	-	-	-	-	-
16	Water Table Fluctuation after withdrawal of required quantity	-	-0.1977	-0.2171	-0.4715	-	-	-	-	-
17	Final Water Table Depth after withdrawal of ground water, (m)	2.7383	2.5948	2.4107	2.7740	2.2621	1.6101	2.0937	2.7377	3.2806

The allocations of the different crops obtained through the Simplex method of linear variation are presented in Table 2. In general Wheat variety WH147 has to occupy 80 hectare followed by gram with the minimum of 4.55 hectare. The economic scenario emphasis to go for vegetables over an area of 40 hectare. Pea (T-19) has appeared to be promising for economic upliftment to offers benefit cost ratio of 2.08. While for rainfed areas through allocation suggests keeping gram over 35 hectare. The overall benefit-cost ratio by these allocations appears to be 1.99, i.e. increased from 1.49 to 1.99, which is highly appreciated. The allocation utilizes the optimum of available resources in accordance to requirements.

In order to satisfy the water requirements, the demands and supplies were subjected to a ground water model for balancing on monthly basis considering both surface and ground water. The results of balancing method are presented in Table 3, for growing period of rabi i.e. from October to March extended to the month of June to acquire the water level of pre monsoon period. It may be observed from the table that the negative recharge occurs during the month of October, April, May and June. The negative values of recharge in these months are due to non-operation of canal and higher evaporative demand. The positive recharge has also been observed in November to March. The water demands for the allocated crops can be observed in excess with respect to the current canal supply particularly in highest demand period. While the current canal supply was observed in excess during the lowest or nil irrigation demand. Therefore, ground water supplies of the order 1.24 to 6.00 ha-m can compensate the deficit in canal supply. It was worked out that the existing 30 wells are capable to supply 57256 m^3 in a month, which is less than by 3544 m^3, during the peak requirement period i.e. January. The extra 3544 m^3 of water can be obtained from two additional new wells. Thus the 32 wells would be capable to supply the required demand of ground water when canal supplies less than the required water. The net fluctuation in water table due to extraction of ground water or recharge shows that the water levels will be maintained from 1.61 m (March) to 3.28 m (June). Which can be considered as safe limit. The balancing activity for the forth coming season with a addition of recharge due to precipitation was expected to pour water level at 1.77 m below ground level in the month of October for the joining rabi season.

The results mentioned above clearly shows that when the suggestive measures are implemented in too will definitely keep the water table below the safe limits for rabi season.

CONCLUSION

It may be concluded from the result obtained that there is an urgent need for policy makers to decide the canal release policies as per the scientific requirements rather than following a thumb rule routing schedule. This implementation will not only improve the production but also will also lead to economic upliftment of farming community and keep the problem of waterlogging for their encroachment.

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